Chapter IV

Institutionalizing experimental psychology: The model in Leipzig in the 1880s.

To make the "experimental ideal" work for psychology, Wundt needed a specific research program which justified experimental psychology as a separate discipline. He had been making arguments for this since 1862; now he had to get an international community of researchers to join him in the effort. Otherwise, psychology would continue to be only a minor part of philosophy, and psychophysical methods would interest only the physicists and sensory physiologists who occasionally used them. To establish a separate experimental discipline of psychology, Wundt sought to relate a theory of mind (at least a preliminary or heuristic model) to a well-defined, quantitative and easily reproducible experimental methodology. He had such a program in his Leipzig laboratory during the 1880s.

A. The work of the Leipzig Institute: What was at its heart?

What kinds of experiments were carried out in Wundt's Institute? And what were they intended to prove or discover? Edwin G. Boring gave one survey of the Institute's publications. He began with the remark that Wundt actually

> defined experimental psychology for the time being,

> because the work of this first laboratory was really the practical demonstration that there could be an experimental psychology . . . . Practically all the work from the Leipzig laboratory was published in the Philosophische Studien (1881-1903) and there is not very much in this journal that did not come either directly from Leipzig, or from Wundt's students so soon after leaving Leipzig that they still represented the intentions of Wundt.[1]

"All the work from the Leipzig laboratory" refers to the five or so doctoral dissertations from Wundt's Institute each year, as well as to a few research reports by more advanced researchers. Many dissertations which Wundt sponsored were not published in Philosophische Studien, but nearly all the experimental studies were.

Following his apt historical remarks, Boring proceeded to classify the work in the Institute in a way that obscures its uniqueness: he draws almost no distinction between Wundt's Institute and the laboratories of contemporary sensory physiologists. Boring classified 109 experimental articles into four categories: (1) more than one-half on sensation and perception, with the proportion increasing toward the end of the series; (2) one-sixth on reaction times, concentrated in the

[1]Edwin G. Boring, A history of experimental psychology, 2nd ed. (NY: Appleton-Century-Crofts, 1950), 339-340. Hereafter Boring.

period before 1890; (3) one-tenth on attention and feeling, especially in the 1890s; and (4) somewhat less than one-tenth on association. Dividing the first category further, he found that vision received the lion's share, nearly a quarter of all the experimental studies in the journal. The next most important area of sensation was auditory perception. In the area of tactile sensation, so important in the history of psychophysics (the Weber law, etc.), there were only a few studies. A couple of researchers published on sense of taste, and there were no articles on the sense of smell. A sixth sense, the "time sense," was represented by three different researchers' studies of the perception or estimation of temporal intervals.

Boring strongly identified with the Wundtian tradition, but his own research specialty was psychophysics, studies of sensation and perception that were not primarily concerned with the issues involved in the other three categories. He suggested that reaction-time experiments represented the core of the work of the early Institute but concluded that that line of research ultimately failed when it proved impossible to measure separately the times required by different mental functions. Boring neglected to emphasize how important this "failed program" was to the development of laboratory psychology. The failure was by no means total, as Metge-Meischner, for example, has argued.[2]

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[2]Anneros Metge, "The experimental psychological research conducted at Wundt's Institute and its significance in the history of psychology," in Advances in historiography of psychology, ed. Georg Eckardt and Lothar Sprung (Berlin, GDR: Deutscher Verlag der Wissenschaften, 1983), 43-49.

A separate discipline of psychology needed an area of study that it could call its own. When Wundt came to Leipzig, studies of sensation and perception were primarily identified with physiology, and Wundt would change that identification only partially. Research on sensation and perception in the Leipzig Institute, in the large picture, was preliminary or ancillary to investigations of complex central nervous processes. Reaction-time experiments sought to measure those processes directly. Leipzig researchers worked in hot pursuit of the parameters and laws of mental chronometry, and Wundt's theory of mental processes implied that reaction-time experiments could serve as the model for investigating many mental phenomena, including attention, association, feeling, and emotion.

B. The research program: Reaction-time studies.

1. Reaction-time studies before the Leipzig Institute.

Chapter Two of this dissertation told how astronomers, trying to gain ever more accurate simultaneous measurements of position and time for a given celestial event, came up against the phenomenon of the personal equation. No matter how careful the observers, they could differ in reporting a given event by as much as a half-second. This dilemma interested Wundt, and his "complication experiment" sought to explain the discrepancies and develop some standard measurement of reaction times. By 1866 Wundt was taking credit for the discovery that the observed time

of a reaction was significantly greater than the time required for a nervous impulse to travel from sense organ to the brain plus that required to travel back to the reacting muscle.[3] In other words, a good chunk of the time was taken up by central nervous processes. For a young physiologist declaring a new scientific psychology, that was a crucial finding. It only remained to discover a way to investigate those central processes experimentally.[4]

At about this time such investigations were made possible by the appearance of an accuate instrument to measure the "speed of thought." The Swiss astronomer Adolph Hirsch (1830-1901) began doing experiments with a chronoscope (a very accurate stop-clock) which had been developed by his precision mechanic, Mathias Hipp (1813-1893).[5] The Hipp chronoscope (see Figure 4.1) registered time intervals to the one-thousandth second. With minor improvements, it remained a standard piece of apparatus in psychology laboratories for at least fifty years after Hirsch published his reaction-time measurements in the early 1860s.[6]

[3]Solomon Diamond, "Wundt before Leipzig," in Wilhelm Wundt and the making of a scientific psychology, ed. Robert W. Rieber (NY: Plenum Press, 1980), 3-70; 49.

[4]The following discussion is based on the chapter "Reaction time" in Robert S. Woodworth, Experimental psychology (NY: Henry Holt, 1938), 298-339.

[5]A. Hirsch, "Expériences chronoscopiques sur la vitesse des différentes sensations et de la transmission nerveuse," Bulletin de la société des sciences naturelles, Neuchâtel, 6 (1861-63), 100-114; A. Hirsch, "Ueber persönliche Gleichung und Correction bei chronographischen Durschgangs-Beobachtungen," Untersuchungen zur Naturlehre des Menschen und der Thiere, 9 (1863), 200-208.

[6]Michael M. Sokal, Audrey B. Davis, and Uta C. Merzbach, "Laboratory instruments in the history of psychology," Journal of

Hirsch determined the times for some simple reactions, in which the subject signaled, e.g. pressed a telegraph key, upon perceiving a stimulus:

visual stimulus	200 ms (milliseconds)
auditory stimulus	150 ms
electric shock	140 ms

It was of great interest to astronomers that visual perception required more time; astronomical photography was then in its infancy, and precision-timed observations still required eye-ear coordinated reports.

At Utrecht, the physiologist Franciscus Cornelis Donders (1818-1889) proposed a way to measure the time taken by different mental functions. His technique, the "subtraction method," was essentially this: find the time for a simple reaction to stimulus (such as those Hirsch did); run another reaction which is set up in the same way but which involves a more complicated mental process; then subtract the first time from the second to get the "physiological time" required by that additional mental process.[7]

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the history of the behavioral sciences, 12 (1976), 59-64; 61-63.

[7]The first presentation of such experiments was the medical dissertation of Donders's student: J. J. de Jaager, De physiologische tijd bij psychische processen (Utrecht, 1865), trans. as "Reaction time and mental processes," in Origins of psychometry, ed. and trans. J. Brozek and M. S. Sibinga (Nieuwkoop, Netherlands: de Graff, 1970). Donders communicated the results more widely in his articles, particularly Franciscus Cornelius Donders, "Die Schnelligkeit psychischer Processe," Archiv für Anatomie und Physiologie (1868), 657-681; trans. "On the speed of mental processes," Acta psychologica, 30 (1969), 412-431.

Donders's experiments rely on the assumption that each part of the reaction (sensation, perception, discrimination, choice, reaction movement) takes a specific amount of time, and that "physiological time" for particular mental processes can be determined if experiments can be devised in which there is first no such process and then that process is simply "inserted." The additional time is the time required by that particular mental process. Donders proposed three reactions that he claimed produced time measurements for "choice" and for "discrimination."

Speech sounds served as stimuli and reactions. These were recorded on a moving drum, from which time differences could be measured. The first reaction, the a-reaction, was the simple response to stimulus. The b-reaction required sensory discrimination and then motor selection in signaling the choice. The c-reaction required sensory discrimination but, according to Donders, no motor selection.

The experiment used five syllables, something like "ka, ke, ki, ko, ku." For the simple reaction, the a-reaction, the stimulus was always "ki," and the response was also "ki." For the "choice reaction," the b-reaction, the stimulus was any one of the five syllables; the subject responded by speaking the same syllable. The subject had to make a sensory discrimination and then a motor selection in order to produce the correct response. For the c-reaction, the stimulus was again any of the five syllables, but the subject was instructed to respond only when he heard "ki." Donders thought that this last reaction involved sensory discrimination but no motor selection, no choice. Donders

found these average results:

a-reaction	197 ms
b-reaction	285 ms
c-reaction	243 ms

Using the subtraction method, sensory discrimination time (c-a) was 46 ms, and pure choice (b-c) took, 42 ms.

Wundt welcomed this quantitative handle on mental processes. The time intervals were very small, considering the crude technology that measured them, but the subtraction method promised to produce time measurements for mental processes. Conscious mental actions had become the focus of Wundtian psychology, and the reaction-time experiment was the raison d'être of the Institute when the work began in 1879.

One active participant in the program, James McKeen Cattell, made a point to correct a common assumption and to distinguish psychometry from psychophysics: "We are naturally glad to find it possible to apply methods of measurement directly to consciousness; there is no doubt but that mental processes take up time, and that this time can be determined. The measurements thus obtained are not psychophysical, as those which we have been recently considering, but purely psychological."[8] Kurt Danziger has accordingly observed: "The reaction-time studies conducted during the first few years of Wundt's laboratory constitute the

[8]James McKeen Cattell, "The psychological laboratory at Leipsic," Mind, 13 (1888), 37-51; 45.

first historical example of a coherent research program, explicitly directed toward psychological issues and involving a number of interlocking studies."[9] Whether or not they directly addressed the reaction-time problem, the measurement of times for specific mental processes, the crucial (and controversial) problems in early experimental psychology grew out of reaction-time work in Leipzig; this was the experimental ground upon which Wundt staked his theoretical claims and set his students to work. Innovations and improvements in psychological experimentation by other researchers often originated in a criticism of Wundt's approach.

2. Reaction-time studies in the Leipzig Institute.

Wundt altered the Donders experiment, for practical and theoretical reasons. He accepted the subtraction method but preferred to use the Hipp chronoscope rather than the rotating drum; direct readout was more convenient for repeated series of experiments than time-consuming measurements and conversions of line-lengths on the drum. (See Figure 4.1, a setup for simple auditory reaction.) In addition to this technical change, Wundt's reaction-time experiment incorporated an important conceptual difference.

Wundt's theory of mental processes involved a stricter

[9]Kurt Danziger, "Wundt's theory of behavior and volition," in Wilhelm Wundt and the making of a scientific psychology, ed. Robert W. Rieber (NY: Plenum Press, 1980), 89-115; 106.

distinction between choice and discrimination. In the first edition of Grundzüge, Wundt expressed doubts about Donders's classification. To him, both the b-reaction and the c-reaction involved choice. In the case of the b-reaction the choice was between different muscular responses; in the c-reaction the choice was to respond or not to respond. In the second edition of Grundzüge, published shortly after advanced students began to work in the Leipzig laboratory, Wundt formally introduced his pure discrimination reaction.[10] In such a reaction there were different possible stimuli, and the subject signaled (always using the same muscular movement) as soon as he "recognized or identified" the stimulus given. This d-reaction involved discrimination [Unterscheidung] but not choice [Wahl].

Although the d-reaction would appear to be little more than an interesting thought experiment--there being no external way to know exactly when recognition occurs--this was in fact the actual discrimination experiment used in the early Institute. It may be that Wundt's strict theoretical requirements resulted in more flexibility in experimental controls, but he was, after all, pioneering new territory.

A purely psychological experiment, employing the advanced instrumentation of current physical and physiological research,

[10]Wundt, Grundzüge der physiologischen Psychologie (Leipzig: Engelmann, 1874), 744-745; 2nd ed. (Leipzig: Engelmann, 1880), vol. 2, 247-256. Woodward mistakenly describes the Donders discrimination reaction as Wundt's own: William R. Woodward, "Wundt's program for the new psychology: Vicissitudes of experiment, theory, and system," The problematic science: Psychology in nineteenth-century thought, ed. William R. Woodward and Mitchell G. Ash (NY: Praeger, 1982), 167-197; 183.

was largely undefined in the 1870s and 1880s. Wundt believed that experiments on purely psychological phenomena were possible and that psychological experiments would necessarily involve subjective elements that physiologists, for example, generally tried to exclude. This was precisely why a special science of experimental psychology, in addition to and distinct from physiology, was needed. Experimental psychology depended upon refined techniques that Wundt variously referred to as self-observation [Selbstbeobachtung], inner observation [innere Beobachtung] and inner experience [innere Erfahrung]. Although Wundt's English-language translators commonly used "introspection" to refer to his experimental methodology, the term has been used too loosely. "Self-observation, controlled by experiment" is perhaps the best description of Wundt's method.

Wundt was no novice at physiological experimentation, so his faith in the d-reaction reveals a strong theoretical commitment. The sharp distinction between discrimination and choice corresponded with Wundt's five-part model for mental reaction. The schema was the centerpiece of the work of the early Institute, and not only of reaction-time studies. Especially in the 1880s, this litany began nearly every paper:

(1) sensation, the movement of the nerve impulse from the sense organ into the brain;
(2) perception, the entry of the signal into the field of consciousness [Blickfeld des Bewusstseins];
(3) apperception, the entry of the signal into the focus of

attention [Blickpunkt des Aufmerksamkeits];

(4) act of will, in which the appropriate response signal is released in the brain;

(5) response movement, or more precisely, the movement of the response signal from the brain to where it initiates muscular movement.

Wundt contended that steps one and five are purely physiological, whereas the three middle steps are psychophysical, i.e. they involve processes that "have both a physiological and a psychic side."[11] Every mental reaction involved all five steps, and there was no direct way to measure separate times for the three middle steps. However, well-constructed experiments using the subtraction method could give estimates of "time of apperception" (discrimination time) and "time for an act of will" (choice time). The subjects in these experiments had to be trained in self-observation in order to report these psychic events.

Wundt's first doctoral students in the Institute used the discrimination reaction in the way just described. In one study using visual stimuli, the simple reaction consisted of pressing a key upon perceiving a flash of light. In another reaction, Wundt's d-reaction, one of two different images was suddenly illuminated before the subject: either a white circle on black background or a black circle on white background. The subject

[11] Grundzüge der physiologischen Psychologie, 2nd ed. (Leopzig: Engelmann, 1880), vol. 2, 221.

pressed the key as soon as he decided which one he was seeing. Initial illumination started the Hipp chronoscope running, and the pressing of the key stopped the dial, giving time elapsed for the entire reaction.

Wundt and two of his doctoral students, Max Friedrich and Ernst Tischer, did the experiments together. One served as the subject, as another initiated the reaction by illuminating the image and the third recorded the times. Then they alternated roles. This was the classical Wundtian experimental set-up: subject [Reagent], experimenter [Experimentator] and observer [Beobachter], respectively. Needless to say, all three had to have a clear understanding of what it meant to "recognize" a black or a white circle, and they had to be consistent in their performance of this recognition. In these early experiments, they trained until average reaction time was as short as possible, and mean variation was minimized for each reacting subject.

The d-reaction seemed to give reasonable results in the first several studies.[12] The simple reaction took from 132 to 226 ms, in fair agreement with Donders, and "recognition" added from 50 ms (Friedrich's average time) to 79 ms (Wundt's). With four different colors the recognition time increased, from Tischer's average of 73 ms to Friedrich's 157 ms.

Similar experiments gave choice times. First was the simple

[12]Numerical results, unless otherwise specified, are from the first communication of the experiments, in the second edition of the Grundzüge (1880), vol. 2, Chapters 16 and 17, 219-327.

choice, to react or not react to the stimulus, e.g., press the key for the white circle but not if it is the black one that appears. (This was the reaction that Donders had claimed involved no choice.) Reaction time averaged between 368 ms and 455 ms, whereas discrimination without the simple choice averaged from 185 ms to 303 ms for the three subjects. Therefore, extra time taken to make the simple choice ranged between 152 ms and 184 ms for these subjects.

There could also be choice between different movements: press a key with the right hand if the image is white, a different key with the left hand if black. This choice time was, conveniently enough, somewhat longer, averaging between 188 ms to 331 ms more than the time for the simple discrimination reaction.

A summary of the results:

1st Experiment:	simple reaction	132-226 ms
	discrimination, 2 stimuli	50- 79 ms more
	discrimination, 4 stimuli	73-157 ms more
2nd Experiment:	reaction with discrimination, but no choice	185-303 ms
	simple choice	152-184 ms more
	multiple choice	188-331 ms more

Wundt and his students recognized that individual differences and external conditions (distractions, fatigue, etc.) could affect

the outcome of a reaction, but at that point they simply considered those factors as topics for further study, once they had established base averages for the different mental functions.

With confidence that they had a way to measure indirectly the time required for two parts of Wundt's five-phase reaction, the Leipzig psychologists undertook to determine the extent to which more complicated tasks called for extra action by the apperception (in recognition) and/or the will (in choice). Max Friedrich's doctoral dissertation, the very first one expressly to treat of experimental psychology, found that time of apperception increased with complexity of stimulus, i.e. it took more time to "recognize" a string of six digits than just one or two, and that practice could shorten discrimination time, but not simple reaction time to any appreciable extent.[13]

Another early doctoral dissertation was Martin Trautscholdt's study of time of association. Association, according to Wundt's theory, was a particular action of the apperception, a successive focussing of attention on different thoughts. The subject in this experiment was instructed to signal the moment an idea, produced by an association with the stimulus, appeared in consciousness. Subtracting this time from

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[13]Max Friedrich, "Über die Apperceptionsdauer bei einfacher und zusammengesetzten Vorstellungen," Philosophische Studien, 1 (1883), 39-78. See Peter J. Behrens, "An edited translation of the first dissertation in experimental psychology by Max Friedrich at Leipzig University in Germany," Psychological research, 42 (1980), 19-38; and Peter J. Behrens, "The first dissertation in experimental psychology: Max Friedrich's study of apperception," in Wundt studies, a centennial collection, ed. Wolfgang G. Bringmann and Ryan D. Tweney (Toronto: Hogrefe, 1980), 193-209.

"recognition time" for the stimulus itself, it was determined that the association part of apperception added 706 to 874 ms to reaction time.[14]

The investigations employing the subtraction method looked promising, but too much depended upon separate measurements of discrimination time, measurements which proved to be very unstable. In the first volume of Philosophische Studien, where Friedrich's and Trautscholdt's dissertations appeared, Ernst Tischer's dissertation on discrimination of sounds already showed some difficulties. Auditory stimulus, as Hirsch noted, gave shorter simple reaction times than visual stimulus. Occasionally discrimination time seemed to be zero, that is, the time required simply to react to an acoustical stimulus was equal to the time required to react when the stimulus was "recognized."[15] Likewise, Emil Kraepelin's article on the effects of drugs on these reaction times found that discrimination time was an unreliable concept, particularly when the subject was under the influence of drugs or alcohol.[16] It was becoming apparent that the discrimination reaction required practice and expertise of such a special and fragile nature that it was uncomfortable, to say the least, to base a whole line of research on it.

[14]Grundzüge, 2nd ed. (1880), vol. 2, 279-291; Martin Trautscholdt, "Experimentelle Untersuchungen über die Association der Vorstellungen," Philosophische Studien, 1 (1883), 213-250.

[15]Ernst Tischer, "Über die Untersuchungen von Schallstärken," Philosophische Studien, 1 (1883), 495-542.

[16]Emil Kraepelin, "Über die Einwirkung einiger medicamentöser Stoffe auf die Dauer einfacher psychischer Vorgänge," Philosophische Studien, 1 (1883), 417-462, 573-605.

An ambitious American student added significantly to the discredit of the discrimination reaction. James McKeen Cattell (1860-1944) made considerable improvements to reaction-time measurements; then he essentially abandoned the discrimination reaction. Early in his work at Leipzig, he determined that the magnetic mechanism on the Hipp chronoscope engaged the time dial faster than it disengaged. The delay in stopping the dial caused overall reaction times to be measured as greater than they should have been. Cattell invented a device to engage and disengage the timer equally, and his improvement became standard on chronoscopes thereafter. Cattell also devised a gravity chronometer [Fallapparat] that improved experiments involving visual stimuli. A gate would drop, starting the Hipp chronoscope running and revealing the visual stimulus (a word, figure, etc.); the reacting subject pressed a key, stopping the chronoscope. Time elapsed was thus registered. This arrangement produced reaction times shorter than the sudden illumination used in Friedrich's experiment, because abrupt change in light level required extra accommodation by the eyes.[17]

Since Cattell's improvements lessened measured reaction times, he had problems keeping enough slack for a distinct discrimination time. Another doctoral student who shared Cattell's critical view of the d-reaction was Gustav Berger, Cattell's closest colleague in the Institute and at times his paid personal assistant and translator. Berger's dissertation

[17]Wundt, Grundzüge, 5th ed. (1902), vol. 3, 476.

concentrated on the simple reaction and questioned the methodological status of the choiceless discrimination reaction: the motor response which actually stopped the chronometer did not depend upon perception, something with a physical correlate, but rather upon apperception, a "psychophysical event" which (at least until the electronic devices of the mid-twentieth century) could not be registered independently. There was no sure way to check for false reactions or otherwise be certain when apperception occurred.[18]

Cattell and Berger ran out of patience with Wundt's five-phase schema for mental action. In one of his occasional critical outbursts, the bright young American in Leipzig wrote to his parents:

> Wundt's laboratory has a reputation greater than it deserves--the work done in it is decidedly amateurish. Work has only been done in two departments--the relations of the internal stimulus to the sensation, and the time of mental process. The latter is my subject--I started working on it at Baltimore before I had read a word written by Wundt--what I did there was decidedly original. I'm quite sure my work is worth more than all done by Wundt and his pupils in this department, and as I have said it is one of the two departments on which

[18]Gustav Oskar Berger, "Über den Einfluss der Reizstärke auf die Dauer einfacher psychischer Vorgänge mit besonderer Rücksicht auf Lichtreize," Philosophische Studien, 3 (1886), 38-93.

> they have worked. Mind I do not consider my work of any special importance--I only consider Wundt's of still less. The subject was first taken up by Exner, and Wundt's continuation of it has no originality at all; and being mostly wrong has done more harm than good.[19]

Cattell's bragging to his parents doubtlessly involved a certain amount of perfunctory denigration of his teacher, but in fact he had some reason to brag.

Cattell's mechanical ingenuity was supplemented by his keen thinking. He compared Wundt's ideas on the reaction-time experiment to what he knew about other studies and found Wundt's view to be wanting. Exner's emphasis on the effects of attention, or preparation for a reaction, figured into Cattell's reaction studies already in his first semester in the Institute, from November 1883 to March 1884.[20]

Sigmund Exner (1842-1926), a physiologist in Vienna who had studied in Heidelberg under Helmholtz and Wundt's uncle, Friedrich Arnold, coined the term "reaction-time experiment." He found that for simple reactions, preparation was the only thing that was voluntary; the reaction itself was involuntary, simply a reflex chain set in motion by the perception of the stimulus.[21]

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[19]James McKeen Cattell to parents, 22 January 1885, quoted in An education in psychology: James McKeen Cattell's journal and letters from Germany and England, 1880-1888, ed. Michael M. Sokal (Cambridge, Mass.: MIT Press, 1981), 156.

[20]Ibid., 98-105.

[21]Sigmund Exner, "Experimentelle Untersuchungen der einfachsten psychischen Processe," Pflügers Archiv für die gesamte

Wundt argued that Exner used incorrect values for the different speeds of nerve impulses in sensory, spinal and motor areas and simply underestimated "psychophysical time"--the time Wundt ascribed to the central nervous processes of perception, apperception, and will.[22] Cattell, however, judged that Exner was more correct than Wundt about the overall times and the effects of preparation.

The whole program, reaction-time research as a way of demonstrating and investigating Wundt's schema for mental processes, was about to fall apart. Yet Wundt was ready to accept the results of experimental research, and he was certainly pleased by the improvements in the instruments. He even gave Cattell the honor of being his first Institute Assistant, though Cattell was unpaid and apparently did not have the extensive responsibilities of later assistants for training students. In any case, Cattell's replacement as Institute Assistant came forth with an idea that revitalized Wundt's program and opened up areas for new research, and for new controversies.

3. Ludwig Lange's approach to the reaction-time experiment: muscular vs. sensorial reaction.

Ludwig Lange (1863-1936) was one of the most interesting and most tragic of Wundt's students. The son of the professor of

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Physiologie, 7 (1873), 601-660; 8 (1874), 526-537; 11 (1875), 403-432, 581-602.

[22]Grundzüge 2nd ed. (1880), vol. 2, 225, fn 4.

classical philology at Leipzig, he had his early education at the famous Thomasschule. After the Abitur in 1882, the military rejected him as "too narrow-chested" [Schmalbrüstigkeit]. So he started university studies, first a semester at Leipzig University, then two semesters in Giessen, then back to Leipzig. He concentrated on mathematics and physics, but he also studied philosophy, attending Wundt's lectures on logic, ethics, history of philosophy and psychology. Lange was another one of those many mathematics students, like Max Friedrich, who were attracted to research in the early Institute.

In 1885, Lange's father became ill, and the sickly son accompanied him that summer as they searched through Italy, the Alps and elsewhere for the right climate and the right physician. Lange's letters to Wundt show him identifying with his father's illness and taking morbid interest in psychological aspects of his own symptoms and of his reactions to the barbaric treatments he endured. For example, to cure sinus problems he took a treatment consisting of electrical burning inside the nose, five to seven times on each of six different days over the course of three weeks. "This had many interesting physiological-psychological consequences," such as simultaneous pains in one side of the jaw and the opposing buttock, and tears flowing out of one eye.

After such gruesome details, Lange's letter went on to tell Wundt of his intention to write a doctoral dissertation in philosophy--a historical-epistemological study of the law of

inertia. Wundt agreed to direct the dissertation.[23] Lange's father died in August of 1885, and Wundt took the young man under his wing. Lange finished the dissertation for the doctoral degree in 1886, and his three articles on intertia appeared in Wundt's journal.[24]

Although Lange's first writings were not on experimental psychology, Wundt chose him to succeed Cattell as Institute Assistant. Lange was the first paid assistant, also the first to have the doctoral degree already in hand. During 1885-86, as Berger and Cattell pursued Wundt's experimental program with great accuracy, and in the process undermined the theory behind reaction-time studies in the Institute, Lange came up with a way to save Wundt's model. His experiments were reported in the 1887 (third) edition of the Grundzüge and appeared in an article in Wundt's journal, "New experiments on the process of the simple reaction to sense impressions."[25] This article was the basis for many publications in experimental psychology for the next several

[23]Ludwig Lange to Wundt, 9 June 1885, UAL, Wundt Nachlass, Nr. 433a; 13 June 1885, UAL, Wundt Nachlass, Nr. 433b. Biographical information was collected by a physicist, famous for his early support of Einstein's theory of relativity, who took an interest in this early critical thinker on inertial systems: Max von Laue, "Dr. Ludwig Lange, 1863-1936. (Ein zu Unrecht Vergessener)," Die Naturwissenschaften, 35 (1948), 193-203.

[24]Ludwig Lange, "Ueber die wissenschaftliche Fassung des Galilei'schen Beharrungsgesetz," Philosophische Studien, 2 (1885), 266-297; "Nochmals über das Beharrungsgesetz," ibid., 2 (1885), 539-545; "Die geschichtliche Entwicklung des Bewegungsbegriffes und ihr voraussichtliches Endergebniss," ibid., 3 (1886), 337-419, 643-691.

[25]Ludwig Lange, "Neue Experimente über den Vorgang der einfachen Reaction auf Sinneseindrücke," Philosophische Studien, 4 (1886), 479-510.

years.

Lange claimed that simple reactions were of two very different types: "sensorial" or "muscular," depending upon whether the subject directed attention toward the stimulus or toward the reacting movement. The sensorial reaction was a "complete" reaction, whereas the muscular reaction was "shortened"--as it were, preparation by directed attention could short-circuit apperception and will in Wundt's schema of mental processes. The purely muscular reaction was nothing more than a "brain reflex."

The experiment to show the distinction between the two types of reactions required the subject to assume certain mental attitudes of preparation. For the muscular reaction he was to concentrate on the response movement and not to think at all about the stimulus. The sensorial reaction required more difficult preparation. As Robert Woodworth explains it, the subject had "to avoid altogether all preparatory innervation of the movement, but to direct the whole preparatory tension towards the expected sense impression, with the intention, however, of letting the motor impulse follow immediately on the apprehension of the stimulus, without any unnecessary delay."[26] The subject practiced to acquire one or the other extreme of attitude. The muscular attitude was easier to assume, but it also produced many premature and false reactions, which did not occur in the sensorial reaction. The muscular and sensorial reactions were

[26]Robert S. Woodworth, Experimental psychology (NY: Henry Holt, 1938), 306.

the extremes; in any given, unpracticed reaction, attention lay somewhere between the two attitudes. Lange thus accounted for the problematic findings of Tischer, Kraepelin, Cattell, and Berger, and at the same time he opened up a line of reaction-time research on attention.

Lange and two colleagues in Wundt's Institute did simple reactions to acoustic and cutaneous stimuli and found that the muscular reaction took about 125 ms, whereas the sensorial reaction took approximately 100 ms longer. Lange interpreted the muscular reaction as action through prepared reflex (à la Exner) and the sensorial reaction as involving the full five steps of Wundt's schema, including the three psychophysical actions. To continue studies of apperception and will, one had only to make sure that subjects did only sensorial reactions.

Lange himself could not stay to carry out this effort. The manic-depressive tendency that was evident in his letters to Wundt in the summer of 1885 got out of control, and he spent the rest of his rather long life as a mental invalid. Perhaps manic energy even played a role in the experimental innovation that had so pleased Wundt, Lange's substitute father-figure. When the depressive side finally surfaced, Lange was forced to leave the Institute, even though Wundt had intended for him to remain as Assistant. A student who arrived in Leipzig a couple of years later noted that "strenuous objection was made to the new laboratory on the grounds that continued self-observation would drive young persons to insanity."[27] Maintaining the "sensorial

[27]Edward B. Titchener, "Wilhelm Wundt," American journal of

attitude" while doing discrimination experiments must have been demanding and tedious. The subject had to concentrate on not anticipating the response movement, since one naturally tended to drift toward that state of preparation during a series of repeated reactions. Lange's problems had become the stuff of gossip and rumors against Wundt, but Lange clearly had weak physical and mental health before he came into the Institute. Nevertheless, the sad developments must have given Wundt cause to think about pathological consequences of psychological experiments.

But the work continued. The sensorial reaction offered renewed opportunity for investigations and time measurements of conscious mental processes: apperception and acts of will. Exner's notion of willful preparation followed by essentially unconscious reaction by reflex was not the stuff of psychological research, as Wundt had envisioned it anyway. Wundt wanted direct experimentation on conscious mental functions. To a large extent, it was in efforts either to reject or defend Wundt's reaction-time research that an international community of experimental psychologists found its identity. Many of them first experienced this community in the Leipzig Institute for Experimental Psychology.

C. The social organization of research in the Leipzig Institute, the set-up for experiments.

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psychology, 32 (1921), 161-178; 178, fn 34.

The Leipzig experiments just reviewed began in 1879. Their research set-up already had its final form, where the human players were concerned. Although instrumentation developed and theories were altered, the social organization of research remained remarkably stable. It is worthwhile to take a closer look at the Wundtian experimental set-up, since it, like instrumentation, was more directly transferable to other institutions and to other cultural environments than were the theories and philosophical framework that reigned in the Leipzig Institute.

Ten years after official establishment of the Institute an occasion arose which called for Wundt to reflect upon his accomplishment. For the 1893 Columbian Exposition in Chicago, an international celebration of industry and science, German academics prepared a volume designed to put the best of their universities forward to the world. Wundt contributed an article, "Experimental psychology and psychophysics."[28] That such a chapter would be included in such a volume is a measure of the importance attached to the development of Wundt's line of research, just twenty years after the Grundzüge first appeared. Sixteen years later, when Leipzig University celebrated the 500th anniversary of its founding in 1409, Wundt had another opportunity to sketch a history and a description of his

[28]Wundt, "Psychophysik und experimentelle Psychologie," in Die deutschen Universitäten (für die Universitätsausstellung in Chicago 1893 unter Mitwirkung zahlreicher Universitätslehrer), ed. W. Lexis, vol. 1 (Berlin: A. Asher, 1893), 450-457.

Institute.[29]

Both sketches describe the same set-up for psychological experimentation. That stability was a result of Wundt's many years of preparation before coming to Leipzig. As de facto director of Helmholtz's institute in Heidelberg, Wundt had ably routinized the work there. He did a similar job in Leipzig, even before he had ministry support for his Institute. When Külpe assumed the position, the Institute Assistant began to run routine operations for Wundt, much as Wundt had done it for Helmholtz.

Wundt's most detailed description of the organization of the Institute's work appears in the 500th-anniversary sketch. The Institute, he wrote, had two functions: to give an introductory course in the methods of experimental psychology, usually taught by an Institute Assistant, and secondly, to carry out original research.

> The plan for the research projects is determined in a special assembly of all participants on the opening day of each semester. The director distributes the topics to be worked on, those to be continued from the previous semester as well as those newly chosen. In the case of the latter, consideration is given to the special wishes

[29]Wundt, "Das Institute für experimentelle Psychologie," in Festschrift zur Feier des 500 jährigen Bestehens der Universität Leipzig (Leipzig: Rektor u. Senat der Universität, 1909), vol. 4: Die Institute und Seminare der Philosophischen Fakultätan der Universität Leipzig. Part 1: Die philosophische und die philosophisch-historische Sektion, 118-133.

of particular older members who are interested in a certain theme. Then the members are divided into groups, each of which is occupied with a special topic. Participation in a group is voluntary, and each member is allowed to participate in several groups, as time and schedules allow. This group structure is as a rule necessary for psychological experiments, because it is best if the observer and experimenter are different persons; moreover it is desirable that results from a single observer should be controlled by those from the others. It can also happen with complicated experimental set-ups that it is necessary for different parts of the apparatus to be handled by different experimenters. There are very few tasks that are suitable for just one person with the combined job of observer and experimenter.

After the participants have been divided into separate groups, the schedule for the semester is determined, as well as the distribution of work space for the different groups at their different times. After groups are constituted, a leader is designated for each one. This is usually an older member of the Institute who has proved himself in previous semesters by helping in others' projects. The leader assembles the results of the experiments and, in the case that they are suitable, prepares them for publication. Whether results are

published or not, the protocols of the experiments always remain the property of the Institute.

[Der Plan für die spezielleren Arbeiten wird in jedem Semester am Eröffnungstage des Instituts in einer besonders dazu anberaumten Versammlung aller Mitglieder festgestellt. Es werden zu diesem Zweck zunächst von dem Direktor die zu bearbeitenden Themata, und zwar sowohl die aus den vorangegangenen Semestern übernommenen wie die neu gewählten mitgeteilt. Bei den letzteren wird zugleich tunlichst auf etwaige spezielle Wünsche der einzelnen älteren Mitglieder, die sich für ein bestimmtes Thema interessieren, Rücksicht genommen. Dann wird eine Verteilung der Mitglieder in die einzelnen Gruppen vorgenommen, deren jede sich mit einem bestimmten Thema zu beschäftigen hat. Der Zutritt zu einer Gruppe erfolgt freiwillig, und es ist, sofern eine Zeitkollision zu vermeiden ist, jedem Mitglied die Teilnahme an mehreren Gruppen gestattet. Diese Gruppeneinteilung ist in der Regel bei psychologischen Versuchen gefordert, da bei ihnen Beobachter und Experimentator meist verschiedene Personen sein müssen und es überdies wünschenswert ist, dass die Resultate eines einzelnen Beobachters durch die anderer kontrolliert werden. Auch kann es bei komplizierteren Versuchseinrichtungen vorkommen, dass es nötig ist, die verschiedenen Teile der Apparate durch mehrere

Experimentatoren bedienen zu lassen. Demgegenüber sind nur wenige Aufgaben zur Behandlung durch eine einzige Person, die dann die Eigenschaften des Beobachters und Experimentators in sich vereinigt, geeignet. Nach der Verteilung der Mitglieder in die einzelnen Gruppen wird der Stundenplan für das folgende Semester festgestellt, mit dem zugleich die geeignete Verteilung der Arbeitsräume an die Gruppen innerhalb der für die Arbeiten bestimmten Zeit stattfindet. Nach der Konstituierung der Gruppen wird ferner für jede ein Leiter designiert. Als solcher funktioniert regelmässig ein älteres Mitglied des Instituts, das sich in vorangegangenen Semestern durch die Mithilfe an andern Arbeiten bereits erprobt hat. Dieser Leiter der Gruppe hat dann schliesslich auch die Versuche zu bearbeiten und, falls sie sich dazu eignen, ihre Veröffentlichung zu redigieren. Übrigens werden die Versuchsprotokolle selbst in jedem Falle, ob nun die Untersuchung publiziert worden ist oder nicht, als Eigentum des Instituts betrachtet.][30]

Unlike the control conditions in today's experimental psychology, all actors typically knew all the roles and simply

[30]Wundt, "Das Institut für experimentelle Psychologie," ibid., 131-132. These protocols, which might have given interesting data on experimental methodology and strategy in the Institute, were destroyed with the Institute during the Allied bombing of Leipzig on 4 December 1943. See UAL, Phil. Fak. B1/14(raised)37 B V, Psychologisches Institut, 1928-1945, Bl. 86-90.

rotated through all the positions: subject [Reagent], experimenter [Experimentator] and observer [Beobachter]. The alternation of roles in the Institute had obvious pedagogical advantages, but Wundt's words make clear his conviction that the arrangement also had scientific value. His description clarifies the need for different observers, but it was also important that observers served as subjects in their own experiments as well. In the Leipzig set-up for psychological experiments, the subject had to know as much about the experiment as the experimenter or the observer, in order to be sure he was doing the reaction correctly. Reaction-time experiments, for example, depended upon consistency in the reporting of "recognition." For experiments in his Institute, Wundt insisted that subjects be trained, perhaps even, as Cattell recalled, "that only psychologists would be the subjects in psychological experiments."[31]

Exceptions to the institute-centered experiment only proved the rule in Leipzig. Cattell preferred to set up his experiments in his apartment, where work would not be limited to the hours the Institute was open. However, he also disagreed with Wundt on the need for the third person; he and his friend Berger worked together, without the separate observer.[32] Their line of thinking and their experimental results challenged and even slightly altered Wundt's design of the reaction-time experiment,

[31]Bird T. Baldwin, ed., "In memory of Wilhelm Wundt," Psychological review, 28 (1921), 156.

[32]Michael M. Sokal, ed., An education in psychology: James McKeen Cattell's journal and letters from Germany and England,1880-1888 (Cambridge, Mass.: MIT Press, 1981), 127, 139.

but Wundt did not change his fundamental theory of mental processes nor his requirements for the experimental set-up.

Although most psychologists now reject essential aspects of Wundt's set-up for the psychological experiments, its advantages in early laboratories should not be overlooked. Like any standard method, it achieved a certain stability of results and gave a clear point of departure for critics. It was also easily transferable. Even foreign students and visitors who had little understanding of, or interest in, German idealistic philosophy and Wundt's larger theoretical concerns could understand the function of the apparatus and the operation of a research team.

Enthusiastic adoption of techniques without due attention to underlying theory and intent spelled conflict down the road; but no alternative theoretical position really threatened Wundt's way of doing things during the 1880s, and Wundt was happy to let a thousand flowers bloom. He had, so he tells us later in life, never intended to be "head of a school." He only wanted to establish a research program for the experimental investigation of conscious mental processes.