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Limits: Essays on the Limitations of Science and Religion

Mario D'Amato
Rollins College, mdamato@rollins.edu

Thomas R. Moore
Rollins College, TMOORE@rollins.edu

Arden Baxter
Rollins College, ABAXTER@Rollins.edu

Evan Rapone
Rollins College, ERAPONE@Rollins.edu

Madeleine Scott
Rollins College, MJSCOTT@Rollins.edu

See next page for additional authors

Authors
Mario D'Amato, Thomas R. Moore, Arden Baxter, Evan Rapone, Madeleine Scott, Morgan McConnell, and Sara Nelson

LIMITS

Essays on the Limitations of Science and Religion

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Preface

This collection of essays represents the work of five first and second year students at Rollins College who spent the spring of 2016 investigating the limits of scientific and religious thought. The work begins with an investigation of the mind-body problem by Arden Baxter, who argues that the mind is not reducible to the brain in practice even if it may be in theory. Evan Rapone opines that a new and concise definition of science is required, and then provides one. In an analysis of Kant's *Critique of Pure Reason* Madeleine Scott suggests that "the unthinkable will become thinkable" should we be able to transcend the limits of cognitive science by combining it with philosophical investigation. Morgan McConnell investigates the relationship between metaphors and models and concludes that the limits of science are intimately connected to the limits of language. Finally, Sara Nelson brings a Christian perspective to the work and proposes that the nature of the divine ensures that humans can never answer some of the most fundamental questions.

The research skills and level understanding necessary to produce these essays exceeds what can reasonably expected of a college sophomore. Yet, although the expectation is unreasonable, these students have risen to the challenge and produced a body of work that encompasses both historical perspective and original thought. We have enjoyed accompanying these young scholars through the process and hope you will be both enlightened and impressed by the work.

Mario D'Amato
Thomas Moore
Winter Park, Florida

Reductionism, Emergence, and the Mind-Body Problem

Arden Baxter

The view that the human mind is unique and behaves differently from anything else in the universe is a belief that has been held and widely accepted for centuries. The world's major religions hold as a central tenet the idea that the mind can exist independently of the body and the brain and is, in fact, distinct from the physical world (Rae 64). In the realm of science, the mind lives at the outskirts of that which has been defined, demanding the answer to the fundamental question: "Can everything be reduced to the fundamental constituents of the world? Or can there be, and are there, non-reducible, or emergent entities, properties and laws?" (Silberstein 80). Such thought is the basis for theories of scientific reductionism and emergence.

Scientific reductionism is the theory that there exists a base science such that every science can be reduced to the fundamental entities described by this basic level. Within the realm of the sciences, reductionism claims that all sciences can be reduced to the basic level of physics. Reductionism is understood as a way to "unify the sciences" (Ney). The theory of reductionism is generally classified by two distinct categories: ontological and epistemological. The ontological form of reductionism concentrates on the "real world items—entities, events, properties, etc." whereas the epistemological form of reductionism focuses on "representational items—theories, concepts, models, frameworks, schemas, regularities, etc." (Silberstein 82). Each distinction aims to rationalize the world by reducing its specific elements down to their "simplest" form. An important principle of reductionism stems from Nagel's introduction of bridge laws, or bridge principles. Bridge laws are described as "bi-conditionals" that link the terms in the vocabulary of the two theories that are being considered for reduction (Riel). Many reductionists state that the derivation of laws constitutes reduction only in instances where the bridge principles have the "status of identities," meaning that the bridge principles are themselves ontological (Ney). Because of this, Nagel's discussion of reduction is said to be a relation that holds between both theories and their ontologies (Riel). This distinction is important when discussing the mind-body problem, since in this case, reduction refers to ontological simplification rather than the unity of scientific theories (Ney).

In contrast to the theory of reductionism, the theory of emergence deems that "emergent entities 'arise' out of more fundamental entities and yet are 'novel' or 'irreducible' with respect to them" (O'Connor). In other words, in the special sciences, like psychology, there exist certain properties that cannot be reduced. In a fashion similar to reductionism, emergence can be separated into the ontological and epistemological divisions. Ontological emergence, known as the strong form of emergence, claims that evolution produces entirely new and ontologically distinct levels of science which are "characterized by their own laws or regularities and causal forces" (Culp). In the case of psychology, ontological emergence claims that the laws of psychology are distinct from those of physics. The weak form of emergence, known as epistemological emergence, holds that new levels are created, or "emerge," but that these levels still follow the "fundamental causal processes of physics," that is, their laws still follow the laws of physics (Culp). Emergence arguments focus on predictability and irreducibility. In the case of predictability, emergentists claim that certain properties are unpredictable from "knowledge of their lower bases" (Kim, "Making Sense" 14). In other words, even with complete knowledge of the neurophysiology of the brain, we would still not be able to accurately predict which mental states or events would arise from a given neurobiological state or event. From an irreducibility standpoint, emergentists provide the arguments of multiple realization, mental generalizations, and mental intentionality, which will be introduced through my discussions of Fodor and Kim.

Both theories of reductionism and emergence attempt to answer the mind-body problem, the problem of explaining how mental states, events and processes—like beliefs, desires, and decisions—are related to physical states, events, and processes. Under the assumption that the human body is a physical entity, what then can we claim of the mind? Are the mind and the body one and the same, or do properties and laws of the mind emerge from the body?

Given the reductionist view of the mind-body problem, the relationship between the mind and the body is that the mind *is* the body. That is, all mental states are themselves neurobiological states. For example, the mental state of pain could be discovered to be the neurobiological state of C-fibers firing. If we were to consider that mental states could be reduced to neurobiological states, then the science of psychology would not be autonomous and would not be necessary in the realm of scientific investigation. In other words, in our previous example of pain, if pain is reducible to C-fibers firing, then any discussion of the mental state pain could be replaced by the neurobiological state of C-fibers firing, making the mental state of pain irrelevant. Patricia Churchland believes this application of reductionism to the mind-body problem is valid and her arguments will be examined further.

It seems reasonable to suggest that psychological states have a physical basis. In fact, most reductionists and antireductionists would not deny that the investigation of the mind is one of "finding a place for the mind in a world that is fundamentally and essentially physical" (Kim, "The Mind-Body Problem" 169). Yet does this imply that mental states can be reduced to neurobiological states? Emergentists would argue that the mind could retain a physical basis and nevertheless have emergent properties that are irreducible to any physical foundation. According to the emergentist, mental states like "perceiving blue" are uniquely psychological. That is, even if it has a neurobiological correlate, the state of "perceiving blue" is a novel property that emerges at an entirely new level—the level of the mind, separate from that of the brain.

In this investigation of the mind-body problem, I will discuss the mind in terms of both the theories of scientific reductionism and emergence. To develop the arguments for emergence, I will examine the positions of Fodor, a token physicalist, and Kim, an emergentist. In addition, I will discuss the arguments of Churchland, a neurophilosopher, in order to develop the position of reductionism. I posit that our current understanding of the mind is best expressed with the theory of token physicalism. Thus, ontological reduction is most likely achieved in principle. However, there is a clear argument for the necessity of epistemological emergence in practice. By extending upon Fodor's initial argument of the existence of irreducible generalizations at the level of the special sciences, I will argue that to maintain effective communication, psychology must be autonomous.

Fodor: Argument Against Strong Reductionism

In his article entitled "Special Sciences (Or: The Disunity of Science as a Working Hypothesis)," Jerry Fodor argues that "reductivism is too strong of a constraint upon the unity of science," that is, classical reductionism does not justify that there exists one unified science (101). However, he claims that the weaker doctrine of reductionism, known as token physicalism, "will preserve the desired consequences of reductivism" (101).

Fodor begins by characterizing reductivism as the "view that all the special sciences reduce to physics" and that any law of the special science can be represented through the appropriate bridge laws that will lead to the law of the special science being reduced to a physical law (98). Under this interpretation of reductivism, Fodor states that bridge laws must be considered to express event identities. This leads us to the definition of token physicalism, which is "the claim that all the events that the sciences talk about are physical events" (Fodor 100). In other words, every event in any special science, such as psychology, has a mapped correlate to a physical event. For example, under token physicalism, the psychological event of "perceiving blue" would have a correlated neurological event.

Token physicalism is weaker than materialism, type physicalism, and reductionism. Materialism "claims both that token physicalism is true and every event falls under the laws of some science or other" (Fodor 100). In other words, every event is the result of material interaction. Since this seems like a reasonable statement, most token physicalists can be said to be materialists as well. Type physicalism differs from token physicalism in that it considers "every *property* mentioned in the laws of science is a physical property" (Fodor 100). Type physicalism is concerned with whether the *kinds* of properties of the special sciences can be reduced to the same lower-level *kinds* of properties, whereas token physicalism is concerned with whether a certain property of the special sciences correlates to some particular, but not necessarily identical, physical property. Lastly, token physicalism is weaker than reductivism, which joins the idea of token physicalism with the idea "that there are natural kind predicates," also known as entities possessing properties bound by natural law, in physics which "correspond to each natural kind predicate in an ideally completed special science" (Fodor 100). This is the burden of Fodor's argument to follow.

According to Fodor, "every science employs a descriptive vocabulary of theoretical and observation predicates such that events fall under the laws of science by virtue of satisfying those predicates" (101). Specifically, every science creates its own vocabulary to decide which events are to be considered a part of that particular science. Fodor defines natural kind predicates of a science as "the ones whose terms are the bound variables in its proper laws," that is, natural kind predicates are the events that are relevant to and whose laws are bound by the particular science (102). In other words, natural kind predicates are a necessary part of the descriptive vocabulary of the science. Fodor claims that reductivism is "too strong of a construal of the doctrine of the unity of science" because if reductivism were taken to be true, then "*every* natural kind is, or is co-extensive with, a physical natural kind" (102). For example, if reductivism were taken to be true for psychology, then every natural kind predicate of psychology is related to a natural kind predicate of physics. The previous statement is unlikely for the special sciences for the following reasons: generalizations can often be made about "events whose physical descriptions have nothing in common," whether the physical descriptions of the events considered by these generalizations have anything in common is "entirely irrelevant to the truth of the generalizations," and the special sciences produce these kinds of generalizations (Fodor 103).

Fodor considers the special science of economics to demonstrate his arguments against strong reductionism. If one is to examine monetary exchanges, for example, Fodor concedes "physics is general in the sense that it implies that any event which consists of a monetary exchange has a true description in the vocabulary of physics and in virtue of which it falls under the laws of physics" (103). Expressly, Fodor does not deny that monetary exchanges could be described within the vocabulary of physics and that, in principle, economics follows the laws of physics. Yet the problem arises with the generalization of monetary exchange. It seems unreasonable to suggest that "a disjunction of physical predicates" which includes all forms of monetary exchange events (exchanges of dollar bills, exchanges made by credit card, exchanges made by check, etc.) could express a single "physical natural kind" (Fodor 103). Fodor claims, "the reasons why economics is unlikely to reduce to physics are paralleled by those which suggest that psychology is unlikely to reduce to neurology," namely the irreducibility of the generalizations of the special sciences (104). Similar to Kim's later argument of multiple realization, Fodor states that psychological ends may be achieved through a wide variety of neurological means.

Strong reductionists have attempted to combat the multiple realization theory by suggesting that an event of the special science can be mapped to the disjunction of physical predicates. For example, our psychological event "perceiving blue" could be mapped to the neurological event of the occurrence of neural pattern A, neural pattern B, or neural pattern C. Yet when we begin to discuss the correlation between different psychological events, this all becomes convoluted. Furthermore, Fodor argues that the disjunction of physical predicates (neural patterns A, B, or C in our previous example) cannot itself be considered a natural kind predicate (109).

Fodor argues that the weaker doctrine of reductivism, namely token physicalism, "allows us to see how the laws of the special sciences could reasonably have exceptions, and, second, it allows us to see why there are special sciences at all" (110). If we wanted to preserve the special sciences as exceptionless, we could "*require* the taxonomies of the special sciences," or the classifications of the special sciences, "to correspond to the taxonomy of physics" by insisting that a distinction be made between events of the special sciences that correspond to a distinct event in physics (Fodor 112). Therefore, any specific event of the special sciences that corresponds to a specific natural kind event in physics would be classified autonomously from the other events of the special sciences. However, this distinction between particular events would erase any generalizations that the special sciences express. Therefore, we must accept physics as the exceptionless "bedrock science" and the special sciences as specialized taxonomies able to state generalizations, and thus able to have exceptions of their own (Fodor 112). It is for this reason that it is not "required that the taxonomies which the special sciences employ must themselves reduce to the taxonomy of physics" and that Fodor suggests strong reductionism is too strong a constraint upon the unity of science (Fodor 114).

Kim: Emergence Prospective

Jaegwon Kim, a Korean-American philosopher best known for his work on mental causation and the mind-body problem, describes an emergent property in terms of its supervenience and its inability to be explained or predicted ("Emergence: Core Ideas"). The supervenience proposition states: "If property M emerges from properties $N_1, \ldots, N_n$, then M supervenes on $N_1, \ldots, N_n$" (Kim, "Emergence: Core Ideas" 550). In other words, systems that have similar basal conditions must be alike in their emergent properties. It is reasonable to suggest that an emergentist would not deny that pain, for instance, would emerge if "the very same configuration of physiological events were to recur" (Kim, "Emergence: Core Ideas" 550). Regarding the mind-body problem, supervenience suggests, "mental life is wholly dependent on, and determined by, what happens with our bodily processes" (Kim, "Mental Causation" 14). Namely, the mental properties of the mind depend on the physical properties of the body.

Supervenience seems to be widely accepted among both reductionists and emergentists. However, emergentists deny that "predictability and explainability hold for an emergent and its basal conditions" (Kim, "Emergence: Core Ideas" 551). Predictability and explainability are the two main arguments for the theory of emergence. If pain is thought to emerge from a certain neural state, emergentists claim this correlation cannot be explained. Furthermore, "full and ideally complete knowledge of the neurophysiology of the brain does not suffice for prediction of conscious states" (Kim, "Emergence: Core Ideas" 551). Even if we had complete knowledge of the neural states of the brain, Kim argues that we would not be able to precisely and accurately predict which mental states would arise from each neural state. This begs the question, why do bridge laws hold? This question of explanation is a prominent argument against Nagel's use of bridge principles to justify reduction. For the emergentists, "Nagelian reduction allows the use of psychoneural correlations" (i.e. bridge principles) as "unexplained additional premises of reductive derivation" (Kim, "Emergence: Core Ideas" 552). Thus, Nagel's bridge principles cannot be scientifically explained, which affects the validity of the theory of reductionism.

Among emergentists, there are two central theories that affect understanding of the emergent properties of the mind: multiple realization and downward causation. Multiple realization, believed to refute psychophysical reductionism, describes mental states as "capable of 'realization', 'instantiation', or 'implementation' in widely diverse neural-biological structures in humans, felines, reptiles" or other organisms (Kim, "Multiple Realization" 1). That is to say, if infinitely many physical properties can realize an emergent property B, then B will not be reducible to a basic physical property (Kim, "Multiple Realization"). One of the first philosophers to explore multiple realization, Hilary Putnam claimed that "classic reductive theories of the mind" suggest that "for each psychological kind M there is a unique physical kind P that is nomologically coextensive with it" (Kim, "Multiple Realization" 4). Here, classic reductive theories of the mind suggest that each mental event has a distinct physical event in which both events cover the same entities in a lawful way. Putnam argued that this thesis, known as the Correlation Thesis, is "empirically false" (Kim, "Multiple Realization" 5). According to Putnam, if the Correlation Thesis was to be validated just for the mental state of pain, a physical-chemical state would have to be specified such that any organism could be said to be in pain if and only if its brain was in that specified physical-chemical state (Kim, "Multiple Realization"). Thus, antireductionists define mental properties as not possessing "nomically coextensive physical properties" (i.e. any mental property does not correlate to any one unique physical property) and favor the position of multiple realization (Kim, "Multiple Realization" 6).

The theory of downward causation assumes that emergent properties have their own "distinctive causal powers," or powers to affect other properties, and are able to "exercise their causal powers downward," meaning to the lower levels from which they emerge (Kim, "Making Sense" 19). Keeping the layered model of the scientific world in mind, three types of causation occur: same-level, downward, and upward. Same-level causation involves relationships between two properties at the same level, downward causation arises when a higher-level property causes the "instantiation" of a lower-level property, and upward causation arises from a lower-level property causing the instantiation of a higher-level property (Kim, "Making Sense"). If we are to assume that the "causal powers of mental properties are novel, and irreducible to the causal powers of the physical properties," then we are forced to find causal powers of the emergent property that are not causal powers of the "physical and biological properties from which it emerges" (Kim, "Downward Causation" 135). Therefore, by the theory of emergence, mental properties must have novel causal powers. According to Kim, "these powers must manifest themselves by causing either physical properties or other mental properties" ("Downward Causation" 136). However, if a mental property causes another mental property, "the only way to cause an emergent property to be instantiated is by causing its emergent base property to be instantiated" (Kim, "Downward Causation" 136). This combination of upward determination and downward causation remains a paradox within the emergentist conception of mental causation.

Kim presents the mind-body problem as the "relationship between mind and matter," primarily the interconnection of mental causation and consciousness ("Mental Causation" 1). Kim claims that mental causation is key in that "the possibility of human agency, and hence our moral practice, evidently requires that our mental states have causal effects in the physical world" ("Mental Causation" 9). It seems reasonable to suggest that our mental desires, beliefs, and decisions must manage to cause our physical bodies to change in the appropriate fashion, as shown in our ability to "find food and shelter, build bridges and cities, and destroy the rainforests" (Kim, "Mental Causation" 9). Yet how can we begin to justify that these mental properties, indeed, have a causal effect on physical properties?

The theory of reductionism naturally suggests that mental properties can be reduced to their physical basal properties, and through this reduction process, their physical causal effects are identified. Kim attempts to deny the reductionist theory of the mind by focusing his arguments on the mental state of pain ("Mental Causation"). According to Kim, to reduce pain, it must first be functionalized, that is, it must be shown that "being in pain is definable as being in a state that is caused by certain inputs and that in turn causes certain behavioral and other outputs" ("Mental Causation" 24). By way of explanation, functionalism states that to be in pain is to have a certain internal state that performs a certain function, or job. In the case of pain, it can be said that pain is the state that is activated by bodily damage and causes a physical reaction, like a scream, for instance. Once functionalization is accomplished, the realizers, or the "states or properties that satisfy the causal specification defining that mental property," must be identified (Kim, "Mental Causation" 24). Kim does not refute the existence of realizers for mental properties, but does refute the possibility of functionalizing mental properties ("Mental Causation"). Kim believes that "phenomenal properties of consciousness," also known as qualia, "are not functional properties" ("Mental Causation" 27). Because Kim declares qualia to be non-functional properties, he states that "qualia are functionally irreducible" and therefore emergent ("Mental Causation" 27). Since mental properties are not functionally definable, mental causation remains unexplainable for phenomenal mental properties (Kim, "Mental Causation"). According to Kim, "the functional irreducibility of consciousness" necessitates that both the problem of consciousness and the problem of mental causation remain unsolvable. Consciousness cannot be defined in terms of its causal relations and mental causation cannot explain consciousness (Kim, "Mental Causation"). This dependence relation is a major area of perplexity in the theory of emergent properties of consciousness.

Churchland: Defense of Reductionism

Patricia Churchland, noted for her contributions to neurophilosophy and the philosophy of mind, has developed two general positions for those who deny the possibility of reduction. The first class of arguments against reductionism claims that "the human brain is more complicated than it is smart, and hence neuroscience cannot hope, even in the long run, to fathom the mystery of how it works" (Churchland 315). Since this argument is empirical, Churchland focuses on refuting the second set of arguments against reduction, which is advanced by those who "find principled reasons for skepticism, deriving for example from the nature of subjective experience or from the fact that some mental states have meaning and significance" (316). Churchland refers to those who advance arguments of this type as "principled skeptics."

Arguments defending principled skeptics fall into two distinct categories. The first category holds the position that "there is a distinctive mental dimension that is not reducible to anything physical" (Churchland 316). Substance dualism claims this irreducible mental dimension "harbors a separate mental *substance* such as a nonphysical mind or soul," whereas property dualism states this mental dimension is "limited to nonphysical *properties* of the physical brain"

(Churchland 316). The second category of arguments defending a principled skepticism of reductionism focuses on the "hypothesis that generalizations of psychology are *emergent* with respect to the generalizations of neuroscience and that mental states and processes constitute a domain of study *autonomous* with respect to neuroscience" (Churchland 317). Antireductionist arguments of this type are considered functionalist and can be seen throughout the work of Fodor.

Substance dualists hypothesize that mental states are not states of the brain, but instead are of a different substance altogether. Churchland argues that a clear problem for substance dualists is the "nature of the interaction between the two radically different kinds of substance" (318). In other words, how can two distinct substances have such an interconnected relationship? According to Churchland, mental states are not independent from the processes of the brain considering "reasoning, consciousness, moral feelings, religious feelings, political convictions, aesthetic judgments, moods, even one's deep-seated personality traits—all can be affected if the brain is affected by drugs or by lesions, for example" (319). This clearly shows that the mental dimension of the mind must have a level of dependence on the brain. Evolutionary biology further diminishes the plausibility of substance dualism. If we assume that humans have evolved from earlier mammalian species, then how can we explain the origins of the nonphysical mental dimension? At what point did the nonphysical mental dimension of the mind arise from the physical dimension of the brain?

Unlike substance dualism, property dualism accepts the mental dimension as a physical substance, yet is based on the conviction that "even if the mind is the brain, the qualities of subjective experience are nevertheless emergent with respect to the brain and its properties" (Churchland 323). For property dualists, subjective experiences have uniquely mental qualities that are irreducible. In line with the emergentist argument, brain states are "causally connected to subjective experience" but the subjective experience itself cannot be reduced to "some process or aspect of neuronal activity" (Churchland 325). For example, property dualists would claim that the "blueness" of water is an emergent property with respect to the physics of H_2O molecules on the basis that the character of "blueness" cannot be predicted from any microphysical information. Churchland argues that "reduction does not require that reduced properties, as conceived within their older conceptual framework, be *deducible* or *predictable* from within the new reducing theory" (325). That is, the reduction of certain properties may require the adaptation of new theories that solely have the obligation to recognize the existence of properties that mimic the causal powers of the reduced properties, not to be predictable. Furthermore, the physics of H_2O molecules does entail that electromagnetic radiation of "liquid aggregates" will scatter at a wavelength that expresses the causal powers of "blueness" at the physical level (Churchland 326).

Functionalist arguments, considered to be the most sophisticated arguments of antireductionists, consider categories of folk psychology as "fundamentally correct for characterizing mental states" and that these categories not only "delimit *intentional* states and *logical* processes" but also "will not reduce to categories at the neurobiological level of description" (Churchland 349). Functionalism is oriented around the thesis that mental states are "defined in terms of their abstract causal roles" (Churchland 351). The functionalist theory aligns with physicalism in its concession that mental states are implemented at the neurological level. Yet functionalists have generally rejected reductionism on the basis that mental states have no single unique physical state identical to the type of mental state, but rather have multiple material realizations.

Churchland suggests that the functionalist view of multiple instantiation incorrectly classifies the aim of reductionism. The temperature of gases was found to "reduce to the mean kinetic energy of the constituent molecules," that is, the temperature of gas *is* the mean kinetic energy of the constituent molecules (356). But as Churchland argues, it was solely the temperature of *gas* that was found to reduce, which demonstrates that "reductions may be reductions *relative to a domain of phenomena"* (357). Thus, the "mere fact that there are differences in hardware has no implications whatever for whether the psychology of humans will eventually be explained in neuroscientific terms" and "that reductions are domain-relative" does not mean that psychology can justify autonomy from neuroscience (Churchland 357). In other words, reductions may be distinctive in their particular domains, implying that multiple instantiations or generalizations do not need to be reduced in the same manner, like with the example of the temperature of gas.

Besides multiple instantiation, another key argument of functionalists relies on the "distinction between *logical/meaning* relations and causal relations" (Churchland 376). According to functionalism, mental states have content, are intentional, and "form a *semantically coherent* system, as opposed to a *causally interconnected* system" (Churchland 377). That is, mental states have *meaning*. Thus, the problem of reduction lies in the intentionality, or meaning, of mental states. Mental states are claimed to have intentionality because "categories of psychological theory will radically cross-classify the categories of neurobiological theory," meaning that mental states can have distinctive realizers, "and consequently neurophysiological generalizations will miss entirely important relations describable only at the level where representations are referred to" (Churchland 378). In other words, psychological generalizations cannot be explained with neurophysiological explanations.

Zenon Pylyshyn presents an example to better understand this claim. Suppose someone believes there is a fire in his or her building. This belief is a certain mental representation that can be realized in multiple ways. Belief that there is a fire in the building could be realized by smelling smoke, seeing flames, feeling a hot doorknob, hearing a fire detector, etc. Given that each of these "neurophysiological realizations are distinct, the neurophysiological generalizations will not capture what is similar in each of these instances"—that is, that each of these instances correlates to the belief that there is a fire in the building (Churchland 379).

Churchland attacks the concept that generalizations cannot be explained in "terms of causal relations between neurobiological states" (380). In reply to Pylyshyn's example Churchland claims, "If there really is a commonality of psychological state in the heads of all who come to believe there is a fire in the building" then it is expected that "*at some appropriate level* of neuropsychological organization, this commonality corresponds to a common neurobiological configuration" (381). By the mere existence of a common psychological state among the multiple brains of those who believe there is a fire in the building, there must exist such a correlation at the neurobiological level as well. Churchland continues by suggesting that the common evolutionary history of all brains would imply that "unless the psychological level is indeterministic" (which is an unpopular theory among both reductionists and antireductionists), it should be possible to explain psychological states neurobiologically (381).

Churchland argues that antireductionists are overconfident about the integrity of psychology as a reputable science when they state that neuroscience cannot explain generalizations of psychology. In other words, psychology should be considered in terms of its conceptual usefulness rather than its scientific autonomy. Furthermore, Churchland claims that if no explanation of psychological states by neuroscience can be achieved, then this may imply that "folk psychology is radically misconceived" (384).

Concluding Remarks

Given the various theories surrounding reductionism and emergence, how then can we attempt to define the mind? As has been previously discussed, ontological reductionism is the belief that reality is composed of a minimum number of physical kinds of entities and substances, and in effect claims that all objects, properties and events are reducible to a physical substance. Ontological reductionism may be classified as two distinct forms: token physicalism and type physicalism. The latter suggests that every specific scientific type of item can be reduced to similar types of items at a lower level complexity. In the instance of the science of psychology, type physicalists, like Churchland, claim that mental states *are* neurophysiological states. I believe that type physicalism is too strong of a constraint on science to be considered empirically plausible and instead uphold the former classification of ontological reductionism, or token physicalism. In contrast to type physicalism, token physicalism holds that every scientific type can be identified with some physical type. A token physicalists argues that in the case of psychology, mental states correlate to particular physical states, but that the mental and physical states cannot be said to be identical.

As a token physicalist, I do not believe the theory of ontological emergence, which asserts that entirely new and ontologically distinct scientific levels arise, characterized by their unique causal forces, and preserve their own laws or regularities. Yet a clear argument may be made for the necessity of epistemological emergence. Epistemological emergence validates the autonomy of psychology by specifying that analysis and description of a system at the level of a special science, like psychology, cannot be reduced to descriptions and analysis at a lower level science, like neuroscience. As Fodor suggests, “there are special sciences not because of the nature of our epistemic relation to the world, but because of the way the world is put together: not all natural kinds are, or correspond to, physical natural kinds” (113). In other words, the generalizations that form at the level of our mental states cannot be explained at the neurobiological level. It is my aim to demonstrate that Fodor’s argument of generalizations at the level of psychology can be further developed to argue for the necessity of epistemological emergence in practice. For the purpose of communication and societal representations, psychology is autonomous and therefore, cannot be reduced to neurology in practice.

Even if we are to concede to the type physicalist and adhere to Churchland’s argument that any mental state, like pain for example, *is* in fact a neurobiological state, this does not deny the autonomy of psychology in practice. Suppose we have come to a level of intelligence where we completely understand the neurophysiology of the brain. That is, we have complete understanding of neuroscience and the neurobiological processes that correlate to all of our mental states. If we were to eliminate psychology as an autonomous science and instead solely practice neuroscience, this would be impractical. To begin, if we are to take into consideration the argument of multiple realization, each individual human would have to learn his or her unique neurobiological relations that correspond to each of his or her mental states. For example, given complete understanding of neuroscience, I could know that in my specific brain, pain correlates to the occurrence of either neural pattern A, neural pattern B, or neural pattern C. While we can begin to see the complexity that arises within individual brains, the denial of psychology as an autonomous science becomes even more convoluted when considering relations between more than one brain. Take for example that my neurobiological correlates of pain, as I have stated earlier, are different from Mary’s neurobiological correlates of pain. How can we then conceive of effectively communicating generalizations at the neurobiological level when our mental realizers for pain are distinct?

Let us first consider the necessity of psychology in practice at the individual level, that is, communicative representations of mental states pertaining to one unique brain. If we temporarily disregard the argument of multiple realization for simplification purposes, say that in my brain it has been proven that when I experience the mental state of anger this correlates to the neurophysiological state of the occurrence of neural pattern F. Yet the mental state of anger has multiple distinct communicative contexts. For example, anger can be triggered as the result of the occurrence of grief, tiredness, pain, humiliation, failure, and even traffic jams or financial problems. Each one of these triggers (grief, tiredness, pain, etc.) has a unique neurophysiological correlate, and the triggers may be completely unrelated to each other at the neurobiological level. Grief may correlate to the neurophysiological state of the occurrence of neural pattern X, while tiredness may correlate to the neurophysiological state of the occurrence of neural pattern C. How can we then find patterns and generalizations for the mental state of anger at the neurobiological level when anger in my brain can have multiple distinct triggers (neural pattern X, neural pattern C, etc.) that all result in the occurrence of neural pattern F? It becomes clear that communication of these patterns and generalizations requires a level of abstraction that psychology provides as an autonomous science.

Furthermore, there are different gradations of anger, all of which provide a necessary function for effective communication. Terms such as *enraged*, *furious*, *irritated, displeased, etc.* all reside on a spectrum of the varying degrees of anger. If we were replace any one of these gradations of anger with its corresponding neurophysiological state, then there is no guarantee that we would still be able to make generalizations about the spectrum of anger as a whole. For example, how are we supposed to notice the subtle difference between *irritated* and *displeased* if their respective neurophysiological correlates are not only distinct, but also seemingly unrelated? Thus, communicating at the neurobiological level instead of the psychological level is not a viable option if we are to maintain a sufficient level of communication.

The communicative representations and relations of mental states when discussing more than one brain further develops the essentiality of epistemological emergence in practice. Given the sophisticated nature of the human race, we have developed certain relationships among different mental states that cannot be expressed at the neurophysiological level. As an illustration, it is commonly understood that the occurrence of the mental state of anger may lead to the followed occurrence of the mental state of remorse. This is an established pattern in our society as a result of observation and development of generalizations. Now if we are to assume that the argument of multiple realization is true, communication of this particular pattern becomes difficult, if not impossible, at the neurobiological level. Suppose that in my brain, anger correlates to the occurrence of neural pattern F and remorse correlates to the occurrence of neural pattern G. In Mary's brain, anger correlates to the occurrence of neural pattern X and remorse correlates to the occurrence of neural pattern Y. Even with complete knowledge of neuroscience, reducing psychology to neurology would forfeit representational communication. If I were to communicate to Mary that I had just had the occurrence of neural pattern F followed by the occurrence of neural pattern G, this would not only be irrelevant to her specific brain, but would also have no significant communicative context. Thus, it seems clear that in the case of both individual and societal representations, psychology is fundamentally necessary for effective communication.

The mind-body problem "has been that of finding a place for the mind in a world that is fundamentally and essentially physical" (Kim, "The Mind-Body Problem" 169). If we are to consider Fodor's concept of token physicalism as a foundation for the discussion, mental properties require a physical basis. However, given the irreducibility of mental generalizations and the sophistication of our communication, the mind can be argued to be irreducible to the brain in practice. Why is it that we are still invested in understanding our mind? Perhaps our investment is due to our human nature to search for knowledge and understanding. Or perhaps it is simply because the mind-body problem is one of the few phenomena that we may never truly grasp, considering our knowledge is and of itself within the scope of the mind. The brain may indeed be more complex that it is smart, in which case the mind-body problem will never be resolved. By continuing to attempt to define the mind in relation to the body, we advance our understanding of the limits of science and perhaps even begin to reach the limits of that which we can understand.

Bibliography

Churchland, Patricia Smith. *Neurophilosophy*. Massachusetts: MIT, 1986. Print.

Culp, John. "Panentheism." *Stanford Encyclopedia of Philosophy*. Stanford University, 04 Dec. 2008. Web. 07 Feb. 2016.

Fodor, J. A. "Special Sciences (Or: The Disunity of Science as a Working Hypothesis)." *Synthese* 28 (1974): 97-115. Web. 20 Feb. 2016.

Kim, Jaegwon. ""Downward Causation" in Emergence and Nonreductive Physicalism." *Emergence or Reduction? Essays on the Prospects of Nonreductive Physicalism*. Berlin: Walter De Gruyter, 1992. 119-38. Print.

Kim, Jaegwon. "Emergence: Core Ideas and Issues." *SpringerLink*. N.p., 09 Aug. 2006. Web. 12 Mar. 2016.

Kim, Jaegwon. "Making Sense of Emergence." *SpringerLink*. N.p., n.d. Web. 20 Feb. 2016.

Kim, Jaegwon. "Mental Causation and Consciousness." *Physicalism, or Something Near Enough* (2005): n. pag. Princeton University Press, 2005. Web. 12 Mar. 2016.

Kim, Jaegwon. "Multiple Realization and the Metaphysics of Reduction." *JSTOR*. International Phenomenological Society, 1992. Web. 12 Mar. 2016.

Kim, Jaegwon. "The Mind-Body Problem: Taking Stock after Forty Years." *The Place of Mind*. Belmont: Wadsworth/Thomson Learning, 2000. 168-86. Print.

Ney, Alyssa. "Reductionism." *Internet Encyclopedia of Philosophy*. N.p., n.d. Web. 07 Feb. 2016.

O'Connor, Timothy. "Emergent Properties." *Stanford Encyclopedia of Philosophy*. Stanford University, 24 Sept. 2002. Web. 07 Feb. 2016.

Rae, Alastair I. M. *Quantum Physics: Illusion or Reality?* Cambridge: Cambridge UP, 1986. Print.

Riel, Raphael Van. "Scientific Reduction." *Stanford Encyclopedia of Philosophy*. Stanford University, 08 Apr. 2014. Web. 07 Feb. 2016.

Silberstein, Michael. "Reductionism, Emergence and Explanation." *The Blackwell Guide to the Philosophy of Science*. 1st ed. Massachusetts: Blackwell, 2002. 80-107. Print.

Defining Science

Evan Rapone

It is perhaps a great irony that while science has provided us with an impressive advancement in knowledge, we have difficulty understanding and defining science itself. In one respect, this could seem unimportant. As long as we continue the effort toward discovery in the natural world, why bother defining the term? A lack of a concrete definition does not impede our ability to perform scientific investigations. Beyond that, even if one accepts the importance of defining the term, why shall we struggle with demarcating it? Why not define science so broadly that most learning practices can be considered scientific? Or, why not establish a straightforward definition and not question what could be considered science? Let us assume we construct a definition that omits thought experiments from being considered scientific. Is there even any point in debating its scientific relevance so long as our thought experiment is still revealing and informative?

Contrary to popular belief, there *is* a reason for defining science as well as understanding the scope of that definition. While it is premature to definitively explain why this task is significant—mainly because a number of perspectives will be introduced that will consider the importance—I understand the necessity for at least a preliminary answer. Defining science is important to ensure that the distinction between true science and pseudoscience is clear and demarcated.

Regarding the term "pseudoscience," it cannot exactly be defined as "not-science," but rather as "almost-science." Pseudoscience superficially appears to be science, in that it takes into account observation, evidence, hypothesizing, etc., yet its underlying methodology lacks legitimacy and sound reasoning (Schembri 6). Take, for example, cryptozoology, the study of fantasy creatures like Big Foot and the Loch Ness Monster. Cryptozoological researchers make a claim that some particular creature exists, gather evidence that supports the claim, and conclude with a result that justifies its existence. However, are they really performing science? Not exactly.

In a general sense, I seek to define science. Such a task will entail a comprehensive review and analysis of some significant definitions, considering their benefits and shortcomings. Through this discussion, I will also address some related and more fundamental issues regarding the difficulty and necessity of defining science. These questions have proven difficult for some of the most noted scientific and philosophical thinkers, but perhaps by examining their work in comparison to that of others we will be able to arrive at a concrete definition.

Initial Assumptions

In the introductory paragraph I made the assumption that science deals with the natural world and our understanding of it. Perhaps that seems too restrictive of a criterion to begin with, but let us consider the magnitude of the natural world. Nature is everything around us. While we live in man-made structures and use man-made objects, these are comprised of elements of the natural world. In that sense, the concept of the natural world was incorporated to provide clarity that science would pertain to everything that physically exists.

Additionally, the words "understanding" and "knowledge" have been used frequently up to this point, which is necessary and has been assumed to be valid. I am sure it is easy to see why comprehension is an integral component of science. The mere presence of nature does not validate the existence of science; rather, it is how we observe and explore the natural world that constitutes science. Beyond this point, that is as far as we can go in terms of establishing an elementary definition for science without beginning to dissect the literature on the topic. Methodology, aim, purpose, and scope all appear relevant to include, but perhaps not uniformly. As a result, we cannot definitively claim that words such as "hypothesis" or "observation" can be assumed to be in the definition. While supposing explanations or witnessing evidence would seem to be characteristic of science, we will later see that perhaps science can occur without them. Thus, we shall continue with the framework that science has something to do with the natural world and incorporates our knowledge.

Godfrey-Smith's Three Components of Science

With a skeleton of a definition in place, we can begin to consider more concretely what should be encompassed in a discussion of science by examining the work of Peter Godfrey-Smith in *Theory and Reality: An Introduction to the Philosophy of Science*. This is not to say that every valid definition of the term will incorporate the components he mentions; however, they are necessary for understanding definitions of science as well as motivations for defining it. As Godfrey-Smith states, there are three recurring themes in attempts to demarcate science: empiricism, mathematics, and social structure. Let us examine each of the three and how they interact with each other.

To begin, empiricism is the idea that all of our knowledge can only come from our experiences via the senses. The consideration of all knowledge—as opposed to just scientific—implies that the means by which we acquire general knowledge is exactly the same as the means by which we acquire scientific knowledge. Empiricism, though, does not state that they are identical. Numerous distinctions between the two exist: scientists work more thoroughly than nonscientists to develop greater detail in knowledge, they work more systematically and with better organization, and they prioritize connecting the knowledge to other aspects of the natural world.

The next component involved in the discussion of science is mathematics. Considering the breadth of what the discussion would entail, I seek not to define mathematics here, but rather to acknowledge the role it plays in science. For example, mathematics can be used to derive equations that we use to describe nature or it can be considered a useful fiction that, while it may not be used as direct support for a scientific claim, can be utilized to assemble our understanding of the natural world into a working model. Either way, mathematics can certainly be used to reveal something about nature.

Finally, social structure plays a pertinent role in discussing science. While significant experimentation and inquiry takes place on the individual or local level, science tends to incorporate a network of communication between scientists. Most, if not all, fundamental scientific discovery requires some form of collaboration and confidence in the work of other scientists. No singular person can possess such a complete enough understanding of the natural world that he or she can progress through scientific research in the absence of verification from peers.

Reflecting on Godfrey-Smith's components, I imagine there is a sense of confusion in the specifications of the elements, mostly because they appear to contradict each other at times. For example, how can empiricism and mathematics coexist in a logical definition of science? Empiricism states that only our senses provide true knowledge while a consideration of mathematics would imply that our experiences are only *one* form of gaining knowledge. Additionally, how can empiricism cooperate with social structure? Social structure by definition incorporates a level of trust in others whereas empiricism would reject that basis for understanding. That is not to say that an empiricist is cynical, but that perhaps social structures ought to be questioned. Furthermore, how is empiricism feasibly possible? Individuals cannot directly experience everything about science. In that sense, empiricism could be valid, but only on a small scale. For example, if I drop a ball, I see it fall to the ground and, based on my own experience, can state that some sort of attraction exists. On that basis, at the local level, I am correct. But that is not a complete enough picture. What my experience does not tell me is that *any* objects can have a gravitational force between them and *both* move to meet each other. I do not witness the Earth moving closer to the ball as the object falls, but does that mean it is not happening? An empiricist would argue yes, while an individual who prioritizes social structures or mathematics might argue no. But, in the same light, is it naïve to believe something that cannot be witnessed? The formula for gravitational attraction is clear and concise but might do little to convince someone of the existence of physical attraction between objects. Likewise, my professors can teach that all objects produce some sort of gravitational force, but if they cannot provide a demonstration I am only accepting their word.

Contrarily, there are plenty of ways in which these components can effectively *combine* to present a definition of science. Mathematics, when taken as a useful fiction, can be used to validate that the experiences of an individual are not a fluke or sporadic. Likewise, social structures can combine with empiricism to allow individuals to conduct various experiments on their own and then collaborate to analyze results. In any case, the three themes involved in defining science will appear in various ways and, in order to understand the logic behind the definitions, it is vital to comprehend the varied manner in which the components will appear and affect our interpretation of science. The contradictions and intermingling of these three core components will help discern one definition from another.

Logical Positivist Approach

The first definition of science to discuss is one that a logical positivist would put forward. Logical positivism, otherwise known as logical empiricism, is difficult to confine to a concrete definition but can be taken as a form of empiricism that prioritizes experimental evidence. A central basis for this perspective is that the meaning of a statement is its method of verification (Schlick et al. 201). Coinciding with these views is a theory of language that covers two primary ideas, the analytic-synthetic distinction and the verifiability theory of meaning (Godfrey-Smith 25). The analytic-synthetic distinction, presented by Kant, discusses the dichotomy between analytic statements that are true or false based on meaning and synthetic statements that are true or false based on meaning *and* reality. An example should clarify the difference. "A square has four sides" is analytic because it will always be true. Alternatively, "I drew a square" is synthetic because its truth requires that I drew one. The other concept, the verifiability theory of meaning, relates directly to the central notion that meaningful statements require verifiability (Godfrey-Smith 27).

We now possess the framework for thinking in the realm of logical positivism and an understanding of the approach to science advocated by the movement. As discussed, logical positivism relies heavily on experience, however, logical positivists would feel comfortable involving mathematics in their definition due to the analytic-synthetic distinction. While they would not accept mathematics as a source of knowledge, they could easily classify it as analytic with the implication that the reality of the natural world is irrelevant to the validity of the statement (Rey). Thus, we can utilize mathematics in synthetic statements when applicable, for example by claiming that the applied force on an object is equivalent to its mass multiplied by the resulting acceleration. The mathematics itself means nothing in terms of the natural phenomenon, but we can use the language of mathematics to describe what we believe to be true.

While logical positivism does not tend to incorporate the idea of social structure, it does present a significant stipulation for defining science. To define science by the standards of a logical positivist, the idea of verification, particularly based on observation, is vital. The term "verification" is used to denote that any sort of scientific claim can be tested and determined as true or false via observation. This is not to say that the *experimentation* has to always be verified in practice—that could be immensely difficult—but that the theory can be confirmed or denied (Godfrey-Smith 27).

With the basis of how a logical positivist would approach science, we can begin to understand a potential definition for it:

> *The process of making falsifiable predictions about the natural world based on past experiences.*

Verification implies prediction; if one can reproduce an experiment, then one should expect to see similar outcomes. The quest for predictability is precisely what every scientist should pursue (Godfrey-Smith 29). Additionally, the term "falsifiability" has been added for concision since verification to a logical positivist implies that something can be wrong, but this is discussed in greater detail below.

Thus, we have our first concrete definition of science. Before moving to another we shall dissect this one and look for potential flaws. First, the prioritization of predictability, while important, limits the definition. Predictability implies the previous existence of something, which implies that the logical positivist definition of science would seem to ignore the possibility of new discoveries. As Godfrey-Smith states, the theorizing of hidden structures in the natural world is a core part of what most people consider to be scientific (36). The logical positivist definition does not account for that discovery. Any statement hypothesizing something in the natural world that may not exist would have no meaning according to logical positivism: it surely is not analytic, and would only be considered synthetic if we could observe it, implying we would have no issue if that were true.

Alternatively, for any observable experiment, the idea of verifiability comes into question when considering the reality of our natural world. The idea of verification is idealistic; it does not consider the whole environment of an experiment and only prioritizes confirming or denying the claim itself. Thus, it implies isolation, which is not possible in the real world. Assumptions are required to be able to test claims, but if a claim fails, one cannot immediately verify whether the claim itself is wrong or an assumption has caused the experiment to fail (Rey). As a result, we see that the definition of science from a logical positivist stance has merit and encompasses critical ideas of predictability and falsifiability, but it appears overly idealistic.

Hypothetico-Deductivist Approach

We shall now consider another perspective on science, that of a hypothetico-deductivist. Hypothetico-deductivism is the belief in a compact scientific method, similar to those taught in elementary science courses. While these procedures can vary greatly across fields, a general notion of the method involves hypothesizing about some aspect of nature, determining new observational predictions based on the hypothesis, and verifying the predictions are valid. In a more condensed view, hypothetico-deductivism is "the idea…that a hypothesis is confirmed when it can be used to derive true observational predictions" (Godfrey-Smith 236). This perspective works well after discussing logical positivism as it builds on the idea of falsifiability, which we have already designated as valid, but also reconsiders the notion of predictability. We will define the concept of "prediction" in contrast to "predictability" because—since we are not in the scope of empiricism—the terms will take on alternative meanings.

While the distinction between "prediction" and "predictability" might seem like a semantic issue, I believe highlighting the contrast is necessary. A logical positivist's concept of "predictability" implies repeatedly performing the same experiment and expecting the same result. A hypothetico-deductivist's concept of "prediction" relies on theorizing and hypothesizing. When put more simply the difference is clear, predictability requires previous experience and prediction does not (Ehrenberg et al. 191). In effect, we are justified in continuing with our rejection of predictability in favor of prediction, a key component to any discussion of the scientific method.

As with the previous perspective, let us now establish legitimacy for the hypothetico-deductivist viewpoint prior to examining a potential definition for it. While the case can be made for the scientific method in the context of longevity—the procedure has been taught for quite some time to aspiring scientists of all fields—we shall focus on more substantive arguments. In his article, "The Fixation of Belief," Charles S. Peirce examines numerous benefits of the scientific method with one of the most prominent ones being the efficient progression from the known to the unknown. Unlike logical positivism, hypothetico-deductivism includes references to hidden structures and other natural concepts of which we may not be familiar. The scientific method provides for a logical transition in which we hypothesize an unknown concept or natural phenomena based on what we believe we know. We can consider Peirce's notion of abduction to clarify this concept. The abductive type of logical reasoning allows for an individual to make sense of an observation by guessing a theory that could account for it. While the process of abductive reasoning appears to be reverse deductive reasoning, it is important to distinguish it from deduction. Abducing an explanation for an observation does not mean that it guarantees the observation. Rather, abduction works as a starting point to introduce new ideas (Frankfurt 597).

Furthermore, Peirce explains that the use of the scientific method eliminates bias or other external influences on scientists (11). With a designated protocol to follow, scientists will display uniformity and consistency in their investigations. Summarized by Peirce, the scientific method allows us to discover:

> Real things, whose characters are entirely independent of our opinions about them; those Reals affect our senses according to regular laws, and, though our sensations are as different as are our relations to the objects, yet, by taking advantage of the laws of perception, we can ascertain by reasoning how things really and truly are; and any man, if he have sufficient experience and he reason enough about it, will be led to the one True conclusion. (10)

Peirce acknowledges that, in contrast to empiricism, we can hold beliefs that lack experimental basis, which could allow for discord among scientific communities over certain phenomena. However, effectively employing the scientific method will lead us to a better understanding of reality, which we can then compare to our opinions. Therefore, we can maintain confidence when utilizing the scientific method since it shall be crucial in ensuring our beliefs coincide with our understanding of nature. To quote Peirce, "no doubts of the method…arise from its practice" (10).

Given the basis for using a general scientific method, let us look more broadly at what a hypothetico-deductivist believes. As implied by the scientific method, hypothetico-deductivism considers falsification and logical reasoning. Hypothetico-deductivism also works as a compromise between empiricism, which I have discussed, and theorization, which I will discuss. Theory prompts the creation of a hypothesis and experimental evidence ensures the validity of one, resulting in a symbiotic relationship between two concepts that can be treated as wholly different. Additionally, a more subtle point about this approach, hypothetico-deductivism includes a dismissal of pseudoscience, which was originally noted as a problem in the introduction. Any type of hypothesis could be created (e.g. "God exists"), but without a scientific means of testing the hypothesis the scientific method could not be used and thus the theory would not be considered scientific. Considering all of this, we can construct a possible definition of science for the hypothetico-deductivism approach:

> *The methodological process of creating a testable hypothesis about nature, performing experiments based on the hypothesis, and evaluating data and observation to understand the validity of the hypothesis.*

Not surprisingly, the definition is derived from the notion of the scientific method.

Let us now scrutinize this definition. To begin, while the hypothetico-deductivist approach attempts to account for bias, there are two ways in which it falters. First, Peirce assumes that scientists will immediately denounce any opinion that contradicts experimental evidence. Contrarily, the complete rejection of observation in favor of a yet-to-be-proven theory occurs with some frequency and can also lead to more accurate theories. Second, humans are susceptible to subconscious bias; even if the scientific method was completely valid in its current form, it could never entirely be accepted because those who perform the procedure, humans, are imperfect and have individual beliefs and preferences (Baumgardner). If we consider the concept of the procedure itself, the scientific method is highly idealistic. The belief that all science exists in clearly defined, multistep processes misrepresents the complexity of the processes involved and creates an unrealistic standard (Blachowicz 306). Scientific research is unpredictable, creative, and revisionary, despite the fact that the scientific method implies that it is rigid, directed, and one-dimensional.

Apart from this criticism, perhaps we should not entirely dismiss the scientific method. While the adherence to a rigid procedure of scientific discovery skews the general investigation of nature, the foundation of the method—critical thinking and analysis—has merit and should be considered. What the scientific method *does* aid with is providing a means by which we think and approach problems (Bauer 149). The specifics of these types of analyses varies across fields, but the general pursuit of knowledge promoted by the scientific method will be integral to our consideration of a definition.

Theorist Approach

As described by Henry Bauer in his *Scientific Literacy and the Myth of the Scientific Method,* a prioritization of theory is essentially the opposite of the logical positivist approach (25). For theorists, theories can be postulated and supported by logical calculations; thus, experimentation is only useful insofar as it agrees with the accepted theory. As such, it could be acceptable to reject experimental outcomes in favor of, for example, a mathematical method. Certainly, in the context of our previous perspectives, this concept seems contradictory to the notion of science we have been discussing. Perhaps, we should consider the implications of theorizing in science.

As mentioned earlier, Godfrey-Smith presents the notion of hidden structures that we could not otherwise perceive without first predicting that they exist. Let us look at an example to see the applicability of this concept. Recently scientists detected gravitational waves, which had been theorized by Einstein in his theory of general relativity roughly one hundred years before their discovery. As our understanding of the universe has expanded over time, the concept of gravitational waves was accepted as true based on calculations, but up until recently we lacked actual observation of them. Armed with evidence, scientists can definitively claim that Einstein's theory is correct and that the tendency to accept the concept of gravitational waves in fields such as astrophysics was justified based on the accuracy of the calculations.

We can take the argument in favor of theorizing even further. Consider, for example, the work of Bas van Fraassen in *The Scientific Image*. Without diverging too much into his discussion of whether science is true or can be accepted as empirically adequate, van Fraassen presents the notion of constructive empiricism in which scientists should only use theories to explain the *observable* aspects of the world (12). While it is entirely possible that unobservable realities could also be addressed by the theory, such an interest is not scientific. Therefore, scientists would accept theories only if they are empirically adequate. As such, van Fraassen's description of constructive empiricism would not include the theorizing of hidden structures as legitimate science.

There are two primary reasons why this notion is incorrect. First, if we consider observability in general, we need to distinguish between "detectable" and "observable." The former would be true for an atom while the latter would be true for the page on which these words appear. While both imply observation, detectability could refer to an image of something being observed. Take an atom as an example. When using an electron microscope, we are not observing the atom itself but rather an image of it. While we feel confident in our observation of the image, we need to acknowledge that we cannot *observe that* something is an atom (Contessa 465). Thus, the vague treatment of observability in van Fraassen's constructive empiricism does not account for this distinction. Also, recalling the discussion of isolation, we need to acknowledge that the belief that only one thing is observable does not make sense; if we consider something observable, it requires that all properties associated with it are observable as well, which almost never happens (Contessa 467). To clarify this, let us consider the universe. We believe in the existence of the Earth, the Moon, the Sun, etc. but are we not to believe in distant stars that are presently unobservable? Constructive empiricists would consider the belief in these stars to be as valid as the belief in atoms, which is problematic. For these reasons, we can state that van Fraassen's notion of constructive empiricism does not provide an adequate rationale for relying on observability.

Furthermore, the simplification of the observable versus unobservable dynamic implied by constructive empiricism could sporadically change as other new discoveries are made; what we consider unobservable today might be observable tomorrow. We would not be as confident with our knowledge of the unobservable as we would be with the observable—which is a completely valid point made by van Fraassen—but there is not sufficient justification for *entirely* dismissing the scientific nature of exploring hidden structures:

> As we learn about the world, we also learn more and more about which parts of the world we can expect to have reliable information about. And there is no reason why science should not try to describe all the aspects of the world that we can hope to gain reliable information about. As we move from one area to another, we must

> often adjust our level of confidence. Sometimes, especially in areas such as theoretical physics, which are fraught with strange puzzles, we might have reason to adopt something like van Fraassen's attitude, at least temporarily. But it is a mistake to think that empirical adequacy of van Fraassen's kind is the aim of science. (Godfrey-Smith 186)

Reflecting on the previous discussions, we can now confidently discuss definitions of science in the context of a theorist's beliefs.

Considering how a theorist would approach science, we can state that an example definition from the field would be:

> *The process of understanding the natural world around us; while experimentation and observation may agree with developed theories, they are not required.*

Probably the most striking aspect of the definition is that it sounds glaringly similar to that of philosophy. While mathematics or logic might agree with a given theory, a lack of physical verification does seem difficult to accept. We can turn to the work of Thomas Kuhn to potentially solve this problem. Kuhn presented the idea of a paradigm that contains all of the accepted theories, concepts, practices, instruments, etc. of a particular subject in science (11). While theories are only part of a paradigm, we can use Kuhn's description of paradigm shifts to rationalize the sample theorist's definition. According to Kuhn, paradigms can exist and be supported even if observation does not necessarily confirm them. In the event that these anomalies—the discrepancies in experimentation and paradigms—begin to accumulate, scientists have no other option but to replace the previously held paradigm with one that more accurately represents our knowledge of the natural world (53). For our case, we can use Kuhn's concept to explain the theorist's definition. The fact that experimentation and observation are not required coincides with Kuhn's belief that we should universally accept the given paradigm. However, if abundant observation rejects the paradigm we support, we can dismiss it on the basis that the theory would no longer be valid. Thus, since the theorist's definition prioritizes knowledge and understanding, we do not need to utilize observation to confirm scientific theories, only to reject them. For that matter, the theorist's definition seems to describe science in a general sense and cleverly refute any oppositions or rejections.

As with the previous perspectives, we will now critique the definition and analyze its shortcomings. Clearly, our concept of science should require some sort of evidence-based verification. To entirely detach our definition of science from the experiences of the natural world is disingenuous because it is precisely the functioning of the natural world about which we are concerned. In our constructed definition, we consider the process of *understanding* nature, but could we not incorrectly interpret a natural phenomenon? Understanding does not imply accuracy but rather thoroughness. We need not look far to discover numerous scientific beliefs that we initially accepted and now believe are incorrect: the concept of the luminiferous aether propagating light waves, the belief in a geocentric universe, and the infamous cold fusion fallacy. While not delving too far into considerations regarding the limits of knowledge, we can be assured that our understanding of the universe and its actual functioning are not always the same. As such, we cannot use a definition of science that is based purely on theory; we require some sort of verification to ensure that we are as representative of nature as possible. I must acknowledge that we can still be wrong even with experimental verification since human error or measurement limitation can prevent us from truly understanding the universe. Science is a human practice, after all. With that considered, the theorist perspective extends too far into philosophy without accounting for at least some sort of evidence.

Having discussed the necessity of verification, we do not need to demarcate a *specific* type of evidence. Although an empiricist would disagree, the testing of hypotheses can involve numerous different methods. Perhaps a particular theory agrees with a mathematical model or perhaps we have experimental evidence confirming a given theory. Either way, both of these examples of verification could serve as evidence of a theory's accuracy and we need not specifically choose one. Take mathematics as an example: while complex mathematical models might be useful in physics to describe the laws of nature, in areas such as biology and geology, we typically look elsewhere for evidence and use mathematics for more general arithmetic (Bauer 25). Specifically, a prominent example of non-experimental based verification of a generally accepted model would be quantum mechanics. While we could be entirely wrong about the concept, the model works well with what we know about the natural world. Some of the components of quantum theory seem almost ludicrous at times—most notably the idea that everything with momentum is made up of wave packets—but we still have no better model to explain the natural world. In this regard, we see that the lack of evidence in the theorist's definition is problematic, but by considering the ambiguity of verification, we can still build on the definition.

A Definition of Science

We have now completed an analysis of our three different approaches: logical positivism, hypothetico-deductivism, and theorization. These perspectives were deliberately chosen since they all lie on the same continuum of what most scientists tend to prioritize. Logical positivism is at one end with a strict reliance on experimentation while theorization lies at the other end with a prioritization of hypothesizing. Hypothetico-deductivism was not added to amend the perspectives but rather to show how theory and experimentation can effectively work in the same approach. At this point, we can now put forth our own definition of science which takes into account all of the components we highlighted in each of the three perspectives:

> *The process of understanding the natural world by means of analyzing falsifiable hypotheses that correlate to some form of evidence.*

I will defend this definition by reviewing it as a whole as opposed to by considering individual components to avoid redundancy.

As stated in the introduction, we assumed that a basic definition of science would involve what humans know about nature. For that reason, I included "understanding" as opposed to "knowledge" of nature since the connotation of the latter seems too definite and does not accurately reflect the potential to be wrong. I also believe the definition best blends the merit of the scientific method with the validity of theorizing and necessity for verification. The analysis of falsifiable hypotheses is not a process, but rather a starting point for critical thinking, which we saw as the greatest result of hypothetico-deductivism. Furthermore, by prioritizing hypothesizing in the definition, we establish that theorizing, thought-experiments, and critical evaluations of nature are integral aspects of science—which eliminates the biggest deficiency of requiring empirical evidence in logical positivism. With that stated, we still need these hypotheses to be based on some form of evidence, not only to coincide with the scientific method, but also to still include empiricism. Evidence could be observation-based on experimentation, but it is not required to be as such. In this sense, I have considered not only the implications of each of the three perspectives, but also how to combat the most severe drawbacks of each.

I conclude by considering some of the implications of this definition. We have effectively omitted any confusion between pseudoscience and science. If a concept cannot provide for a meaningful and testable hypothesis, it need not be considered scientific. Furthermore, we have accurately described ambiguous fields such as astronomy as scientific. While most individuals would consider astronomy to be science, we saw that many perspectives struggled to include it as scientific. As such, astronomy, and any other field that does not exclusively rely on experimentation, is rightfully included. We have also effectively excluded other fields that have been considered scientific at times, namely social sciences. Although they pertain to the natural world (e.g. history), social sciences tend not to include meaningful, falsifiable predictions. With that considered, certain fields such as economics and psychology present trickier cases in which the definition may be upheld, but the fields are not completely recognized as truly scientific. For example, the notion of the "natural world" in the context of economics is ambiguous. In one case, we might take everything as nature, while in the other, we might exclude man-made institutions that rely on our actions. Perhaps the discrepancies in the cases of economics or psychology are not based on how we define science, but rather how we perceive the individual fields. For that matter, we might always experience some gray area when attempting to define science. Regardless, we have arrived at a comprehensive definition.

Bibliography

Bauer, Henry H. *Scientific Literacy and the Myth of the Scientific Method*. Chicago: U of Illinois, 1994. Print.

Baumgardner, J. "Exploring the Limitations of the Scientific Method." *Acts & Facts.* 37 (3): 4. 2008. Web. 2 Apr. 2016.

Blachowicz, J. "How Science Textbooks Treat Scientific Method: A Philosopher's Perspective." *The British Journal for the Philosophy of Science* 60.2 (2009): 303-44. *Oxford Journals*. Web. 2 Apr. 2016.

Contessa, Gabriele. "Constructive Empiricism, Observability and Three Kinds of Ontological Commitment." *Studies in History and Philosophy of Science Part A* 37.3 (2006): 454-68. Web. 2 Apr. 2016.

Ehrenberg, A. C. S, and J. A. Bound. "Predictability and Prediction." *Journal of the Royal Statistical Society. Series A (Statistics in Society)* 156.2 (1993): 167-206. *JSTOR*. Wiley for the Royal Statistical Society. Web. 2 Apr. 2016.

Frankfurt, Harry G. "Peirce's Notion of Abduction." *The Journal of Philosophy* 55.14 (1958): 593-97. *JSTOR*. Web. 2 Apr. 2016.

Godfrey-Smith, Peter. *Theory and Reality: An Introduction to the Philosophy of Science*. Chicago: U of Chicago, 2003. Print.

Kant, Immanuel, J. M. D. Meiklejohn, Thomas Kingsmill Abbott, and James Creed Meredith. *The Critique of Pure Reason*. Chicago: Encyclopædia Britannica, 1955. Print.

Kuhn, Thomas S. *The Structure of Scientific Revolutions*. Chicago: U of Chicago, 1970. Print.

Peirce, Charles S. "The Fixation of Belief." Popular Science Monthly 12 (1877): 1-12. Biblioteca On-line de Ciências da Comunicação. Web. 2 Apr. 2016.

Quine, Willard Van Orman. "Main Trends in Recent Philosophy: Two Dogmas of

Empiricism." *The Philosophical Review* 60.1 (1951): 20-43. *Duke University*. Web. 13 Mar. 2016.

Rey, Georges. "The Analytic/Synthetic Distinction." *Stanford Encyclopedia of Philosophy*. Stanford University, 14 Aug. 2003. Web. 23 Feb. 2016.

Rothenberg, Paula S. "Peirce's Defense of the Scientific Method." *Journal of the History of Philosophy* 3.4 (1975): 481-490. *Project Muse*. Johns Hopkins University Press, Oct. 1975. Web. 3 Apr. 2016.

Schembri, Elise. "Cryptozoology as a Pseudoscience: Beasts in Transition." *Studies by Undergraduate Researchers at Guelph* 5.1 (2011): 5-10. Web. 2 Apr. 2016.

Schlick, Moritz, Rudolf Carnap, Otto Neurath, and Sahotra Sarkar. *Logical Empiricism at Its Peak: Schlick, Carnap, and Neurath*. New York: Garland Pub., 1996. Print.

Van Fraassen, Bas. *The Scientific Image*. Oxford: Clarendon, 1980. Print.

Theoretical Reason: Knowledge and its Limits in Immanuel Kant's *Critique of Pure Reason*

Madeleine Scott

Introduction

Many scientific studies today attempt to outline the exact system of the human brain as it processes information and turns this information into knowledge. However, parallel to science, and based on philosophical thought and argumentation rather than research on neurological processes, there exist conceptions of thought through the dual lenses of practical and theoretical reason. Within theoretical reason, Immanuel Kant and his seminal work *Critique of Pure Reason* are integral to understanding of knowledge and its limits. In what follows I will examine *Critique of Pure Reason*, as well as critical readings from W.V.O. Quine and Graham Priest, to explore the extent of the limits of thought.

Historical Context: Rationalism vs. Empiricism

To understand Kant's account of theoretical reason, it is necessary to examine first its philosophical background. The pre-Kantian world of the 17^{th} and 18^{th} centuries, known as the Early Modern Period, contained two major schools of thought within epistemology, the "branch of philosophy devoted to the study of the nature, sources, and limits of knowledge"—both of which sought to answer the subject's question of how we gain knowledge (Markie).

The first, rationalism, is based on the claim that knowledge is derived from reason in and of itself, independently of sense experience. Rationalism draws from the collective work of the Continental Rationalists, most notably Descartes, Spinoza, and Leibniz; and the acceptance of at least one of three theses: Induction/Deduction, Innate Knowledge, and Innate Concept. All of these are dependent on a variable subject area, hereafter known as S.

> *Induction/Deduction Thesis*: Some propositions in S are able to be known through intuition, while some are able to be known through deduction from intuited propositions.
>
> *Innate Knowledge Thesis*: We have knowledge of some truths in S as part of our rational nature.
>
> *Innate Concept Thesis*: We have knowledge of some concepts in S as part of our rational nature; that is, we have concepts inside of us that are brought to light by experience.

Rationalism also contains two more theses of note—and though acceptance of either of these is not required to be considered a rationalist, they do broaden the perspective's notions and stance against empiricism.

> *Indispensability of Reason Thesis:* The knowledge we gain in S, whether through induction/deduction or through innate knowledge, cannot be gained through experience. In the same way, experience cannot provide what we gain through reason.
>
> *Superiority of Reason Thesis:* Reason is superior to experience as the source of knowledge.

These theses, admittedly, seem to be conclusions unsupported by strong premises, and almost—dare I say—redundant. If reason is superior, why and how is that the case? Descartes claims that what we know from innate reason is certain, while what we know from experience is at least somewhat uncertain. This is grounded in Plato's perhaps more controversial claim that what we know from reason alone is in and of itself superior, because what we know from reason often exists on a more fundamental, universal plane within the context of metaphysics—though I won't delve into metaphysics quite yet.

Empiricism, on the other hand, is the claim that knowledge is derived ultimately from sense experience, and sense experience alone. It is based on the work of the British empiricists, most notably Locke, Berkeley, and Hume. Whereas rationalism draws from several theories, empiricism relies on one.

> *Empiricism Thesis:* Only sense experience is the source of knowledge in, and for concepts used in, S.

However, in the same way that within rationalism there exist two theses directly to contrast with empiricism, empiricism asserts rejection of the Induction/Deduction and Innate Knowledge theses. Ultimately, empiricism, having no inherent connection to that which is considered empirical information, argues that on one hand, if knowledge can be gained, it is by experience; and on the other, if experience cannot and does not give us knowledge, we have no knowledge and know nothing.

Many today maintain that rationalism and empiricism can and even should be relativized, with each applying to different subjects. So it is interesting that often in examination of this historical context, key philosophers tend to be categorized as staunchly on one side of the debate, when that was not the case. John Locke, for example, a British empiricist, was known to adopt the Induction/Deduction thesis of rationalism with regards to knowledge of the existence of God (Markie).

Kant is notable, perhaps even revolutionary, for delineating and then synthesizing the role of reason in the two previously discussed schools of thought—critiquing both the "unprovable pretensions of reason in earlier 'rationalist' philosophers" and the "subservient role accorded to reason by the British empiricists" (Williams). The following section will discuss how Kant came to accomplish this synthesis, through his account of experience interpretation and thereby the acquisition of knowledge.

How We Understand the World Around Us

It seems near impossible to have a conversation about rationalism vs. empiricism, and therefore theoretical reason, without using the terms *a priori* and *a posteriori*—popularized by Kant, they are applied in retrospect to early works because of their definitive nature. As defined in *Critique of Pure Reason,* knowledge *a priori,* more aligned with rationalism, is that which is "altogether independent of experience"—to the point of not being "independent of this or that kind of experience, but…. absolutely so of *all* experience." In the same way, knowledge *a posteriori*, more aligned with empiricism, is that which is known after any kind of experience.

Kant's next key distinction is between analytic and synthetic knowledge. Analytic judgments are "those in which the connection of the predicate with the subject is cogitated through identity"—i.e., the predicate is contained by the subject—whereas synthetic judgments are "those in which [the connection of the predicate with the subject] is cogitated without identity"—i.e., the predicate is not contained by the subject. The analytic-synthetic distinction is one of the most crucial concepts of modern empiricism, becoming so far engrained in its tenets that Willard Van Orman Quine christened this distinction one of the "two dogmas" of modern empiricism. To understand Kant's conception of theoretical reason, we must fully understand the analytic-synthetic distinction.

First and foremost, to follow the Kantian definition we must understand the meaning of subject and predicate beyond how these terms are colloquially conceptualized. Kant falls in line with the tradition of Aristotelianism, designating the subject as "'that which lies under,'" necessary to speak logically of "that of which things are predicated," and/or to designate matter. He accepts Descartes' notion that the ultimate subject is the self-conscious I, the idea that "I think therefore I am," but does not grant that this I truly exists; rather, it is a logical function. This is the important distinction between the subject and the acting subject referred to in the antinomies, which itself is a substance; however, though notable, the acting subject is not relevant quite yet and as such will not be further discussed in this section. It follows then that predicate is that which logically combines with subject—and this relationship is determined by the structure of either the analytic or the synthetic, as defined above (Caygill).

These dictionary definitions, while helpful, are based on a historical chain of philosophies and do not easily allow us to examine critically all aspects of the distinction—so here I turn to Quine and his seminal work, "Two Dogmas of Empiricism." Before entering into summary and analysis of this text, it is important to note that Quine's position is to defeat both dogmas, and this includes defeating the analytic-synthetic distinction. However, examining his process of argumentation illuminates what the distinction intends to accomplish, and that in and of itself carries importance.

Exegesis of W.V.O. Quine's "Two Dogmas of Empiricism"

After establishing what he believes to be the two dogmas (the existence of the analytic-synthetic distinction and the truth of reductionism, the latter of which will not be explored) Quine begins with his critique of analyticity. According to Quine, background for the distinction can be found in the work of both Hume and Leibniz. Hume established a distinction between relations of ideas and matters of fact, while Leibniz established one between truths of fact and truths of all reason, truths that are "true in all possible worlds"—which is to say that they "could not possibly be false." Similar to this is the idea that analytic statements are those whose "denials are self-contradictory," however, this definition is already flawed, in that its notion of "self-contradictoriness" needs just as much clarification as that of analyticity itself.

Quine then restates Kant's definition of the analytic statement as "one that attributes to its subject no more than is already conceptually contained in its subject," interestingly removing from this the potential complication of the word "predicate" as originally used by Kant. He proceeds to argue against this definition, bringing up two shortcomings: that it limits itself to subject-predicate form, and relies on the idea of containment at a metaphorical level. Because of these shortcomings, Quine believes, Kant's intent is more based on his notion of analyticity than his definition, more properly phrased as that "a statement is analytic when it is true by virtue of meanings and independently of fact."

If this notion is the case, though, an examination of the concept of meaning is in order. Here Quine creates the important delineation that meaning is not the same as naming—terms can "name the same thing, but differ in meaning." This applies to both the singular term, which "purports to name an entity," and the general term, which does not purport to name an entity but is "*true* of an entity, or of each of many, or of none." When there is a general term, there also exists the *extension* of this term, which Quine defines as the "class of all entities of which the general term is true." To clarify—in meaning there are two contrasts, between meaning of a singular term and the entity that it names, and between meaning of a general term and its extension.

Quine also gives historical context, arguing that the modern notion of meaning, or intension, is based on the Aristotelian notion of essence. According to this, things have essences, but only linguistic forms carry meaning—and that meaning is "what essence becomes when it is divorced from the object of reference and wedded to the word." If we accept this, we must ask the inevitable—what sort of things, then, are meanings? However, this question is dependent on a "felt need for meant entities," which Quine argues is derived from an earlier failure to distinguish between meaning and reference. Once we make this distinction, we can understand that the theory of meaning only needs to concern the "synonymy of linguistic forms and the analyticity of statements"—that meanings themselves are beside the point.

Quine's initial description of analyticity is based on its concept of meaning, but he concludes that, as he has shown through deconstruction, "meaning" can be abandoned—however, the issue of analyticity still remains. Here, Quine puts forth the two classes of analytic statements, which inform the argumentation of the rest of the paper.

The first class is comprised of those statements which can be called *logically true*, such as the statement:

(1) No unmarried man is married.

This example stands because it is not just true as is—it is true under "any and all reinterpretations of 'man' and 'married'." Accepting this means that, in general, we can understand a logical truth as a statement which is "true and remains true under all reinterpretations of its components," aside from so-called logical particles such as "no," "un-," and "if…then." Logical truths, then, are relatively straightforward, and we question why such a big fuss is made over analyticity until we turn to the second class of analytic statements:

(2) No bachelor is married.

Such a statement is characterized by the fact that it can be turned into a logical truth by replacing synonyms with synonyms—in this case, (2) becomes (1) by replacing "bachelor" with its synonym "unmarried man." While this characterization is somewhat acceptable, it brings up a need to clarify the notion of "synonymy," as on this the second class of statements is dependent, and in turn, on this second class is analyticity itself dependent.

Quine begins his attempt to begin clarification of synonymy with an analysis of the concept of definition. It can seem adequate to say that second class analytic statements are essentially logical truths by definition, as, for example, "bachelor" is defined as "unmarried man." However, Quine challenges this notion—who makes this definition? When? How? Definition is dependent on antecedent facts. How then, can we affirm synonymy without depending on antecedent? It seems to Quine that these interconnections have to be grounded in usage, or, perhaps, what philosopher Rudolf Carnap calls *explication*. Explication does not intend to merely paraphrase the definiendum (what is being defined) into an "outright synonym," but to improve the definiendum. However, even this still rests on pre-existing synonymies, as any word "worth explicating" has some contexts in which usage is useful, and explication must both maintain usage in this original contexts while sharpening usage in new contexts. As such, Quine concludes, definition is dependent on prior relationships of synonymy, and therefore does not "hold the key" to synonymy and therefore analyticity.

Next, Quine turns to interchangeability, as it seems natural to assume that synonymy consists solely of interchangeability of two linguistic forms "in all contexts without change of truth value," or interchangeability *salva veritate*, as labeled by Leibniz. However, following this notion, the synonyms "bachelor" and "unmarried man" are not everywhere interchangeable *salva veritate*. Quine puts forth several examples that can only be described as silly in their obviousness, such as the logical inability to substitute "unmarried man" for "bachelor" in the term "bachelor of arts." Based on these, interchangeability *salva veritate* is inadequate, and so Quine examines what can be called *cognitive synonymy*. Referring back to the reoccurring example: if "bachelor" and unmarried man" are cognitively synonymous, then the statement

(3) All and only bachelors are unmarried men

is analytic.

What is necessary then is "cognitive synonymy not presupposing analyticity"—and this is, in concept, interchangeability *salva veritate*. However, this is a sort of circular argument, and Quine's arguments regarding both interchangeability *salva veritate* and cognitive synonymy, their relationship to each other, and their derivation of and from analyticity ultimate conclude with a decision to abandon both, in doing so abandoning the idea of interchangeability at all entirely.

The third and final concept Quine considers in trying to understand synonymy is that of semantical rules, but this becomes dependent on a concept of artificial language, and again, becomes an argument Quine sets up for himself solely to defeat. While it can seem Quine's reasoning is circular, he is in fact critiquing and defeating common methods of setting up the distinction, and we are left to accept that the boundary between analytic and synthetic has not been, and cannot be drawn.

The Intersection of Kant's Two Distinctions

To continue this understanding of Kant, we must only draw from Quine his logical processes in addressing both analytic and synthetic, and uphold belief of the distinction. Here we come to an intersection of these two key distinctions, analytic versus synthetic and *a priori* versus *a posteriori*. In this intersection subjects (the S's of section one's theses) are able to be categorized, as is best understood through visualization—thus, the following chart.

	ANALYTIC	**SYNTHETIC**
A PRIORI	• X=X • A bachelor is a male • A square is a rectangle	• Metaphysics
A POSTERIORI	• Not applicable	• Sciences • This rectangle is a square

The overlap of analytic and *a priori* knowledge focuses on propositions exemplified by mathematics' reflexive property of equality—for example, X=X. These concepts are inherently definitive, and as such, typically do not require higher-order discourse. Synthetic *a posteriori* knowledge takes the next step, exploring propositions in subject areas such as the sciences, wherein work must be done in order to determine the conclusion: I have a hypothesis, I conduct research, and I am able to draw results from the evidence I collected. Analytic and knowledge *a posteriori* is the null set of this chart, they cannot overlap because there is innate contradiction—if predicate is logically contained by a subject, we already know this prior to experiencing it.

So, that leaves the overlap of synthetic judgment and knowledge *a priori*. How can synthetic *a priori* propositions even be possible—in mathematics, science, and metaphysics (Grier)? Each question is answered by a section of the text—the Transcendental Aesthetic, Transcendental Analytic, and Transcendental Dialectic, respectively. Simply enough, the conclusion of the first two sections is that this overlap is not possible in mathematics and science. It is metaphysics which must be further explored, and this exploration occurs in the Transcendental Dialectic—a brief outline of which will occur here, for further exploration in the next section.

To understand the content of the Transcendental Dialectic, we must first understand the meaning of its title. Kant uses the word "transcendental," traced from the medieval denotation of "extra-categorical aspects of beings," such as truth and goodness, throughout *Critique of Pure Reason* to describe "all knowledge which is occupied not so much with objects as with the mode of our knowledge in so far as this mode of knowledge is to be made possible *a priori*" (Caygill). From there, the dialectic is defined as the using of the elements of understanding and reason "as if they were an *organon* for the actual production for at least the semblance of objective assertions" (Kant).

Within this section is a solid conclusion to the question of the possibility of synthetic *a priori* propositions in metaphysics. Kant argues that these propositions are not possible at all in a rejection of the disciplines of special metaphysics. He then offers a critique of these disciplines—rational psychology, rational cosmology, and rational theology. This rejection, though, is not a rejection of theoretical reason—which, ultimately, he believes, has a cognitive role as the "arbiter of truth in all judgments."

As is evident, *Critique of Pure Reason* first accomplishes a bridge of the gap between rationalism and empiricism by arguing that we can only gain knowledge of the world through both "sense experience and concept formation… to form empirical judgments," and then proceeds to break down reason itself to gain knowledge of the transcendent world, as we will see in the next section (Williams).

The Limits of This Understanding: Exegesis of Graham Priest's *Beyond the Limits of Thought*

Once we understand the Kantian intersection of distinctions of knowledge, we can build upon that foundation and turn to *Critique of Pure Reason's* exploration of the limits of four concepts: cognition, expression, conception, and iteration. This section will examine these limits through literature review of chapters 5 and 6 of Graham Priest's *Beyond the Limits of Thought*, examining the phenomena-noumena distinction and the Antinomies, respectively.

Priest is most notable for his defining work on dialetheism, which claims that true contradictions, though very limited, do exist. Though these chapters do not specifically focus on dialetheism, they are a testament to the contradictions of Kant—some, interestingly, simply because of the disjointed manner of assembly of *Critique of Pure Reason*; and some because of the actual composition of his argumentation.

Chapter Five of Priest's work, "Noumena and the Categories", begins with an explanation of Kant's most crucial distinction, between the phenomena, that which Kant defines as "those things perceivable by the senses," and which are in space and time; and the noumena, that which, in essence, is not phenomena. While phenomena can be perceived, noumena can only be conceived, including such concepts as God and the Soul. This distinction is further developed by what Kant calls Transcendental Idealism, that "objects in themselves cannot be… intuited…what are perceived are our mental representations of such objects." In other words, all that can be given to us immediately is appearance, which is just representation—so, the representation perceived is a phenomenon, and the thing in itself is a non-empirical noumenon, the transcendental object. This is the beginning of our limits of conception.

Once we understand this, Priest explains, we can understand how knowledge works, or how judgment is categorized. Referring back to the definition offered by Caygill in *A Kant Dictionary*, judgment is simply how we understand the relationship between subject and predicate. Every judgment has quantity, quality, relation, and modality, and three "pure" (meaning lacking in empirical content) Categories apply to each of these aspects of judgment, as illustrated in the following table (Priest).

Quantity	Unity Plurality Totality
Quality	Reality Negation Limitations
Relation	Substance Cause Community
Modality	Possibility Existence Necessity

The most important conclusion that can be drawn from this is that these categories only apply to phenomena. Priest outlines two arguments given by Kant to support this.

The first, the Transcendental Deduction of the Categories, claims that the nature of consciousness is how we can be sure that categories, or language, apply to anything, or reality. Unity is a feature of individual consciousness, made possible because objects of consciousness themselves possess unity—and in turn, unity itself is possible because judgments using categories unify disparate things. Kant argues that applicability of the categories is guaranteed by unity of consciousness, and categories are "constitutive [only] of…perceptions"—and because perceptions are mental representations, this process of consciousness is only applicable to phenomena.

The second, the Schematism of the Pure Understanding, states that in order to apply a category we must have some criterion/schema of how to apply it/what it can be applied to. Since criteria for all categories involve time, it only makes sense to only apply criteria to that which is in time, or phenomena. While this is a straightforward argument, it is also straightforwardly criticized—Priest contends that accepting this Schematism depends on accepting that all criteria are temporal.

Here, Priest begins to argue the limitations on Kant's distinction between phenomena and noumena, which exist first in the form of contradiction. If categories cannot be applied to noumena, as is a key component of this distinction, there is contradiction in the very limit of thought.

This is the first limit, the limit of cognition—that categories can only be applied to phenomena means that there can be no knowledge of noumena, which puts precise limits on the extent of knowledge itself. If this is the case, Kant is inherently-self referential, as his book purports to inform its audience about noumena. However, Kant did face this argument, and counters that *Critique of Pure Reason* does not actually give *knowledge* of noumena, but something less, stating that "though we cannot *know* these objects as things in themselves, we must be in a position to at least *think* them as things in themselves." To this, Priest's argument is as follows: it is misleading to think that we cannot know anything about noumena, because it suggests an impossibility of knowledge due to epistemic access, when it is actually due to conceptual access; in fact, we cannot have knowledge because we cannot make statements, as any statement would have to apply the categories; and ultimately it is as impossible to entertain thoughts about noumena as it is to actually know anything about them—which is ultimately a more fundamental contradiction than previously even expected.

Limits of expression are also relevant, as Kant's distinction makes assertions about noumena, and in doing so, it applies the categories that he himself conceptualized. If, then, noumena are precisely contradictory, this is beyond the third type of limit, the limit of conception—if we cannot make judgments about noumena, we cannot think of them at all, and they are beyond conceivable. However, judgments about noumena *are* made, and therefore they are thought about; Kant's awareness of this contradiction results in what he calls The Ground of The Distinction of All Objects in General into Phenomena and Noumena. Kant distinguishes between the "illegitimate positive" notion of noumenon, and the "legitimate negative (limiting)," notion of noumenon. The latter places limits on where we can apply categories and make judgments—but to say that there are things we cannot judge is to make a judgment.

Essentially, this constitutes a problem of contradiction, which applies to anyone who holds that categories do not apply to noumena yet wants "even to consider propositions about them." Priest offers two solutions to this problem: that we give up all talk of noumena, which is admittedly not feasible; or that we accept Transcendental Idealism, which purports that "things we normally take ourselves to be familiar with are representations."

Now we delve into Chapter 6, "Kant's Antinomies," and the fourth limit of thought—the limit of iteration/the iterable. There are four Antinomies, corresponding to four kinds of categories and all following the same abstract structure. Each category produces a condition, and the accepting of a condition can produce a series. An arbitrary phenomenon is then created: from a starting point, applications of a generator are iterated, from which we may obtain the limit. Since each category produces a condition, the limit of each Antinomy is that which is unconditioned. Priest also clarifies that a sequence can be generated either this way, or as a result of applying an operator as frequently as possible. While this structure does get confusing, what is necessarily consistent is that each Antinomy possesses a generator, an antithesis demonstrating that it is "always possible to apply the generator again" with a limit "too small for the concept," and a thesis demonstrating that if the limit is generated by an infinite amount of applications to the generator, trouble ensues, with a limit "too large for the concept."

The First Antinomy, The Beginning of the Cosmos, rests on a distinction between time and space. Its generator is an "*event at a (fixed) temporal duration prior to x*," for which the limit is obtained by iterated applications of this generator to an arbitrary event, and in this case, the limit is a sequence of events stretching back as far as possible. The contradiction of the First Antinomy is that its limit both has and does not have a last/temporally first member—that the cosmos "is and is not bounded in time past." Without such a member, the thesis argues, we would be faced with a completed infinite, which is impossible. On the contrary, as Priest explains, the antithesis argues that if there were a last member, there would be an infinity of time when no events occurred, therefore there never would have been a reason for the beginning of cosmos—and therefore there never would have *been* cosmos.

The Second Antinomy, The Divisibility of Matter, is spatial, and its generator is the "*fixed fractional part of x*." In this case, we begin with an arbitrary piece of matter, apply the generator iteratively, and produce a limit in the form of a piece of matter to which the generator can no longer be applied. This piece of matter is called the simple, and contradiction comes into play in the understanding that physical objects are and are not made of simples. The thesis argues that, in thought, it is always possible to decompose any compound part of an object—and if all parts decompose the object disappears, making it not a subject. The antithesis argues that the simple part would occupy space, and as all spaces are divisible, the simple itself would be correspondingly divisible, which is impossible.

The Third Antinomy, Causal Chain, is related to the causation of events, and its generator is the "*natural cause of X*"; here, we begin with an arbitrary event, apply the generator as far as possible to obtain the limit (in this case, a chain of causes)—we are faced with the contradiction that the chain has and has not a first member. If the chain of causes for an event has no first member, the thesis purports, it goes back to infinity, so the event has no sufficient cause and is therefore impossible. In turn, the antithesis states that if a chain has a first member, this has no causal determination. The contradiction here is especially notable, as it contradicts a law of Kant's—the Law of Causality, that every event has a cause.

The Fourth and final Antinomy, A Necessary Being, is about necessary beings, and its generator is the "*ground of X*" where it produces an object, or a ground, on which X depends for its existence when applied to X. This suggests that the contradiction is that dependence is causal, which Priest points out as puzzling—is it merely a rerun of the Third Antinomy? If the generator is applied iteratively to an object it creates a chain of objects, and the limit becomes the last member of the chain (if there is one), or the whole chain (if not). The thesis here is dependent on the antithesis, which states that if the limit is the whole chain, it cannot be necessary because no part of it is necessary; if the limit is the first member of the chain this is impossible, because the first member is an object in the world, and therefore must have a ground (again, failing by Kant's Law of Causality).

Kant argues, ultimately, that though these Antinomies arise in our reasoning about the limits of thought, and are often considered to be valid, they are contradictory—and contradictions, even at the limits of thought, are not possible. Priest, in keeping with his belief in dialetheism, contends that while the arguments of the Antinomies may be flawed, such contradictions are possible at the limits of thought. In order to fix the structure of the Antinomies, and defeat Kant, Priest proposes his own solution—a Fifth Antinomy.

This Antimony is of the limit of thought, and it aligns with Kant's idea that Antinomy is inherent in our reasoning about limits of thought. With this Antinomy, an infinity generator is applied to a certain object, and the contradiction lies in that the thought of T is "both (closure) and not (Transcendence)," in other words, that the thought of T is both distinct from T and in T—even if something does not exist, its content does. At its essence, this Antinomy is the idea that the limit can be, and has been, thought of.

I will conclude this section with a table included in *Beyond the Limits of Thought*, simplifying both Kant's Antinomies and Priest's proposed fifth, for clarification.

ANTINOMY	**GENERATOR**	**LIMIT**	**[ANTI]THESIS**
1st	Event prior to	Totality of past states	Has [not] a beginning
2nd	Part of	The Simple	Objects are [not] composed
3rd	Cause of	Chain of causes	Has [not] a first member
4th	Ground of	First member of chain if there is one, whole chain if not	Is [not] necessary
5th (Priest)	Thought of	T	Can[not] be thought of

Concluding Remarks

Considering Kant's original text and Priest's critique, the ultimate question is whether true contradictions exist. If we accept Priest, that at the limits of thought, they do, then we open the door to infinite questions that challenge the very fabric of even the simplest things we hold to be true. I side with Kant, and the commonly accepted conclusion that contradictions do not exist. However, it is also important to note that sometimes, in extreme contexts such as the limits of thought, it can seem that contradictions are possible—is there that which in principle can never be conceived by the human mind? Again, here, I agree with Kant—we have the ability to think that there are things that in principle can never be conceived, but we cannot think of these things themselves.

On a more practical level, in the face of modern cognitive science, can we even argue that Kantian examinations of mind functions are valid? I argue that the latter has merit as a logical puzzle, an endless cycle of argumentation and refutation. As there are benefits to be reaped from understanding of both explanations, from both disciplines, perhaps mind activity is an area where science can draw from philosophy, and vice versa. If, in this way, we transcend limits of both areas through interconnectedness and interdependency, it is not inconceivable to suggest that the unthinkable will become thinkable, and the unanswerable questions will be answered.

Bibliography

Caygill, Howard. *A Kant Dictionary.* Cornwall: Blackwell Publishers Ltd, 1995. Print.

Grier, Michelle. "Kant's Critique of Metaphysics." *The Stanford Encyclopedia of Philosophy* (Summer 2012 Edition), Edward N. Zalta (ed.). 10 Feb 2016.

Kant, Immanuel. *The Critique of Pure Reason.* Trans. J. M. D. Meiklejohn. Encyclopedia Britannica, Inc., 1952. Print.

Markie, Peter. "Rationalism vs. Empiricism." *The Stanford Encyclopedia of Philosophy* (Summer 2015 Edition), Edward N. Zalta (ed.). 10 Feb 2016.

Priest, Graham. *Beyond the Limits of Thought.* New York: Oxford University Press, 2002. Print.

Priest, Graham and Berto, Francesco. "Dialetheism." *The Stanford Encyclopedia of Philosophy* (Summer 2013 Edition), Edward N. Zalta (ed.). 10 Feb 2016.

Quine, Willard Van Orman. "Two Dogmas of Empiricism." *From a Logical Point of View.* 2nd ed. Harvard University Press, 1961. Web.

Williams, Garrath. "Kant's Account of Reason." *The Stanford Encyclopedia of Philosophy* (Spring 2016 Edition), Edward N. Zalta (ed.). 10 Feb 2016.

Metaphors and Models

Morgan McConnell

People use language to communicate and explain complex ideas. This language, however, is only symbolic representation. As an essential part of language, metaphor conveys ideas through representational comparison. These comparisons are necessary in language when no other existing word or phrase can properly express a concept. Since metaphors are so prevalent in communication, scientists also use metaphors through scientific models to explain the world and how it works. Although scientific models have predictive ability and provide other valuable scientific benefits, their metaphorical properties limit their scientific utility due to barriers presented by the limitations inherent in verbal and nonverbal human communication. I will first examine the general definition and role of metaphors as explained by David Hills as well as the arguments of Donald Davidson and Max Black on the function and limits of metaphors. I will then analyze the views of Ronald Giere and Black on models and their properties. Finally, I will identify specific cases in which scientific models and metaphors interact, including a closer look at the use of metaphor in model building. Through my analysis, I will demonstrate how the relationship between models and metaphors limits science.

Metaphors

Metaphors exemplify the ways in which language is limited. In “Metaphor,” David Hills states, “The primary subject of a metaphor may be a particular thing, or it may be a whole kind of thing, and likewise for the secondary subject.” In this sense, metaphor may attempt to describe something simple. For example, a person may be compared to an animal or a celestial object to better explain certain characteristics belonging to that individual. However, a metaphor can also describe a complex system. Meteorological phenomena interact to create a weather system, but this system can still be described and understood through a simple metaphor. For instance, the weather may be likened to a battle. This comparison allows the reader to draw conclusions and gain understanding about the process even though it is explained in linguistic terms.

However, metaphors are not limited to speech and literature; they have other uses. Hills argues that metaphors can be comprised of both verbal and nonverbal signs. These signs do not possess specific meaning until they are used to communicate an idea. For instance, a plus sign is a nonverbal form of communication that possesses different meanings based on the context; it could imply that something is being added or that something is positive. Since nonverbal signs are just as flexible as verbal signs in interpretation and use, images and objects can also be used metaphorically to represent a system as words do. Therefore, the variety of meanings that can be associated with verbal and nonverbal signs makes it difficult to accurately describe a system. If language is nothing more than symbolic representation, then any model conveyed to others through language is only symbolic. Thus, anything created with metaphorical properties must be understood based on use.

In “What Metaphors Mean,” Donald Davidson argues that metaphors are literary devices that do not hold any hidden meaning; their meaning is understood based on how the metaphors are used. He states, “What metaphor adds to the ordinary is an achievement that uses no semantic resources beyond the resources on which the ordinary depends” (Davidson 31). Metaphorical statements differ from ordinary statements; however, metaphors are still restricted to the ordinary use of language. In this regard, they should be taken literally. Since metaphors have literal meanings, they cannot be paraphrased. This act of paraphrasing would change the metaphor and alter its literal meaning. If the meaning of the metaphor is altered in this manner, then the interpreter is attempting to find a different meaning within the metaphor, which is an incorrect approach that fails to recognize the literal statement. For this reason, understanding a metaphor requires analysis of only the literal meaning of the metaphor. The interpretation of the literal meaning of the metaphor separates it from all other literary devices, including similes.

Davidson compares metaphors to similes to demonstrate how metaphors should be understood as literal statements. The intended use of the metaphor is the best way to understand its literal meaning. When interpreting a metaphor figuratively, an individual may attempt to analyze each separate word of the metaphor to decipher the deeper meaning. This interpretation ignores literal meaning and the importance of use in metaphor. Let us look at this statement: “An infant is like an infant.” The term “like” directly compares the word “infant.” This comparison relates the infants based on the fact that they share similar properties because they are both infants. Likewise, if one states, “A man is like an infant,” then one indicates that the man and the infant literally share similar properties, such as personality or behavioral traits. However, this literal comparison through simile is not the literal meaning of the metaphor. Davidson states, “the figurative meaning of a metaphor is the literal meaning of the corresponding simile” (38). Therefore, the figurative meaning of the sentence “A man is an infant” has the same literal meaning as the sentence “A man is like an infant.” This simile leads an interpreter to understand the term “man” based on what is known about the word “infant.” The interpretation is limited to the definitions of words, because the understanding of the subject will be shaped only through the primary definitions of the word to which it is compared; it does not take into account how two words can interact to create new meaning. For example, when taking the figurative approach, the interpreter may only come to the conclusion that a man has the same defining qualities as an infant, including dependence and frequent crying. However, this surface-level interpretation of metaphor fails to recognize more complex interpretations.

In contrast, the literal meaning of the metaphor inspires interpretation based on use. Davidson states, “The most obvious difference between simile and metaphor is that all similes are true and most metaphors are false” (41). He elaborates by explaining that it is true that the Earth is like a floor, but it is false to argue that the Earth is a floor. By adding the “like,” the simile automatically declares that it is comparing the properties of two things. In contrast, a metaphor that states that something “is” something else fails to convey this note of comparison. For this reason, metaphor attempts to argue that something is fact even when it is not. However, metaphors may not actually be false; instead, metaphors are interpreted to be false. Metaphors, although primarily serving as modes of comparison, possess qualities that appear outwardly false because they state that two unlike things are the same thing. The literal meaning or intent of the metaphor, though, is not false even if the metaphor appears outwardly false. A metaphor requires the use of words to draw an unlikely comparison with the intent of revealing something new but truthful. A metaphor functions more as a tool for explanation, using comparisons that strengthen a literal idea or argument. Thus, metaphors should be interpreted based on the use and interaction of words, a concept that Max Black explains further in his article “Metaphor.”

Black mostly agrees with Davidson in his explanation of metaphor. According to Black, in a linguistic metaphor, at least one word is metaphorical and at least one word is literal. The metaphor is connected to the literal word to expand upon the literal scenario or description given by that word. In this sense, the metaphor is an expansion upon what is known to be literal. When discussing what would occur if a metaphor were translated into another language, Black asserts that a metaphor is a metaphor because of its semantic meaning and not because of its syntactical properties. Therefore, the meaning of a metaphor can be understood in another language, and the main qualities of that metaphor and its intended use can also be understood. Even though cultural differences may result in different interpretations of the metaphor, the statement will still be acknowledged as metaphorical, and the best form of interpretation would be to analyze the intent of the author to understand the original meaning in its cultural context. In this regard, Black agrees with Davidson on the matter of usage and meaning of metaphor. While a metaphor is open to interpretation, this interpretation needs to relate to the original intent of the creator. An interpretation of the metaphor without understanding the intent will result in a misinterpretation. However, the process for unlocking the intended meaning of the metaphor depends on the view of metaphor to which the interpreter subscribes.

The substitution, comparison, and interacting views highlight the different routes for interpreting metaphors. The substitution view of metaphor understands metaphors as stand-ins for other words or phrases. This substitution means that the metaphor is literal since it can be replaced with a literal word or phrase. For example, Black explains that mathematicians used the word "leg" when describing the line of an angle. This example articulates how a metaphor can possess a practical, literal meaning. The metaphor is intended to explain something that actually exists but that cannot be briefly explained without substituting it for another word or phrase.

The comparison view understands metaphor as an alternative way of presenting an analogy or simile. It is a case of the substitution view that argues that a metaphor is "a condensed or elliptical *simile"* (Black, "Metaphor" 283). This view highlights how a metaphor uses substitution to draw a comparison between two things. The elliptical simile is a simplified version of understanding the role of metaphor; this view holds that the literal meaning of the metaphor shares the same literal meaning as the simile that it attempts to substitute. Black explains the elliptical simile by presenting the sentence, "Richard is a lion." While the substitution view would understand this sentence to mean, "Richard is brave," the comparison view would understand it to mean, "Richard is *like* a lion (in being brave)" (Ibid 283). This comparison provides literal meaning of the metaphor through the literal meaning of the simile. It indicates that a metaphor can be understood literally without an appreciation of the figurative elements provided by metaphor.

Black most strongly agrees with the interacting view of metaphor. As the name implies, the interacting view focuses on the interactions between two or more concepts that create a new meaning or understanding through their interaction. Metaphor creates something new beyond the obvious meaning of the metaphor. The metaphor allows for a new perspective based on the interaction of the words and ideas in the metaphor. For this reason, Black explains, "I would not deny that a metaphor may involve a number of subordinate metaphors among its implication. But these subordinate metaphors are, I think, usually intended to be taken less 'emphatically'" (Ibid 290). Metaphors can be interpreted differently, meaning not all metaphors possess a single literal meaning as intended by the creator. Due to the interaction between the two or more elements of a metaphor, multiple meanings can be interpreted. While these other meanings are not as significant as the primary, intended meaning, they do exist and can be interpreted in a new and different way. In this regard, metaphors are subject to new interpretations and function as a basis for establishing new understanding. However, this understanding must still relate to the initial use, which allows these new interpretations to form.

Davidson and Black both identify how metaphor has literal meaning in its goal to either compare two or more subjects based on likeness or to create new understanding through the interaction of these subjects. Assuming that models function like metaphors, based on Davidson's argument, scientific models do intend to literally communicate a concept. However, they are limited by the tools that scientists use to explain a system. Metaphors allow for literal comparison to occur, meaning that the understanding of models as metaphors still allows models to be considered literal depictions of the system when they are used to predict outcomes. However, viewing models as metaphors suggests that the ability to understand a system is restricted to the current view of reality and the descriptions that humans can create based on that reality through comparison. Black's argument suggests that, while the literal meaning exists, literal meaning may also carry with it other metaphors and interpretations. This idea relates to how scientific models, if they are in fact metaphors, shift and inspire new hypotheses and learning. Since metaphors and models both function through intended use, they both provide insight on a subject to improve thought and analysis. The literal intent of metaphors and models allows one to explore and test an idea through comparisons and the interactions of different concepts, but the development of new interpretations and the establishment of new models through other comparisons may lead scientists farther from the actual system as they examine it through layers of metaphor. Deeper analysis of models and their functions in reality will clarify these points.

Models

In "An agent-based conception of models and scientific representation," Ronald Giere argues that models function as forms of representation that lead to deeper understanding about the world. Giere begins his analysis of scientific models by examining their relationship with hypotheses. He states, "A 'hypothesis' is a claim (statement) that a fully interpreted and specified model fits a particular real system more or less well" (271). Models are used in hypotheses, and these hypotheses establish ideas about realistic systems. Thus, by their association with hypotheses, models are intended to enhance understanding of real systems. However, although these models relate to a system, models do not perfectly fit this system. Giere explains, "claims of perfect fit cannot be justified simply because every experiment has a margin of error. In addition, there is good reason to think that the only model that might exhibit a perfect fit to the world would have to be a model that fit everything perfectly" (273). Uncertainty in experimental data can produce discrepancy between the model and the experimental results. While models are still valid forms of understanding the system and making predictions of the outcomes or responses of the system, models will never exactly fit every system that is tested. For this reason, models cannot be either true or false, because the fit of the system is dependent upon the use of the model. Since the model is not a perfect fit, the model by itself cannot convey absolute truth. The model does carry truth in how it is used to examine a system, but this truth does not convey every aspect of the system. Thus, the model is neither true nor false; the hypothesis that is modeled is true or false, and the model still will not portray an absolute truth.

Giere continues his analysis by relating models to symbols and language. He argues that scientists use models with intention, stating, "Agents (1) intend; (2) to use model, M; (3) to represent a part of the world, W; (4) for some purpose, P" (274). A model, then, is created with specific purpose, and this purpose is to demonstrate elements of the world and how they function through an alternate form. For this reason, the use of language is similar to the use of models. Models, like language, utilize symbolic representations. In this regard, models function as alternate forms of communication for explaining scientific theories and hypotheses. A model uses symbols with intended meaning that allow for an accurate representation of the world. Similarly, people that possess language naturally create abstract objects, including symbols and other forms of representation. Scientific models, which are expressed through symbols like objects and equations, are created through the same processes as language, because both models and language have symbolic and representative attributes. In this sense, models function as explanations of the world through representational terms. The creation of models requires symbols, and these symbols communicate information based on their use, just like language.

Likewise, in "Models and Archetypes," Max Black argues that models primarily exist as representations of the world. Black states, "There is no such thing as a perfectly faithful model; only by being unfaithful in *some* respect can a model represent its original" ("Models" 220). Thus, models cannot be perfect fits to the original, because then they would be duplicates. Models must be different from the original in some ways, but the model cannot be so different that it does not relate to the original. In this sense, Black agrees with Giere by arguing that models, while accurate, cannot fit the system perfectly. According to Black, models are solely representative and are not perfect reflections of a system. He asserts that this claim is true even when dealing with data in mathematical models. Mathematical models are "*simpler* and *more abstract"* than the modeled system. Mathematical models are developed by analyzing data to represent systems, and these models simplify these systems. In a simplified model, it is easier to make calculations by eliminating certain complications posed by a complex model. This manipulation of the model indicates that models represent the system and are not entirely, although partially, true to the system.

Black continues this analysis of models as representation through an examination of analogies. When considering early models of the atom, the models were constructed as representations and not exact depictions, even though the intention of the models was to show the atom as it is. The goal is not to portray every aspect of a system; it is to establish a model that can be used for study and experimentation. Models explain a system through different means of comparison, and scientists consciously understand that they are not describing all of the qualities of a system when creating a model. However, models are not in themselves analogies or metaphors. Black states, "[Scientists] used language appropriate to the model in thinking about the domain of application: they worked not *by* analogy, but *through* and by means of an underlying analogy" (Ibid 229). Models are specific representations and not loose comparisons between a system and another object or function. The model is not in itself an analogy or metaphor; a model is its own entity that is created by utilizing properties of comparison. For instance, a model of the solar system may use perfect spheres to represent planets to simplify the model. These perfect spheres are used to create the model, but the model still represents the system as it is.

In spite of the similarities between metaphors and models, Black does not view models as direct metaphors. Although metaphors and models are similar, their dissimilarities preclude any inference that all models are metaphors. For example, both metaphors and models use elements of analogy, or comparison. This comparison creates new insight by explaining a system or idea. However, while any person could create an average metaphor, a scientific model requires greater insight and more skill than merely drawing a basic comparison. For this reason, models cannot be metaphors. Instead, he thinks of models as archetypes, explaining, "By an *archetype* I mean a systematic representation of ideas by means of which a given thinker describes, by *analogical extension*, some domain to which these ideas do not immediately and literally apply" (Ibid 241). The archetype uses elements of analogy to describe or represent a system, however, he does not believe that these analogies provide literal description. Thus, models are not literal due to their use of analogy; instead, the system is literal and the model is only an attempt to represent it. Therefore, using metaphors to describe a system can spark scientific investigation and serve as a tool for explanation; however, models are also more than just metaphors, because models have predictive qualities that metaphors lack. While the metaphor may be the starting point, the model must be validated through empirical evidence.

Both Giere and Black explain models in terms of representation. They agree that models do not perfectly describe a system. This limitation confirms that models in themselves are not exact. This conclusion relates to metaphors in the sense that metaphors also do not perfectly describe the world either. Metaphors, like models, must draw comparisons between two things to encourage new insight. For example, Giere specifically examines models in terms of language symbols and their comparative elements. This relationship between models and symbols demonstrates how models are created through processes similar to language. Thus, although models may lack perfect truth when describing a system, their goal is to explain the system using symbols that can communicate a concept relating to a true and literal system. While Giere is accurate in explaining how models function in relation to realistic systems in terms of perfect fit, he ignores the process of experimentation. Seldom is the isolated system investigated in scientific experiments; the system interacts with too many variables that affect the outcome. For this reason, scientists attempt to control the variables in an experiment so that the experimental system can fit the model. In this sense, models work most accurately when certain elements of the system are controlled, meaning the model may not function correctly when analyzing the system outside of the controlled environment. In his own examination of models, Black recognizes the comparative properties of models in relation to their fit to a system but denies that models are exactly like metaphors or analogies. However, his belief that models are like archetypes supports the argument that models use representation through means of comparison that cannot completely describe a system. Even if models are not metaphors, they utilize a structure similar to that of a metaphor, because the modeled system must be represented through metaphorical or comparative terms. It is how the models and metaphors are used that determines their intent and success when exploring ideas. A look at specific examples of metaphor in science will help to expand on this concept.

Metaphors and Models

A commonly raised question is whether models are synonymous with metaphors based on how they are understood by those who study them. In "Models in Science," Roman Frigg and Stephen Hartman argue that a description can be translated into another language, noting that the description can be and must be changed to make sense in a different language. However, a model does not need to be changed to make sense in another language. Furthermore, models and descriptions have different properties. I argue that, presumably, all people looking at a model of the solar system will understand the model in the same way regardless of their native language. However, models still use elements similar to language, including symbols, in their attempts to explain a system. This use of symbols cannot be ignored.

Let us look at this concept in terms of the moon. There may be many different ways to describe the moon, but the moon still remains the moon. Similarly, there may be different ways to explain or portray a system, but the system still remains the system. Now, let us say that there is no discrepancy in language and that a universally understood word for "moon" exists. Everyone who hears the word "moon" should understand the general properties of the moon based on that word. Likewise, a description of the moon should also convey at least similar ideas about the moon. If a scientific model of the moon was created to demonstrate what the moon is, then everyone who saw the model should be able to know the general properties of the moon. This scientific model may be more precise than a verbal description, but they are both limited in similar ways. Although there may be more interpretations of a description than of the model, both the model and the description may not successfully explain all of the information that can be known about the moon. We are still limited in our ability to fully explain the moon in either situation. Even though linguistic descriptions may possess different properties than scientific models, both are limited by the use of symbols. Both, to some extent, struggle to accurately represent every aspect of a system. Since scientific models only describe certain aspects of a system, they are like metaphors, which only capture certain elements of the described subject while trying to convey deeper understanding through use.

This similarity between metaphors and scientific models highlights how the two interact. Frigg and Hartman outline the variety of models used to explain phenomena, including idealized models and analogical models. These models both attempt to explain or study a system by simplifying the system. For example, an idealized model alters some information about the system to reduce the difficulties of calculations. The example provided by Frigg and Hartman explains how a model of the solar system may portray the planets as perfect spheres to simplify calculations. This example demonstrates how models possess elements of metaphor, because it must be simplified so that it can be understood and used. While the model can produce outcomes, the system still has to be described differently than how it actually exists to make that prediction easier. Similarly, an analogical model examines a system through the lens of another system. Frigg and Hartman provide the example of how the atomic nucleus can be explained through a fluid drop. The analogical model takes two seemingly separate systems to outline the function of one or the other. For this reason, the use of analogy is valuable in both literary and scientific contexts. It appears that models can explain systems through comparison, proving that models are limited to current understanding of language and other systems.

Along with analogy, models also contain symbolic representation that assists in describing an idea. For example, visual scientific models may use certain colors and shapes to explain a process or to show the structure of an object, like a cell. However, these colors may not exist in the actual system or subject. Similarly, the shapes used in the model may be close or similar to those in the actual system or subject, but they may not be entirely precise. The lack of precision in scientific models is further confirmed by the simple fact that that models have changed throughout history while the actual system remains the same. For example, let us look at the different models of the atom. Dalton's model of the atom showed only the atom as a solid circle while the current model of the atom contains a nucleus surrounded by electrons. When scientists gained more knowledge about the atom, they managed to describe it with better models. The failure of the original model to be entirely accurate, however, proves that the model is only symbolic. It does not flawlessly explain a system; it only attempts to describe it through representational symbols.

Symbols also appear in models in the form of symbolic language. The measurement of light demonstrates the limitations of models based on terminology. In *Quantum Physics*, Rae states:

> One of the consequences of wave–particle duality is that it sets limits on the amount of information that can be obtained about a quantum system at any one time. Thus we can either choose to measure the wave properties of light by allowing it to pass through a double slit without detecting through which slit the photon passes or we can observe the photons as they pass through the slits. (282)

The model of wave-particle duality exists because scientists already understand how waves and particles function. Since light seems to possess characteristics of both waves and particles, it is difficult to understand how it functions outside of current knowledge regarding wave and particle behavior. Light is neither a particle nor a wave, but the experiments result in either particle or wave behavior. Scientists already understand waves and particles, so "wave-particle duality" is applied to explain the properties of light by comparing it to what is already understood. However, using this comparison limits the understanding of light by constraining it to what is already known. In this regard, models are limited by the terms that scientists choose to use. These terms have preexisting meanings that restrict what can be communicated through models because the models are based on the other terms, indicating a lack of ability to portray new concepts without using comparison.

Building Models Through Metaphor

Having discussed some examples of the relationship between metaphors and models, let us examine a more nuanced explanation of metaphor with regard to model building. This section will analyze how physicists use elements of metaphor to establish models based on simple harmonic motion. These metaphorical properties identify the limitations of science through barriers in communication and explanation as they use models.

In "Models and Representation," R.I.G. Hughes demonstrates how models in physics, including quantum mechanics, are based on theoretical concepts about physical systems. Hughes states, "Quantum mechanics, on the other hand, starts from simple energy configurations like the infinite potential wells, simple harmonic oscillators, and Coulomb potentials that are introduced in basic texts, and deduces the permissible wave-functions of systems in these configurations" (331). Complex concepts in physics, like the wave-function, can be understood and modeled through these other configurations. These configurations, including simple harmonic oscillations, are theoretical concepts that explain physical systems. These theories function as the backbone for other models in physics. When explaining how scientific models are representations, Hughes explains, "Similarly, the wave theory of light represents light as a wave motion. It invites us to think of optical phenomena in terms of the propagation of waves, and so to anticipate and explain the behavior of light" (331). This idea of light functioning as a wave is connected to understanding the wave-function and how it relates to basic energy configurations. The wave-function, then, is a representation that explains the behavior of light based on previously understood concepts. For this reason, scientists understand elements of quantum mechanics through models of other configurations that are limited to representational properties and limitations of the model used for comparisons.

I argue that basing scientific concepts on other configurations brings into question the ability of models to explain an actual physical system. Simple harmonic motion is a cyclic motion of a mass that results from a linear restoring force. The inertia of the moving mass ensures that it continues through the equilibrium point and continues to oscillate. In physics, this motion is often, but not exclusively, demonstrated through the "mass on a spring" model. This model, which features a mass attached to a spring to illustrate the motion, is based on the theoretical concept of simple harmonic motion. The model helps to show the physical process so that it can be studied. The model is then often used as an analogy in physics to explain more complex ideas. Mathematical equations are created to explain these processes, including particle motion. However, developing a model based on another model raises issues when deciphering what the second analogical model is describing. This model could be modeling the actual system, or it could be modeling the model of that system. If Model A is an accepted model of a system, then one who creates Model B based on Model A will be confined to the existing limitations of Model A. Thus, Model B is limited by Model A. The relationship between Model A and Model B shows that models can be constructed through analogical concepts. This relationship illustrates that models may not be exact representations of a system but attempts at comparing what is unknown (Model B) to what is known (Model A.)

This development of Model A and Model B is similar to the development of metaphor because both use analogy, further highlighting how metaphors and models share similar properties. As previously explained, the "mass on a spring" model is known to be a representation of the system, and a reference to the model directly relates to the system that it attempts to describe. For this reason, many analogical models in physics are based on it. A similar process occurs in language. Let us think about how a word can relate to an object or system. The word "sun" directly represents the sun, the center of our solar system. Anyone with basic knowledge about the sun would hear or see the word "sun" and automatically think of that object. As argued in previous sections, metaphors attempt to literally describe something through comparison and interaction. For this comparison to occur, the new concept must be related to or interact with another word that carries a similar idea so that new insight can be gained. For instance, when describing a person, one could say, "He is the sun." This metaphor describes someone as he is by using a previously understood symbol or concept to explain these characteristics and inspire deeper thought. Thus, people create metaphors similarly to how scientists create analogical models. Both require the building of ideas based on currently existing symbols, and these new ideas move farther away from the original concept as more layers of comparison are added. Since metaphors exist to explain an idea that cannot be communicated without comparison, the use of comparison by scientists demonstrates a limitation in their ability to communicate new ideas. Therefore, if models possess metaphorical properties, then models may not be perfect fits to a system because of the limitations of communication and use. Models are valuable to scientists based on their use and not on their ability to fully capture every aspect of a system.

Conclusion

Models and metaphors have many similarities, and these similarities reveal the limits of science as scientists attempt to describe systems. Metaphors are created through comparison to help explain concepts when the existing language does not have the proper words to convey an idea. These comparisons should be taken literally, expressing something as it actually is even though the metaphor has limited descriptive ability. Saying that a model is metaphorical is not to say that a model fails to explain how the world functions or that the functions of the world do not actually exist. Instead, models work like metaphors in that they try to explain a system as thoroughly and accurately as possible in spite of the barriers surrounding scientific communication. Models are valuable in scientific experimentation because they can be used to cross the barrier between what is known and what is unknown. Like metaphors, models are able to answer questions about the world through their use. The intended purpose of the model and the metaphor enables them to function accurately, and this use allows them to inspire discovery. Therefore, models are capable of testing hypotheses and expanding scientific knowledge through comparison so that scientists can overcome the limitations surrounding communication and the study of abstract concepts.

Also, like metaphors, models build on preexisting representations. In this regard, models are embedded in higher-level models, pulling farther away from the actual system by explaining the process in other terms. The development of analogical models makes the new models limited to the accuracy of the original model, because the original model is the base for the other models. If Model B is based on Model A, then Model B is limited to the preexisting limitations of Model A. If Model C is based on Model B, then Model C is limited to the preexisting limitations of Model A and Model B. Therefore, the number of limitations increases as new models are developed based on other models. Although these models are valuable in their use, the creation of new models based on other models is similar to creating an extended metaphor that continues to grow in its explanation of a concept. As the metaphor grows, it deviates farther from the actual system in its attempt to describe an idea. When taken literally, the metaphorical description is still valid in providing insight, but the reality is not portrayed exactly. Therefore, as models develop through the use of other models, the layers of metaphor build, and these layers distance the new models from the reality as new limitations are created through these comparisons.

In his examination of a theory of anti-realism, philosopher Bas van Fraassen notes, “the language of science should be literally construed, but its theories need not be true to be good” (624). Thus, if scientific language is meant literally, then this language, as with metaphors, is fallible but valuable in use. If the theories explained through scientific language are fallible, they can still be useful even if they are not accurate, because they can still lead to insight, just like metaphors. While models are not exactly like metaphors in terms of their linguistic properties, models rely on the use of symbols and comparisons in a way that indicates that they are not capable of truly capturing the system and how it operates; even though they come close to doing so, the need for comparison adds an extra barrier. This problem in communication prevents scientists from knowing the full reality, indicating that the limits of science are connected to the limits of language. While the function of scientific symbols is to explain the system, the symbols still may not entirely capture that system in its entirety since the system is limited to these forms of expression. Assuming that the scientific language is accurate and literal, then scientists are still limited to how those scientific symbols are used. Scientific theories, then, are not entirely accurate because all theories are limited to human ability to comprehend and explain the world.

Bibliography

Black, Max. “Metaphor.” *Proceedings of the Aristotelian Society* 55 (1954): 273–294. Web. 9 March 2016.

Black, Max. “Models and Archetypes.” *Models and Metaphors*. Cornell University, 1962. Print.

Davidson, Donald. “What Metaphors Mean.” *Critical Inquiry* 5.1 (1978): 31–47. Web. 9 March 2016.

Downes, Stephen M. “The Importance of Models in Theorizing: A Deflationary Semantic View.” *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association* 1992 (1992): 142–153. Web. 16 Mrch 2016.

Frigg, Roman and Stephen Hartman. "Models in Science." *The Stanford Encyclopedia of Philosophy* (Fall 2012 Edition), Edward N. Zalta (ed.). Web. 13 February 2016.

Frigg, Roman. “Scientific Representation and the Semantic View of Theory.” *Philosophy of Science Archives.* The University of Pittsburgh, 2006. Web. 7 March 2016.

Giere, Ronald N. “An agent-based conception of models and scientific representation.” *Synthese* 172.2 (2010). Web. 13 March 2016.

Hartman, Stephen. “Idealization in Quantum Field Theory.” *Philosophy of Science Archives.* The

University of Pittsburgh, 2005. Web. 20 March 2016.

Hills, David, "Metaphor." *The Stanford Encyclopedia of Philosophy* (Winter 2012 Edition), Edward N. Zalta (ed.). Web. 16 February 2016.

Hughes, R.I.G. "Models And Representation." *Philosophy Of Science* 64.4 (1997): S325. *Academic Search Premier*. Web. 3 Apr. 2016.

Rae, Alastair. *Quantum Physics*. Cambridge University Press, 2004. Print.

Ridley, B. K. "The Limits of Science." London and New York: Routledge. Print.

Rothbart, Daniel. "The Semantics of Metaphor and the Structure of Science." *Philosophy of Science* 51.4 (1984): 595–615. Web. 16 March 2016.

Tal, Eran, "Measurement in Science." *The Stanford Encyclopedia of Philosophy* (Summer 2015 Edition), Edward N. Zalta (ed.). Web. 24 February 2016.

Toon, Adam. "The ontology of theoretical modeling: models as make-believe." *Springer Link.* Springer Science + Business Media, 25 March 2009. Web. 10 March 2016.

Van Fraassen, Bas C.. "To Save the Phenomena." *The Journal of Philosophy* 73.18 (1976): 623–632. Web. 4 February 2016.

Winther, Rasmus Grønfeldt, "The Structure of Scientific Theories." *The Stanford Encyclopedia of Philosophy* (Spring 2016 Edition), Edward N. Zalta (ed.) Web. 12 February 2016.

The Limits of Human Knowledge: Christianity, Science, and the Human Mind

Sara Nelson

The human mind is an inherently complex, ever-changing entity. It allows human beings the experience of a conscious existence, an understanding of what we perceive to be our reality, as well as growth in various domains of our being. The mind is the lens through which we discover ourselves and others, shaping our beliefs. It gives us the ability to question, to wonder, and continues to develop throughout one's lifetime. While our mind seems to be the key to unlocking what was once unknown and acquiring new knowledge, an enduring question remains: is there a limit to the capacity of our mind, and, if so, why must this be? I have found meaningful and relevant insight exploring this complicated and multi-faceted inquiry, pertaining to both religious constructs and scientific fields. As Karl Popper wisely states, "The more we learn about the world, and the deeper our learning, the more conscious, specific, and articulate will be our knowledge of what we do not know, our knowledge of our ignorance" (Yanofsky 9). The tenets of Christian faith and the methods and discoveries of science yield revelations regarding perspectives of limitations faced by human beings, especially those related to the capacity of the mind.

In the pages that follow, I will endeavor to capture the foundational framework of the aforementioned viewpoints, including references to resources offering historical research and context for conceptualizing these central topics. While there remains much to be discovered in this world and beyond, I posit that the limits of our cognition indeed exist, in practice as well as in principle, and ensure a boundary between our current knowledge and unlimited discovery, which is evident by our lack of ultimate clarity or understanding in both science and religion. Limitations which are said to exist in practice are not insignificant, as inherent within them are forces which we cannot understand, those which establish our ultimate, in principle, limitations. In other words, what limits us in practice does so due to an underlying principle, often beyond our capacity to know, thus playing a fundamental role in conveying ultimate limitations of human knowledge. The work of Immanuel Kant, as it relates to the limits of concrete knowledge and reason in order to "make room for faith", sets the stage for a parallel exploration of limitations to ultimate meaning and understanding (Pasternack). In fact, the religious and scientific limits we experience whilst on earth serve a meaningful intention, to guide the very purpose of our lives, shaping both our physical and spiritual existence. We can strive to expand upon our body of knowledge but undeniably become overwhelmed when faced with questions such as the nature of God and the afterlife, or our purpose of being brought into existence in the first place. Therefore, the boundaries we encounter as we strive to push forward in discovery of deeper meaning and understanding of all aspects of our lives can serve to balance our expectations of fulfilling seemingly limitless goals.

Knowledge and Christianity

In this section, I will detail Christianity's exploration of the unknown and highlight supporting assertions which parallel the notion that the limit of human understanding is a fundamental truth, presenting human beings with the opportunity to experience faith as a nexus to lived reality when complete knowledge is unattainable. Throughout history, various religions have developed ideologies with diverging characteristics yet with a unifying emphasis on faith and belief. Christianity is one of the widespread religions with unique rituals and an enduring presence, powerful in the lives of its many followers. Especially in times of uncertainty, religion is called upon as a source of comfort, community, and hope. Individuals who follow the tenets of Christian faith turn to representatives of the church and to their own connection with Jesus through prayer, sermons, and in living their lives in a way which reflects their religious commitments. In this religious approach, acceptance of the unknown is addressed through both active teachings as well as references found in the Bible, connected with faith in God and his vision. Faith remains a central component of processing questions which seem to be out of reach or especially challenging to comprehend, thought-provoking and abstract topics regarding creation, the meaning of our existence, God, and death, for instance.

The consistency and predictability found to be a characteristic of many religions is also present in Christianity's approach to addressing these natural questions. By looking to a monotheistic religion for insight into perspectives of faith, one can develop an appreciation for how followers believe God to determine and design us as well as the world, including other instrumental forces we come into contact with, such as those at the heart of scientific pursuits. In the Bible, God is said to reveal himself to us in ways he hopes for us to know him, and these revelations allow us to perceive God as we experience his presence around and within us. While religion inherently can allow followers the feeling of limitless expression, connection, and promise for an eternal life with God, it does not seek to provide concrete answers to all inquiries one might seek. Therefore, limits to religion as experienced by humankind during a lifetime do exist: "Human understanding of God is further limited by the finite faculties that man has been created with. Our knowledge of God cannot be exhaustive, for the finite is attempting to understand the Infinite who has revealed Himself" (Fowler). Furthermore, these limitations can be viewed as existing in principle as well as in practice:

> Palin tells us that 'God's activity is accordingly to be conceived as the luring influence of love which respects the proper integrity and intrinsic value of others.' Hartshorne believes that God is so important to us that his influence will be so great that it sets narrow limits to our freedom', and thus 'God can rule the world and orders it, setting optimal limits for our free-action, by presenting himself as an essential object... (Polkinghorne 67)

God's intent in giving us life, opportunity, and limitations of our human experience are seen in a most positive light, offering us the chance to fully experience the freedoms he intended for us in this existence, as created and guided by his all-knowing and all-loving presence. Christianity offers a unique set of beliefs which yield insight into the quest to discover perspectives on the limits of human cognition with regard to religious and ideological discoveries. This religion does not seek to minimize the fact that questions regarding the true nature of things, especially the works of God, will always remain unanswered and incomplete. Instead, Christianity is one example of a religion that offers as a guiding tenet the premise that God himself is an eternal mystery, inaccessible to man in the ways which we traditionally seek understanding:

> Our rational inquiry must not blind us to the awe-inspiring and ineffable mystery of God to which religious experience bears testimony. Kierkegaard said 'May we be preserved from the blasphemy of men who without being terrified and afraid in the presence of God…without the trembling which is the first requirement of adoration…hope to have direct knowledge.' (Polkinghorne 69)

There can be no concrete *proof*, or scientific assurance, of the existence of God and of how the divine intervenes within our lives. John Polkinghorne illustrates this point in his work, *The Faith of a Physicist*: "Theology, of course, faces an additional problem in that its method is not only elusive but its infinite Subject is also necessarily beyond the total grasp of finite minds. A consequence is that it is easier to say negatively what is not the case than to describe positively what is the case" (Polkinghorne 39). However, the power of faith strives to close the gap between the unknown and that which is comprehensible to human beings: "Vernon White encourages us to think of God's revelation in terms of divine saving action rather than in terms of propositional knowledge. He says 'epistemology must not hijack ontology'" (Polkinghorne 179). While faith does evolve over time, this does not equate to a discovery of ultimate truths and knowledge, which are in conflict with the very principles calling faith into practice. The construct we as a species have created, faith, can satisfy our desire to explain phenomena that we cannot otherwise detail.

The principles of faith that establish the basis for Christianity promote a belief in the power of the Creator even when concrete proof is absent. Certain aspects of life as a human being necessitate spiritual reflection to be conceptualized, though never completely understood. When we experience phenomena from the unique perspective of a conscious human being, we often find instances for which we cannot offer a satisfactory explanation, our minds are unable to understand in depth. Often intangible and with a strong connection to our emotional selves, experiences such as those we find when listening to music, admiring the beauty of nature, feeling love or loyalty, have a spiritual nature and can take over our present state and are indicative of the presence of the divine: "George Steiner says, 'I can only put it this way (and every true poem, piece of music or painting says it better): there is aesthetic creation because there is *creation*'" (Polkinghorne 45).

The sensations, which transport us to a deeper state of being, are however limited. We cannot always summon them independently, they are often transient and fleeting, and human beings cannot cognitively explain the occurrences, attributing them to a spiritual state and simply appreciating them, reflecting the human capacity. In Ridley's *The Limits of Science*, the author makes a relevant connection explaining the limitations of science in allowing us understanding of certain occurrences:

> Aesthetic and moral experiences are highly complex and highly subjective, with aspects that are essentially unique to the individual. They are, nevertheless, experiences and part of nature, but such unique experiences are for ever outside science's ken. Artworks are also unique. Not that it would seriously dream of doing so, but what can science say of interest about Beethoven's Ninth, the *Prima Vera*, or Durham Cathedral? (Ridley 34)

This commentary sheds light on the challenge of capturing some lived experiences in words, let alone understanding in our minds the forces which bring them into being and determine our responses to them. We qualify our experiences as spiritual when we acknowledge the limitations of any other facet of life to explain them. In the effort of finding a means of categorization, human beings search for answers that do not always exist. This realization is an uncomfortable one for many because of the innate drive for knowledge we possess and in which we take great pride.

Author John Shelby Spong delves into the exploration of Christianity from a unique perspective in his book *Why Christianity Must Change or Die*. As a retired bishop of the Episcopal Church, Spong is a believer in God who shares insight into the ability of human beings to fully understand the religion which guides their lives. He states that "God is the ultimate reality" in his life, and that he has an ever-present awareness of the divine (Spong 3). At the same time, he notes that upon attempting to translate his internal understanding of God into spoken words, he claims that language serves to "contract and diminish my God awareness" (Spong 4). This author suggests that the passing of time has resulted in a similar process on a much larger scale; believers and followers of traditional religious tenets have become more distant and removed from what were once unwavering commitments and beliefs. He continues with the suggestion that this includes the "loss of God", as the literal meanings, images, and biblical teachings once at the heart of the religion are increasingly challenged and not fully understood (Spong 45).

This work includes an argument for inherent limitations experienced by human beings as a result of our fundamental nature as designed by our creator:

> But theism and God are not the same. Theism is but one human definition of God. Can any human definition ever exhaust the meaning of God? Are we not aware of that ancient bit of folk wisdom suggesting that 'if horses had gods they would look like horses'? No creature can fully conceptualize beyond its own limits or its own being…despite our human pretensions, that is also true of human beings. If human beings have gods, they will look and act remarkably like human beings. None of us can ever get beyond that. If we are going to speak of God at all, we must begin by acknowledging that limitation. Even if we admit revelation as a source of knowledge, that revelation will be received and understood within the limits of the human experience. (Spong 47)

Spong's view of Christianity comes from experience as both a leader and a follower of the faith, and is one which confronts criticisms and controversies many choose to avoid. In a contrasting yet complementary discipline, scientists seek to close the gap left by the unknown, and succeeds in doing so in many instances, especially those explaining how our world fundamentally works. Even so, unanswered questions about our nature, purpose, and spirituality are not brought to resolution.

Knowledge, Miracles, and Tragedies

The way that we view certain defining events and circumstances such as miracles is inherently connected to the way we perceive and interface with the world in our conscious existence. This exploration also provides an example of a way in which religion and science differ in perspective regarding the existence of limits to human knowledge. Those who believe miracles are indeed acts of God, divine interventions beyond our capacity to explain, predict, and comprehend, have a perspective closely aligned with many who practice the Christian faith. Often in contrast is the view of the scientific minded, who may believe that what appears to some as miraculous can in reality be explained by concrete and objective physical phenomena and processes, that objective miracles do not exist. The same can be said for tragedies; scientists would believe in an underlying cause that could be explained by fundamental occurrences of the natural world, not a supernatural or all-knowing force. Christianity addresses questions regarding the reason suffering exists and what the Creator intended by allowing such experiences as pain, loss, and hatred through the premise of free will, God's gift to man to ultimately affect his own destiny. This serves to acknowledge the uncertainty about why God would inflict tragedy on those to whom he gave life, but complete knowledge is unattainable.

In Terence Nichols' *Miracles In Science and Theology*, the miracle is thought to be "an event that is consistent with but transcends natural processes" (Nichols 703). What this suggests is that miracles do not by definition undermine science; instead, they surpass what could be expected or predicted by traditional means. Nichols goes on to explain that:

> Miracles are better understood as signs of divine action, which, like grace, do not violate nature but work through it, perfect it, and reveal its divine ground. Nature is not a closed system but an open system within a larger, divine context; viewed within this context, miracles can be seen as rational and even lawlike events that express the divine ground within which nature exists. Just as the laws of nature behave in extreme ways in unusual contexts (for example, superconductivity or black holes), so it may be that the ordinary laws of nature, within a context of faith, behave in unexpected ways. (Nichols 705)

This author suggests that the theological framework views miracles as evidence of the existence of God, confirmation of his divine presence through acts we cannot always explain. Thus, he disagrees with the common scientific definition, attributed to David Hume and a product of scientific progress that a miracle is "a violation of the laws of nature" (Nichols 704). In science, it is noted that an explanation for miracles is necessary because their very essence contradicts the fundamental aspects of science by being an example of "inexplicable and irreproducible phenomena" (Nichols 704). However, despite the seemingly polarized perspectives on miraculous occurrences adopted by science and religion, Nichols believes there is merit in studying these events to further our knowledge about our world and deepen our understanding of both domains. In acknowledging the reality that there is not a consensus on whether miracles truly are divine acts of God or simply are natural physical processes, we can see that limitations to our conceptualization and understanding of events do exist as is made evident by this lack of certainty. Christianity further explains these limits as existing not only in practice but also in principle, designed by the all-knowing and all-loving vision and purpose of the divine.

Knowledge and Science

Science is responsible for countless achievements affecting our lives in powerful ways on an immediate and long term basis. Science has proven to be a discipline deserving of great prestige in our society, expanding our knowledge of our own biology, the physical world, and providing theoretical frameworks for such sophisticated concepts as quantum mechanics. The aims of science include discovery, explanation, as well as the expansion of knowledge of the world and its complex and dynamic components. The breakthroughs of scientists have saved lives as well as promoted a sense of curiosity and yearning to learn more, faster. In Henry Bauer's *Scientific Literacy and the Myth of the Scientific Method*, the known, the known unknown, and the unknown unknown are identified as categories in which science seeks to gain deeper understanding. Although scientists are able to identify beginning realms in which we have not yet attained a wealth of knowledge, it is difficult to reach a level of certainty in the many facets of science when exploring what remains to be discovered; this is due to the fluid nature of the physical world, its impermanence and depth of which we cannot begin to ascertain.

Knowledge and Reason

The limitations of human knowledge as defined by various elements of logical reasoning, including those relevant to science, mathematics, and philosophy, are explored throughout Noson Yanofsky's *The Outer Limits of Reason*. This author takes the stance that there are limitations to the possible discoveries humankind can achieve. Through the careful analysis of the above disciplines, Yanofsky suggests one can identify specific areas, problems, and questions that are inaccessible or unsolvable. Despite noteworthy historical achievements and those that will undoubtedly come to fruition in the future, limitations do exist, establishing a boundary between what becomes known and that which remains out of reach.

Reason is a central concept explored by Noson Yanofsky. The true definition of reason proves more complicated than it may initially appear. Perspectives vary between individuals, and philosophers have yet to come to a consensus regarding a universal meaning of what is reasonable and the forces that guide reason in human beings. Often associated with virtue and wisdom, reason influences thought, behavior, and the justification of both. What remains after all of the conflicting viewpoints are processed is the underlying proposition that "one cannot use reason to derive contradictions and false facts" (Yanofsky 345). As a result, reason must result in revelations yielding insight that has proven to be supported, or at least has yet to be disproven or fundamentally challenged. Understanding reason is crucial so that one may discern what is real and what is subjective or contradictory. However, reason itself is not a constant; over time, with expanding knowledge comes the realization of falsities and errors previously believed to be reasonable (Yanofsky 346).

Thus, science, a field which relies largely on reason, valuing concrete supportive evidence to validate claims, is not a constant either. Rather, it is the ongoing practice of evolving discoveries and theories, to which reason must correspond or changes must be made. The limits of a human's knowledge of science, then, parallel the limits present in the field itself. What must be true in the physical world is that there cannot be something that is at once both true and false; when our reasoning suggests that there is something false, the limitation lies within our reasoning (Yanofsky 346). Additionally, this author identifies the reality that we do not even have an awareness of what causes us to act in an irrational manner, coming to false conclusions and erring in our logic. We are more capable of determining the wrong outcome than the right, which usually will change over time. There are many examples of instances where what was previously believed to be a scientific truth ultimately was proven false and also beliefs which were discounted but in the end proved justifiable. For instance, phrenology was once a common practice in seeking to identify patterns characteristic of human behavior by studying an individual's bone structure around their brain (Yanofsky 346). Only relatively recently was this discredited as an unsound approach. On the other hand, Yanofsky discusses the fact that Louis Pasteur, a chemist and microbiologist, and Ignaz Semmelweis, a physician, raised the notion of germ theory, which was met with doubt and disbelief (347). Today, its relevance and acceptance has vastly expanded in modern society. In *The Outer Limits of Reason*, the discourse regarding reason itself continues to come into play in significant ways as the author forms connections with limits that present in various other aspects of life.

The perspective conveyed by this professor of computer and information science centers around four defining limitations believed to exist in the lives of human beings. These categories include: physical limitations, mental-construct limitations, practical limitations, and limitations of intuition (Yanofsky 341). Physical limitations, as explained by Yanofsky, pertain to the belief that we may not use reason to "permit a certain physical object or physical process to exist" (Yanofsky 340). Examples include limitations of computers and even quantum mechanics as being unpredictable to some extent, unable to be anticipated or expected. Paradoxes and unsolvable problems cannot be solved through reason or other means. We cannot simply explain conditions into existence by means of reason alone when physical properties suggest impossibility; there must be other supporting elements to our determination. The author continues with an exploration of what he considers limitations of our mental constructs.

Yanofsky suggests that there are various identifiable mental states and ideas that are impossible to exist; he supports his argument by turning to language, a central element influencing the processes of our knowledge. Specifically, he cites scenarios such as sentences which are at once both true and false, and thus incomprehensible to the human mind. Examples such as vagueness of specifications, descriptions, and statements prove to highlight our limitations of logic (Yanofsky 341). When inconsistencies exist, Yanofsky points out the tendency of human beings to steer clear of confronting these issues. However, in the common use of language, people do not have such a vehement opposition to contradiction; rules can be broken as a means of avoiding potential limitations of language. On the other hand, the same is not true when referring to physical objects and properties as we strive to express the ultimate reality (Yanofsky 342). Reductionism comes into play in that one limitation, once discovered, often gives way to others; negation, for example, often accompanies self-referentiality, thus illustrating a limit of the original principle and our ability to overcome it (Yanofsky 344). In addition to these in principle limitations, Yanofsky continues with an exploration regarding limitations of a practical nature.

Rather than emphasizing the impossibility of the previously discussed facets of knowledge, practical limitations focus on those feats of knowledge which are possible but are considered by the author to be "extremely improbable" (Yanofsky 342). To see them through to full realization would not only be extremely time intensive, unrealistic, and demanding of finite resources, but also require dedication beyond what human beings would naturally be inclined to demonstrate. Chaotic systems, defined as having "sensitive dependence on initial conditions", including weather predictions and anticipation of certain behaviors and phenomena, fall under this domain (Yanofsky 164). This is indicative of a limitation as the ultimate effects of such elements cannot be fully understood, depending largely on initial conditions and subject to corresponding, unpredictable changes to the end result throughout the processes that occur over time. In addition to these limitations of practicality, Yanofsky includes information on intuition and limits of our unconscious understanding.

Pondering limits of intuition offers insight into the way the human mind processes information and responds to stimuli of various types. Limits in this case can be defined again as errors, because false beliefs and perceptions do in fact limit our accurate perspective of the objective world of knowledge. Especially pertaining to science, limitations of knowledge can be found in instances of self-referentiality (Yanofsky 343). When an occurrence or process refers to its own characteristics, it must be accompanied by limitations. Furthermore, what we are able to describe based on our current body of knowledge represents only part of the whole picture; it is incomplete as it leaves out what is unknown and what has not even been identified as yet to be discovered. With the limitations explored in the work *The Outer Limits of Reason* in mind, other aspects of human knowledge and cognition can shed light on additional components of learning and limits.

Knowledge and Memory

An interesting and abstract area in which the limits of human cognition also become evident proves to be memory. Forces influencing our memory have been explored from a scientific perspective and include factors such as age, emotional state, and physical health at the time of a given experience. For example, the capacity of a human being's memory includes various lapses as well as misconceptions. Little is remembered from one's early years, as the process of storing memories is just unfolding, and details quickly fade and become inaccessible as time continues to pass. The loss of memory also accompanies the aging process; from forgetting dates or events to diagnosable conditions such as Alzheimer's disease or dementia, remembering even the simple things becomes something we no longer take for granted.

In addition, throughout one's lifetime factors such as trauma or heightened emotional states may inhibit the formation and retention of facts or experiences. This can serve as an explanation for instances such as eyewitness misidentification or false memory. Furthermore, certain memories in our subjective minds are given greater weight than others. Our conscious and subconscious thoughts mold our perceptions and influence which items remain prominent in our mind and which fall to the background, further and further from our reach, replaced by those we choose to emphasize. This can occur due to one's interests and drives, or to external factors such as surroundings and life circumstances. When we are not able to retrieve memory, or when we create it falsely according to our own subjective state, it is a phenomenon out of our control, and this is evidence indicative of a natural limitation of knowledge.

While the limitations of memory exist in practice throughout many aspects of the life of a human being, in principle limitations can be revealed through the exploration of such functional limitations. Limitations which present themselves in practice form the foundation of ultimate limitations, those about which we cannot develop a full understanding. That human beings have limitations presents the opportunity for faith to enter our lives. Revelations of this type serve to highlight the importance of considering limitations in practice, which often then lead to corresponding discoveries of the essence of in principle limits to humanity.

Knowledge, Interest, and Motivation

A parallel to the concept of limitations of memory is the notion that we are limited by the very things which we are attracted to or are interested in pursuing. The content or domains an individual decides to explore and learn, gaining knowledge and awareness of them, are in large part determined by innate drives and forces that we do not consciously set out to choose. It is not as if human beings actively select interests or passions that captivate our minds and attention. Instead, we follow paths according to our instinctual drives, abilities, and capacities, which vary greatly from person to person and even within the lifetime of one human being (Bauer 32). This in turn serves to control the extent of what we discover and the areas of study we are exposed to in the first place. Limits come into play because, in opening doors for us, the processes of both nature and nurture invariably close others as a result. We simply do not demonstrate an interest or calling for all things, and this is in fact what makes each person unique, we all possess distinctive characteristics and tendencies.

To build upon the framework of individual instinct and interest limiting which aspects of the world we even become exposed to, let alone have the chance to truly enrich our minds with, Henry Bauer discusses a relevant idea regarding motivation. He claims that "Scientists choose projects that offer a reasonable prospect of success, for without being successful, scientists cannot make careers for themselves" (Bauer 7). Factors which motivate us are also unique to each individual. However, certain forces that exert power over us are almost universal, including those related to recognition, reward, and fulfillment. Acknowledging this tendency allows us to understand another cause for limitations to our potential knowledge and cognition. What motivates each one of us has the ability to influence our direction, actions, and where we spend our time.

Consequently, if we pursue a course of study or profession based upon intrinsic or extrinsic motivators, to earn the most money for example, by default we are narrowing our awareness of other possibilities and restricted in the realms that we will have the chance to discover.

Thus, science, too, offers a natural opportunity for exploring questions of fundamental knowledge, the limits of our cognition for the study of external forces. It could be suggested that, what Bauer claims to be the "myth of the scientific method", is in fact an indication of a limit when our constructs of the world and reality come up against forces beyond our control, or the ultimate reality: defining forces created and maintained by an external power surpassing our ability to both study and comprehend. Is the reliance on "models" additional evidence of our limitations, or merely representative of the possibilities remaining for our future discovery and refinement of processes and laws? How do we know whether these findings, grounded in scientific methods, really reflect objective truths when such change and evolution of concepts has undeniably dominated the discipline's history, and the history of human beings. While it seems that certain fields of scientific progress, such as quantum mechanics, have propelled us forward into better understanding of what was once largely unknown and unexplained, exceptions and anomalies do remain. Quantum mechanics, "probably the greatest development in all of physics", has yet to provide a concrete description of the force of gravity (Yanofsky 175). While this framework otherwise accurately describes our physical world, the future will likely bring changes to these theories too, as our history consistently demonstrates occurs as time unfolds and new proofs are uncovered and others disproven. Complete knowledge of the ultimate truth, it seems, will always remain out of reach during the life of a human.

Conclusion

It can be posited that science offers a compelling illusion of limitless discovery, while the ultimate reality will remain unknown to us as human beings, as our construct for the world is a conventional tool to allow for conceptualization of our surroundings and a fulfillment of the desire to learn and grow. It gives us the opportunity to learn about our world in concrete and abstract ways, through observation, experimentation, and logical reasoning for example. This discipline also has produced findings that have saved lives and improved both the quality and direction of our species' future on various levels with technology, medicine, and groundbreaking revelations of how our physical world works and the processes that occur to create the universe and ourselves. New concepts capture the attention of leading scientists and those simply curious about learning more about how the world works, and represent a fundamental quest of the scientific discipline.

Changes to theories unfold as time progresses and new discoveries are made, replacing and modifying others which were once thought to be true or conclusive. Defining characteristics of each individual drive him or her to pursue certain directions, ultimately affecting and limiting others that might have been discovered. Concrete limitations to our mental capacity, memory, and motivation alter our course and put a cap on the parts of our world to which we even become introduced. However, if science was approached from a viewpoint of limitations, it is hard to imagine the progress we see today being realized. Overall, science allows for us to conceptualize physical phenomena and experiences, while acknowledging without being discouraged by our limitations, maintaining the goals of constant discovery to enrich our lives and satisfy our minds, to the best of our ability.

Religion seems to offer a complementary yet unique perspective on our limitations, embracing the truth that humans are uncertain about fundamental questions, and that these unknowns are an inherent aspect of the life that we are destined to live. Through both ideology and science, we improve functionality to facilitate our ease of existence and attain subjective and relative “knowledge” to fuel our minds’ desire to learn and grow. Religion begins where science leaves off, as limitations to reason have allowed for the practice of faith. Being human is not without limitations, but this reality need not undermine the relevance of the discoveries, frameworks, and constructs that we as a species have developed, evolved, and maintained over time. While many argue that the abilities of human beings with regards to the acquisition of knowledge are limitless and ever increasing, evidence from both religious and scientific domains supports the notion that limitations are in fact both practical and intrinsic components of our existence. In fact, I hold the belief that the religious and biological limits we experience whilst on earth exist as a meaningful intention, to guide the very purpose of our lives, ultimately complementary to our scientific endeavors. The principles of faith and practices of science shape and affect our spiritual and physical existence. We are, in fact, limited in both domains, but the limits of science exist to leave room for faith and religious experience.

Limitations must not always be viewed as demeaning or as hindrances to humankind. They can serve as the very catalysts for growth and allow for the practice of faith to fulfill our need for expression and exploration of that which cannot be captured and proven by the methods of science. As explained by Stephen Jay Gould, the belief that science and religion are “nonoverlapping magisteria”, distinct in purpose and purview, sheds light on the meaning and value inherent within each domain, independent from one another, but both furthering our human experience (Gould). Faith is what exists beyond the limits of knowledge, and as Albert Einstein stated, “Once we accept our limits, we go beyond them” (Boudreau et al. 111). Thus, science and religion, while in apparent conflict in various instances, in fact offer complementary perspectives in the exploration of compelling questions such as limits of our cognition and our existence, allowing us to further explore the meaning of this life.

Bibliography

Bauer, Henry H. Scientific Literacy and the Myth of the Scientific Method. Urbana: U of Illinois, 1992. Print.

Boudreau, Gwen, et al. "Words of Wisdom: Albert Einstein." Google Books. Balboa Press, 2013. Web. 24 Apr. 2016.

Fowler, James A. "A Christian Understanding of God." *A Christian Understanding of God*. Christ In You Ministries, 2002. Web. 07 Feb. 2016.

Gould, Stephen Jay. "Stephen Jay Gould, "Nonoverlapping Magisteria," 1997." Stephen Jay Gould, "Nonoverlapping Magisteria," 1997. N.p., n.d. Web. 24 Apr. 2016. <http://www.stephenjaygould.org/library/gould_noma.html>.

Nichols, Terence L. "Miracles in Science and Theology." Zygon 37.3 (2002): 703-16. Web. 20 Mar. 2016.

Pasternack, Lawrence and Rossi, Philip, "Kant's Philosophy of Religion", The Stanford Encyclopedia of Philosophy (Fall 2014 Edition), Edward N. Zalta (ed.), URL = <http://plato.stanford.edu/archives/fall2014/entries/kant-religion/>.

Polkinghorne, John. The Faith of a Physicist: Reflections of a Bottom-up Thinker: The Gifford Lectures for 1993-4. Princeton: Princeton UP, 1994. Print.

Ridley, B. K. On Science. London: Routledge, 2001. Print.

Spong, John Shelby. Why Christianity Must Change or Die: A Bishop Speaks to Believers in Exile: A New Reformation of the Church's Faith and Practice. San Francisco, CA: HarperSan Francisco, 1998. Print.

Yanofsky, Noson S. The Outer Limits of Reason: What Science, Mathematics, and Logic Cannot Tell Us. Cambridge: MIT, 2013. Print.