

ESSAY

To What Mode of Logic Does Evidence-Based Decision-Making Adhere? Implications for Science and Faith

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Evidence-based decision-making as practiced under the What Works Network (WWN) consortium in the United Kingdom has emerged as a world leader in the collection and appraisal of evidence to reach policy-relevant conclusions. The network consists of ten independent centers such as the National Institute for Health and Care Excellence (NICE) and the Education Endowment Foundation (EEF). The consortium is united by the goal of inculcating robust evidence evaluation as the basis for sound policy-making and public-sector service delivery (Gold 2018). Its practices can be linked to current schools of thought in the history and philosophy of science.

The most intriguing area of philosophical inquiry is the subdiscipline of epistemology, which simply refers to knowledge, and more specifically, the legitimate routes to valid knowledge acquisition. Three such modes of rational inference dominate the epistemological landscape: deduction, induction, and abduction. The intent here is to demonstrate that recent insights in the philosophy of science conclude that the scientific method is an abductive process. Furthermore, this abductive process animates social scientific inquiry as demonstrated in the professional standards of best practice embodied in the WWN's centers of excellence. This is important because identifying the logical framework and epistemological underpinnings of the social and general sciences enables further scrutiny and refinement of the scientific program, and consequently its cost effectiveness. How the Christian faith influenced the historical development of the scientific method will also be considered.

Classic epistemology, also known as foundationalism, asserts that things may be known to be true in an absolute sense either through the authority of reason (deduction) or the authority of experience (induction) (Philips 1987). Deductive inference or reasoning moves from the general to the specific, that is, from theory to observation. Deduction is associated with the belief that true knowledge can only be acquired or known through the introspective application of reason and logic (Philips 1987; Teddlie and Tashakkori 2009). For example, during the scientific revolution, the Catholic philosopher Rene Descartes pioneered analytic geometry which he developed from self-evidential mathematical truths or axioms (e.g., $1 + 1 = 2$) without systematic reference to or interaction with external reality (Descartes 1999; Teddlie et al. 2009). Fully developed, Descartes's discovery allowed geometric shapes to be subject to algebraic analysis, with practical uses in, for example,

engineering and aviation. The mathematical language made amenable by Descartes's discovery is further seen as essential in the development of modern theories of science, such as Albert Einstein's theory of general and specific relativity and quantum theory of the 20th century (Gribbin 2002). Descartes also completed a deductive defense for the existence of God (Kenny 2007; Feest 2021). Deductive reasoning assesses whether premises (statements which are either true or false) which comprise a theory are connected to one another in a rationally congruent manner. If true, a theory is valid. Deduction therefore relates to things that can be known *a priori*, that is, without the need for or reference to sense experience, but exclusively via the proper employment of rational thought (Lee 2017). On the other hand, inductive inference or reasoning moves from the specific to the general, that is, from observation to theory. It travels the opposite direction, moving from interaction with the external world to theoretical conceptualization of that external reality. Induction is associated with the belief that true knowledge can only be acquired or known through observation and sensory experience (Phillips 1987; Teddlie et al. 2009). During the scientific revolution, Francis Bacon posited an inductive scientific methodology capable of eliminating bias from observation, one that relied upon calibrated instrumentation which yielded standardized measurements. In his methodology of enumerative induction, gathered empirical evidence could be used to refute or verify theoretical causes of phenomena in an absolute sense. For example, through the systematic comparison of things displaying the phenomenon of hotness with things displaying its opposite of coldness, and all gradients in between, Bacon came remarkably close to the modern-day kinetic theory of heat which pinpoints molecular motion as the theoretical cause of heat (Ladyman 2002). Induction therefore relates to things that can only be justified *a posteriori*, that is, through sense experience (Lee 2017).

Certain aspects of the modern empirical method animated learning in antiquity (Kenny 2007; Mittwede 2020). Aristotle did hold a passive observer model of empirical inspection, but his logical method of reasoning from first principles, granted an almost hollowed reverence by his intellectual successors, severed any fruitful connection between logic and observation up into the Middle Ages (Ladyman 2002; Teddlie et al. 2009; Meyer 2021). On the other hand, the rapid discoveries of the scientific revolution (~1450-1650) were due to scientists pragmatically utilizing both inductive and deductive routes to knowledge in a nuanced and self-substantiating manner, in order to discover the immediate causes and general laws of material reality. For example, Isaac Newton used mathematical axioms alongside imaginative theorizing constrained by common logic (deduction) and detailed observation (induction) to develop his theory of universal gravitation, and laid forth a predictive mathematical model which supported the new heliocentric worldview (Gribbin 2002; Teddlie et al. 2009). Francis Bacon posited the use of experimentation to rule out alternative hypotheses as an isomorphic precursor of modern day falsificationism (Ladyman 2002). Actual practice of the scientific method was intuitively approximated during the scientific revolution, however, its philosophical appreciation is, arguably, still being developed.

Historians of science agree that Christian concepts emerging during the late Middle Ages and into the Protestant Reformation were likely responsible for the rise of the scientific method (Butterfield 1957; Barbour 1997; Harrison, 1998; Hodgson 2001; Meyer 2021). The newly nuanced Christian worldview resulting from the Bible being translated into common English and printed widely contained two concepts held in tension: i) the original image of humans as a reflection of God, capable of rationality and discernment of God's creation, and ii) the sinful and error-prone nature of human understanding (Meyer 2021). Thus, the mental faculties of humans were envisaged as functionally capable yet somewhat impaired. These two concepts, when pragmatically employed by Christian practitioners of science during the scientific revolution, facilitated the development of the empirical method. It rejected the Aristotelian method of reasoning from first principles, and instead advocated detailed observation in conjunction with rational analysis. Recent scholarship in the history of science therefore argues that these theological concepts animated late-medieval scholarly thought, and were ultimately responsible for the rapid advances of the scientific revolution (Meyer 2021). Interestingly, the epistemological principles this nuanced Christian worldview engenders align with the conceptual underpinnings of abduction. And contrary to popular belief, immediate causes and natural laws commonly associated with atheistic modern science actually originated from a theistic paradigm; nature was viewed as the marvelous handiwork of God, with immediate causes and general laws akin to the mechanics of an elegantly designed watch (Meyer, 2021).

A major turning point in the philosophy of science occurred when the infallibility of the traditional routes to knowledge—reason (deduction) and observation (induction)—came into question. These reservations gained traction as science moved into the 20th century, especially as the empirical method, as espoused by Bacon, relied upon ever increasingly complex instrumentation to take measurements, the working and correct implementation of which relied upon theory. Most notably, Karl Popper attacked these traditional means to knowledge by asserting that all observation was prone to error and not absolute. Popper also posited that, because all observation is error-prone, no amount of confirmatory evidence could ever prove a theory in an absolute sense. This concept is also known as theory underdetermination, which states that theoretical alternatives will always exist to account for any body of evidence; any theory is always underdetermined by the evidence (Philips 1987).

Popper therefore rejected the confirmation model of theory validation and replaced it with the protocol of falsification by which theories could be legitimately refuted. As operationalized in modern sciences, falsification is associated with the hypothetico-deductive model, whereby theories generate testable hypotheses subject to experimental protocol. If predictions do not obtain under Popper's strict standards of falsification, the theory must be adapted or dismissed as incorrect. Popper thus provided a model whereby incorrect theories could be culled from the body of scientific knowledge as it advances (Philips 1987; Teddlie et al. 2009).

However, recent thought in philosophy has questioned the pragmatic and rational

validity of falsification. Pierre Duhem questioned whether theories could be tested in an all-or-nothing manner via the experimental protocol. He noted that if a theory's predictions do not manifest empirically, then either the theory itself is incorrect or a theory to which it is conjoined is incorrect. For example, if a planetary motion Newton's theory of celestial mechanics predicts does not manifest, either Newton's theory is incorrect or the law of optics upon which the celestial observation was made is incorrect, alongside an unending host of alternative hypotheses (Duhem 1962; Ladyman 2002).

Duhem also questioned whether all potential confounding variables could be included in an experimental protocol. For example, the randomized control trial (RCT), seemingly the protocol of choice in the social sciences, assumes to ameliorate completely the effect of potential confounders between control and effect group(s). Effects which obtain in experimental groups(s) are then causally attributed to the intervention itself. However, recent scholarly thought is coming to the realization that confounders, either known or unknown, that are potentially correlated with the intervention outcome cannot be distributed equally across groups in an absolute sense via the act of randomization (Worrall 2007; La Caze, Djulbegovic and Senn 2012; Senn 2013). The act of randomization may only significantly decrease the chance of potential confounders not being distributed equally among groups; randomization only eliminates potential confounders in a probable sense, and thus the results obtained from an RCT may only be attributed causally to intervention effects in a probable, not in an absolute deterministic sense.

Furthermore, Shepherd (2020) demonstrated the faulty logic which undergirds falsification. Even if acts of observation are not necessarily free from error, a founding premise upon which Popper developed his principle of falsification, the results obtained from an experimental protocol are nevertheless probable. For example, even in an observation conducted under the strictest of experimental protocols, there is still a chance, however small, that the observation was made in error. Therefore, experimental designs can only ever yield confirmatory or dis-confirmatory evidence in relation to a theory, and can only ever confirm or refute a theory in a probable sense. Consequently, falsification has been modified to include the intersubjective agreement of experimental results as an objective standard of hypothesis refutation (Ladyman 2002).

However, increasing the quality of evidence for hypothesis refutation in a probable sense does not yet meet the principal critiques found in Duhem's thesis (1962), not to mention that the empirical evidence which supports the existence of the plethora of unobservable entities which comprise theories of modern science, such as electrons, are derived indirectly through theory dependent and therefore not wholly empirical scientific instrumentation (Ladyman 2002; Quine 1999). The extreme skepticism in Descartes' meditations undermine further the absolute veracity of even first-hand evidence derived directly via the senses, by showing that there is no objective point of reference with which to calibrate or compare our own introspective experience of reality (Descartes 1996; DeWitt 2018). Hopefully, by demonstrating the impossibility of absolute knowledge derived through either deductive or inductive means, the contradiction entailed in falsification is evident. In

essence, Popper asserts that all forms of evidence are prone to error and thus fallible, yet ironically also asserts that this fallible and incomplete evidence may falsify theory in an absolute sense!

Fortunately, abduction offers a rationally sound and non-contradictory mode of theory evaluation. Otherwise known as inference of the best explanation, abduction is primarily based upon the parameter of explanatory power, whereby a theory is evaluated against a body of empirical evidence in order to choose, adapt, or create theory which best fits the known body of evidence. An abductive inference therefore bypasses the faulty and unfounded Popperian principle of theory refutation or acceptance in an absolute sense, and instead produces theory which is most likely true with reference to a particular body of empirical evidence. This accords with the realization that empirical evidence can only ever yield probable, never absolute, support in relation to a theory, especially in the social sciences where the object of study—people—is so complex. Therefore, the epistemic value of a social scientific theory is based upon its explanatory power in relation to a body of empirical evidence. If a theory explains or ‘fits’ the current body of evidence better than alternatives, it is regarded as the most probable explanation of the evidence (Lipton 2004; Dellse’n 2018).

Simplicity, otherwise known as parsimony, and antecedent plausibility are also generally regarded as additional parameters, alongside the principal parameter of explanatory virtue, used to assess theory probability during an abductive inference. Antecedent plausibility refers to how well a new theory fits with what one already believes to be true, or how well it connects with other commonly accepted theories or dominant worldview paradigms (Lipton 2004; Dellse’n, 2018). Thomas Kuhn’s seminal thesis (1962) demonstrated the potentially biasing effects of lay or technical paradigmatic worldviews, which he described as the “received tradition.” The proper implementation of abduction is dependent upon a rigorous methodology which allows for discernment of evidence at odds with priori theoretical structures, hence the adaptation and approximation of theory as advanced in abduction. But in fact, the ability to identify evidence incongruent with a current paradigmatic worldview, a phenomenon which Kuhn acknowledged, discredits Kuhn’s principal assertion that prior formed worldviews completely dictate an interpretive construction of social reality (Kuhn 1962; Philips 1987). Hence, when subjected to a rigorous methodology, antecedent plausibility is not a liability which predisposes biased interpretations, but rather carries epistemic virtue in its instrumental value of predictive success, technological innovation, and more. It actually adds to the probable truthfulness of a new theory which fits in well with, or minimally adapts current theory in order to best explain a body of evidence. Illustrative of this point, abductive reasoning was applied formally to diagnostic testing and medication prescription. It was found that increased background theory collection which surrounded the substantive field of Type 2 diabetes management increased the predictive efficacy of drug selection (Lucas 2003).

Although abduction has been given formal treatments in precise logical syntax (Lucas 2003; Glass 2018), its beauty lies in its principal application as a general inferential heuristic

used to assess the probability of a theory (Lipton 2004; Dellse'n 2018; Shepherd 2020; Meyer 2021). This is advantageous because research has shown that the average person is not adept at applying formalized probabilistic reasoning which relies upon mathematical syntax (Tversky and Kahneman 1984). However, abduction is the most commonly used mode of inference that we humans rely upon in our everyday lives. For example, everyday inferential processes display the aforementioned features of abductive reasoning, with the average person showing preference for hypotheses that are more explanatorily powerful (Preston and Epley 2005), that fit better with what one already believes (Pennington and Hastie 1992; Sloman 1994), and that exhibit parsimony (Lombrozo 2007).

Furthermore, the inferential shortcut via which abduction operates represents an ideal merging of both deductive and inductive inferential pathways in order to choose a theory which best fits the evidence. The philosopher Igor Douvan (2021) gives an example of high-performance professionals using the abductive inference in such an optimized manner. When reaching a prognosis, doctors in accident and emergency settings will compare the best available evidence at hand inductively, such as patient history, X-ray images, and blood diagnostics, with the deductive realm of their theoretical medical knowledge base, such as their expertise in anatomy and physiology, to determine the most likely cause of a patient's illness.

However, what differentiates the conclusions of experts from the conclusions made by everyday persons is the quality of evidence used in the inferential process. This is why abduction, as it operates in the creation of scientific theories, highlights the quality and quantity of evidence used in order to substantiate a theory or hypothesis. In turn, this translates into the assessment of the methodological rigor used to collect said evidence.

RCTs under a scientific protocol animated by abductive epistemological values are still considered the highest quality of available evidence in sociological research, because they hold the highest probable likelihood of negating potential confounder effects, and alongside the concomitant use of large sample sizes, means their results hold the highest probability of being internally valid and generalizing to the population of interest (Fowler 2014). A scientific program animated by abductive epistemological values would therefore be able to accept a wide range of evidence types, from quantitative to qualitative research offerings, acknowledging that all evidence is probable in nature, while displaying preference towards evidence which was produced under higher standards of methodological rigor, such as RCTs.

This ability to assess an aggregate body of evidence while preferring evidence of a higher quality when reaching conclusions abductively is uncannily reflected in the current best practices of the WWN consortium of centers. This network demonstrates a commitment to producing evidence that is methodologically rigorous. For example, the Trial Advice Panel (TAP) of the WWN Cabinet Office Team promotes the use of experimental or quasi-experimental designs which reflect the standards of RCTs as the best possible method to uncover what works for whom and in what contexts (Gold 2018).

Secondly, the WWN demonstrates the abductive principle of assessing an aggregate body of evidence to reach conclusions which are most likely true. For example, a primary

feature of the WWN is the production of reviews to inform practitioners in diverse fields of expertise. These reviews appraise the overall evidence base and are conducted using a set of evidence standards that preferentially accommodate evaluations which are more methodologically robust. Prior to the date of their most recent report, the 10 research centers which comprise the WWN have produced 288 reviews, representing a prolific contribution toward evidence-informed decision-making (Gold 2018).

However, the WWN would benefit from reflecting upon the abductive values which animate its research output. Specifically, the probable nature of evidence should engender the use of all evidence types, including qualitative designs. Furthermore, due to issues in the operationalization of sociological constructs, the use of qualitative studies should be used alongside quantitative designs. For example, the typical theoretical entities under investigation in sociological research, such as a person's level of self-esteem, may be operationalized either quantitatively through survey questions which reduce to a numeric scale, or represented through the medium of narrative discourse in more qualitatively aligned studies. Although quantitative designs such as RCTs are more robust and thus favored in reviews, the operationalization of the theoretical entities of interest would likely be best captured through the triangulation of both techniques. The recently uncovered logic which undergirds and unites both quantitative and qualitative modes of sociological enquiry further legitimates its combination through triangulation (Shepherd 2020). Principally, the over-reliance of quantitative RCT designs by the WWN demonstrates a leaning toward the faulty logic of Popperian falsification. However, greater appreciation of the scientific endeavor as an extrapolation of abductive inference would guide current practice in evidence-based decision-making in the right direction.

An individual's or a group's worldview—their ontology—is often associated with emotionally charged beliefs, and therefore respectful but honest dialogue should be practiced. Ontologically, abduction may only operate within a post-positivistic paradigm because it rejects both the positivistic 'naive objectivism' of knowing facts absolutely and the constructionist fallacy of multiple realities based upon self-refuting and impractical logic (Corman 2005). For example, if all subjective social constructions of reality are equally valid, then the opinions of constructionist academics lose any epistemic validity, and by their own reasoning are just as useful to society as the opinions of any randomly selected member of the public (Nagel 1982; Moreland and Craig 2017). Practically, a legal system necessary for maintaining a functioning society is dependent upon the objective assessment of witness testimonies, and therefore relativistic paradigms are not axiologically congruent with at least one fundamental institution of society. Abduction therefore only permits a single reality which may be cognized in an approximate and probable manner (Corman 2005; Shepherd 2020). Incidentally, when an either-or decision must be made for the safeguarding of society, the 'beyond reasonable doubt' verdict reached in a court of law is highly analogous to null hypothesis statistical testing (Tokunaga 2019), which aligns with the probabilistic epistemology of abduction.

In conclusion, what we believe to be true can never be established resolutely as fact through foundationalism, that is, through either the experiential senses or through our rationality, but only ever accepted as likely true or likely false. Furthermore, abduction is the most commonly used mode of inference when approximating the truth of reality, and we as sentient beings are aware of this. Therefore, our actions, especially when exercised with conviction, are based upon faith, not facts. However, it is the author's inference that only believers in Jesus are walking by faith in Christ (1 Corinthians 15:3-4; John 20:27-28; 1 John 5:1; Psalm 46:10; Ephesians 2:8-10; John 7:38). Furthermore, we cannot be perfect, but exactly how accepting Christ's agape love (1 Corinthians 13:1-13) leads to being instructed and empowered to enjoy His design in a godly manner (Hebrews 8:10; Titus 2:12; Hebrews 13:4), while loving others as we would love ourselves, is certainly a mystery beyond rational discernment. "The righteousness of God is revealed through faith for faith, as it is written, 'The one who is righteous will live by faith'" (Romans 1:17).

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