The first golden age of psycholinguistics 1865 – World War I

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It is a great honor for me to be the recipient of this years' Sarton Chair for the history of science. The Sarton Committee's decision is moreover a courageous one because it is the common, ineradicable belief that my inter-discipline, psycholinguistics, hardly has any history. Textbooks and handbooks concur in telling us that psycholinguistics took off half a century ago during the so-called "cognitive revolution" in the United States. However, nothing is less true. I am most grateful for this eminent opportunity to sketch a different story. It is based on research reported in Levelt (2013/2014). Inevitably, the present paper occasionally uses materials from that book.

Psycholinguistics, its four epirical roots and its golden age

But first, what is psycholinguistics? It studies what we are doing right now. I am formulating my thoughts for you, transmitting them to you by means of amazingly rapid articulations, some 12 speech sounds per second. You are at the same time decoding the such produced stream of aerial vibrations hitting your ear drums, with a seemingly immediate interpretation of what I meant as a result. Psycholinguistics studies this amazing feat and the neural infrastructure on which it is based. It also studies the rapid acquisition of these skills during the first few years of life. There are clearly four disciplines involved in this enterprise: psychology, both experimental and developmental, linguistics, and neuroscience.

The empirical roots of this inter-discipline go back to the end of the 18th century. Let me begin by mentioning these four historical roots.

There was, first, the discovery of the Indo-European language family, first formulated in the famous 1786 lecture by Sir William Jones in Calcutta, who noticed the correspondences between Sanskrit, Latin and Greek and their probable relations to Gothic, Celtic and Persian. Apparently, languages had evolved from a common source that could be partly reconstructed, which raised the question: What had been the psychological origins of this primordial language?

There were, second, the beginnings of serious brain anatomy – pioneered by Franz Joseph Gall in *fin-de siècle* Vienna. It initiated the fascinating search for the localization of language faculties in the brain.

There was, third, Rousseau's plea in his *Émile* to systematically observe the developing child. It led to Dietrich Tiedemann's 1787 publication in Hamburg of a diary reporting among others on the early development of speech in his infant son, which was soon followed by other, similar diaries.

And there was, fourth, the first engineering approach to modeling adult speech production – Von Kempelen's cleverly designed speaking machine, built over a 20-year period in Vienna. It could produce complicated utterances such as *Leopoldus secundus*. It was described as a model of the human vocal tract in Kempelen's wonderful 1791 book on the mechanisms of human speech.

These four roots initially developed independently, but began interacting in the course of the 19th century and led to what I called "The first golden age of psycholinguistics", the topic of this lecture.

It can conveniently be dated as beginning exactly 150 years ago in 1865. In that year Marc Dax and Paul Broca independently published their discovery of the region in the left frontal brain controlling articulate speech, now known as Broca's area. It was also the year in which Franciscus Donders invented a way of measuring mental durations, "mental chronometry". The golden age covered an era of five decades, ending with World War I. Then a period of tragic decline set in. Many of the sophisticated tools, discoveries and theoretical notions of the golden age went into oblivion for half a century or more, leading to the general amnesia I already noticed.

The Genetic Stance

Many pioneers of this prolific period shared a theoretical perspective, which I will call the "genetic stance". It was introduced by Wilhelm von Humboldt in 1827. By then already substantial knowledge existed about the Indo-European language family and it was obviously based on the analysis of written texts. Humboldt acknowledged that these texts were *products* of language, but they are not language itself. Language is not a product (*Ergon*), according to Humboldt, but an activity (*Energeia*). "Hence, its true definition can only be a genetic one. It is namely the ever repeated labor of the mind, to enable the articulated sound to express the thought." (1963-edition, p. 192). Language is what the speaker does, a process extending over time. I have called this rapid process the *microgenesis* of language. The measurement and analysis of this mental process became core business during the first golden age.

However, the genetic stance became much more encompassing than this. After the discovery of Broca's area neuroscientists began constructing *neurogenetic* models, explaining the neural processes involved in this microgenesis of speech. It led to intensive study of aphasics' speech and the post-mortem analysis of their brains. At the same time biologists, neuroscientists and developmental psychologists began studying the child's acquisition of speaking abilities, that is the *ontogenesis* of speech. And finally linguists and psychologists addressed what they considered the ultimate *phylogenetic* problem: how did language evolve in evolution? How did language emerge in the minds of primordial human beings?

The shared genetic stance naturally connected these four strands of research and daring steps were taken to develop unifying theories. The one monumental outcome of these efforts was Wilhelm Wundt's two-volume *Die Sprache* of 1900. It provided a unified account of the micro-, neuro-, onto- and phylogenesis of language.

I will now highlight these four strands of genetic research during the first golden age, in the following order: phylogenesis, neurogenesis, ontogenesis, and finally microgenesis, which was of amazing sophistication, but still went into total eclipse by the end of the golden age.

Phylogenesis

How did the primordial human mind create language? The issue was hotly discussed all over the 19th century and linguists concurred in devising ever more colorful theories. They were somewhat successful in reconstructing the original roots, the *Urwurzel* of a language family and roughly their meanings. The famous Sanskrit scholar Max Muller, for instance, claimed to have reconstructed the 121 Sanskrit roots and their meanings. "These 121 concepts", he stated in 1887 (p. 406), "constitute the stock-in-trade with which I maintain that every thought that has passed through the mind of India, so far as it is known to us in its literature, has been expressed".

The logical next question had to be: how did these root words emerge in the minds of primordial *homo sapiens*? Here there was no limit to the inventiveness of linguists, especially because the explanations could not be evidence-based. No trace of the original speech sounds had been preserved. In order to check this limitless proliferation of theories, the Parisian Société de Linguistique, which was founded in 1864, stated in its bylaws that no communications would be accepted on the origins of language.

Charles Darwin expressed in *The descent of man* (1871) his sympathy for the "imitation theory", primordial man imitating the sounds of nature in order to make reference to their sources, such as calling a cuckoo 'cuckoo'.

"I cannot doubt that language owes its origin to the imitation and modification, aided by signs and gestures, of various natural sounds, the voices of other animals, and man's own instinctive cries." (1871, Vol. I, p. 56).

This had been proposed a century earlier by Herder (1772), who used the example of imitating the sheep's bleating to make reference to the wooly animal. Darwin also accepted the "interjection theory", expressive cries becoming referential to the events provoking them. And he added the new suggestion of language emerging from sexual selection, courting song as the origin of vocal communication.

"primeval man..., probably used his voice largely, as one of the gibbon-apes at the present day, in producing true musical cadences, that is in singing;... this power would have been especially exerted during the courtship of sexes, serving to express various emotions." (p. 57).

Wilhelm Wundt reviewed this gigantic literature in the last chapter of *Die Sprache* and proposed from his genetic stance a still different psychological theory of language origins, the "gestural theory". The *explanandum* is this: how did expressive vocal sounds become symbols of conscious content, of thoughts and ideas? Wundt's answer consisted of a negative and a positive component. Here is the negative one: The relation between a speech sound and its meaning is hardly ever a direct one (as in "cuckoo" for a cuckoo). Language cannot have developed from such direct expressiveness. It is rather the *vocal gesture* which can be directly expressive of affect or meaning. The sound produced by that articulatory gesture is a mere, arbitrary by-product; it has no intrinsic relation to that affect or meaning.

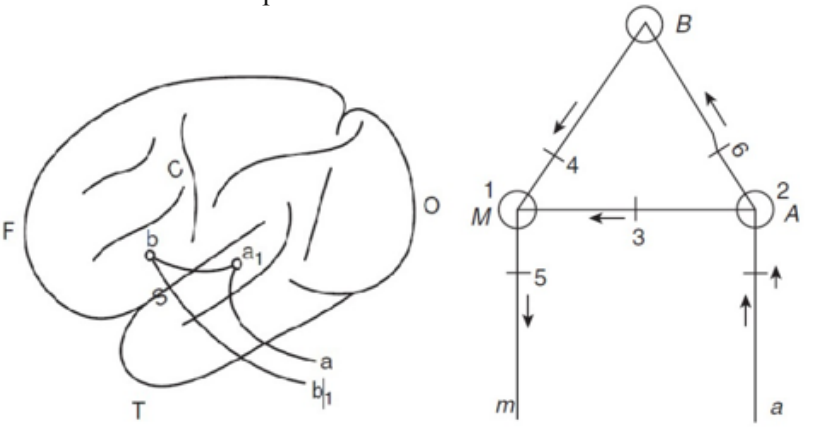
The positive component is this: Expressive movements, including articulatory ones, *are* directly expressive of affect, meaning or thought. We still see this, according to Wundt, in the mimic and pantomimic gestures which universally accompany the speech of children and *Naturvölker*. Sign language is the universal, natural expressive means of *homo sapiens*. It arises spontaneously in any community, just because it is directly expressive of meaning, both in its referential deictic gestures such a pointing, and in its iconic, imitative gestures. Articulatory gestures are just part of these larger pantomimic patterns. They happen to produce initially meaningless sounds. The simultaneity, however, of the meaningless sound and the meaningful gesture creates the mental association between sound and gesture and from there between sound and meaning. This is the seed from which spoken languages developed and still develop.

Wundt had been the first to sketch a grammar of sign language. His contemporaries always denied that Deaf sign languages have a grammar. It took six decades before the grammatical analysis of sign language was re-initiated, without any reference to Wundt.

Gestural theories of language origins are still popular, though again without acknowledgement of Wundt's work. I have argued that a theory of gestural origins of language cannot explain the emergence of the spoken language mode (Levelt 2013, p. 203). But I do agree with Wundt and all of my colleagues that gesturing has always been a component in the phylogeny of language, as it is in the ontogeny of language.

Neurogenesis

Let us now turn to the study of neurogenesis during the first golden age. The discovery of Broca's area in 1865 initiated a serious search for language processing in the brain. In 1874, Carl Wernicke, at the age of 26, published his 68 page master piece *Die aphasische Symptomencomplex. Eine psychologische Studie auf anatomischer Basis*. It proposed the first neurogenetic theory of speech processing. The booklet was revolutionary for two reasons. First, it published Wernicke's discovery of a left-hemisphere "sensory speech center", now called "Wernicke's area", near the projection site of the acoustic nerve in the first temporal gyrus. It reported on the symptoms of patients with a lesion in that area. It described and theoretically accounted for the aphasic symptoms of such patients, which we now call Wernicke's aphasics.



(a) (b)

Figure 1.
(a) Wernicke's (1874) "reflex arc" with its centers and connections and the speech defects resulting from their disruptions.
a-a1: the incoming acoustic nerve from oblongata – deafness
a1: Wernicke's area – Wernicke's aphasia
a1-b: fibers connecting Wernicke's and Broca's area – connection aphasia
b: Broca's area – Broca's aphasia
b-b1: the centrifugal speech motor nervse – alalia

(b) Lichtheim's (1881) "house", adding a "conceptual center" to Wernicke's reflex arc. Disrupting its "transcortical" connections to Wernicke's and Broca's area will result in "transcortical sensory aphasia" and "transcortical motor aphasia" respectively.

Second, Wernicke took the theoretical step of anchoring the psychological centers and connections figuring in his psychological process model to the neural architecture of the brain (see Figure 1a). The discussion no longer centered on the faculty of articulate speech as in Broca's work, but on a componential model of language processing. The network, also called "reflex arc", can be disrupted in five locations, each causing specific speech disorders (see Figure 1a). When the auditory nerve is damaged you will be deaf. When the newly discovered sensory speech center is damaged, your recognition of speech will be affected – we now call this "Wernicke's aphasia". When the neural pathway between Wernicke's and Broca's area is damaged, you will be unable to monitor your own speech, which Wernicke called "conduction aphasia". When Broca's area is damaged, the ability to plan articulate speech will be damaged, which became referred to as Broca's aphasia. And when the motor connections between Broca's area and the articulatory musculature are damaged, you will suffer from dysarthria or "alalia".

Wernicke was the first to anchor the functional, psychological architecture for speech in the neural architecture. The neural network embodied the psychological processes going from auditory perception, to speech sound and spoken word perception, to spoken word planning and finally to speech articulation. This neurogenetic anchoring became a research endeavor of great and long-lasting significance. Wernicke's monograph triggered an industry of network models for over four decades to come (cf. my second Sarton Lecture). One of those neurogenetic models became highly influential: Lichtheim's "house" (see Figure 1b).

Lichtheim had been Wernicke's assistant in Breslau and extended Wernicke's diagram with a "roof", connecting Wernicke's speech sensory and motor centers, Wernicke's "reflex arc" with a *Begriffszentrum (B)*, a conceptual center (Lichtheim 1885). This became a crucial addition to the componential psycholinguistic model. It resulted in the addition of two types of speech disorder to Wernicke's five: You will suffer from "transcortical sensory aphasia" if the connection between Wernicke's area, the sensory speech center (A), and the conceptual center is disrupted; you will not *understand* the speech you perceive. And you will suffer from "transcortical motor aphasia" if the pathway from the conceptual center to Broca's area (M), the motor speech center, is disrupted. It will cause loss of volitional speech. Wernicke accepted Lichtheim's scheme almost

in full. Both Wernicke and Lichtheim stressed the impossibility to localize the conceptual center in a circumscribed region of the cortex.

Lichtheim realized that, as a psychological model, his theory could be tested without post-mortem examinations. It predicts the existence of seven clear cases of language disorder, each with an explicit phenotype. Discovering these clear cases became the grand challenge for the research community. Most cases of actual aphasias were, of course, cases of multiple distortion of 'the house', again with precisely predictable features. Here was Mendelejev's table for neurological language disorders.

The Wernicke-Lichtheim model of neurogenesis was the only highlight of the first golden age that was preserved to modern times. Refugees from Wernicke's school who fled for the Nazi's, transmitted the theoretical model to their American students and colleagues. Lichtheim's house became, almost till the present day, the textbook introduction to aphasiology. My second Sarton Lecture discusses the intensive fights over language in the brain from Franz Joseph Gall to the 1950s. Let us now turn to ontogenesis, the process of language acquisition in the child.

Ontogenesis

In 1876 the French man of letters, Hippolyte Taine published in the *Revue Philosophique* the diary notes he had collected on his daughter's language development. Here he made ample reference to evolution theory:

"Speaking generally, the child presents in a passing state the mental characteristics that are found in a fixed state in primitive civilizations, very much as the human embryo presents in a passing state the physical characteristics that are found in a fixed state in the classes of inferior animals.".

The next year the new journal *Mind* published an English translation of Taine's paper (with the above citation on p. 259). This triggered Charles Darwin to publish, in the same year 1877 and the same journal, a 10-page *Biographical sketch* of his own son William's development as an infant. The sketch was based on copious notes Darwin had made between 1839 (upon William's birth) and 1841. Clearly, after reading Taine's paper, Darwin didn't want to repeat the Wallace affair. He had been the first to keep a diary, over 30 years before Taine, and the world should know. Celebrity Darwin's paper appeared the same year also in French, German and

Russian, not failing to promote on a grand scale the keeping of diaries on infants' and toddler's development. From now on, keeping diaries on child development was real science. A tsunami of diary keeping emerged, which reverberates till the present day.

Darwin's sketch includes some observations on the development of William's language skills, hardly more than the 15 observations Tiedemann had provided almost a century earlier. Darwin stressed in particular the invention of first words, such as *mum* to express the wish for food. He also noticed the "instinctive" use of intonation patterns, "voice modulation", to express various modes, such as interrogation and exclamation. Here he concluded, repeating what he expressed in *The Descent of Man*, that "before man used articulate language, he uttered notes in a true musical scale" (p. 293), the singing origins of language, which never stopped echoing in the literature.

The importance of Darwin's paper was not so much in its content. But in one swoop it made the study of child development a respectable branch of human biology. Diaries now appeared at an accelerated rate, and in various languages. Table 1 presents an overview of golden age diaries including and following the Taine and Darwin papers.

Table 1. Ontogenetic diaries published during the first golden age of psycholinguistics

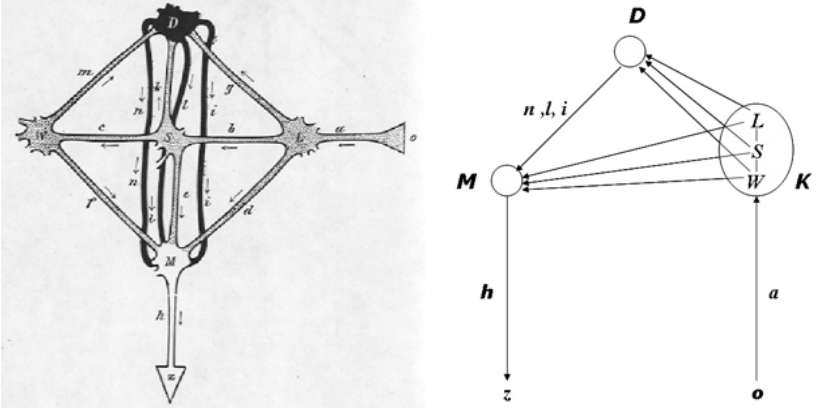
Baudouin de Courtenay (1869), Polish	Compayré (1893), French
Taine (1876, 1877), French	Balassa (1893), Hungarian
Darwin (1877), English	Frederic Tracy (1894), English
Perez (1878, 1886), French	Paola Lombroso (1894), Italian
Strümpell (1880), German	Preyer (1896), German
Sikorsky (1883), Russian	Kathreen Moore (1896), English
Blagovescenskij (1886), Russian	Milicent Washburn (1898), English
Machado y Álvarez (1885-1887), Spanish	Ament (1899), German
Sayce (1889), Arabic	Clara & William Stern (1907), German
Chamberlain (1890), Algonkin	O'Shea (1907), English
Gabriel Deville (1890/91), French	Gheorgov (1908, 1910), Bulgarian
Garbini (1892), Italian	Ronjat (1913), French, German

The quarter century following Taine and Darwin was quite rich in its theoretical analyses of child language development. Much theory centered around Haeckel's so-called "phylogenetic" or "biogenetic law", as we already saw in the Taine citation. According to Haeckel "the mental development of every child is only a short recapitulation of that long phylogenetic process." (Haeckel 1874, p. 706). The child runs, so to say, an accelerated film of evolution, not only in bodily development, but also in mental and language development. This linked the study of language acquisition, ontogenesis, to the linguistic study of language origins, phylogenesis.

A major supporter of this theory was Haeckel's colleague at Jena University, William Preyer, who adored Darwin. It was a happy coincidence that Preyer's son Axel was born in 1877, shortly after Darwin published his *Biographical sketch*. It triggered Preyer to keep a careful, detailed diary on his son's development. That in turn became a major data source for his grand work *Die Seele des Kindes*, which appeared in 1882. This book became a classic text, going through four, ever updated editions during his lifetime and five more later.

But Preyer also forged another link in this book, namely between language ontogeny and neurogenetics. Three years earlier than Lichtheim, he had already conceived the idea of adding a conceptual center to Wernicke's "reflex arc", constructing a network diagram which was topologically quite similar to Lichtheim's "house".

Figure 2. Preyer's (1881) diagram of the language/speech architecture (left) and its topological mapping on Lichtheim's house (right). Wernicke's reflex arc is represented by o-a-K-M-h-z. It is the first to mature in the child. The connections to the conceptual center D(iktion) are acquired later through learning, imitation and association.



He then proposed a theory about the ontogeny of this network. The basic idea was "that every known form of adult speech disorder finds its complete reflexion in the child that learns to speak" (p. 375). Take any node or connection in the network. As long as the infant still lacks it, it should show the same symptoms as the aphasic patient who has lost that very node or connection.

Here is one example, out of some 50 which Preyer worked out in much detail: If Broca's area is damaged (*M* in Figure 2), you can understand, but no longer produce spoken words. This corresponds to the child in a stage where it understands and remembers words, which it cannot yet produce.

The general pattern of development is that Wernicke's reflex arc is the first to mature. That allows the child to imitate spoken words. But it doesn't mean that the child also understands them. That requires the development of the conceptual center *D*; it is slowly built up through imitation, explicit learning (see legend to Figure 2).

There was one further remarkable highlight in the study of language ontogeny during the first golden age. In 1907 Clara and William Stern published *Die Kindersprache*, which was based on the most extensive German diary data ever. Clara was first author. She had kept a detailed day-to-day diary on the speech and language development of their three children, Hilde, Günther and Eva. And together with William she had systematically collected experimental test data. This study set the new standards for decades to come, in terms of data collection and analysis and in terms of ontogenetic theory. The book provides the first, detailed evaluation of Haeckel's phylogenetic law. It also provides a definitive rejection of the dominant 19th century view that children exclusively acquire language by imitation. The Sterns showed that analogy formation is an important and highly productive alternative mechanism. The child will for instance keep saying *getrinkt*, in spite of the fact that it always hears *getrunken*. How come? *Getrinkt* is the regular form, as in *gebaut* and *gehört*. It is highly economical for the child to generally apply that past tense rule. The child actively discovers and invents grammatical rules.

Clara Stern was born in 1878, thirty years before German universities accepted women as students. She was entirely self-made as a scientist. But that was hardly appreciated in the male-dominant academic society. Her standard work was frequently cited, but usually as the work of second au-

thor William, such as here: "In his work *Die Kindersprache*, William Stern says..." (Röttger 1931; see for many more such cases Levelt 2013, p. 316).

The data base of the Sterns ended up in Harvard's Widener Library. It was literally never consulted. Stern daughter Eva then moved it to Hebrew University. Some 30 years ago the late Werner Deutsch of our Max Planck Institute had the complete hand-written diaries transcribed, assisted by Eva Stern, who was in her eighties, and whom I had the great pleasure to welcome in our Institute. The data base is now accessible through the Institute's website.

Die Kindersprache had completely passed into oblivion after World War II. The next great work on Language acquisition was *A first Language* by Roger Brown of Harvard University. It appeared in 1973 and makes no reference whatsoever to the epoch making accomplishments of Clara and William Stern.

Let us, finally, turn to microgenesis and consider two remarkable highlights in the study of mental processing in the production of speech.

Micorgenesis – Mental Chronometry

In 1883 James McKeen Cattell arrived in Leipzig. He was 23 years old, had a master degree from Lafayette College in Pennsylvania and had decided to write a dissertation under the supervision of Wilhelm Wundt, who had established the world's first psychology laboratory in Leipzig just four years earlier. And so he did. He stayed in Wundt's laboratory from 1883 to 1887 and became, in 1886, the first American to obtain a PhD in psychology.

Wundt put him on a dissertation project on mental chronometry. It had long been the dominant view of philosophers and neurologists that mental processes are infinitely or at least immeasurably fast. But this common opinion had been recently undermined. In 1850 Helmholtz had published his measurements on the speed of nerve conduction in frogs, later reconfirmed in humans, which had turned out to be about 30 meters per second. Helmholtz's dear friend Franciscus Donders, ophtalmologist at Utrecht University, then invented a brilliant way to measure durations of mental processes, which he published in 1865.

Here is one of his original experiments. It is in fact the first chronometric experiment in psycholinguistics ever. Donders and his student De Jaager

would sit in front of their *phonautograph*. This was a hollow paraboloid device. You could speak into it at the wide open side. The other, narrow end was covered by a membrane. As soon as you speak into the wide funnel opening, the membrane starts vibrating. The vibrations are transmitted to a turning cylinder where they are recorded on soot-covered paper, together with the vibrations of a tuning fork.

Donders would now say *ki!* and De Jaager's task was to respond immediately by also shouting *ki!* By counting the number of tuning fork cycles between the two onsets of *ki*, De Jaager's reaction time could be determined. It was 250 milliseconds.

But now Donders took his epoch making step, by complicating the experiment somewhat. It was still the case that de Jaager should respond *ki!* when Donders said *ki!* However, Donders would also shout other syllables into the phonautograph, such as *ka!* or *ku!* De Jaager was instructed not to respond to any of the stimuli, except for *ki!* Under this condition it took de Jaager on average 338 ms to respond with *ki!* to *ki!* How come de Jaager was slower bij 88 ms (i.e. subtracting the original 250 milliseconds from 338)? It was because he had to perform an extra mental operation, namely identifying the relevant stimulus *ki* in the set of possible stimuli, discriminating it from the stimulus alternatives. In other words, the extra 88 ms was de Jaager's identification duration, recognizing *ki!* as *ki!*, a real mental duration. Donders' own mental identification duration also happened to be 88 ms. This so-called "subtraction method" of measuring mental duration soon conquered the world.

Young James McKeen Cattell brilliantly used this paradigm in analyzing the mental steps involved in the naming of pictured objects, colors, numbers, printed words and letters. For all of these now classical naming tasks, he did the first chronometric measurements. His procedure for all these tasks can be exemplified with the case of picture naming.

Which mental steps are you going through when you name the picture of, say, a bird? The main two steps, according to Cattell are, first, identifying the bird as a bird, exactly like identifying *ki!* as *ki!* in Donders' experiment. Cattell called this identification or "perception time". The second step is selecting the correct response word, i.e. *bird* for the picture of a bird, or *tree* for the picture of a tree. Cattell called this response preparation or "will time". How to measure these mental durations?

Here is what Cattell did. First he designed a far better chronoscope than Donders' phonautograph with its turning cylinder. It was a sophisticated electrical instrument with a "voice key", which would send an electrical impulse to an electrical time piece as soon as its membrane was set into motion by speech. It allowed for repeated chronometric measurements with millisecond accuracy.

Using this equipment he began by determining the identification or perception time. This required two steps, like in Donders' experiment. The first step was to measure the simple naming duration. The bird appears and you say "*bird*". And the bird is again flashed on and you say "*bird*". This is repeated several times. This is exactly what de Jaager had to do, time and again saying *ki!* when Donders shouted *ki!* into the phonograph.

After determining this simple naming duration for himself and for his colleague Berger, Cattell took the next step by measuring what he called the "discrimination duration". The subject would say *bird* each time a bird appeared, but nothing when another object, such as a tree or a candle was displayed. This again exactly followed Donders' procedure where De Jaager had to say *ki!* to *ki!*, but nothing when *ko!* or *ku!* was shouted by Donders.

The duration of identifying the bird as a bird could now be determined by subtracting the measured simple naming duration from the just measured discrimination duration. This identification duration turned out to be 117 milliseconds for Cattell himself and 96 milliseconds for Berger.

Next Cattell determined the "response" or "will time". For this it was necessary to measure the "choice latency". Here the experimental subject had to name each picture with its own name, i.e. *bird*, *tree*, *candle*, etc. This task clearly involved retrieving the appropriate response word. But it also involved the just measured full discrimination duration, i.e. from presentation of the picture to identifying the object to be named. Hence, Cattell subtracted that earlier measured duration from the now measured choice latency. That should be a true estimate of the will time, the mental duration of selecting the appropriate response. It turned out to be 278 milliseconds for Cattell and 231 milliseconds for Berger.

Many hundreds of measurements went into this picture naming paradigm. And then Cattell did the same for letters, for printed words, for numbers and for colors. Table 2 is his summary table.

	B	C
Reaction-time for Light	150	150
Perception-time for Light	30	50
" " a Colour	90	100
" " a Picture	100	110
" " a Letter	120	120
" " a (short) Word	120	130
Will-time for Colours	280	400
" Pictures	250	280
" Letters	140	170
" Words	100	110

Table 2 Cattell's chronometric averages for perception and will time in naming colors, pictures, letters and words by two observers, Berger and Cattell.

Notice that stimulus identification or perception time for colors, pictures, letters and short words are all in the short range of 90-130 ms. But response selection or "will-time" varies widely, letters and words being much faster than colors and pictures. Naming a chair, for instance, takes some 100 ms longer than naming the word "chair", because it activates an extra process, identifying the object.

All this wonderful work and much more appeared in three foundational papers, published in *Mind*, 1886-1887. And then it was all forgotten. It took almost a century before chronometric measurements of the same sophistication were taken up again and all this was rediscovered.

The following quote captures Cattell's epoch-making establishment of experimental psycholinguistics:

"I think these experiments show that it is possible to apply scientific methods to the investigation of mind. We have determined the times required for those processes which make up a great part of our mental life, and found these times to be constant; they are no more arbitrary, no less dependent on fixed laws than, for example, the velocity of light." (1887, p. 539).

And here is his optimistic view on mental evolution:

"If in the course of evolution, as is probable, the molecular arrangement of the nervous system becomes more sensitive and delicately balanced, we may suppose that the times taken up by our mental processes become shorter, and we live so much the longer in the same number of years." (1887, p. 534).

Micorgenesis – Speech errors

Cattell's work on microgenesis considered the word as the unit of speech production. What is the time course of retrieving a word response such as *bird* or *candle*? But it is possible to go one step further. Consider this slip of the tongue: *denile Semenz*. It suggests that words are not retrieved as wholes, but as strings of speech sounds, vowels and consonants. Occasionally these elements end up in the wrong place, as do *d* and *S* in this case, which were exchanged in the slip of the tongue. Can such spontaneous speech errors tell us more about the underlying microgenesis?

The linguist Rudolf Meringer made it his life's project to answer this question. He was born in Vienna and held teaching positions there and, since 1899, in Graz. He was a confirmed empiricist: "one who cannot observe is not a researcher, but a bookworm" (Meringer 1909, p. 597). His grand empirical project became the systematic collection, analysis and psycholinguistic explanation of spontaneous slips of the tongue. He organized the collection of errors by involving the participants in a regular lunch time meeting. They agreed to stick to certain rules, such as speaking one person at a time and halting all conversation as soon as a tongue slip occurred. This would allow for proper recording of the error and for immediate introspection on the part of the speaker concerned. This procedure introduced an important methodological feature: *all* occurring speech errors were recorded, not just the remarkable, interesting, or funny ones as had been the tradition – and as would regrettably become the tradition again, masterminded by story teller Sigmund Freud (see Meringer 1923). The total corpus recorded by Meringer amounted to some 2500 slips of the tongue. Their analyses were published in two books, the first one in 1895, the second one in 1908.

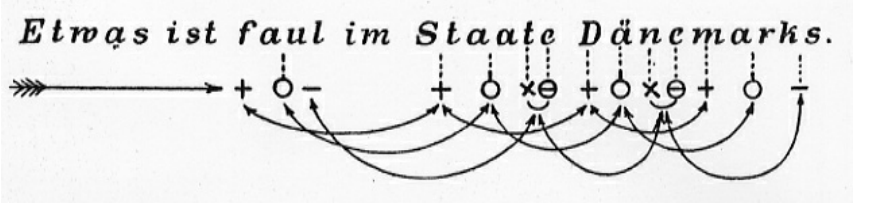
Meringer distinguished three basic error categories, which are still in good use: exchanges, anticipations and perseverations and the core observation in all three categories was that the exchanged elements are functionally similar. In the exchange *denile Semenz*, for instance, two word-initial consonants are exchanged. The anticipation *lässen nämlich* (for *lassen nämlich*) involves two stressed vowels in word-initial syllables. And the perseveration *konkret und kontrakt* (for *abstrakt*) perseverates the first word initial syllable as the second word's initial syllable.

Meringer considered speech errors as resulting from the regular speech producing mechanism:

"Only attention fails in a speech error, the machine runs without a supervisor, is left to its own devices. And what makes speech errors instructive for linguistics, is the circumstance, that the clockwork's cover has been taken off in such moments and a view on the cogs is possible." (Meringer and Mayer 1895, p. vii)

Linguistic elements, not only consonants and vowels, but also syllables, roots, prefixes, suffixes, whole words or phrases, get ordered by the production machine. They should end up in particular target positions. This he depicted in the diagram reproduced in Figure 3, which shows the microgenesis, the process of ordering, which is run in the generation of a simple utterance such as *Etwas ist faul im Staate Dänemarks*:

Figure 3.
Top: possible exchanges of functionally similar elements in the preparation of *Etwas ist faul im Staate Dänemarks*.
Bottom: for each planning position in the sentence the table lists all possibly competing sounds that are still active or already active. From Meringer and Mayer (1895, pp. 53, 164).



Etwas ist	f	a u	l	im	St	aa	te	D	ä	ne	m	ar	ks
	st, –	aa, –	te, —		D, f	ä.au	ne, l	m, St	ar, aa	ks, te	—, D	—, ä	–, ne
	D, –	ä, –	ne, —		m, –	ar, –	ks, –	—, f	—, au	—, l	—, st	—, aa	—, te
	m, –	ar, —	ks, —								—, f	–, au	—, l

When we generate such a simple utterance, there are always multiple elements simultaneously conscious in our "inner speech". Occasionally an active element ends up in a wrong, but functionally similar target position, with an ordering error as outcome. He worked this out in much detail for the example in Figure 3. Elements targeted for a stressed-vowel position, for instance, may end up in the wrong stressed-vowel position. This could cause an error such as *Etwas ist faal im Staute Dänemarks*, and so on. Target positions differ in weight. Word initial consonants, for instance, such as the *f* of *faul* and the *D* of *Dänemark* are heavy. Vowels in unstressed syl-

lables, such as *e* in *Staate* are light. Heavy elements have better access to consciousness than light elements and hence are better intruders into functionally similar target positions. This weight hierarchy is a good predictor of the frequency distribution of sound errors he had observed.

We will not go into the further details of the "cogs" in Meringer's "clockwork", but they have stood the test of time. They figure in one way or another in all modern theories of error generation. But all of this brilliant work went into oblivion till around 1970. Only then the study of speech errors started booming again till the present day.

The first golden age of psycholinguistics shared the fate of the German and Austrian empires, where it had so exuberantly blossomed. It disappeared during World War I. The scientific point of gravity in this interdiscipline began shifting to the United States, where precisely then Watson's 1914 book introduced the radical extermination of everything mental in psychological, linguistic and neuropsychological theory, which would debilitate the field for almost half a century. This aberration in science was almost entirely local to the United States, as Brysbaert and Rastle (2009, p. 212) correctly argued. It is a fascinating case of self-imposed isolation in science, which has never been fully explained and deserves thorough historical analysis.

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