Introductory Lectures: The Nature and History of Cognitive Science

Chapter 4: Philosophy's Convergence Towards Cognitive Science

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The 20th Century and the Semantic Twist

4.1 Introduction

Recall that ontological frameworks provide a general framework within which theorists specify domains of inquiry and construct theories to predict, manipulate, and explain phenomena within the domain. Once researchers have articulated an ontological framework with sufficient clarity, they begin to formulate and test theories. Chapter two ends with the suggestion that oppositional substance dualists face two major challenges in transitioning from the articulation of their ontological framework to formulating and testing theories purporting to predict, manipulate, and explain mental phenomena. On the one hand, oppositional substance dualists have problems formulating theories providing predictions, manipulations, and explanations of the continual, seamless interaction between the mental and the physical. On the other hand, the very nature of a mental substance--substance defined so as to share no properties with physical substance--gives rise to additional challenges. Specifically, how does one utilize the categories, types, and interrelationships of this mental substance to formulate theoretical mechanisms through which one can predict, manipulate, and explain the dynamic changes in mental phenomena?

Chapter four looks at the question, "do monistic physicalists fare any better?" Recall, physicalist theories—theories formulated within monistic physicalism--must meet the challenge of formulating theories specifying physical mechanisms that plausibly predict, manipulate, and explain how physical substance, physical properties, and/or physical processes give rise to mental properties and processes. Chapter three traces the development of scientific psychology from Wundt's voluntarism through psychological behaviorism. The chapter emphasizes how psychology develops an experimental tradition in large through adaptation of approaches from astronomy, navigation, and physiology. Experimental traditions include a repertoire of operationalization techniques and devices as well as a repertoire of experimental designs, tools for data analysis, and an appreciation of experimental control. For instance, the chronoscope and chronometer allow precise measurement of reaction times and control hammer provides a mechanism for precise calibration of the chronoscope and chronometer to insure reliable inter-subjective measurements. The introduction and development of introspection and its associated experimental design from physiology—both through its successful adaptations and its failings provide psychologists with important lessons in experimental design. Of particular importance, psychologists realize the potential for experimenter and subject bias and the need for calibration techniques for operationalizations. Together this convergence of categorizations together with tractable and reliable operationalizations allowing theorists to define a domain—learning and memory—as well as to adopt and adapt experimental techniques that allow theorists to gain traction in the tasks of predicting, manipulating, and explaining mental phenomena in one aspect of one mental domain—learning and memory. Finally, the introduction of statistical techniques by Gustav Fechner[1] and especially their use by

Hermann Ebbinghaus[2] helps theorists to analyze data with significant intersubjective variability and better measure the fit of theoretic models with data.[1-10] Ultimately, much more powerful statistical tools enter the experimental tradition from the works of Ronald Fisher[11-15] (e.x. null hypothesis testing,[16] z-distribution,[17] and frequentist inferential[18] interpretations and methods generally), William Gossett (aka student)[19-21] (e.x. t-testing[22]), Jerzy Neyman[23-33] (e.x. randomized experimental design, stratified sampling of significant subpopulations,[26] The Neyman-Pearson lemma for hypothesis testing,[25] and the confidence interval[34]), Karl Pearson[35-39] (e.x. Chi-squared distribution[40]), and Egon Pearson[25, 29, 30, 33, 41-43] (e.x. The Neyman-Pearson lemma for hypothesis testing[25] and Pearson's chi-squared test[43]). This confluence of descriptive and experimental elements gives rise to behaviorism in psychology.

This chapter and lecture outline what I call the "semantic twist." The semantic twist marks a dramatic shift in philosophic methodology and conceptualization that fundamentally alters the conception of the mind-body problem as well as the methodology within the philosophy of mind. It also marks a sharp, but largely unrecognized division between philosophic approaches to the philosophy of mind. This chapter portrays the overt confluence from which the semantic twist emerges. It also outlines the covert division with philosophy of mind resulting from the semantic twist. Thus, the narrative begins with an historical exposition to facilitate an appreciation of the forces that ultimately culminate in the semantic twist. As a result, the exposition begins with the rise of logical empiricism as a philosophy of science, tracing the inspiration for the view to the dramatic developments in physics as well as in logic and mathematics at the turn of the 20th century.

With the outlines of logical empiricism in place the chapter and lecture traces the influence of those developments upon the philosophy of mind. Specifically, the chapter focuses on the confluence of psychological behaviorism, philosophy of language, and philosophy of science in the formulating and advocating the philosophical doctrine known variously as logical behaviorism, philosophical behaviorism and analytical behaviorism. Analytical behaviorism represents a shift in the philosophic understanding of the mind-body problem as well as a corresponding shift in philosophic methodology.

Philosophers from Descartes until the semantic twist focus primarily upon two projects. First, philosophers emphasize developing and advocating various versions of two ontological frameworks for theorizing about the mind—oppositional substance dualism and monistic physicalism. Second, philosophers debate the relative potential of these two general types of ontological frameworks to give rise to adequate theoretical explanations of mental phenomena. After the semantic twist, most philosophers seek to understand how monistic physicalism can accommodate mental phenomena. Specifically, philosophers seek to advocate monistic physicalism by subsuming mental phenomena within the physical—not through positing physicalistic theories providing mechanistic explanations of mental phenomena—but through semantic reduction. In other words, philosophers adopt the project of demonstrating how ordinary, pre-theoretic talk about the mind expresses nothing over and above what one can express using physicalistic language. As a result, philosophers adopt the methodology of demonstrating the viability of monistic physicalism by showing that the meanings of ordinary language mental terms can be specified completely using only physicalistic terms. Since philosophers do not formulate physicalistic theories of mental phenomena, they rely primarily upon scientific results to provide the data upon which they base their reduction. Moreover, the new philosophic project does not directly involve transitioning from the articulation of an ontological framework to formulating and testing theories purporting to predict, manipulate, and explain mental phenomena. Hence, the new philosophic project is best understood as attempting to reduce one ontological framework—oppositional substance

dualism—to another ontological framework—monistic physicalism. The doctrine of logical behaviorism represents the first in a series of such attempts at semantic reduction. As future lectures indicate, the project of semantic reduction—or rejection thereof--occupies most of the philosophy of mind for the 20th century.

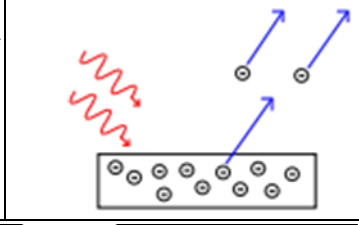
Ultimately, the doctrine of logical behaviorism succumbs to two central lines of criticism. On the one hand, critics like Putnam deny the viability of attempts to identify mental states and properties with the effects of those mental states and properties. These theorists essentially adopt a direct reference theory of reference for mental terms in that they claim that the reference of mental terms such as belief or pain consists of the mental state itself regardless of its typical causes and effects. Often such theorists adopt a phenomenological essentialism regarding many of these terms. Specifically, such theorists look to conscious mental states—especially qualitative conscious experiences like pain--asserting that the conscious phenomenological experience provides a direct referential link to the state. Pains, on this line, are painful and this feature alone defines these states. For example, Thomas Nagel denies that science can formulate adequate theories of consciousness mental states because such theories cannot capture "what it is like" to have such mental states.[44-49] Putnam adopts this line of argument in "Brains and Behavior"[50] when presents a series of counterfactual thought experiments in which, he suggests, one can intuitively judge that the mental states in counterfactual examples count as pains despite being dissociated from their typical causes, their typical effects, or both.[50-54] On the other hand, critics such as Chisholm adopt a descriptivist theory of reference for such mental state terms. Chisholm argues that attempts to define mental state terms like belief in terms of their typical overt physical causes and effects fails precisely because such states have no typical causes and effects absent their relationships to other mental state terms. Thus, argues Chisholm, one cannot define mental state terms in isolation. Mental state terms constitute a closed holistic lexicon or conceptual scheme.[55-57] Thus, three features of mental states drive the rejection of logical behaviorism. First, the meanings of many mental terms seem essentially or importantly tied to qualitative subjective experience as opposed to overt behaviors. Thus, many people find the awfulness of pain essential to being in pain, but few find verbal demonstrations essential to being in pain. Second, many mental properties such as ennui (Listlessness or dissatisfaction associated with inoccupation or an absence of excitement.) seem to lack any definitive set of behavioral effects without seeming meaningless or less meaningful than other mental terms. Third, mental terms do not operate, for the most part, in isolation from one another. Rather, the interactions of mental states with other mental states mediate the connections between the typical behavioral causes and typical behavioral effects--even for those mental terms that appear to have more or less criterial overt behavioral causes and effects.

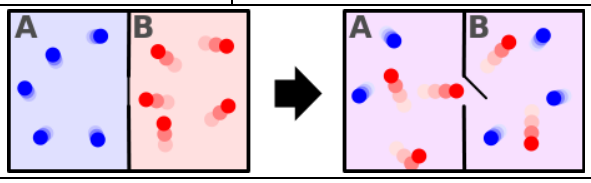
4.2 The Scientific Explosion of the Early 20th Century

The productive confluence of experiment and categorization at the beginning of the 20th century is not unique to scientific psychology. The end of the 19th century and the beginning of the 20th century witnesses the rise of a newly robust science in many fields. Physics in particular witnesses a number of dramatic advances that tear apart the older orthodoxy. Within a period of approximately sixteen years the groundwork for atomic physics, quantum mechanics, and space-time physics falls into place. In 1901 Max Plank[58] publishes "On the Law of Distribution of Energy in the Normal Spectrum"[59] (Zur Theorie des Gesetzes der Energieverteilung im Normalspektrum) in which he introduces Plank's Law to calculate the electromagnetic radiation emitted by a black body[60] in thermal equilibrium at a given temperature. Plank's paper introduces the idea of quantum theory to physics. Albert Einstein's[61] miracle year in 1905 sees him publish three famous and foundational

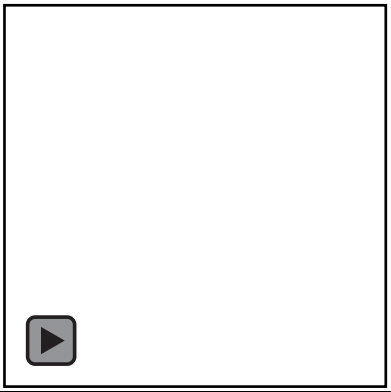
papers. "On a Heuristic Viewpoint Concerning the Production and Transformation of Light,"[62] ("Über einen die Erzeugung und Verwandlung des Lichtes betreffenden heuristischen Gesichtspunkt") adapts Plank's work on black body radiation to explain the photoelectric effect.[63] "Investigations on the Theory of Brownian Movement,"[64] ("Über die von der molekularkinetischen Theorie der Wärme geforderte Bewegung von in ruhenden Flüssigkeiten suspendierten Teilchen") describes the motion of pollen molecules in a liquid using statistical mechanics.[65] Importantly, Einstein demonstrates the existence of atoms (the reality of which were debated) by showing how one can count them using an ordinary microscope. These two papers taken together lay the groundwork for the coming atomic physics and for quantum mechanics. Finally, "On the Electrodynamics of Moving Bodies," ("Zur Elektrodynamik bewegter Körper")[66] introduces what we now know

(Right) The photoelectric effect describes the emission of electrons by various types of metals, solids, gases, and liquids when exposed to short wavelength, high frequency electromagnetic radiation (e.x. UV light)
From: Wikipedia

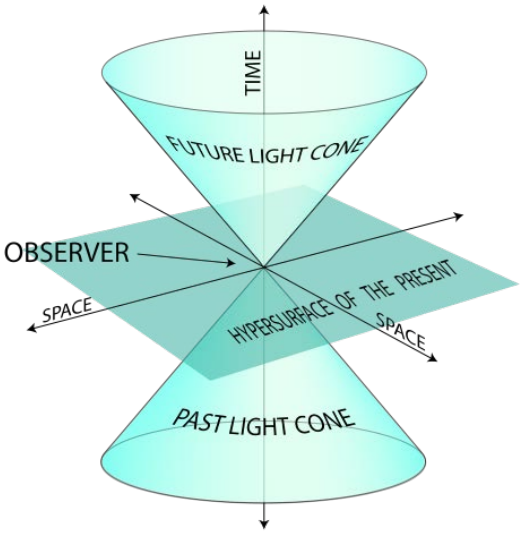




(Above) Diagram illustrating the differential distribution of energy in a medium. Statistical mechanics utilizes probability theory to predict such differences in distribution. For instance, according to statistical mechanics there is a non-zero probability that all of the oxygen molecules in the classroom will shift to the upper left corner of the room. From: Wikipedia



(Right) Animation illustrating the movement of a large molecule as it collides with smaller molecules of varying direction and velocity. Brownian motion consists of the movement of a particle in a gas or liquid caused by the energy transferred from collisions with the molecules of atoms of that liquid. Adapted from: Wikipedia



(Above) Diagram depicting the observer-relative inertial reference frame used by Einstein in special relativity to explain such phenomena as time-dilation, length expansion, and the composition of velocities—each of which is refers to the differences between observer measurements across different inertial reference frames. For instance, time dilation refers to the variance between observer's measurements of the time lapse between events. From: Wikipedia

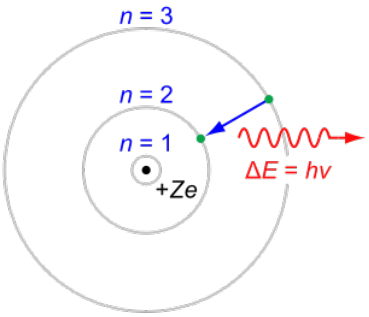
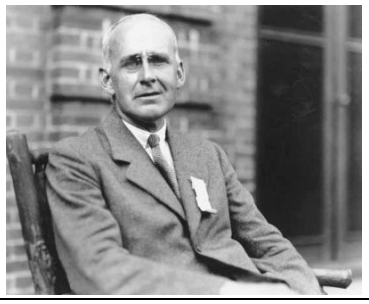
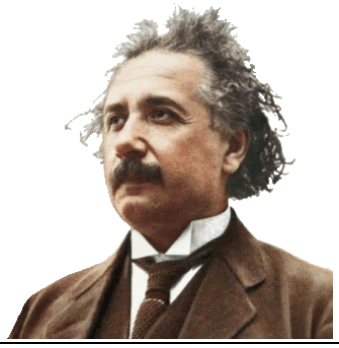
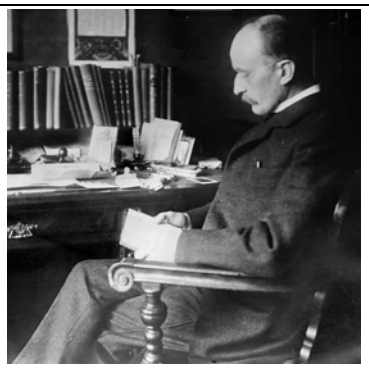
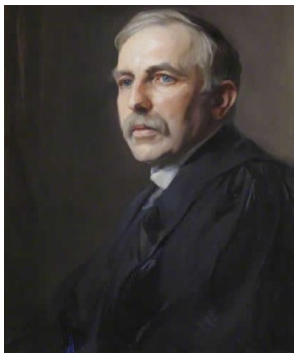


Diagram depicting the Bohr model of the atom in which electrons rotate in fixed circular orbits around a nucleus. From: Wikipedia

as the theory of special relativity. More specifically, Einstein reconciles Maxwell's work in electromagnetism with classical mechanics by introducing the principle of relativity and the principle of the invariance of the speed light. Einstein's former mathematics professor, Hermann Minkowski,[67] publishes "Space and Time"[68] ("Raum und Zeit") in 1908 in which Minkowski provides a space-time geometry to subserve special relativity. Ernest Rutherford[69] publishes "The Scattering of α and β Particles by Matter and the Structure of the Atom"[70] in 1911. In 1913 Neils Bohr publishes "On the Constitution of Atoms and Molecules" parts 1,[71] 2,[72] and 3[73] in

which he modifies Rutherford's account within the framework of quantum mechanics. The resulting theory of atomic structure goes under several names; The Solar System Model, The Bohr-Rutherford Model, and The Bohr Model. In 1916 Einstein publishes, "The Foundation of the General Theory of Relativity,"[74] ("Die Grundlage der allgemeinen Relativitätstheorie") outlining the theory of general relativity[75] and completing the reconceptualization of gravitational physics. In 1919 Arthur Eddington[76] travels to the African island of Principe provides photographic evidence (specifically, light bending around the sun) during the May 29,

			
Percy Williams Bridgeman (1882-1961) Adapted from: nndb.com	Niels Bohr (1885-1962) Adapted from: Wikipedia	Arthur Stanley Eddington (1882–1944) Adapted from: optcorp.com	Albert Einstein Adapted from: Biography.com
			
James Clerk Maxwell (1777–1851) From: BBC	Herman Minkowski (1864-1909) Adapted from: The Space-Time Society	Max Plank(1858-1947) Adapted from: Feira De Cencias	Ernest Rutherford (1831-1937) Adapted from: BBC

1919 solar eclipse. Finally, American physicist Percy Williams Bridgman[77] forwards the doctrine of operationalism[78, 79] or operationism in his 1927 *The Logic of Modern Physics*.[80] The book and its author intend the doctrine for physics primarily, though it inspires a number of psychologists including the neo-behaviorist Edward Chace Tolman.[81] Bridgeman, inspired by general relativity and his own prowess as an experimental physicist, identifies theoretical concepts with the (single) unique procedure for their measurement. The doctrine remains somewhat ambiguous regarding its status as a theory of meaning, though it naturally lends itself to such an interpretation. Bridgeman interacts with two prominent early logical positivists, Otto Neurath[82, 83] and Moritz Schlick[84] regarding his theory.

4.3 The Logical and Mathematical Explosion of the Early 20th Century

The strides in logic and mathematics at the turn of the 19th century rival those in physics and the sciences. Gottlob Frege[85] publishes *Begriffsschrift*[86] in 1879. In *Begriffsschrift* Frege adopts Georg Cantor's[87-89] naïve set theory and presents the first rigorous axiomatized first- and second-order predicate logic including functions. Frege's takes as his ultimate goal the derivation of mathematics from logic, thereby reducing the former to the latter--a project called logicism.[90] Logicism represents one approach to the overarching project of providing an axiomatic treatment of all of mathematics on the model of Euclid's *Elements*. More precisely, the project

then underway seeks to axiomatize basic arithmetic on the natural numbers.[91] In 1899 David Hilbert[92] publishes Foundations of Geometry[93] (Grundlagen der Geometrie) in which he offers an axiomatization of the geometry of Euclidean solids (3d Euclidean geometry). An American graduate student, Robert Lee Moore,[94] develops and publishes an alternative axiomatization in 1907.[95] Bertrand Russell[96] and Albert North Whitehead[97] publish *Principia Mathematica*[98] in three volumes in 1910,[99] 1912,[100] and 1913.[101] Principia attempts to axiomatize mathematics (arithmetic on the natural numbers) in the logicist tradition. The development of second-order logic and the

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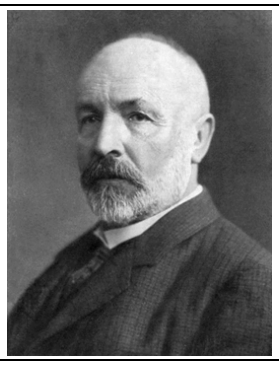
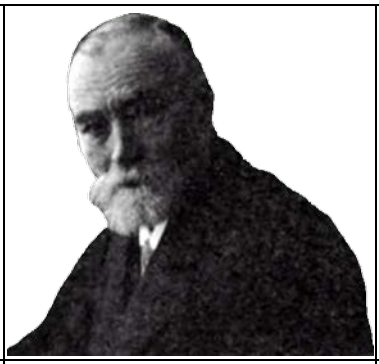
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td>Georg Cantor (1845-1918)
Adapted from: Wikipedia</td><td>Gottlob Frege (1848-1925)
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<tr><td>Bertrand Russell (1872-1970)
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progress towards axiomatizing mathematics creates a sense that logic and mathematics is on the verge of completion. This sense continues until Kurt Gödel[102] publishes "On Formally Undecidable Propositions of 'Principia Mathematica' and Related Systems"[103] ("Über formal unentscheidbare Sätze der 'Principia Mathematica' und Verwandter Systeme") in 1931 in which he demonstrates that any axiomatic inference system capable of expressing the truths of basic arithmetic on the natural numbers must be either inconsistent or incomplete. Hilbert, an axiomatization enthusiast, famously suggests that mathematicians can save much of the benefits of axiomatization if one can demonstrate a general technique to identify unsolvable problems (the elements rendering any axiomatization incomplete). However, "An Unsolvable Problem of Elementary Number Theory" by Alonzo Church[104, 105] and "On Computable Numbers, with an Application to the Entscheidungsproblem" by Alan Turing[106-108] demonstrate the impossibility of this last hope for the axiomatization project.

4.4 The Rise Logical Empiricism

Some philosophers conceive of the dramatic advances in science, mathematics, and logic as a lens through which one can see the outlines of a coherent picture of knowledge, science, and philosophy. Thus, in Vienna

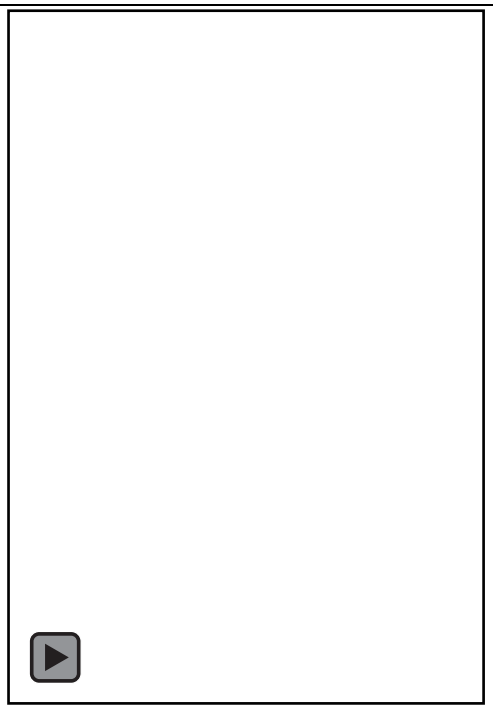
and in Berlin two groups of philosophers and scientists begin to extrapolate from the developments in science, math, and logic to frame a philosophy of science. These philosophers and scientists eventually articulate and advocate the philosophical doctrine of logical empiricism (also known as logical positivism). The individual members of this group of philosophers do not march in ideological lockstep. However, I will portray them homogeneously for the purposes of exposition. The picture painted here does not distort the views of individuals too dramatically.

The logical empiricists hold four key doctrines. First, they hold what is now called the verification criteria of meaning. Second, they hold that scientific laws are universal, exceptionless statements. Third, they adhere to the doctrine of the unity of science, i.e., they held that the structure of science consisted in a nested hierarchy of axiom systems in which the higher, less fundamental sciences (the special sciences) consisted of laws that one could reduce to one or more lower sciences by ideological reduction of the higher science terms to those of the lower science. Finally, the logical empiricists hold that the role of philosophy of science is to rationally reconstruct the sciences so as to reveal their logical structure, empirical foundations, and epistemic justification. I will outline each doctrine, its sources, and its implications within logical empiricism.

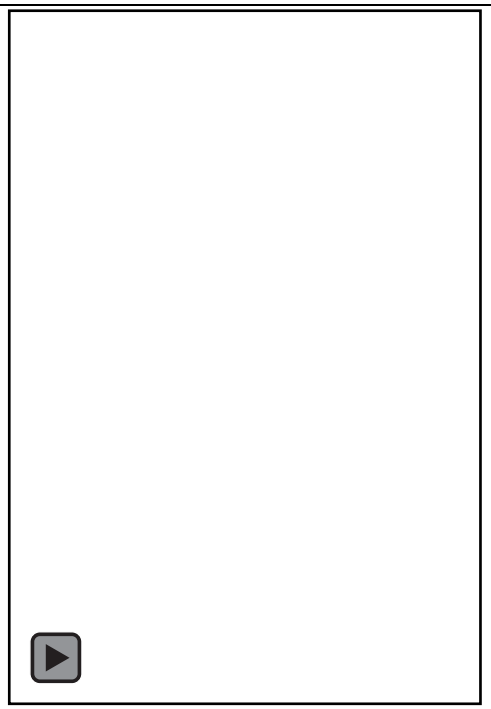
The logical empiricists from Vienna and Berlin include both philosophers and scientists. They view the explosion of scientific progress from the beginnings of the scientific revolution, and particularly the explosion at the beginning of the 20th century, as deriving primarily from tying theories and theoretical terms to rigorous empirical measurement and experimentation. Many of the logical empiricists view this practice of operationalism in the sciences in stark contrast from the prevailing philosophy of German idealism. German idealism seeks to create philosophical systems through the process of dialectic and apriori speculation. The positivists view German idealism as stagnant and vacuous. Thus, the logical empiricists identify progressive, productive theorizing with the method of operationalization employed by the sciences, and come to adopt an interpretation of operationalization as their doctrine of meaning. Indeed, an integral part of the logical empiricist reductionist program in science as well as their rejection of metaphysical speculation lies in their doctrine regarding the meaning of theoretic terms. The earliest version of the positivist doctrine of meaning usually goes under the name of the verifiability theory of meaning,[109, 110] the verificationist theory of meaning, or simply verificationism. This doctrine holds that the meaning of a proposition or theoretic term consists solely in the method of its verification. This doctrine along with the moniker of positivism traces back to Auguste Comte[111] (1798-1857), though positivists like Schlick[112-114] and Neurath[115, 116] also have extensive familiarity with operationalist the writings of Bridgeman.[80] The verificationist doctrine strikes out against vacuous metaphysical speculation in that verificationism implies that no statements have meaning unless one can cash-out their meaning in terms of their conditions of verification. The early positivist writings often invoke this principle to critique philosophic problems as pseudo-problems. The verificationist theory of meaning also fits well with the notion of an interpretation function providing semantics for a formal language. Such interpretation functions act to pick out the class of objects in the domain that satisfy the predicate in the formal language.

The overall picture many logical empiricists embrace, at least early on, portrays science as a hierarchical set of axiomatic systems. Specifically, as a set of universal, exceptionless laws together with operational or bridge laws that serve to tie theoretic terms to the particular domain (see illustrative diagrams below) and/or to the theoretical terms of lower-level theories. This structure comes from the sciences themselves as well as from

the logical and mathematical work by Hilbert, Frege, Russell, and Whitehead. Indeed, as noted above the work of these philosophers and mathematicians creates a great sense of optimism that mathematicians and logicians will find and axiomatization for all of logic and mathematics. In this way, Euclid's influence reaches its full bloom—his *Elements* provides the paradigmatic structure for all of logic and mathematics. The logical empiricists make the final step in supposing that even the sciences should find their best expression as an axiom system in which the axioms are physical laws. Thus, the logical empiricists hold that the logical structure of each science is an axiom system. Moreover, these individual sciences cum axiom systems are unified; higher, less basic sciences like psychology or sociology reduce to lower level sciences and finally to the laws of physics. That is, the terms of higher level sciences reduce to the terms of successively lower-level theories. Ultimately, the theoretical terms of physics itself find their meaning through bridge laws that link the theoretical terms of physics to the experimental operations used to detect and/or measure the presence or amount of the referents of those terms. As a result, experimental operations thereby define the referents of the theoretical terms of physics in an ontologically neutral observation language. This result, then transfers throughout the entire hierarchy so that all theoretic terms of all sciences ultimately trace their meanings, either directly or indirectly, to conditions expressible in an ontologically neutral observation language.Logical empiricists refer to their hierarchy of axiom systems conception of the nature of scientific theories and their interrelationships as the unity of science.[117] The logical empiricists, especially those in Vienna, are deeply influenced by Ernst Mach,[118] an Austrian physicist and philosopher, as well as by the works of Max Planck,[58]



Animated diagram depicting the sort of inter-theoretic structure proposed by the logical empiricists. Higher, less basic sciences like sociology eventually reduce to successively lower sciences until all sciences ultimately find reduction into physics, which itself them cashes out the meanings of its terms in an ontologically neutral observation language. Click on picture to view animation.



Animated diagram depicting the epistemic dependence of science. Much like Descartes' foundationalism, each science traces its epistemic merit to the lower sciences to which it is reduced. Ultimately, all of the structure rests upon the certainty of immediate experience and the intuitive steps of logical proofs. Click on picture to view animation.

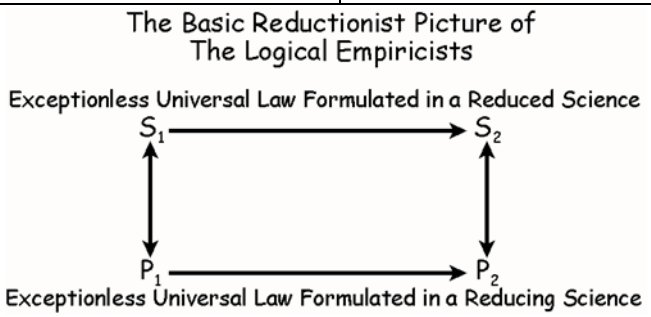


Diagram depicting the general picture of inter-theoretic reduction imagined by the logical empiricists. Terms in the theory at the higher level are reduced (ideally) analytically to terms in the reducing theory. Exceptionless universal laws in the higher reduced theory thereby become subsumed by the laws in the lower reducing theory.

the German theoretical physicist who introduces the idea of quantum theory into physics. Mach also develops a philosophy of science and makes contributions to physiology and psychology.

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<tr><td colspan="2">Mach bands: Mach bands appear as if the color bands curve inward or that each band is a gradient. However, each band is a solid color. Each band reflects different amounts of light with the darker bands reflecting less and lighter bands reflecting more. Caption and image from: Retinal Illusions</td><td>Ernst Mach (1838-1916)
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<tr><td>Rudolph Carnap (1891-1970)
Adapted from: Wikipedia</td><td>Herbert Feigl (1902-1988)
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Indeed, the Vienna philosophers originally call their group Verein Ernst Mach (the Ernst Mach Society) in 1928, but they ultimately adopt the moniker Vienna Circle.[119, 120] The group publishes their manifesto, *Wissenschaftliche Weltauffassung. Der Wiener Kreis* (*The Scientific Conception of the World. The Vienna Circle*) in 1929.[121] A kindred school with common members exists in Berlin, known both as and the Berlin Circle.[119, 122, 123] This group includes such luminaries as Paul Oppenheim[124] and Hans Reichenbach.[123, 125] Both groups are strongly influenced by their common belief that human knowledge and especially science form part of a long evolutionary process creating a hierarchical set of sciences all of which ultimately reduce to physics. For instance, Rudolph Carnap's[126] classic work, *Der Logische Aufbau der Welt* (*The Logical Structure of the World Pseudoproblems in Philosophy*),[127] provides readers with the most sophisticated and systematic attempt to reconstruct science as a series of hierarchical axiom systems that reduce to one another and ultimately to

observations framed in an ontologically neutral observation language. Similarly, Otto Neurath[82, 83] edits multiple volumes of *Foundations of the Unity of Sciences*[128] and *International Encyclopedia of Unified Science*.[129] These works set as their goal the organization and presentation of science as a unified body of knowledge. The logical empiricists do not suppose that the structure of a hierarchy of axiom systems actually represents the practice of scientists as they develop their theories. Rather, they suppose that this structure represents a rational reconstruction of the sciences that makes explicit and rigorous the logical structure and epistemic dependence of each science and the sciences as a whole.

The logical empiricists share a common disdain for metaphysical speculation and a desire to further human understanding through rigorous epistemological doctrines addressing methodological issues and minimizing ontological issues. In many ways they turn the focus of philosophy of mind towards philosophy of science and issues of scientific methodology. Likewise, they follow the methodological lead of behaviorists in reexamining the proper understanding of mental properties and processes. However, their focus on theoretic terms and meaning gives rise to the semantic twist in the philosophy of science.

4.5 Logical Behaviorism

In reaction to the developments in science, mathematics, logic, and especially psychology many philosophers of mind alter their focus from formulating and defending various ontological frameworks to understanding the relationship between scientific theories of the mind and ordinary conceptions of the mind. It is during the early 20th century that the emphasis in philosophy of mind—though still focused almost exclusively upon ontological issues—turns towards the developments in science for inspiration. Within philosophy itself a number of scientifically inspired general strategies emerge in the 20th century for trying to flesh-out a monistic physicalist framework. This movement towards closer integration between philosophy and science also marks a shift in methodological emphasis.

During this period philosophers begin increasingly to think of theories not simply in terms of theoretical posits, but in terms of the relationships between categories of scientific theories and the terms of ordinary language and of perceptual experiences. As a result, during this time philosophical theorists become increasingly interested in semantic reduction. For instance, whereas earlier philosophers focus upon ontological frameworks, most 20th century strategies for offering monistic physicalist explanations involve directly identifying mental terms with physical terms. The underlying inference driving such identifications lies in the notion that by directly equating mental and physical terms one indirectly identifies the referents of those terms--mental phenomena and physical phenomena. In other words, 20th century philosophers locate the explanatory problem for the monistic physicalist in an inability to recognize or gather sufficient evidence for the co-referential nature of mental and physical terms.

Two general approaches to pursuing this general strategy emerge within philosophy during the first half of the 20th century. On the one hand, theorists try to identify the meaning of mental terms with sets of overt, observable, physical behaviors definitive of those terms. On the other hand, theorists seek to identify the reference of mental property, process, and entity terms with the reference of physical property, process, and entity terms through something akin to analytical reduction. The next chapter turns to this second strategy, often called type-type reductionism. The remainder of this chapter focuses upon the first strategy.

Theorists call the first systematic attempt to flush-out the first strategy for asserting that mental properties are just physical properties logical behaviorism. Logical behaviorism (also called analytical behaviorism and philosophical behaviorism) represents the first attempt to systematically address the difficulties for physicalism within the scientific framework of the time. It is important to note that philosophers of starkly different methodological orientations follow this line of theoretical speculation. Indeed, historians identify Gilbert Ryle[130, 131] and Carl Hempel[132, 133] as the two most prominent figures in logical and/or analytic behaviorism. Ryle is a philosopher of language, particularly of ordinary language. Ryle holds that researchers can dissolve many philosophical problems through the correct analysis of the ordinary language terms that theorists employ the formulation of those problems. In his classic book, *The Concept of Mind,* Ryle argues extensively that mind-body oppositional dualism results from a category mistake—an incorrect use of language:[134]

> My destructive purpose is to show that a family of radical category-mistakes is the source of the double-life theory. The representation of a person as a ghost mysteriously ensconced in a machine derives from this argument. Because, as is true, a person's thinking, feeling, and purposive doing cannot be described solely in the idioms of physics, chemistry, and physiology, therefore they must be described in counterpart idioms. As the human body is a complex organized unit, so the human mind must be another complex organized unit, though one made of a different sort of stuff and with a different sort of structure. (p.18)

In contrast, Carl Hempel is a philosopher of science and a logical positivist/empiricist. Logical behaviorists like Hempel who embrace logical empiricism seek to build upon real progress by experimentalists like Pavlov, Watson, and Skinner as well as by scientists across a wide swath of the sciences. Logical positivists and empiricists believe that terms get their meaning through their conditions for verification and that science provides one with the most rigorous and explicit methodological definitions of terms through operationalizations—the procedures that scientists use to detect and measure theoretical entities, properties, etc.. Logical positivists and empiricists also tend to hold a doctrine called the unity of the sciences. The unity of the sciences asserts that one can ultimately reduce all sciences to the most basic science, physics. That is, one can reduce the terms of sciences like elemental chemistry to the terms of atomic physics. Moreover, logical empiricists see a further benefit from such semantic reductions—the terminological reduction demonstrates that the laws in the reduced science follow from or merely represent special instances of more fundamental laws in the fundamental science.

Most historians cite Gilbert Ryle's book, *The Concept of Mind* (1949)[134] as the first tract in logical behaviorism and assign Hempel's "The Logical Analysis of Psychology" (1935,1949) [135] to the second position. However, Hempel published his article, though in French, over 14 years earlier than Ryle's book. Both works have historical significance because they share a common shift of emphasis that continues to shape thinking about the mind in philosophy. Both Ryle and Hempel seek to defuse the seeming difficulties in understanding how mental properties arise from or are identical to physical properties by arguing that the meanings of mental terms are exhausted by behavioral terms. In other words, establishing monistic physicalism involves escaping referential opacity. Hempel tells readers,[135]

> All psychological statements which are meaningful, that is to say, which are in principle verifiable, are translatable into statements that do not involve psychological concepts, but only the concepts

> of physics. The statements of psychology are consequently physicalistic statements. (p.18)

Similarly, Ryle asserts,[134]

> In this chapter I try to show that when we describe people as exercising qualities of mind, we are not referring to occult episodes of which their overt acts and utterances are effects; we are referring to those overt acts and utterances themselves. (p.25)

While Hempel aims primarily to address scientific and ontological issues, Ryle sees his work in a different light. Ryle tries to provide an analysis of the concepts of ordinary language. Both philosophers, however, trace the seeming difficulties associated with the equation of mental processes and properties with physical properties and processes to an improper understanding of the true meanings of mental terms. Ryle asserts that,[134]

> This book offers what may with reservations be described as theory of mind. But it does not give new information about minds. We possess already a wealth of information about minds, information which is neither derived from, nor upset by, the arguments of philosophers. The philosophical arguments which constitute this book are intended not to increase what we know about minds, but to rectify the logical geography of the knowledge which we already possess. (p.7)

Additionally, Ryle's emphasis on intelligent behavior marks a differentiation between mental properties and non-mental properties which has come to serve as an important standard in the philosophy of mind, and which later allows for the initial explanatory focus of cognitive science on cognition. Specifically, philosophers differentiate between mental properties and states that are strongly (or even definitively) phenomenal in nature, called qualia or qualitative mental states, and mental properties or states that are primarily (or even definitively) intentional, called intentional states or propositional attitudes. Examples of the former (qualia) include pains, itches, seeing red, anger etc.. Examples of the latter (intentional states) include beliefs and desires. Intentional states may have some phenomenal aspects, but intentional states are importantly, even fundamentally representational. That is, intentional states represent objects, properties, relations and/or events in the world.

Thus, one can see that logical behaviorists—both the ordinary language variety and the logical empiricist variety--as seeking to understand the meaning and hence the reference of psychological terms like belief and desire in terms of the behaviors of intelligent creatures. Nevertheless, philosophers often misrepresent logical behaviorism as a unitary movement with a strongly shared set of background theoretical commitments. Logical behaviorists do share a commitment to science, and specifically to the promise of behaviorism in psychology. They also share a desire to capture the meanings of mental terms in behavioristic terms thereby identifying the referents of mental terms with the referents of physical terms.

However, logical behaviorism marks a significant point of divergence in the philosophy of mind. On the one hand, the logical empiricists give rise to an orientation in the philosophy of mind that seeks to understand the new and rapidly advancing sciences in terms of the theoretic posits, explanatory schemas, and methodological practices of those sciences. These theorists likely now identify themselves as philosophers of psychology or cognitive science. On the other hand, Ryle and other philosophers of language devote their efforts primarily to understanding the ascription conditions of ordinary language terms describing the mind, mental properties,

and mental processes. These theorists, like Ryle himself, seek to understand the world by clarifying the ontological posits and theories implicit in ordinary language as used in everyday life. Ryle describes himself, for example, as philosophical cartographer.[136, 137] Ryle likewise begins his discussion in *The Concept of Mind* by telling his readers that, "The philosophical arguments which constitute this book are intended not to increase what we know about minds but to rectify the logical geography of the knowledge we already possess."(p.1) [134]

No matter what motivations lead logical behaviorists to advocate their doctrine, logical behaviorism faces three significant difficulties. First, the meanings of many mental terms seem essentially or importantly tied to qualitative subjective experience as opposed to overt behaviors. Thus, many people find the awfulness of pain essential to being in pain, but few find verbal demonstrations essential to being in pain. A person paralyzed by curare will not exhibit the normal behavioral effects of pain when stabbed in the arm. However, it seems improbable to suppose that such a person feels no pain. Likewise, actors really do suffer for their art according to logical behaviorists in that these actors actually suffer when overtly behaving as if they were suffering. Second, many mental properties such as aibohphobia (a fear of palindromes), ankylophobia (fear of stiff or immobile joints) and malaise (a vague feeling of discomfort, one cannot precisely identify, but which is often described as a sense that things are "just not right.") seem to lack any definitive set of behavioral effects. These terms do not seem meaningless or less meaningful than other mental terms, yet they do not exhibit a small group of overt behaviors that one might consider criterial of the state. Third, mental terms do not operate, for the most part, in isolation from one another. Rather, the connections between the typical behavioral causes and typical behavioral effects--even for those mental terms that appear to have more or less criterial overt behavioral causes and effects--are mediated by the interactions of mental states with other mental states. This last point finds emphasis in the work of Roderick Chisholm criticizing logical behaviorism and in the latter work of Hilary Putnam outlining functionalism.[52-57] For instance, one cannot determine the causes and effects of your belief that this text is remarkably dry in isolation from your interest in the subject, your desire to do well in the class, etc.. If you love dry and boring texts, you may read all night. If you are hungry, your belief may result in your getting a chocolate bar. The seeming interconnection between mental terms leads Putnam and others to formulate a new approach to theorizing called functionalism discussed later in this text. As Chisholm tells his readers:[57]

> Nevertheless, difficulties in principle seem to be involved when we attempt to extend the preparatory-stimulus theory to human behavior. [Logical behavioristic reductions of mental terms to collections of stimuli and responses]
>
> These difficulties concern the specification of the occasions upon which the appropriate fulfillments or disruptions must occur. According to our paradigm, these must be caused by the occurrence, or nonoccurrence, of the referent. But it is easy to think of elementary human sign situations where the appropriate events do not occur in the manner required. And to accommodate our definition to such cases, we seem required to make qualifications which reintroduce the intentional concepts we are trying to eliminate. [Other mental terms] (p.61)

Likewise, Chisholm later asserts that:[55]

> …when we wish to describe anyone's believing, seeing, knowing, wanting, and the like, either (a) we must use language which is intentional or (b) we must use a vocabulary we don't need when we talk about non-psychological facts. (p.132)

Theorists explore the general difficulties facing approaches like Ryle's and Hempel's in the technical literature even before Ryle publishes *The Concept of Mind*. The verification theory of meaning and the difficulties involved in the inter-theoretic reduction that the logical empiricists initially advocate begins to attract the great minds of philosophy and science long before the 1950s. However, Putnam's "Psychological Concepts, Explication, and Ordinary Language"[54] (1957) and Chisholm's "Intentionality and the Theory of Signs" [57] (1952) serve to make explicit and popularize the implications of these technical problems for logical behaviorism. Chisholm's classic paper adopts a descriptivist theory of reference for such mental state terms. Chisholm argues that attempts to define mental state terms like belief in terms of their typical overt physical causes and effects fails precisely because such states have no typical causes and effects absent their relationships to other mental state terms. Thus, argues Chisholm, one cannot define mental state terms in isolation. Mental state terms constitute a closed holistic lexicon or conceptual scheme.[55-57] In Psychological Concepts Putnam agrees that mental terms cannot be defined in isolation. He adopts a technical trick to specify a definite description of each mental term utilizing its interrelationships with other mental states and connections to typical causes and typical effects. Putnam's technique here as well as how he manages to maintain his direct reference position while utilizing definite descriptions will become clearer in the chapter on functionalism. For now, suffice it to say that Putnam claims that definite descriptions directly refer to mental states because mental states consist of all and only those things satisfying the definite description.

Gilbert Ryle (1900-1976)
Adapted from: Corpuscular Philosophy

Carl Gustav Hempel (1905-1997)
Adapted from: Today in Science

Roderick Chisholm (1916-1999)
Adapted from: Laurence.edu

Hilary Putnam (1926-)
Adapted from: matematica

In "Brains and Behavior" Putnam straightforwardly denies the viability of attempts to identify mental states and properties with the effects of those mental states and properties, adopting a direct reference theory of reference for mental terms according to which the reference of mental terms such as belief or pain consists of the mental state itself regardless of its typical causes and effects. Often such theorists adopt a phenomenological essentialism regarding many of these terms. Specifically, such theorists look to conscious mental states—especially qualitative conscious experiences like pain--asserting that the conscious phenomenological experience provides a direct referential link to the state. Pains, on this line, are painful and this feature alone defines these states. Putnam adopts this line of argument in "Brains and Behavior"[50] when presents a series of counterfactual thought experiments in which, he suggests, one can intuitively judge that the mental states in counterfactual examples count as pains despite being dissociated from their typical causes, their typical effects, or both.[50-54]

These challenges together with the limitations and difficulties emerging in methodological behaviorism or simply behaviorist psychology combine to lead theorists to reject the behavior gambit. Monistic physicalist ontological frameworks for understanding the mind, mental properties, and mental processes must include more than mere overt behaviors and their probabilistic associations. By the later 1950s and early 1960s theorists actively seek to develop alternative methods of reducing mentalistic terms to the terms consistent with monistic physicalistic ontological frameworks for philosophy and psychology.

4.6 Identity Theories: Type-Type Identity

The last section and traces the developments that lead to the semantic twist. Specifically, sections outline how philosophers of mind alter their focus from formulating and defending various ontological frameworks to understanding the relationship between scientific theories of the mind and ordinary conceptions of the mind. The shift in emphasis comes in reaction to the dramatic advances in science, mathematics, logic, and especially psychology at the dawning of the 20th century. The emergence of logical empiricism as the predominant philosophy of science strongly shapes how philosophers understand the engine that drives the rapid advances in the sciences at the beginning of the 20th century. Specifically, the logical empiricists focus upon scientific categorizations. The doctrine of the verification theory of meaning postulates that categorizations drive scientific progress only when they get their meaning through operationalizations—through being tied to empirical phenomena through intersubjective procedures and observations. Likewise, intertheoretic reduction and the unity of science emphasize semantic reduction as the key element of intertheoretic equivalence. As a result, philosophers begin increasingly to think of theories not simply in terms of theoretical posits, but in terms of the relationships between categories of scientific theories and the terms of ordinary language and of perceptual experiences.

After the semantic twist, therefore, most philosophers seek to understand how monistic physicalism can accommodate mental phenomena. Specifically, philosophers seek to advocate monistic physicalism by subsuming mental phenomena within the physical. Philosophers do not posit physicalistic theories providing mechanistic explanations of mental phenomena. Rather, philosophers seek to demonstrate the viability of monistic physicalism through semantic reduction. In other words, philosophers adopt the project of demonstrating how ordinary, pre-theoretic talk about the mind expresses nothing over and above what one can express using physicalistic language. As a result, philosophers adopt the methodology of demonstrating the viability of monistic physicalism by showing that one can specify the meanings of ordinary language mental terms completely using only physicalistic terms. Since philosophers do not formulate physicalistic theories of mental phenomena, they rely primarily upon scientific results to provide the data upon which they base their reductionist theories. The underlying inference driving such identifications lies in the notion that by directly equating mental and physical terms one indirectly identifies the referents of those terms--mental phenomena and physical phenomena. In other words, 20th century philosophers locate the explanatory problem for the monistic physicalist in an inability to recognize or gather sufficient evidence for the co-referential nature of mental and physical terms.

The last chapter outlines one of two general approaches to pursuing this general strategy emerge within philosophy during the first half of the 20th century. On the one hand, theorists try to identify the meaning of mental terms with sets of overt, observable, physical behaviors definitive of those terms. Analytical behaviorism, discussed in the last chapter and lecture represents the first instance of this strategy. On the

other hand, theorists seek to identify the reference of mental property, process, and entity terms with the reference of physical property, process, and entity terms through something less than, but sufficiently akin to analytical reduction. The current chapter and lectures explore theories within this second strategy, often called type-type reductionism. The delineation of identity theories in this lecture and chapter will emphasize two important features of type-type identity theories. First, identity theories operate within the general framework of logical empiricism. Specifically, identity theories view intertheoretic reduction as proceeding through semantic reduction of higher-level theoretical categories to lower-level physical categories. Second, while analytic behaviorism views reduction as requiring meaning equivalence, identity theories seek a weaker identification--specifically, reference equivalence. In other words, identity theories do not seek to understand intertheoretic reduction through meaning reduction. Instead, identity theorists suppose that intertheoretic reduction requires only co-reference. Thus, type-type identity theory asserts that folk mental concepts prove co-referential with physiological concepts. In contrast, token-token identity theorists only require that tokens of mental types are also tokens of some or other physical type.

4.7 Identity Theories: Type-Type Identity

Theorists often call the successor to logical behaviorism type-type reductionism or type-type identity theory. Type-type reductionism proposes to identify types of mental entities, mental properties, and mental processes with specific types of physical entities, physical properties, and physical processes. For instance, one might identify the mental property of pain with the physical property of stimulated c-fibers. Historians generally credit the British philosopher and psychologist U.T. Place (1924-2000) and the Austrian philosopher Herbert Feigl (1902-1988) as the source of the modern identity version of type-type physicalism. Place's colleague J.J.C. Smart (1920-) also adopts this position. The motivations of identity theorists stem in large part from (and build upon) difficulties with logical behaviorism. For instance, Place tells readers,[138]

> The view that there exists a separate class of events, mental events, which cannot be described in terms of the concepts employed by the physical sciences no longer, commands the universal and unquestioning acceptance amongst philosophers and psychologists which it once did. Modern physicalism, however, unlike the materialism of the seventeenth and eighteenth centuries, is behaviouristic. Consciousness on this view is either a special type of behaviour, 'sampling' or 'running-back-and-forth' behaviour as Tolman (1932,p. 206) has it, or a disposition to behave in a certain way, an itch for example being a temporary propensity to scratch. In the case of cognitive concepts like 'knowing', 'believing', 'understanding', 'remembering' and volitional concepts like 'wanting' and 'intending', there can be little doubt, I think, that an analysis in terms of dispositions to behave (Wittgenstein, 1953; Ryle, 1949) is fundamentally sound. On the other hand, there would seem to be an intractable residue of concepts clustering around the notions of consciousness, experience, sensation and mental imagery, where some sort of inner process story is unavoidable (Place, 1954). It is possible, of course, that a satisfactory behaviouristic account of this conceptual residuum will ultimately be found. For our present purposes, however, I shall assume that this cannot be done and that statements about pains and twinges, about how things look, sound and feel, about things dreamed of or pictured in the mind's eye, are statements referring to events and processes which are in some sense private or internal to the individual of whom they are predicated. (p.44)

Two central ideas define type-type identity: First, Place and Feigl hold that behavioristic and identity analyses of mental terms do not exhaust the meaning of mental terms in ordinary language. That is, the new definitions of mental terms are not analytic--they do not capture the individually necessary and jointly sufficient

conditions thought to dictate the meanings of ordinary terms. Place and Feigl hold that mental and physical terms pick out classes or kinds of things in virtue of their meanings, and that a significant part of the meaning of ordinary mental terms (as well as of the identity theorists new analyses of those terms) is synthetic--i.e., going beyond the definitional meaning, usually as a result of experience. Specifically, type-type reductionists hold that the various behavioral associations between mental terms and physical/bodily terms serve to provide an initial description of a physical (brain) state. One can modify the initial behavioral descriptions, to the extent necessary, as a result of experience. Such descriptions ultimately determine the physical state that corresponds to the mental state. The identification of the physical state with the mental state constitutes a synthetic discovery. Synthetic truths or discoveries differ from analytical truths or discoveries in that analytical truths follow from the meaning of the terms involved. Analytic truths equate statements or terms and have truth-values dependent upon the meaning of the constitutive terms and/or logical structure. Denying an analytic statement therefore results in a contradiction. For example, "All triangles are three-sided planar figures," is an analytic statement, so is "A square is a four-sided, regular planar figure." Likewise, "It's false that all unmarried human males are bachelors" is a contradiction, since by definition bachelors are unmarried men. Analytic statements are said to be true by definition and/or their logical structure. In contrast, synthetic truths do not follow merely from the meaning of the terms involved. Someone can negate a synthetic statement without a contradiction. For example, one can assert the negation of the statement that "Long Beach has a population of 360,000 people," without a contradiction. "It's false that Long Beach has a population of 360,000 people." is not a contradiction. For this reason, discovering the population of Long Beach is a synthetic discovery.

The synthetic nature of the discovery that brain states and processes prove identical to mental states and processes allows type-type theorists to side-step many of the objections raised by dualists. Place tells readers,

> To say that statements about consciousness are statements about brain processes is manifestly false. This is shown *(a)* by the fact that you can describe your sensations and mental imagery without knowing anything about your brain processes or even that such things exist, *(b)* by the fact that statements about one's consciousness and statements about one's brain processes are verified in entirely different ways and *(c)* by the fact that there is nothing self-contradictory about the statement*, X* has a pain but there is nothing going on in his brain'. (p.45)

In other words, mental terms and physical terms share the same referent, but not the same meaning. Philosophers refer to terms that have the same referent, but which do not necessarily have the same meaning in all contexts as referentially opaque. Recall, two terms are referentially opaque if they refer to the same object or property, but one cannot intersubstitute the terms *salva veritate* (i.e. without changing the truth value of the statement) in many contexts—or instance belief descriptions. For example, people in northern latitudes can watch the northern lights (aurora borealis) regularly. They may proclaim that they see the northern lights or that the northern lights are beautiful. However, most would not say that they are watching the photonic discharge resulting from ionized nitrogen atoms regaining an electron and nitrogen and oxygen atoms returning to a grounded state from an excited state after collisions with charged particles (solar winds) traveling along the magnetic field lines of the Earth's magnetosphere. Nor would most observers likely say that the photonic discharge is beautiful. The difference, according to Place, between saying that the northern lights are photonic discharge and saying that the northern lights are beautiful is a logical feature:[138]

This logical feature may be described by saying that in both cases both the grammatical subject and the grammatical predicate are expressions which provide an adequate characterization of the state of affairs to which they both refer. (p.45)

Herbert Feigl (1902-1988)
Modified From: University of Minnesota

U.T. Place (1924-2000)
Modified From: Adelaide University

John Jamieson Carswell "Jack" Smart (1920-)
Modified From: Monash University

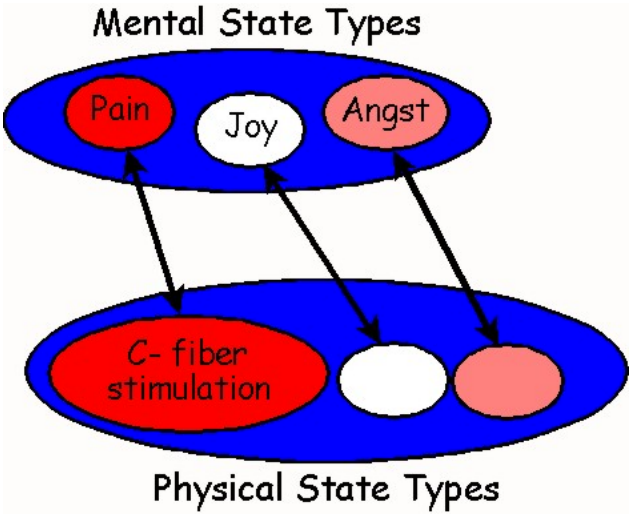
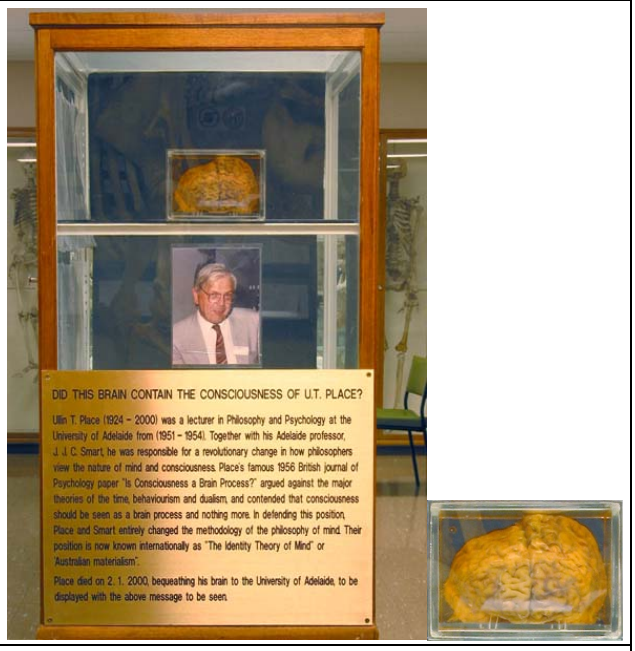


Diagram depicting Type-Type Identity Theory. Type-type theorists claim that there is only physical substance. Mental properties exist, but are type-identical to types of physical properties. Theorists discover the identity using the physical and behavioral associations between mental and physical terms to identify the physical state type corresponding to the mental state type.

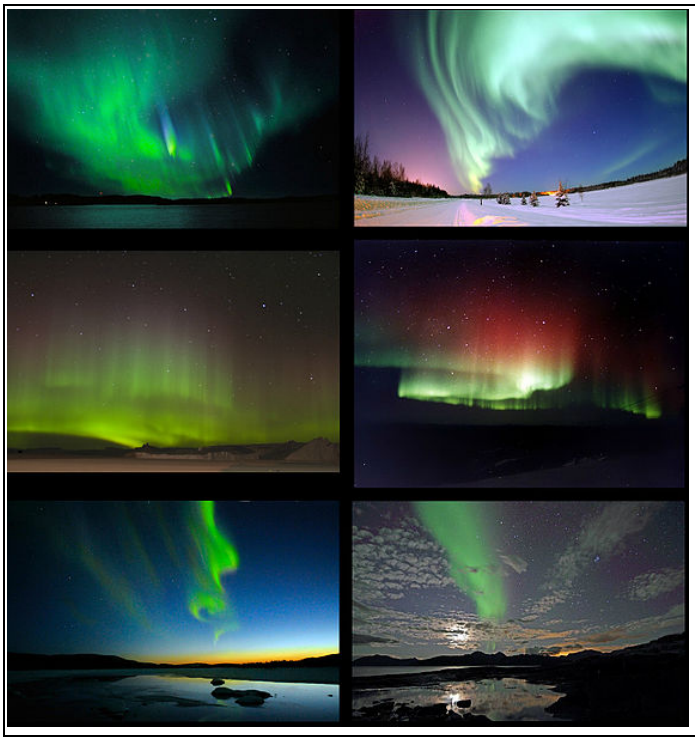


Pictures of U.T. Place's brain located at the Anatomy Museum in Medical School Building at the University of Adelaide. Place taught as a lecturer in Philosophy and Psychology at Adelaide University from 1951-1954. From: Adelaide University

Feigl expresses a similar point by telling readers that:[139]

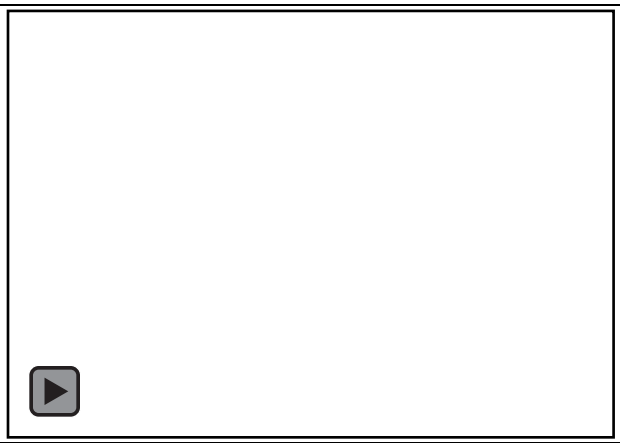
> The identity thesis which I wish to clarify and to defend asserts that the states of direct experience which conscious human beings "live through," and those which we confidently ascribe to some of the higher animals, are identical with certain (presumably configurational) aspects of the neural processes in those organisms. …we may say, what is *had-in-experience*, and (in the case of human beings) knowable by acquaintance, is identical with the object of knowledge by description provided first by molar behavior theory and this is in turn identical with what the science of neurophysiology describes (or, rather, will describe when sufficient progress has been achieved) as processes in the central nervous system, perhaps especially in the cerebral cortex. In its basic core this is the "double knowledge" theory held by many modern monistic critical realists. … The "mental" states or events (in the sense of raw feels) are the referents (the denotata) of the phenomenal terms of the language of introspection, as well as of certain terms of the neuro[-]physiological language. For this reason I have in

previous publications called my view a "double-language theory." But, as I have explained above, this way of phrasing it is possibly misleading in that it suggests a purely analytic (logical) translatability between the statements in the two languages. It may therefore be wiser to speak instead of *twofold access* or *double knowledge*. The identification, I have emphasized, is to be empirically justified, and hence there can be no logical equivalence between the concepts (or statements) in the two languages. (Section E ¶4 and 5)



(Right) Several pictures depicting the beautiful photonic discharge resulting from ionized nitrogen regaining atoms electron and nitrogen and oxygen atoms returning to a grounded state from an excited state resulting from their collisions with charged particles (solar winds) traveling along the magnetic field lines of the Earth's magnetosphere. Er, the beauty of the northern lights (aurora borealis). From: Wikipedia

(Below) A movie of the sudden large-scale discharge of electrons between bodies of suspended liquid and frozen crystals measuring no more than a few tens of microns and having a negligible fall velocity, i.e., a lightening discharge between clouds. Click to play. From: Youtube



4.8 Two Arguments For Type-Type Identity Theory

Place and Feigl, then, have two lines of argument for their identity theory. On the one hand, they argue that traditional dualist arguments like the argument from Leibniz's Law and the argument from introspection do not apply to the identities Place and Feigl advocate. Call these the inapplicability arguments. On the other hand, Place and Feigl present an argument from analogy with other historical examples of scientific reduction. Call these the reductive analogy arguments. Object color is really surface reflectance. Heat is mean kinetic energy. Sound is compression waves traveling through the atmosphere and pitch is just the oscillatory frequency of those waves. Lightening is just the sudden large-scale discharge of electrons between clouds. Feigl tells readers that:[139]

> …the advance of scientific theories consists essentially in the reduction of a variety of originally heterogeneous observable facts and regularities to a unitary set of explanatory concepts and postulates. Customarily it is said, for example, that visible light is electromagnetic radiation (within a certain interval of wave lengths); that table salt is NaCl; that magnetized iron is an aggregate of iron atoms with a characteristic spin of certain of their electrons; that the transmitters of hereditary traits are the genes in the chromosomes of the germ cells; that (at least) short range memory traces are reverberating circuits in cerebral cell assemblies, etc. The "is" and the "are" in these sentences represent identities. But these identities differ in their mode of certification from the analytic identities of pure logic and mathematics. … …the identities established in the factual sciences are confirmed on the basis of empirical evidence. … …there are also such empirically ascertainable identities as those of Tully and Cicero, of William Thompson and Lord Kelvin, or of the evening star and the morning star. In

the examples just given we have (extensional) identities of individuals labeled or uniquely described in two or more ways. (Section D, ¶2 &3)

4.9 Identity Theories: Token-Token Identity

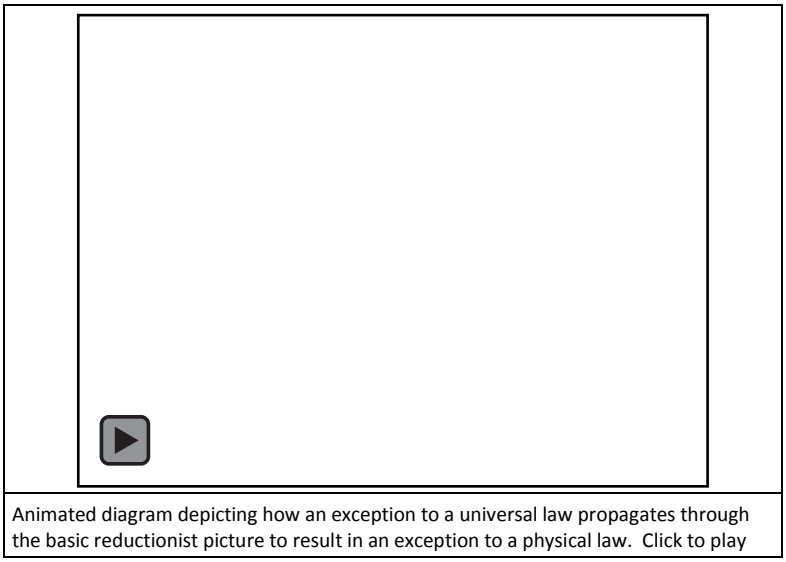
In 1970, Donald Davidson (1917-2003) proposes a new version of identity physicalism. Davidson starts his chapter, "Mental Events,"[140, 141] by stating his motivation for the view,

> Mental events such as perceivings, rememberings, decisions, and actions resist capture in the nomological net of physical theory. .... I start from the assumption that both the causal dependence and the anomalousness of mental events are undeniable facts. My aim is therefore to explain, in the face of apparent difficulties, how this can be. (p.138)

By nomological Davidson simply means law-like, and by anomalousness Davidson means not falling under exceptionless universal laws. Davidson thinks that the failure to find the simple type-type identifications theorists like Smart, Place, and Fiegl suggest together with the failure of psychology and sociology to generate universal exceptionless laws warrants a reconsideration of the type-type identity theory. In the quote above, Davidson tells readers that he takes the anomalousness of the mental as an undeniable fact. That is, Davidson holds that psychologists have not and cannot discovery universal, exceptionless laws formulated in mentalistic categories.

The anomalousness of the mental presents a problem for Davidson because he accepts both (1) the monistic physicalistic framework and (2) the basic logical empiricist picture of laws and reduction in science. That is, Davidson holds that the dramatic success of sciences like physics proves the mechanistic and deterministic nature of the physical world as one describes it using the physical conceptual scheme. Specifically, scientists formulate laws using exclusively physicalistic descriptions. These physicalistic descriptions represent a conceptual scheme for describing the world. This conceptual scheme has proven itself capable of describing the world so that the sciences produce finite, exceptionless universal laws. Indeed, the collection of such laws forms a closed, complete deductive system. That is, given a complete physicalistic description of some state of the world, called a physical event, scientists can, at least in principle, deduce how the world will unfold by deducing the resulting physical event, i.e., the exclusively physicalistic description of the world resulting from the prior event.

The standard view of physical laws looks like the bottom of the diagram (below) for the reductionist view of science. However, what happens to the picture if the mental has exceptions to its laws? If one supposes that physical laws and bridge laws between the mental terms and the physical terms are exceptionless and universal, then an exception to a psychological law between S_1 and S_2 is an exception to the physical law between P_1 and P_2. That is, all members of S_1 are members of P_1 and all members of S_2 are members of P_2.



Animated diagram depicting how an exception to a universal law propagates through the basic reductionist picture to result in an exception to a physical law. Click to play

Thus, the exception to the psychological law between a token (member) of S_1 and token (member) of S_2 is also an exception to the physical law. The exceptionless bridge laws mean that the token (member) of S_1 is also a token (member) of P_1 and token (member) of S_2 is also a token member of P_2. Thus, P_1 and P_2 violate the physical law just as S_1 and S_2 violate the psychological law.

Yet, Davidson famously argues that the anomalousness of the mental proves consistent with a certain sort of physicalism in his paper. However, many people think that Davidson offers no reason to accept the anomalousness of the mental. In fact, Davidson does offer a reason for the anomalousness of the mental. Mental terms, like physical terms, form a conceptual scheme. Unfortunately, the conceptual scheme for the mental differs from the conceptual scheme for the physical. Davidson holds that the physical conceptual scheme has as its exclusive purpose conceptualization of the physical world for the purpose of formulating and testing physical laws. In contrast, the primary purpose of the mental conceptual scheme consists in making attributions of mental terms so as to provide one with an understanding of other people. Specifically, Davidson argues that in order to understand the actions, beliefs, desires, etc. of a person one must understand the person as a rational agent. In other words, in so far as one cannot see the actions, thoughts, etc. of an individual as rational one cannot understand them. That is, the actions of the individual make no sense in the mental conceptual scheme if one cannot understand that person as acting in accordance with one's own standards of reasonableness. This emphasis on rational understanding can, and Davidson suggests does, often trump ascriptions that would support universal and exceptionless laws in psychology. Davidson feels that one can use psychological generalizations to explain and predict by relating mental events, i.e., descriptions of some state of the world using exclusively mentalistic terms. However, mental events, events one describes using mental terms, do not lend themselves to the expression of exceptionless universal mental laws because the mental conceptual scheme works to maximize one's ability to understand others, even if such understanding violates psychological laws. Hence, psychological laws, as mere heuristic generalizations, do not form a closed, complete deductive system.

But how can one avoid the seeming dire consequences of an anomalous mental realm? Specifically, Davidson wants to preserve three principles:[140]

(1) Causal interaction occurs between the mental and the physical. (pp.137-138)

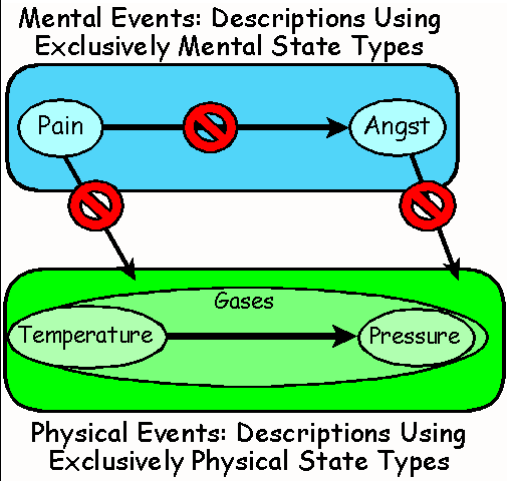
(2) If causal interaction occurs, then strict deterministic laws (universal and exceptionless) govern that interaction. Davidson refers to this property as "the Principle of the Nomological Character of Causality." (p.138)

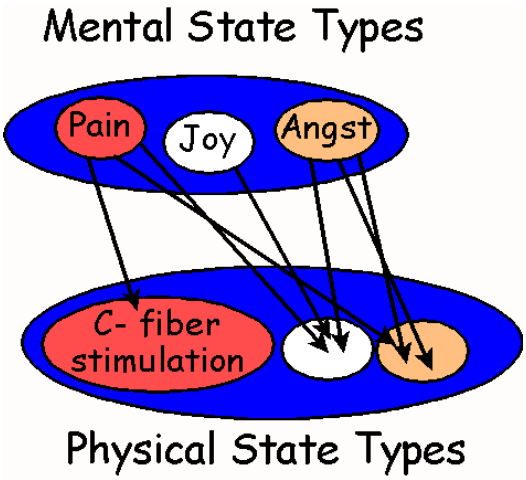
(3) “The third principle is that there are no strict deterministic laws on the basis of which mental events can be predicted and explained (the Anomalism of the Mental).” (p.138)

How does Davidson solve his difficulty of rendering these principles consistent? The answer lies in his notion of the two conceptual schemes. Davidson holds that since the mental and physical conceptual schemes differ in their goals, no possible reduction of mental terms to physical terms exists. In other words, Davidson denies the possibility of exceptionless universal "bridge-laws"--laws relating mental descriptions of states of the world (mental events) to physical descriptions of states of the world (physical events). Though the argument seems complex, it's actually pretty straightforward. Physical laws are universal and exceptionless. Mental laws are neither universal nor exceptionless. As a result, if there were universal and exceptionless laws linking mental and physical events (bridge-laws), then those bridge-laws would provide a basis for universal exceptionless mental laws. Yet, there are no exceptionless universal mental laws. Conversely, if there were universal and exceptionless laws linking mental and physical events (bridge-laws) and mental laws has exceptions, then those universal and exceptionless bridge laws would transfer those exceptions of mental laws into exceptions in physical laws. Yet, there are no exceptions to physical laws. Hence, there can be no universal and exceptionless bridge laws.

Donald Herbert Davidson
(1917–2003)

(Below) Two diagrams of the relationships in Davidson's anomalous monism or token-token identity theory. Individual mental event tokens are identical to some or other particular physical event token. However, under their mental and physical conceptual scheme type descriptions the association might seem somewhat random. (Bottom right). However, anomalous monists deny that mental event types (kinds) are identical to physical event types (kinds). Instead, any individual token mental event--an event one describes using the mental conceptual scheme—is also a token physical event—an event one describes using the physical conceptual scheme. The physical conceptual scheme of science describes all events and specifies the universal exceptionless laws of science’s closed, deductive system. However, the mental conceptual scheme does not describe events in manner conducive to the formulation of universal exceptionless psychological laws. As a result one finds no exceptionless universal bridge laws relating mental terms to physical terms. (Bottom left)





What about the causation between the mental and the physical (principle 1) and the strict deterministic nature of all such causation (principle 2)? Easy, says Davidson; mental events are just descriptions of the world using the mental conceptual scheme. Every mental event is just an event described using mental terms. But one can also describe that event using physical terms from the physical conceptual scheme. Thus, every token of a mental event is also a token of a physical event. The physical and mental descriptions might only hold for that token event, or the descriptions may prove more general. However, mental types do not reduce

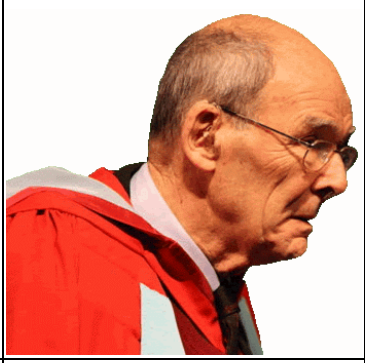
to physical types. So, some tokens of a particular type of mental event, call it M_1, will have token physical descriptions from different physical types than other tokens of mental events from that type, .i.e. M_1. Thus, despite the lack of mental-type to physical-type reduction, one can understand how token mental events are identical to token physical events—they are just different descriptions of the same event.

Moreover, since every token of a mental event has a physical event description, token mental events can causally interact with token physical events in a strict deterministic manner—the manner dictated by the strict deterministic law relating their physical event descriptions. Since physical event descriptions yield finite, exceptionless universal laws that combine to form a closed deductive system, all tokens of mental causal interaction with the physical fall under strict deterministic laws—just not laws using mental terms.

4.10 Functionalism

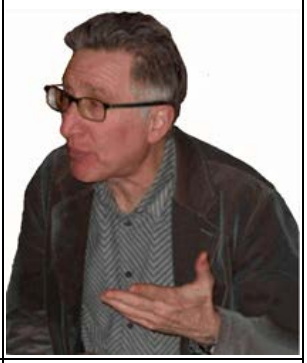
Not all philosophers see the failure to discover the mental type to physical type identities and robust psychological laws predicted by type-type identity theory, as the central difficulty for theorists like Feigl and Place. Putnam didn't suppose that psychology must formulate universal exceptionless laws. Instead, Putnam held that psychological laws would take the form of statistical generalizations. In two classic articles, " Minds and Machines"[27] (1960) and "Psychological Predicates[28] (1967) (later published as The Nature of Mental States), Hilary Putnam (1926-) formulates a slightly different solution to the problems that motivate Fiegl and Place called functionalism. As noted earlier, philosophers like Plato and Aristotle seem to advocate theories that are roughly characterized as functionalist. However, Putnam puts the modern face on functionalisms. Putnam suggests that mental terms like pain and belief are not properly identified with some state that causes the behavioral indicators. Rather these mental terms refer to the functions that pain, belief, etc. play in the overall functioning of the organism. Specifically, Putnam suggested that physical causes of mental states (inputs), their causal relationships to other mental states, and the effects of mental states of physical states (outputs) served to definitively characterize mental states. Putnam identifies mental states with their functional characterizations, in part because, he argues, systems may come to have different states from a physiological perspective that have the same functional characterization. Such states, Putnam suggests, would be instances of the same psychological type, but instances of different physiological types. For example, if you believe that lobsters feel pain, you won't find type identity theory very satisfying because lobsters lack a centralized nervous system, and hence, lack the structures associated with pains in humans. This idea came to be known as multiple realizability. Ned Block (1942-) and Jerry Fodor (1935-) publish "What Psychological States are Not"[29] in 1972, further articulating and defending functionalist theory. Even as Putnam articulates a synthetic, empirical functionalism, D. M. Armstrong (1926-) published his *A Materialistic Theory of the Mind*[30]. Like Putnam, Armstrong argued that mental states were best characterized by descriptions incorporating physical causes of mental states (inputs), their causal relationships to other mental states, and the effects of mental states of physical states (outputs). However, unlike Putnam, Armstrong views these descriptions as strict analyses of the concepts of our ordinary language terms that give the individually necessary and jointly sufficient conditions that the terms meaning. Finally, like Place, Armstrong viewed these descriptions as picking out the physical state that corresponded to the mental state.

Hilary Putnam (1926-)



D. M. Armstrong (1926-)

Jerry Fodor (1935-)



Ned Block (1942-)

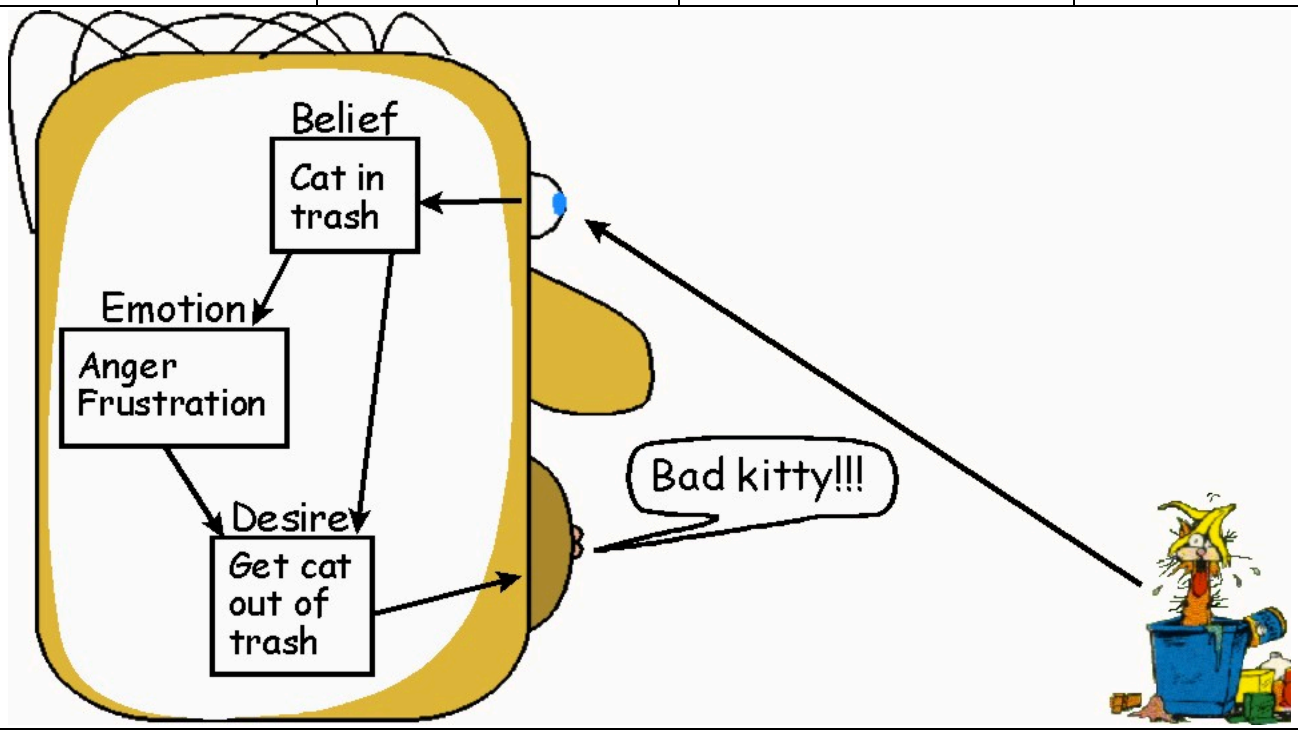


Diagram depicting the relationships important for characterizing mental states according to functionalism. These theorists hold that a mental state is the type of state it is in virtue of its place in one's overall cognitive economy (one's causal nexus as described by an accurate theory), specifically the physical causes of mental states (inputs), their causal relationships to other mental states, and the effects of mental states of physical states (outputs).

4.11 Computationalism

The connection between functionalism and computation as well as computers traces back to Putnam's early formulations. However, starting in the late 1970s philosophers converge upon the basic explanatory schema of the CTC/RTI both as a theory of cognition and cognitive states, and as a theory of explanation and explanatory methodology. Work by Ned Block (1942-) ["Introduction: What is Functionalism"[31] and "Troubles with Functionalism"[32]], Robert Cummins (1948-) ["Functional Analysis"[33] and *The Nature of Psychological Explanation*[34]], Dan Dennett (1942-) [*Brainstorms*[35]], Jerry Fodor (1935-) ["Special Sciences (Or: The Disunity of Science as a Working Hypothesis)"[36] *The Language of Thought*[37]], and John Haugeland (1945-) ["Semantic Engines"[38] and *Artificial Intelligence: The Very Idea* [39]] further articulate the structure of explanations in Cognitive Science. The resulting picture is beautifully articulated in their work. The last few of these introductory lectures, outlines the salient features of this picture.

				
Block (1942-)	Robert Cummins (1953-)	Daniel Dennett (1942-)	Jerry Fodor (1935-)	John Haugeland (1945-)

4.12 Property Dualism

The explanatory schema and methodology outlined in these introductory lectures does not have homogeneous acceptance across all researchers in all the core disciplines of cognitive science. Two other views emerge in the late 1970s and 1980s. One position that emerges stems from the difficulties faced by functionalism, specifically functionalism's inability to easy capture the qualitative aspects of consciousness, also called qualia. Thomas Nagel (1937-) publishes "What it is like to be a Bat?,"[40]. Frank Jackson (1943-) publishes "What Mary Didn't Know,"[41] and David Chalmers (1966-) publishes "Absent Qualia, Fading Qualia, Dancing Qualia"[42] and *The Conscious Mind: In Search of a Fundamental Theory.*[43] Each of these works suggest, for different reasons than Armstrong, that some if not all mental states are not physical states as traditionally understood. Nagel and Chalmers both take a page from Spinoza, and suggest that the notion of physical substance should be expanded to allow for both the traditional physical properties and mental properties. This view is known as property dualism.

	Frank Jackson (1943-)	

Diagram depicting the relationship between mental and physical properties according to property dualism. In such theories all possible properties, mental and physical, are properties of a single physical-like substance. However, mental and physical properties are irreducible to one another. Generally, such views seek to preserve the special character of mental properties, holding that scientific progress requires some new conceptual and/or scientific reconceptualization and methodological revolution.

Thomas Nagel (1937-)

Frank Jackson (1943-)

David Chalmers (1966-)

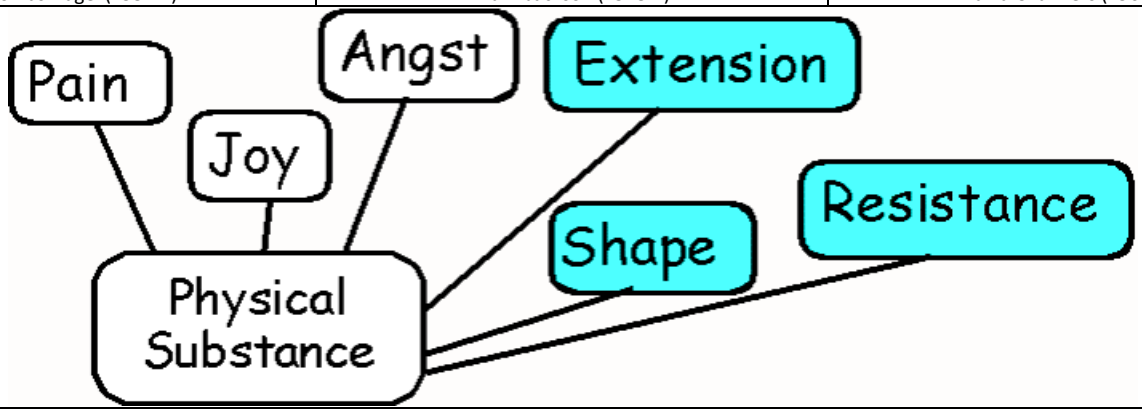


Diagram depicting the relationship between mental and physical properties according to property dualism. In such theories all possible properties, mental and physical, are properties of a single physical-like substance. However, mental and physical properties are irreducible to one another. Generally, such views seek to preserve the special character of mental properties, holding that scientific progress requires some new conceptual and/or scientific reconceptualization and methodological revolution.

4.13 Eliminative Materialism

The final view we'll consider in this lecture, eliminative materialism has a amorphous history. The basic idea behind the view had been in the air for a long time. Historians often attribute it to James Cornman's " On the Elimination of 'Sensations' and Sensations"[44] (1968). Cornman himself attributes it to WVO Quine's *Word and Object*[45](1960). William Lycan and George Pappas attribute it to Richard Rorty's "Mind-Body Indentity, Privacy and Categories"[46](1965). However, few doubt that eliminative materialism rose to prominence and came to be associated with the University of California, San Diego and three philosophers who spent the early 1980s there. It is these three thinkers as well as Daniel Dennett that gave the view its modern formulation, and its most rigorous defense. As the seventies end and the eighties begin, Paul Churchland, Patricia Churchland, Daniel Dennett, and Stephen Stich publish papers outlining and defending the view that our ordinary mental terms constitute a psychological theory--folk psychology. Eliminativists hold that our theoretical terms pick-out (or fail to pick-out) real objects or properties in virtue of the role these terms play in our theories. In other words, theoretical terms pick-out (or fail to pick-out) real-world objects in virtue of that the theory asserts about those objects. For instance, Phlogiston theory tells us that flammable objects contain phlogiston, the fire stuff. Object combustion, according to the theory is just the process of phlogiston leaving the object. So, the phlogiston theory picks out a real-world object, just in case there is something in the real world that satisfies the properties and relations attributed to phlogiston by the theory. In the case of phlogiston, scientists discover that the net byproducts of combustion have a greater mass than the original material. This finding, among others, suggests that there is no phlogiston, i.e., there is no real world object that plays the role of leaving a combustible material when it burns. Similarly, if a theory proves inadequate to explain phenomena, then we ought to suppose that the theory is false, and the objects it posits do not exist.

Folk psychology, the eliminativists argue, is both explanatorily inadequate and, taken as whole, radically false about the states and properties of the mind. For instance, consider the following *prima facie* inadequacies of

our ordinary folk psychological understanding of our minds: Nothing about our ordinary notion of consciousness explains why we have to spend approximately eight hours a day unconscious. Nor does the folk psychological concept of consciousness explain what happens when we go from being conscious to being unconscious, or why we can't simply will ourselves to be unconscious. Likewise, folk psychology proves woefully inadequate to explain why people develop illnesses like schizophrenia. As Paul Churchland observes:[47]

> In sum, the most central things about us remain entirely mysterious from within folk psychology. And the defects noted cannot be blamed on inadequate time allowed for their correction, for folk psychology has enjoyed no significant changes or advances in well over 2,000 years, despite its manifest failures. (p.46)

Similarly, Dennett[48] notes that our ordinary notion of pain as a unified experience looks prima facie false when one notices that the painfulness and the adverseness or awfulness of pain can, and in many cases do, appear in isolation from one another. For example, people given morphine prior to their operations often report feeling the painful sensations without the adverse or awful aspects when prodded by the surgeon. Similarly, the awfulness of pain can be diminished by concentrating on the painfulness aspect of the qualitative experience.

Patricia Churchland (1943-)

Paul Churchland (1942-)

Stephen Stich (1943-)

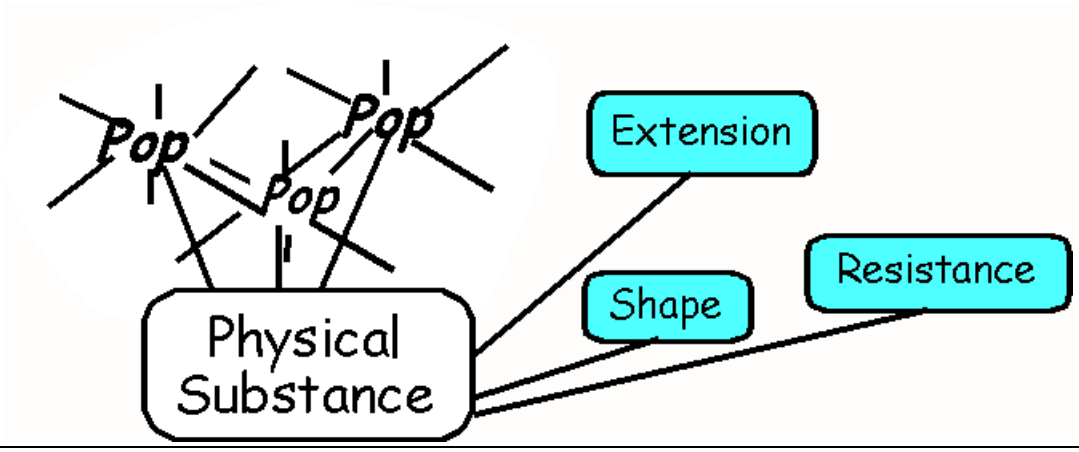


Diagram depicting the eliminative materialist view that ordinary mental terms constitute a folk psychology that is radically false about the nature and properties of the mind. As a result, mental properties as conceived in our folk psychology do not exist.

As a result, eliminativists argue, mental properties as conceived by our folk psychology do not actually exist. This position has come to be known as eliminative materialism. Daniel Dennett's "Why You Can't Make a Computer that Feels Pain,"[48](1978) and *Consciousness Explained* [49](1991), Paul Churchland's " Eliminative

Materialism and the Propositional Attitudes"[50](1981), " Reduction, Qualia, and the Direct Introspection of Brain States,"[51](1985), Stephen Stich's *From Folk Psychology to Cognitive Science: The Case Against Belief* [52](1982), and Patricia Churchland's *Neurophilosophy: Toward a Unified Science of the Mind-Brain*[53] (1986) are perhaps the best known and most definitive statements of the view. It is important to note that the contemporary statement of the view does not deny the existence of any kind of mental states or properties. Rather, it denies the existence of the mental states and properties found in and understood through our ordinary concepts. Thus, while Paul Churchland and Daniel Dennett deny that pains exist, they do not deny that we experience adverse sensations when stuck with a pin. They deny that a state or property exists that satisfies the description ingrained within our ordinary mental concepts of the typical causes and effects of pains.

A final point to note with regard to eliminative materialists; the staunchest advocates of eliminative materialism are also among the most influential architects of the contemporary understanding of computationalism. In other words, denying that an adequate explanation of cognition and cognitive capacities will include our ordinary folk concepts (together with their alleged referents) is consistent with asserting that such explanations will take the form of computational/representational theories.

In the next lecture we turn to the historical development of physiology. One might think that physiology marks a detour out of the core disciplines of cognitive science. However, physiology makes two significant connections in the history of cognitive science. First, psychology has two parent disciplines; philosophy and physiology. Philosophy introduces the “big questions” regarding the nature and operations of the mind. Physiology--particularly the early physiology of the nervous system--marks the beginnings, not only of neuroscience, but also of the introduction of experimental methodology to the study of the mind. Second, neuroscience develops out of physiology.

2.9 Glossary of Key Terms

Dualism: According to Wallis, dualism refers to the supposition within an ontological framework of exactly two fundamental categories to fill a specific role. Substance dualism provides an example of a dualistic view regarding the number of categories of substance in that it hold that both mental and physical substance exist. Dualisms with regard to causation appear in many ontological frameworks. For instance, in Chinese philosophy the concept of yin and yang—complementary interacting forces represents a dualism of forces.[142]

Monism: According to Wallis, monism refers to the supposition within an ontological framework of a single fundamental category to fill a specific role. Thus, both monistic idealism and monistic physicalism provide examples of monistic views regarding the number of categories of substance. Unified field theory would constitute a monistic view regarding the number of categories of force in physics. Unified field theory seeks to replace the current four fundamental forces with a single force.[143]

Monistic Idealism (Idealism): Monistic idealism holds that mental substance constitutes the only entity in the universe. Berkeley stands out as one of the most influential monistic idealists. Berkeley holds that all mental and physical phenomena consist of nothing but ideas in minds.[144, 145]

Monistic Physicalism (Physicalism or Materialism): Monistic Physicalism holds that physical substance constitutes the only entity in the universe. Therefore, monistic physicalists hold that all phenomena—both

physical and mental phenomena—result from modifications or permutations of physical substance. The Presocratic philosophers Leucippus[146] (and his pupil Democritus[147] (460-370 BCE) founded one school of monistic physicalism--atomism.[148] Greek atomists like Democritus hold that the universe consists of atoms and the void.

Oppositional Dualism: According to Wallis oppositional dualism refers to the supposition within an ontological framework of two fundamental categories to fill a specific role where the framework assigns opposite or fundamentally different properties to each category. Plato's dichotomy between the sensible and the intelligible introduces a dualism of ontological kinds sharing no essential properties—an oppositional dualism. For Plato the sensible realm consists of entities that are changeable, divisible, and capable of manifesting contradictory properties. In contrast, the intelligible realm consists of immutable, indivisible entities that never manifest contradictory properties.

Oppositional Substance Dualism: According to Wallis oppositional substance dualism to refers to those substance dualisms that assign opposite or fundamentally different properties to each kind of substance. Thus, Descartes substance dualism counts as an instance oppositional substance dualism in that Descartes defines mental and physical substance in terms of opposing properties. For example, physical substance is divisible while mental substance is not divisible.

Pluralism: According to Wallis, pluralism refers to the supposition within an ontological framework of two or more fundamental categories to fill a specific role. For example, the current four fundamental forces in physics represents a pluralistic view regarding the number of categories of force in that physicists hold that the four fundamental forces, gravitation, electromagnetism, strong nuclear force, and weak nuclear force, constitute the set of forces necessary to explain physical phenomena. Similarly, Anaxagoras[149] (500-428 BCE) of Clazomenae (an area in Turkey in Asia Minor) appears as the ultimate substance pluralist, holding that all types of materials—from milk to gold—constitute distinct eternally existing substances with their respective characteristics.[150-152] Empedocles[153](490-430 BCE) of Agrigentum (now known as the city of Agrigento in Sicily) appears likewise to adopt a pluralism. Empedocles posits the existence of the basic four elements (earth, air, fire, and water) together with two forces, love for combining and strife for separating these elements to create other materials. [150, 154]

Substance Dualism: Substance dualism posits the existence of two fundamental kinds of substance-- mental substance and physical substance. In general, substance dualists assert the existence of two fundamental kinds of substances on the grounds that a single substance cannot explain both mental and physical phenomenon. Thus, substance dualists claim that all mental phenomena result from modifications or permutations of mental substance. All physical phenomenon, in contrast, result from modifications or permutations of physical substance. Importantly, substance dualism holds that mental substance and physical substance are irreducible to one another. Rene Descartes probably stands out as the most famous substance dualist.[155]

Substance Monism: Substance monism holds that only one type of substance exists; there is only one kind of entity in the universe. According to substance monism all of the universe's phenomena-- both mental and physical phenomena--result from some sort of modification or permutation of a single kind of entity. The two

most common versions of substance monism are monistic physicalism (also called physicalism or materialism) and monistic idealism (also called idealism).

The domain hypothesis: According to Wallis the domain hypothesis refers to the often tacit theoretical supposition that some diverse set of phenomena, in fact, form a common set of interrelated phenomena (i.e., a domain). In this chapter Wallis suggests that the development of the Greek concept of the soul ultimately leads thinkers to formulate a domain hypothesis with regard to mental processes and properties. That is, theorists ultimately come to suppose that mental processes and properties form a common, interrelated set of phenomena—a domain.

The Common Locus Hypothesis: According to Wallis theorists forward the common locus hypothesis whenever they come to suppose that a set of interrelated processes and properties have a common locus—that there is a single thing that has the properties and where the processes occur. In this chapter Wallis suggests that the development of the Greek concept of the soul ultimately leads thinkers to formulate a common locus hypothesis with regard to mental properties and processes. That is, theorists ultimately come to suppose that there is a single entity—the mind—that has mental properties and in which mental processes occur.

The Mental Distillation Hypothesis: The process of property and process accretion through which theorists come to identify the contemporary mental processes and properties with the soul also infuses the notion of the soul with other, non-mental properties. Once Greek thinkers have come to accrete the set of contemporary mental properties and processes to the soul, they must also disentangle other properties and processes from that entity. Wallis calls this the mental distillation hypothesis.

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