Philosophy's Movement Toward Cognitive Science

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Chapter 4
The Rise of Empirical Psychology Through Methodological Behaviorism

4.1 Introduction

Chapter three ended with the suggestion that oppositional substance dualists face two major challenges. On the one hand, oppositional substance dualists have problems explaining the continual, seamless interaction between the mental and the physical. On the other hand, the very nature of mental substance gives rise to the challenges in positing explanatory mechanisms for mental phenomena. What features of mental substance and/or mental properties drive the dynamic changes mental phenomena and why? Put another way, what "mental mechanisms" bring about mental properties and processes? Even if one can formulate theories about such "mental mechanisms," how does one go about investigating and confirming one's theories about "mental mechanisms"? How can one experimentally manipulate the elements of a non-physical mental substance? How can one measure such a substance or its properties?

But, do monistic physicalists fare any better? Physicalist theories must meet the challenge of formulating physical mechanisms that plausibly explain how physical substance, physical properties, and/or physical processes give rise to mental properties and processes. Chapter four outlines how psychology comes to develop the categorizations and experimental techniques that allow it to gain traction in predicting, manipulating, and explaining one aspect of one mental domain—learning and memory. This confluence of descriptive and experimental elements gives rise to behaviorism in psychology.

The switch to psychology may seem somewhat out of place in a philosophy course. However, one must understand the developments in psychology and related sciences to understand in the philosophy of mind during the 20th century. Indeed, one must have some familiarity with the development of empirical psychology to understand the developments that shape philosophy during the first half of the 20th century. This chapter and lecture, therefore, takes a detour to briefly recount the development of empirical psychology. The progression between psychological schools of thought in this brief history emphasizes three trends: First, psychology progresses towards becoming a science and ultimately towards cognitive science by developing, evaluating, and integrating several important experimental methods. The development, evaluation and integration of experimental techniques together with a clear conception of their role in theory formation and testing constitute what I call an experimental tradition. Psychology develops an experimental tradition at first through the introduction of experimental methods from other sciences. Later as this tradition blossoms researchers become increasingly innovative and adaptive in their use of experimental methodology. Second, psychological schools of thought move from emphasizing conscious, qualitative aspects of mind and mental processes to emphasizing characterizations of the mind and mental processes in terms of information processing and observable behavior. This change in emphasis does not merely represent a recognition by theorists of an important set of phenomena for understanding the mind and mentality—though it surely is—it represents a shift from phenomena ill-suited to the conceptual and experimental methods of the time to phenomena better understood and testable by those resources. That is, psychology progresses by shifting its

categorizations and theories towards those aspects of the mind best suited to the experimental tradition of the time. Third, psychologists develop and adapt experimental techniques in order to more reliably explore those elements of their information processing models not directly observable by experimenters. The development of experimental methodologies, the refinement of animal and other models, increased knowledge of human mentality, development, and physiology, as well as the development of technical ideas such as information theory and computation ultimately coalesce, allowing for the conceptual framing of cognitive phenomena as well as its systematic experimental investigation.

4.2 Reaction Times and Mental Chronometry

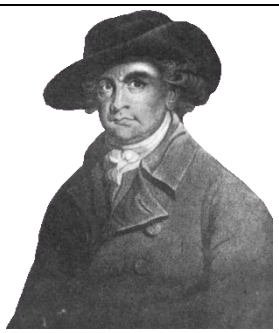
Recall that in discussing the development of physiology, I emphasize that physiology introduces a strong empirical and experimental emphasis to thinking about the mind. Indeed, many early psychologists receive their training from physiologists and anatomists. Consistent with that idea, I begin the discussion of the development of psychology towards cognitive science with the development of an experimental technique that has proven quite central to psychology—reaction time.

Reaction time refers to the time it takes from the initial presentation of stimulus until the subject reacts. For instance, the time between a light flashing and a subject pressing a button is that subject's reaction time for that stimulus-response pairing. Reaction time measurement begins with Friedrich Wilhelm Bessel[1] (1784-1846), a German astronomer and Gymnasium drop-out. Bessel becomes intrigued by a controversy regarding disparate observations of transit times between the astronomers Maskelyne and Kinnebrook, and later between Enckes and Gauss. Transit times are measurements of how long it takes stars to cross hairlines in telescopic observations. Transit times have significance because they indicate the time it takes the star to pass over the meridian of the observatory. Astronomers use transit times for a star to determine the coordinates of the star. Precise measurements of star coordinates are becoming increasingly important in the 1700s and 1800s, both for the astronomers and also because nautical tables of the time rely upon coordinate information for stars. Twenty years after the original dispute (1821), Bessel looks at the dispute using two approaches: First, Bessel analyzes the observations of different astronomers. Second, Bessel performs a simple experiment; he compares observational measurements between astronomers using the same equipment. Bessel determines that skilled astronomers will vary consistently in their observations of transit times. As a result, Bessel introduces the notion of an "involuntary constant difference," in describing his findings in the preface to the eighth volume of his *Astronomische Beobachtungen*[2] (1823).

In astronomy, the phenomena now commonly goes under the name introduced by John Pond[3] (1767–1836) in 1933[4], as the "personal equation." One can describe Bessel's work as the first experimental quantitative measurement of reaction time without fear of accusations of hyperbole. Indeed, Bessel's work eventually results in the first attempt to control both for reaction time and also for individual differences in scientific observation. In addition to the benefits to science of the development of techniques to test reaction time and a conception of reaction time as a variable, experimental science benefits from the invention of improved measuring devices. Chronometers have already seen employment in marine navigation, but through increases in accuracy, these devices begin to serve scientific purposes as well. In 1847 the German-born Swiss clock maker and inventor, Matthäus Hipp,[5] builds a modified chronoscope based upon the design of its inventor, Charles Wheatstone[6] (1842). Wheatstone originally designed the chronoscope for British artillery applications, but the devices allow increased accuracy in temporal measurement over pendulum clocks and

other measuring devices. Scientists and inventors follow chronoscopes with other devices like the increasing advanced chronometers and the Control Hammer Apparatus for better time keeping and calibration.[5, 7]

Friedrich Wilhelm Bessel (1784-1846)
From: Wikipedia

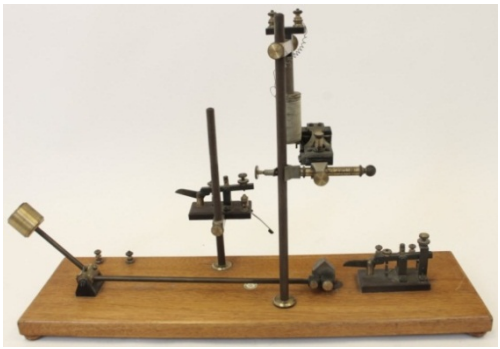


John Pond (1767-1836)
From: Wikipedia

Matthäus Hipp (1813-1893)
From: Twigsdigs.com

Charles Wheatstone (1802–1875)
From: BBC

A chronoscope built by the Swiss inventor and clock maker Matthias Hipp in 1888. Early psychological and physiological researchers used chronoscopes to measure reaction times in their experiments. This chronoscope is accurate to 1/1000th of a second. From: U of Texas



Picture of a control hammer appartus used to calibrate timing devices like the chronoscope. From: U of Toronto

A mechanical marine chronometer invented by John Harrison in 1737. From: Wikipedia

Among those researchers who employ these devices, the German physiologist, Hermann Ludwig Ferdinand von Helmholtz[8] (1821-1894), publishes his "On the Rate of Transmission of the Nerve Impulse,"[9] in 1850. The Swiss astronomer Adolph Hirsch (1830-1901) publishes his "Sur l'equation Personnelle dans les Observations Astronomiques (On Personal Equation in Astronomical Observations) and his "Experiences Chronoscopiques sur la Vitesse des différentes Sensations et de la Transmission Nerveuse (Chronoscopes Experiments on the Speed of Different Sensations and Nerve Transmission)"[10, 11] In the latter work Hirsch [12]

> …was the first (1) to use Hipp's chronoscope in scientific literature, (2) to study reaction time in connection to psychological interest, and (3) to study velocity of conduction in humans with appropriate techniques. Using Hipp's apparatus, Hirsch showed differences in time for manual response (1) to auditory, visual, and tactile stimulation; (2) between observers; (3) in Hirsch's own results when fresh and when fatigued; (4) according to the locus of tactile stimulation and the hand used for response; and (5) according to whether the stimulus was expected or unexpected. Moreover, observations made on one of his colleagues relate the conduction speed in nerves, from which he concludes that the differences in reaction time were due to the varying lengths of nerves. The speed of transmission in sensory nerves was evaluated by Hirsch at about 34 m/s. (p.261)

Hermann von Helmholtz (1821-1894)
From: NDSU.edu

Adolph Hirsch (1830-1901)
From: Wikipedia

Franciscus Cornelis Donders (1818-1889)
From: Wikipedia

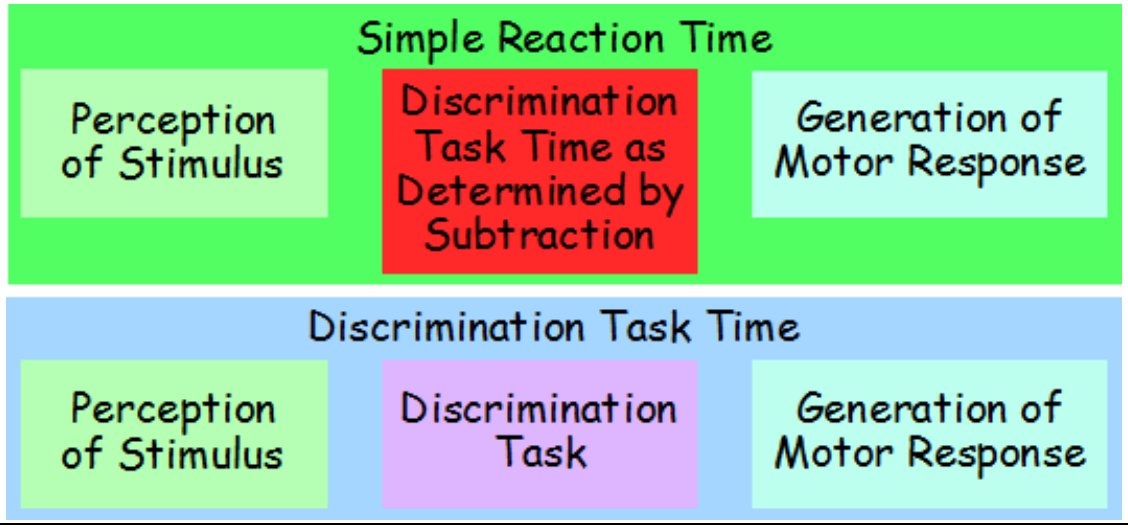


Diagram illustrating the subtraction technique. A researcher takes two tasks that differ only by one component task. In this case, the first task is a simple reaction task composed of a perception task and a motor response task. The second task is a discrimination task composed of a perception task, a motor response task, and the discrimination task. The researcher determines the mean time for subjects to complete each task. Subtraction of the simple reaction time from the discrimination task time to yield the time of the discrimination task alone.

Researchers usually cite Franciscus Cornelis Donders[13] (1818-1889) as the first researcher to use differences in human reaction time to infer differences in cognitive processing time. Building on the work of his graduate student, Johan Jacob De Jaager[14], and with an awareness of earlier work by Helmholtz and Hirsch, Donders uses the same subtraction method employed by Helmholtz, to make inferences about the times of various mental processes. In 1868, Donders publishes "On the Speed of Mental Processes,"[15] in which he shows that a simple reaction time is shorter than a recognition reaction time, and that the choice reaction time is longest of all. Using these times, Donders makes inferences as to the speed of mental processes through subtraction: recognition = (recognition reaction time - simple reaction time). Donders' results are an instance of mental chronometry,[16] i.e., the study of the relative speed and temporal sequencing of mental process under some specified set of conditions. The ideas of subtraction, mental chronometry, and reaction time are now part of the central methodological framework of cognitive psychology. The next experimental technique, introspection, has a less venerable history.

4.3 Introspection and Introspection-Based Psychologies

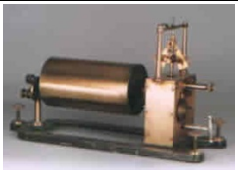
The development of the categorization of phenomena through reaction time and the invention of devices for precise quantification of reaction time in experimentation represent a significant success in the development

of an experimental tradition within physiology and what would eventually become psychology. The next example of the development of an operationalization (measurement procedure) proves less definitely positive. One difficulty theorist face in developing theories of mind lies in finding ways to categorize and measure qualitative conscious experiences. Some researchers turned to introspection, an individual's (seeming) observations of their own conscious states such as beliefs, desires, emotions, and sensations as a means of gathering observations of such phenomena. The technique of introspection enters psychology through the work of Wilhelm Maximilian Wundt,[17] (1832-1920) a German physician, psychologist, physiologist, and university professor. Wundt, Edward Titchener,[18] and Franz Brentano[19] are often portrayed together under the title of Introspectionist Psychology. However, as we will see, these theorists differ significantly in their theoretical perspectives as well as their use of introspection as a means of collecting data for experimental psychology.

Wilhelm Wundt (1832-1920)
From: Europeword

Edward Titchener (1867-1927)
From: Allaboutpsychology

Franz Brentano (1838-1917)
From: 50watts.com



(Above) A Kymograph first used by physiologists, but adapted by psychologists to record response times, stimulus presentations and other temporal events. The drum rotates and events are recorded on sheet of paper. Picture and caption adapted from: University of Indiana

(Far Left) An Aerometer used by Wundt to investigate pressure sensitivity. Experimenters put weights on the left side of the device, and the subject's had rested beneath the adjustable pole on the right-hand side of the device. From: North Taiwan University **(Left)** A tachistoscope used to present images from a fixed period of time. The images where loaded on the wheel which psychologists placed behind a screen. The screen had a single slit through which an image would become visible as its place on the wheel rotated in front of the opening. From: North Taiwan University

4.3a Introspectionist Psychology: Voluntarism

Wundt creates the first laboratory explicitly dedicated to psychological research (as opposed to labs for teaching demonstrations) at the University of Leipzig in 1879. He also begins the first journal for psychological research in 1881. If Freud is the "father of Psychiatry," Wundt likely deserves the title of the "father of Experimental Psychology." The experimental tradition begun by Wundt spreads throughout Europe as well as the United States.[20]

Wundt studies under the German anatomist Heinrich Müller and Helmholtz prior to writing his first book, *Contributions to the Theory of Sense Perception*[21] (1862). He follows this book with his second, *Lectures on Human and Animal Psychology*[22] (1863). This second book results from lectures Wundt gives for the first ever psychology course. Nevertheless, Wundt still teaches and conducts research primarily in physiology. He publishes a physiology textbook in 1865, and is promoted to assistant professor of physiology at Heidelberg in 1964. Not until around 1867 that Wundt devotes seems to devote his teaching and research primarily to

psychology when begins lecturing regularly on physiological psychology. Wundt has founded the first school of psychological thought by 1974, when he publishes *Principles of Physiological Psychology*.[23] Ironically, Wundt's success at training a new group experimental psychologists leads to a distortion of his own views. One Wundt's students, Edward Titchener[18] (1867-1927), actively, but misleading, associates Wundt's view with Titchener's on view, structuralism. Wundt names his view voluntarism, and as we will see, it differs somewhat from the typical views attributed to structuralism.

Wundt equates mentality with consciousness, and holds that experimentation can help one to understand simpler conscious phenomena, but not more complex phenomena. Essentially, Wundt limits psychology to studying sensation and perception. For Wundt, psychology represents an extension of the techniques of physiology into the domain of conscious experiences. However, Wundt precisely and modestly limits the scope of such an extension to conscious experiences associated with sensation and perception. Wundt holds that one must employ historical analysis and naturalistic (non-experimental) observation to understand higher mental functioning. Thus, reasoning, problem solving, and similar processes typically associated with mentality in the contemporary mind fall outside the preview of psychology under Wundt's conception.

Picture of Wundt together with his research associates at the Leipzig laboratory. From: Wikipedia

Despite the seeming modesty of Wundt's proposed psychology, he executes it with considerable ambition. In 1879 he opens the first psychology lab at the University of Leipzig. Wundt adopts two primary experimental techniques for studying simple conscious phenomena; introspection and reaction time. Reaction-time enters Wundt's experimental repertoire from Helmholtz and Donders. However, he eventually abandons the use of reaction time as too unreliable. Unlike many other psychologists who follow him, Wundt uses introspection in a highly constrained fashion in keeping with its use in physiology and psychophysiology. Subjects often provide only yes or no answers to signify whether they are experiencing a sensation. However, Wundt trains subjects in introspection, ostensively so that the subjects can to learn the appropriate categories. For Wundt introspection provides immediate observation of mental phenomena—direct observation unmediated by measuring and recording devices.

Wundt studies perception—the passive and involuntary combination of multiple sensations--and apperception--active voluntary perception involving attention. He seeks the fundamental constitutive elements of conscious mentality as well as the rules by which these elements combine into more complex experiences. In this way, Wundt follows the mental chemistry model of the mind that one finds in the British Empiricists. However, for Wundt attention and the will act as a sort of catalyst, making apperception active. Thus, Wundt differentiates himself from the British Empiricists, in part, because of his introduction of an active, volitional component to the mental chemistry account. Likewise, Wundt's exclusion of higher mental functioning from the domain of scientific studies of the mind differs from other atomists.

Wundt breaks mental elements into two categories; sensations and feelings. Sensations result from stimulation of the sense organs. Each sensation has an intensity value (ex. bright vs dim) and a modality (touch, taste, etc.). Each modality has associated qualities such as sweet and sour for taste. Feelings are

distinct from sensations but co-occur with sensations. Wundt proposes a tridimensional account of feelings in which feelings have values along three orthogonal (opposing and independent) dimensions; pleasantness-unpleasantness, excitement-calm, and strain-relaxation.

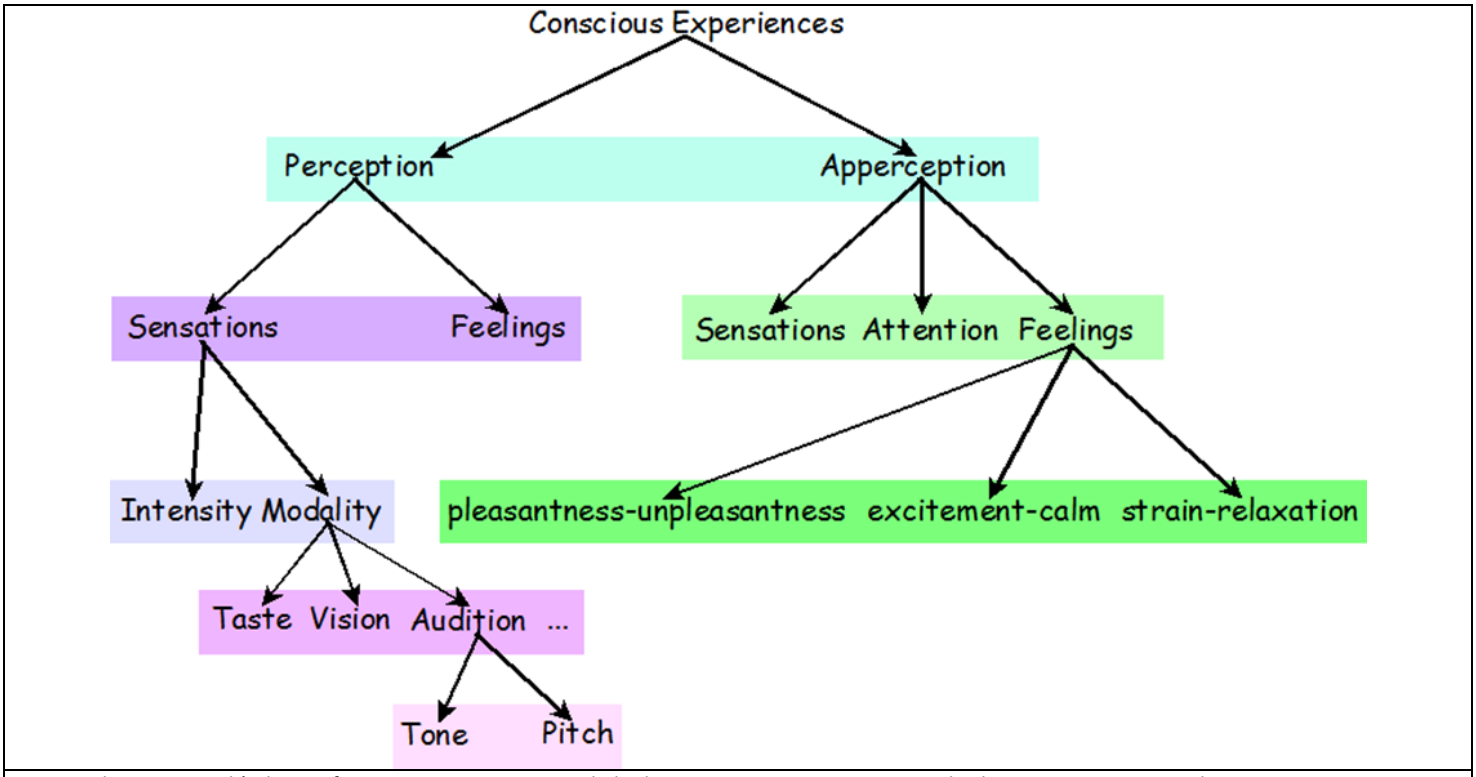


Diagram depicting Wundt's theory of conscious experience. Wundt divides conscious experiences into two kinds; passive perception and active apperception. Perception consists to two elements; sensations and feelings. Apperception consists of the elements of sensations and feelings together with attention. Sensations have two components (depicted on the right); intensity and modality. Each modality has qualities; in this case, audition has tone and pitch. Feelings (depicted on the left) vary along three orthogonal dimensions; pleasantness-unpleasantness, excitement-calm, and strain-relaxation.

4.3b Introspectionist Psychology: Structuralism

Edward Titchener[18] (1867-1927) is an English student of Wundt who comes to Cornell University where he continues Wundt's general project of trying to identify the elements of simple human consciousness and their interactions. However, Titchener's views and methods differ significantly from Wundt's. Unlike Wundt, Titchener seeks to apply the lens of experimental psychology to higher order mental phenomena as well as simpler conscious phenomena. Titchener views experimental psychology as generating a morphological account of mental experiences—that is, an account of the elements and composite structure of conscious mental experiences. In his article, "The Postulates of a Structural Psychology,"[24] (1898), Titchener tells readers that,

> The primary aim of the experimental psychologist has been to analyze the structure of mind; to ravel out the elemental processes from the tangle of consciousness, or (if we may change the metaphor) to isolate the constituents in the given conscious formation. His task is a vivisection, but a vivisection which shall yield structural, not functional results. He tries to discover, first of all, what is there and in what quantity, not what it is there for. (p.450)

Likewise, Titchener differs from Wundt in that Titchener rejects the idea of an active volitional component of mental experiences. Titchener rejects as unscientific volitional, functional and teleological descriptions of

mental processes at the psychological level. Instead, Titchener follows the British Empiricists in supposing that psychology should create an account of mental experiences in terms of structures created through the combination of basic elements through the mechanism of association. Similarly, Titchener holds that mental elements can only be known through their attributes. Titchener distinguishes three kinds of mental elements; sensations, images, and affections. Titchener associates ideas with images, following Hume in supposing that ideas are formed from perceptions. Thus, perceptions are composed of sensations, ideas are composed of images, and emotions are composed of affections. Titchener further analyzes sensations and ideas into intensity, quality, duration, and extent. He also distinguishes modalities like touch and vision. Affections also possess intensity, quality, and duration. However, affections lack clearness and extent. Titchener's primary mechanism of association is the law of contiguity. The law of contiguity states that occurrent mental states will tend to cause other mental states that have co-occurred with that state in past experiences.

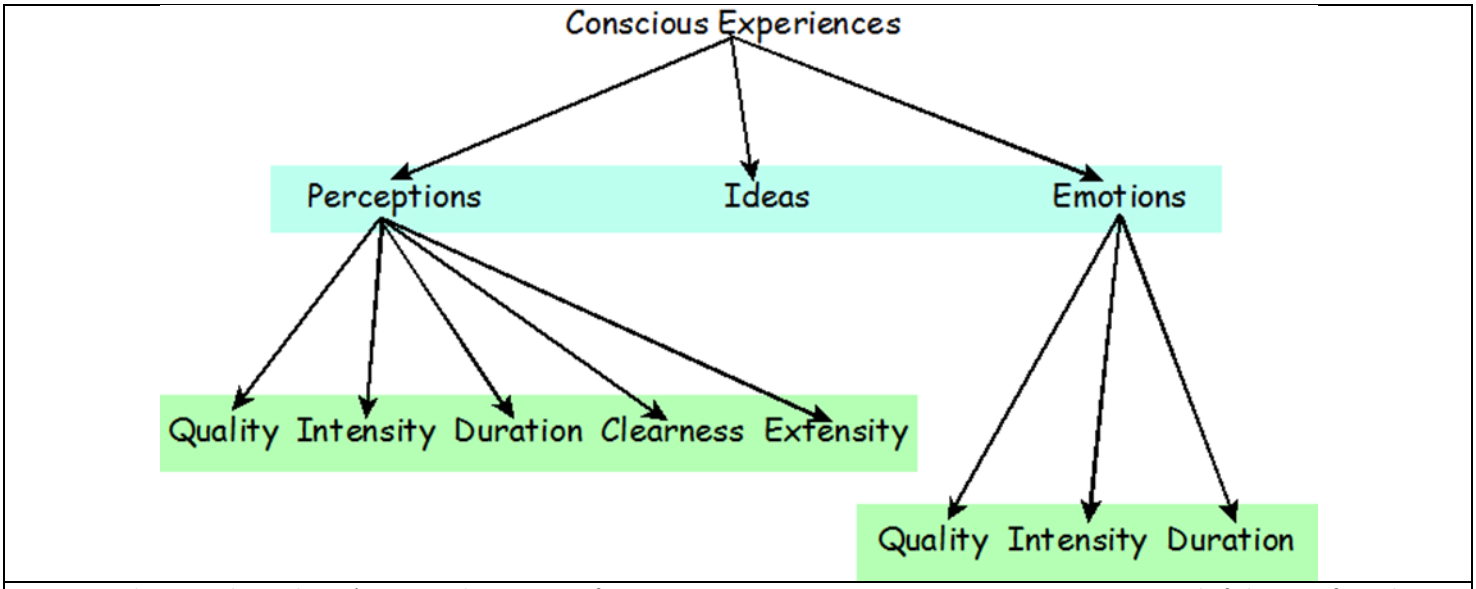


Diagram depicting the Titchener's structuralist account of conscious experiences. Conscious experiences are composed of elements from three categories (in blue); perceptions, ideas, and emotions. Each element has attributes (in green) that differentiates it and through which it is known. Perceptions and ideas have the attributes of quality, intensity, duration, clearness, and extensity. Emotions have the attributes of quality, intensity, and duration.

Titchener's use of introspection differs from Wundt's in that Titchener requires subjects to actively probe or analyze their experiences to formulate reports. This requires extensive training. Titchener intends his training to cultivate an ability to observe and describe conscious experiences without the tincture of "stimulus error." Stimulus error occurs when subjects report their perceptions--reporting the meaning of the stimulus (or its conceptualization). For instance, if a subject saw an apple, the subject must report the hues, shapes, etc. of their experience—they should not report seeing an apple or a fruit. This combination of indoctrination into descriptive categories and active, even retroactive, analysis by subjects renders introspection even more methodologically problematic as an experimental tool.

In addition to the difficulties surrounding Titchener's use of introspection, he also ignores as irrelevant numerous research areas where significant progress is occurring. For instance, Titchener discounts animal behavior and evolution, abnormal behavior, learning, development, and inter-subjective variation.

4.3c Introspectionist Psychology: Act Psychology

If one seeks a true Introspectionist villain, Franz Clemens Honoratus Hermann Brentano[19] (1838-1917)

probably best fits that description. In his major work, *Psychologie vom Empirischen Standpunkte*[25] or *Psychology from an Empirical Standpoint* (1874), Brentano coins the term "intentionality" to characterize his view that every mental act has an object to which it refers. For example, when someone sees an apple, they see it as an apple, an object, and not merely as a qualitative experience. Brentano tells readers:[26]

> Every mental phenomenon is characterized by what the Scholastics of the Middle Ages called the intentional (or mental) inexistence of an object, and what we might call, though not wholly unambiguously, reference to a content, direction towards an object (which is not to be understood here as meaning a thing), or immanent objectivity. Every mental phenomenon includes something as object within itself, although they do not all do so in the same way. In presentation something is presented, in judgement something is affirmed or denied, in love loved, in hate hated, in desire desired and so on. This intentional in-existence is characteristic exclusively of mental phenomena. No physical phenomenon exhibits anything like it. We could, therefore, define mental phenomena by saying that they are those phenomena which contain an object intentionally within themselves. (p.88-89)

Brentano also eschews the study of static simple conscious experiences, framing mentality in terms of acts, that is, in terms of the mind being directed towards an object in order to perform some function. Indeed, he holds that psychology should study mental processes in order to determine their function.

Though Brentano never practices experimental psychology, he does employ and advocate "phenomenological introspection," in his theorizing about the nature of the mind and its processes. In employing phenomenological introspection, the researcher either asks the subject to analyze temporally extended processes such as inferences, or performs such an analysis themselves. Though Brentano publishes very little, he influences many people, for instance, Freud.

4.4 The Downfall of Introspectionist Psychology

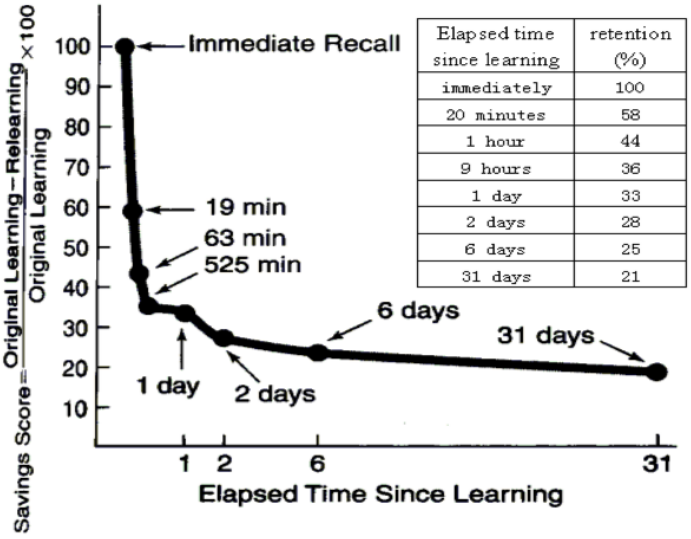
The over reliance upon introspection as their experimental methodology, together with the implicit biases introduced by extensive training of subjects, and allowing extended and retroactive introspective analysis that ultimately doom the methodological side of introspective psychology. Its practitioners make little to no effort to assess the accuracy or to calibrate introspective reports. Similar failures with regard to recognizing and controlling for subject and experimenter bias serve only to amplify their methodological difficulties. Instead, perhaps naturally, they assume introspection proves perfectly reliable across all of its methodological uses. Quite to the contrary, systematic studies assessing the reliability of introspective reports reveal that under a wide range of conditions and tasks introspection proves relatively unreliable, poorly calibrated, and susceptible to massive subject and experimenter bias. The behaviorists heavily criticize introspection as part of their rejection of the various forms of introspective psychology. The contemporary uses of introspection, as a result, are highly constrained and subject to extensive cross-validation. Indeed, Richard Nisbett and Timothy Wilson publish an influential literature review in 1977,[27] which still serves to highlight the perils of introspection as a means of data collection regarding psychological processes.

As we'll see, the failure of introspection and the various schools of psychological thought that rely heavily upon it also serves to shift the emphasis from understanding the mind through conscious experience towards understanding the mind through behavior and eventually cognition. However, difficulties in experimental methodology do not in themselves lay the groundwork for a successful psychology. Nevertheless, even as Wundt opens his laboratory in Leipzig, the beginnings of a systematic psychological treatment of learning and memory are emerging in the work of Hermann Ebbinghaus.

4.5 Ebbinghaus: The Quantified Study of Memory as a Process

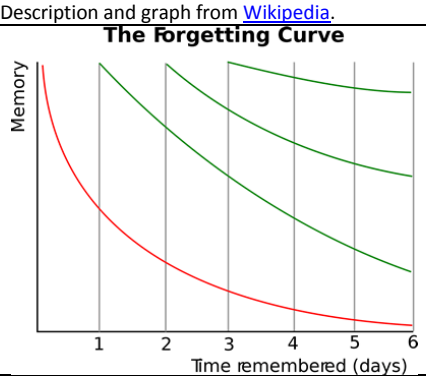
Hermann Ebbinghaus[28] (1850-1909), begins one of the first systematic studies of memory in 1879. He studies only the ability to memorize nonsense syllables by rote. He selects nonsense syllables since previous learning will not influence learning of these meaningless sounds. This choice represents one of his contributions to memory research, namely, that ease of memorization is increased by meaningfulness and relevance to the memorizer, and vice versa. Ebbinghaus might have used some of his students as subjects, but he seems primarily to use only himself as a subject. Ebbinghaus publishes his results in his book, *Über das Gedächtnis Untersuchungen zur Experimentellen Psychologie* [29] or *On Memory* (1885), which is later translated and published as *Memory: A Contribution to Experimental Psychology*[30] (1913).

Hermann Ebbinghaus (1850-1909)
From: Wikipedia



Elapsed time since learning	retention (%)
immediately	100
20 minutes	58
1 hour	44
9 hours	36
1 day	33
2 days	28
6 days	25
31 days	21

(Right top) Graph depicting data Ebbinghaus' data on savings and forgetting. From: Student Sri Lanka **(Right bottom)** Table from Ebbinghaus' *Memory* presenting data on savings. (Below) A typical representation of the forgetting curve. Description and graph from Wikipedia.



Repetitions for the learning and recital of 6 series	Immediately successive repetitions for the sake of greater surety	Total number of repetitions used for the 6 series	After 24 hours the memorization of the series required	Thus the work saved by the total number of repetitions amounted to
104	294	398	41	63
101	285	386	39	62
114	324	438	46	68
109	309	418	38	71
m = 107	303	410	41	66 P.E.$_m$ = 1.4

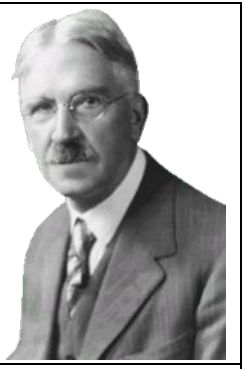
In *On Memory* Ebbinghaus reports results that are the basis for the "learning curve" and the "forgetting curve." The learning curve shows that learning time, measured as number of repetitions, increases exponentially with the number of items memorized. Likewise, the increase in retention for each repetition decreases exponentially so as to approach complete retention asymptotically. The forgetting curve is similarly exponential, showing the forgetting decreases at an exponential rate, so as to approach complete failure of retention asymptotically. Specifically, $R = e^{-t/s}$ (where R = retention, t = elapsed time, and s = strength of original memory). Ebbinghaus also documents the serial position effect, viz. the recency and primacy effects (subjects are more likely to remember the last item in a series [recency] and the first item in a series [primacy]). Likewise, Ebbinghaus documents "savings." If one memorizes a list and then waits until recall is zero, one will still generally relearn the list at a faster rate despite the seeming lack of recall. Ebbinghaus terms the difference between the first and second memorization the savings.

Ebbinghaus proves neither prolific nor strongly aligned with any particular school of psychology. He, in fact, does not identify himself with any psychological school of thought, and does not seek out pupils. Nevertheless, his work spurs research on memory. Ebbinghaus' careful, well-designed experiments, his rigorous quantified results, statistical analysis, and systematic presentation prove extremely influential. Of equal importance, Ebbinghaus has found a way to study psychological (mental) processes that has highly reliable operationalizations (methods for categorizing and quantifying phenomena). He likewise has developed a set of categorizations that allow for the formulation of dynamic changes in those same mental phenomena.

4.6 Functionalism

Most historians consider William James[31] (1842–1910) the first figure in the first school of psychology in the United States--functionalism. Functionalism overlaps significantly with both structuralism and behaviorism. James' text, *The Principles of Psychology*[32] (1890), actually predates by two years Titchner's arrival a Cornell.

William James (1842–1910)
From: Litkicks.com



John Dewey (1859-1952)
From: Pragmatism.org

The Principles, a two volume twelve hundred page text, makes James as famous and widely studied as Wundt. Though James' textbook has a greater influence at the time, the first textbook articulating functionalism in psychology comes from John Dewey at the University of Michigan. Dewey publishes his book, *Psychology*,[33] in 1887. Dewey's book elaborates upon a conception of psychology he articulates in his article, *The New Psychology*,[34] three years earlier.

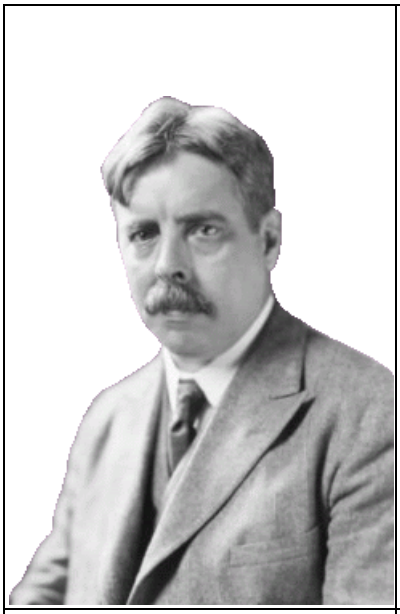
Functionalism, much like pragmatism, the philosophical movement with which James is also associated, has no central figure, nor a clear-cut doctrine. However, functionalists make important criticisms and contributions to other schools of psychological thought, and do share several common general commitments. (1) Functionalists oppose the search for the basic elements of thought that characterizes Wundt's and Titchener's views. In fact, *Principles* portrays mentality as a stream of consciousness incapable of analysis into elements. (2) Functionalists, in contrast to voluntarists and structuralists, think of the mind as dynamic and mental processes as serving functions. (3) They view the function of mind through the lens of evolution. Thus, functionalists understand mental processes and behavior in terms of the general goals of adaptation and selectional advantage. (4) Unlike the rather rigid determinism of structuralism and behaviorism, functionalism tends to emphasize adaptation and differential responses driven by motivation. (5) Methodologically, functionalists tend to accept both introspection and behavioral observation as methodological tools. Though few early functionalists conduct experiments, later functionalists do conduct experiments. Functionalists also support psychological research on animals, children, and abnormal populations as a means to understand normal human mentality. (7) Finally, unlike Wundt, who views psychology's mission as pure basic research, functionalists tend to see psychology as a means to improve society and people's lives.

The functionalists act as a counterweight to both structuralism and behaviorism. For instance, historians often cite John Dewey's "The Reflex Arc Concept in Psychology,"[35] (1896) as the beginning of functionalism. In this article Dewey criticizes the notion of the reflex arc as consisting of discrete stages; stimulus and response. He also anticipates challenges facing behaviorists by noting the difficulties in specify a context-free notion of

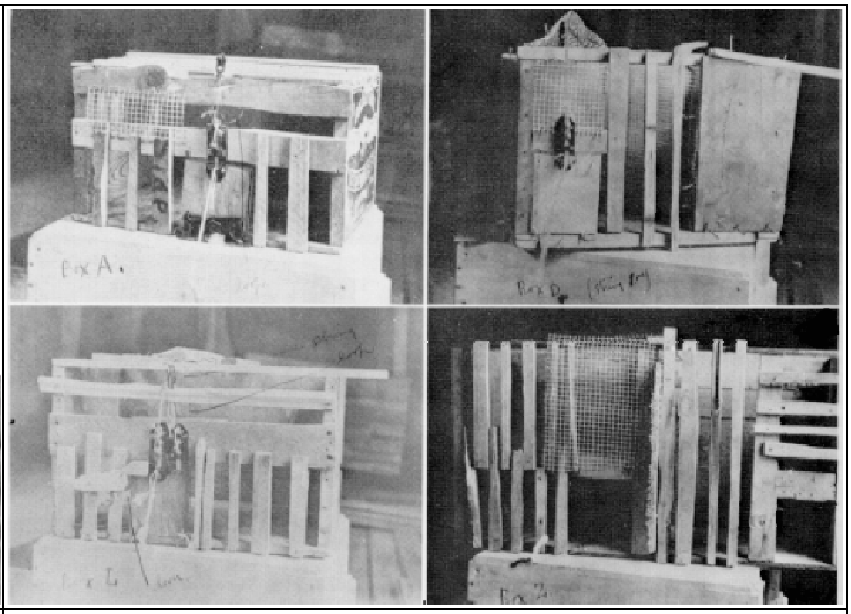
stimulus and response, i.e., specifications capturing the relevant features of particular stimuli and responses as well as specifications which predict the generalizations to future cases. Furthermore, the functionalist emphasis on practical applications in psychology, evolution, and diversity in methodology as well as research areas help to plant the seeds for cognitive science.

4.7 Thorndike's Law of Effect

Historians classify Edward Lee Thorndike[36] (1874-1949) as a functionalist. However, much of his work is arguably the first research on conditioning and is certainly the first work on operant conditioning. Thorndike publishes his dissertation, "Animal Intelligence: An Experimental Study of the Associative Processes in Animals," in 1898--predating Pavlov's first public reference to conditioned reflexes by approximately a year. Thorndike republishes this work in 1911 as *Animal Intelligence*.[37]



Edward Lee Thorndike (1874-1949)
From: Wikipedia



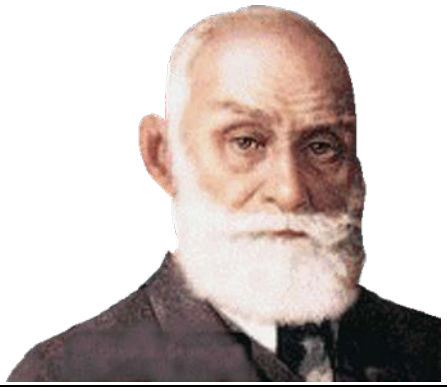
Four of Thorndike's puzzle boxes From: cwu.edu

Thorndike studies a number of animals, but he is most famous for his studies of learning in cats using homemade puzzle boxes (above). Thorndike puts a cat in a box, and lets it behave randomly until it stumbles upon the release mechanism. He repeats this procedure until the cat can release itself in negligible time. Thorndike then plots the decline in time to escape relative to times in the box, using this ratio to characterize learning by "learning curves." He formulates his generalized results in terms of the law of effect:[37]

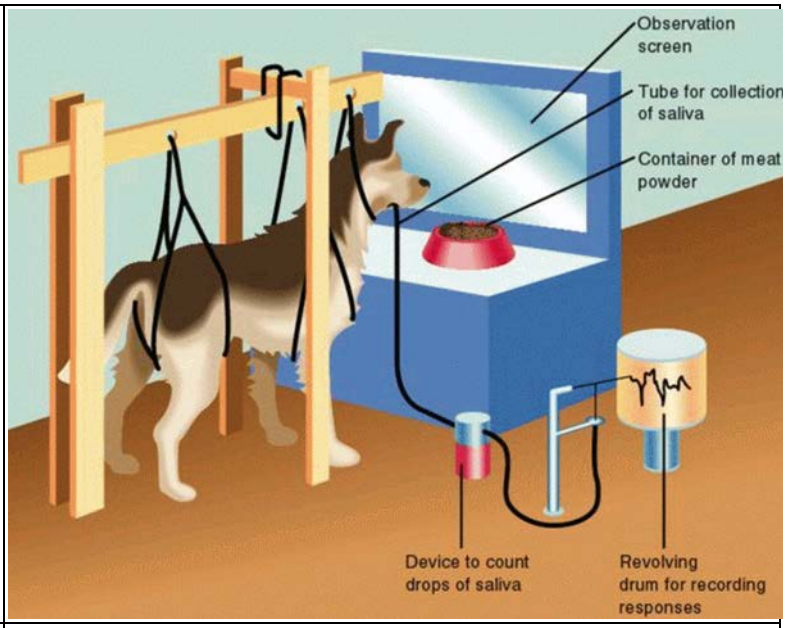
> The Law of Effect is that: Of several responses made to the same situation, those which are accompanied or closely followed by satisfaction to the animal will, other things being equal, be more firmly connected with the situation, so that, when it recurs, they will be more likely to recur; those which are accompanied or closely followed by discomfort to the animal will, other things being equal, have their connections with that situation weakened, so that, when it recurs, they will be less likely to occur. The greater the satisfaction or discomfort, the greater the strengthening or weakening of the bond. (p.244)

4.8 Behaviorism: Pavlov's Discovery of Classical Conditioning

Ironically, it is Ivan Pavlov (1849-1936), a Russian physiologist studying digestion, who provides the key finding around which Behaviorism evolves--classical conditioning.



Ivan Pavlov (1849-1936)
Adapted from: Exploring the Mysteries of Behavior

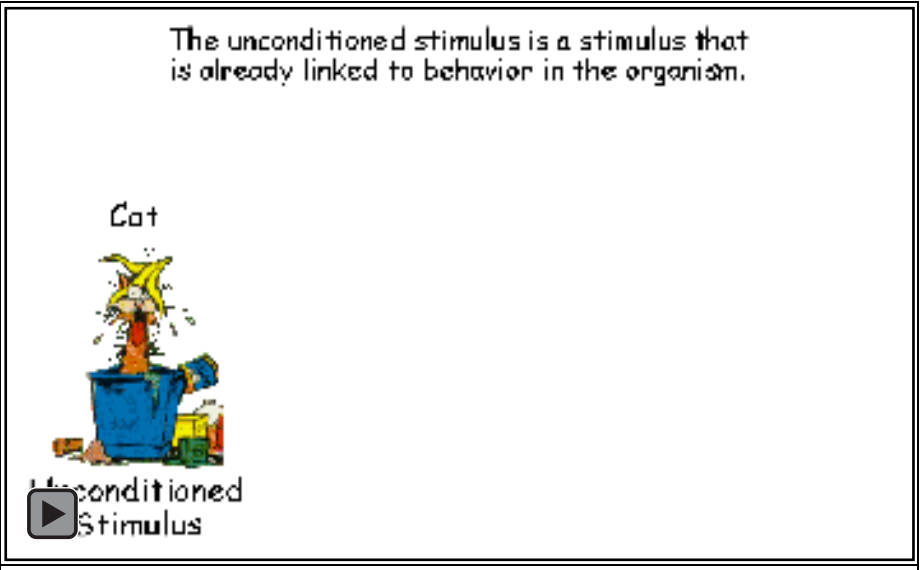


Depiction of Pavlov's experimental apparatus for his studies of digestion.
From: Simply Psychology

Pavlov's research includes the physiology and the neurophysiology of temperament, conditioning, and involuntary reflex actions; but the bulk of his work focuses on digestion. Pavlov's experimental research on digestion was innovative and sophisticated—so much so that he won the Nobel prize for his work on digestion. Pavlov's techniques include surgical removal of components of the digestive system from animals to facilitate observations of their functions, lesioning nerve fibers to trace their function by observing the lesion's effects, and implanting fistulas (tubes or holes) draining into pouches to examine the organ's contents. In the 1890's Pavlov's lab is performing experiments on digestion using dogs. Specifically, Pavlov's group is studying the salivary functions of dogs by surgically externalizing a salivary gland so that the saliva could be collected and analyzed. During their research Pavlov notices that the dogs begin to salivate before receiving food. He calls this phenomena "psychic secretion"[38] (p.7), and the lab begins to investigate this phenomena. The researchers realize that these "psychic secretions" result from associations between the food and other stimuli. These investigations eventually reveal what Pavlov calls "conditioned reflexes," and we now call classical conditioning.

Pavlov first mentions his discovery in a lecture to the Society of Russian Doctors of St. Petersburg in 1899. Printed accounts of the research appear in a dissertation by Pavlov's student, Wolfson, and in a report to the 1903 Congress of Natural Sciences by Ivan Tolochinov,[39] Pavlov's collaborator. However, the discovery does not receive significant attention until Pavlov discusses it in his Nobel Prize acceptance speech in 1904. Pavlov's own account does not emerge until he publishes, *Conditioned reflexes: An Investigation of the Physiological Activity of the Cerebral Cortex*[38] in 1927.

A picture of one of Pavlov's dogs complete with a fistula and collection chamber. From the Pavlov Museum in Russia.



Animation depicting the elements and process of classical conditioning. To play movie, click on the picture.

As illustrated in the diagram above, classical conditioning works by associating a stimulus (the unconditioned stimulus) that triggers a specific response with a novel stimulus (the conditioned stimulus). Specifically, the unconditioned stimulus is a stimulus that elicits a particular response called the unconditioned response. The conditioned stimulus is paired with the unconditioned stimulus repeatedly, so that the pairing elicits the unconditioned response. This repeated pairing increases the association between the conditioned stimulus and the unconditioned response, as reflected in the increasing likelihood of the conditioned stimulus eliciting the response in and of itself, making the unconditioned response a conditioned response.

Pavlov also discovers and studies extinction and spontaneous recovery. When one elicits the conditioned response using only the conditioned stimulus, the association between the conditioned stimulus and conditioned response weakness over time. This weakening is called extinction. After an association between a conditioned stimulus and a conditioned response reaches extinction, the conditioned stimulus can elicit a conditioned response at a later; such cases are called spontaneous recovery.

4.8 Behaviorism: John Watson

John Watson[40](1878-1958) adapts the work of Pavlov into a general approach to psychology, which he presents in his 1913 paper, "Psychology as the Behaviorist Views It".[41] Watson embraces the idea of classical conditioning and sets the goal of psychological investigation as the prediction and control of behavior. Additionally, Watson explicitly rejects the project of analyzing conscious experience, and the methodological tool of introspection. Watson describes his view as follows:[41]

> Psychology as the behaviorist views it is a purely objective experimental branch of natural science. Its theoretical goal is the prediction and control of behavior. Introspection forms no essential part of its methods, nor is the scientific value of its data dependent upon the readiness with which they lend themselves to interpretation in terms of consciousness. The behaviorist, in his efforts to get a unitary scheme of animal response, recognizes no dividing line between man and brute. The behavior of man, with all of its refinement and complexity, forms only a part of the behaviorist's total scheme of investigation. (p.158)

While Watson emphatically distances behaviorism from Introspectionist psychologies, there are strong similarities under the surface. Watson limits the appropriate phenomena of psychology to behavior, and sets the goals of behaviorism as prediction and control of behavior. However, in practice Watson's treatment of behavior is quite atomistic. Watson divides behavior into four classes; explicit learned behavior such as riding a bicycle, implicit learned behavior such as a rumbling stomach when smelling someone else's dinner cooking, explicit unlearned behavior such as pulling your hand away when it is hurt, and implicit unlearned behavior such as sweating when it is hot. For the purposes of this class, we'll focus upon Watson's theoretical framework for the prediction and control of learned behavior. Watson hypothesizes that explicit, complex learned behaviors--such as chess playing or language—can be understood as a series of simpler learned and unlearned behaviors performed in a sequence. These sequences get cultivated in the organism by imitation and classical conditioning. Thus, the environment, unlearned behaviors, and conditioning history combine to explain complex behaviors as the result of the combination (through associative learning) of simple learned and unlearned behaviors. For instance, implicit learned behaviors (like a fear response) develop from simple conditioning and appropriate environmental ques. As Watson tells readers of his text, *Behavior: An Introduction to Comparative Psychology*[42] (1914):

> It is useless to ask young children to imitate acts as wholes where the elementary coördinates [these are the basic habit units] are lacking or are ill-formed. There must be complete mastery of simple habits,--a readiness to respond to a difficult and complex environmental setting in a variety of ways—the ability to change responses ever so slightly to meet the slightest change in a heretofore well-known object. In order to do this our stock in trade of acts must be much more numerous than the objects to which we respond. … Apparently new coördinations are not established by imitation either in man or in animal. What is new is the combination or method of grouping. Where imitation appears there are found always groups of flexible responses to every object worked with. (p.49)

John Broadus Watson (1878-1958)
From: Furman.edu

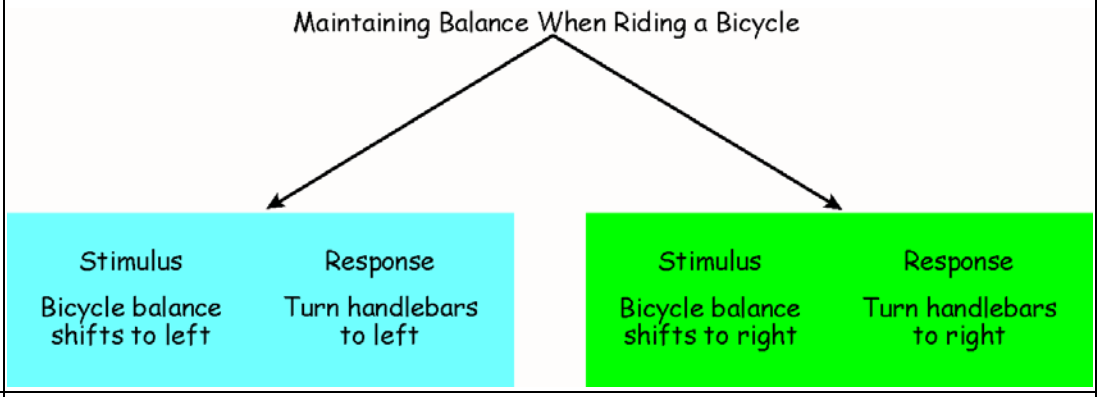


Diagram depicting how a more complex overt behavior, maintaining balance when riding a bicycle, might be analyzed into simpler overt behaviors.

If this general approach seems familiar, it should. Watson, in effect, proposes an atomistism for behavior; a set of elemental behaviors—unlearned behaviors—from which all learned behaviors are generated and combined through a process of association based upon contiguity and frequency.

4.9 Neo-Behaviorism

Historians classify the behaviorists that follow Watson as neo-behaviorists. One can find the general motivation behind the neo-behaviorist research in the above quote from Watson. On the one hand, Watson seeks to provide a highly mechanistic/deterministic account of the generation of behavior. On the other hand,

Watson wants to use his account to explain complex, flexible behavior, including behavior in novel circumstances. Neo-behaviorists seek to expand the basic behaviorist framework to allow for increased flexibility and complexity. For instance, suppose that a researcher trains a rat to associate food with a blue box. Sometimes when presented with the box, the rat does not try to eat. Why doesn't the rat respond all the time? Will the rat respond to the box when the researcher changes the color or the shape slightly? How much change to the box can occur before the conditioned response is no longer triggered?

Neo-behaviorists continue to view overt behavior as the central phenomena for psychology. They also hold that the prediction and control of behavior is the central goal of psychology. Learning remains central to psychology. Finally, neo-behaviorists share Watson's conviction that animal models of learning and perception are easily and robustly transferable to humans.

Neo-behaviorists commonalities go beyond Watson as well. For example, neo-behaviorists share Watson's general commitment to grounding psychology in observation. However, unlike Watson, neo-behaviorists seek to tie all theoretical terms to experimental operations for the measurement and/or application of those terms. Researchers call this view about the treatment of unobservable theoretical terms operationalism. Operationalists refer to the specification of a set of operations for a theoretical term as an operational definition. Watson and the neo-behaviorists see animal experimentation as essential to psychological research because of the continuity of animal learning and perception with human learning and perception. However, neo-behaviorists see additional value in animal experimentation because it allows for more rigorous controlled experiments.

Lastly, neo-behaviorists differ from Watson and one another in the manner in which they seek to extend behaviorism. Radical behaviorists like B.F. Skinner hold that the prediction and control of behavior must eschew internal, unobservable mental and physiological events. Methodological behaviorists allow for appeal to internal states so long as those terms are tied to observation.

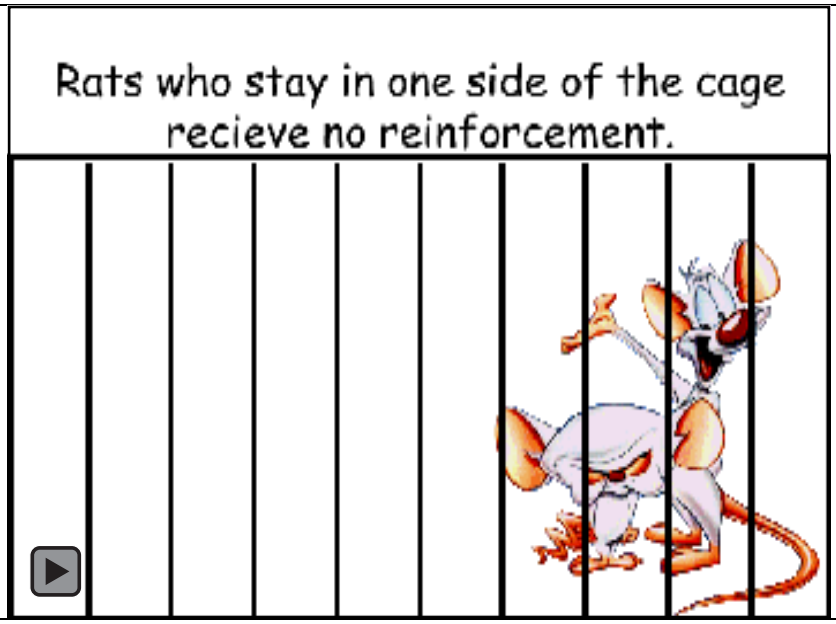
4.9a Neo-Behaviorism: Radical Behaviorism

Historians classify Burrhus Frederic "Fred" Skinner[43] (1904-1990) as a neo-behaviorist, though Skinner is very strongly associated with behaviorism in the popular mind. Skinner's association with behaviorism is due in part to his theoretical approach. Like Watson, Skinner insists that theorists focus on predicting and controlling behavior. Likewise, Skinner also supposes that conscious mental states have no part to play in psychological theorizing, insisting instead that environment and conditioning history provide sole basis for the psychological understanding of human conduct.

However, Skinner's theoretical perspective diverges from Watson on several key points. Skinner adopts an approach called "functional analysis" that he traces to Ernst Mach. Functional analysis has a quite different meaning for Skinner than for the theorists we will discuss later. For Skinner functional analysis characterizes dependencies--not meticulously detailed step-wise causal relationships--between observable phenomena, i.e., between conditioning histories and environments. Specifically, Skinner understands functional analysis as a method for establishing relationships between stimuli and responses through the application of operant conditioning. Skinner's analysis is often called a "three-term contingency" analysis in that it characterizes the environmental features that act as a trigger for the behavior (sometimes called the discriminative stimulus),

the response (the specific rigorously characterized behavior), and reinforcement (the consequence of the behavior that positively or negatively influences the probability of the behavior in the eliciting conditions). While Watson rejects Thorndike's law of effect as too subjective, Skinner creates a systematic, objective formulation of the learning paradigm--operant conditioning. Unlike Watson, Skinner does not understand behavior as something exclusively elicited by environmental stimuli. Rather, Skinner views the majority of behavior as active operations on the environment. Likewise, Skinner sees patterns of behavior emerging as a result of those behaviors being selected by contingent environmental reinforcement.

B. F. Skinner (1904-1990)
From: nndb.com



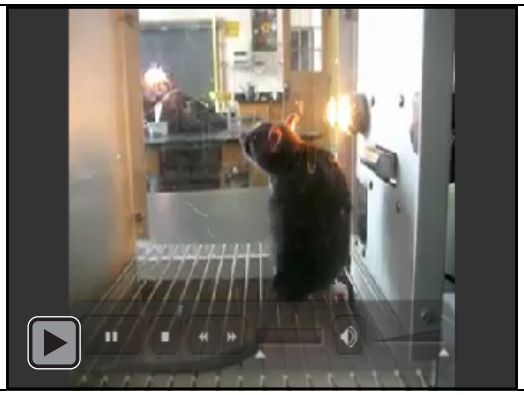
Animation depicting operant conditioning with a negative reinforcer. To play movie, click on the picture.

Skinner writes his famous book, *The Behavior of Organisms*[44] (1938), while at his first job at the University of Minnesota. In that book Skinner reformulates Thorndike's law of effect so that it describes environmental selection of behavior through the reinforcement resulting from the behavior. Skinner makes no reference to subjective states like desires, drives, etc. in characterizing reinforcement.

In operant conditioning a creature's behavior--often random behavior--is either positively or negatively reinforced (rewarded or punished). The probability of the behavior occurring again in the relevant eliciting conditions increases or decreases in proportion to the number of behavior/reinforcement pairings. For example, as depicted in the animation above, a cage might be divided into two sections. Whenever a rat wanders into one section, experimenters administer an electric shock. Over time, the probability that the rat will, for instance, leave that section of the cage whenever placed there increases.

Operant conditioning together with classical conditioning broaden the range of learned organism-environment interactions. Classical conditioning provides a mechanism whereby stimuli from the environment can elicit a response, i.e., stimuli cause organism responses. Operant conditioning provides a mechanism whereby behavior becomes part of the organism's repertoire as a function of its consequences, i.e., consequences elicit behaviors.

Video of Skinner discussing operant conditioning. From: Youtube



Video of rat in a skinner box. From: Youtube

Thus, one sees in be rise of behaviorism a meeting of experimental method, categorization, and theory building that comes to dominate universities, particularly in the United States. Between the period of 1914 and 1950 behaviorists continue to elaborate and expand their research. Their results on conditioning-based learning and memory exhibit the rigor and experimental sophistication that allows them to stand as solid results of scientific practice.

Indeed, behaviorists seek to apply their approach to all aspects of mentality. In 1957 Skinner publishes a book, *Verbal Behavior*,[45] based upon lectures originally given at the University of Minnesota, and further refined at Columbia and as the lectures William James. Skinner supposes that verbal behavior has no significant and essential differences from other sorts of behavior. For instance, he denies that verbal behavior results from an innate capacity. Skinner proposes to treat verbal behavior using his functional analysis method. Skinner's book marks the peak of behaviorism as a psychological school. Its meteoric rise and intersubjectively verifiable results have given psychology the status as a "special science," for many philosophers.

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