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Correspondence and coherence in science: A brief historical perspective

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Abstract

This paper introduces historical aspects of the concepts correspondence and coherence with emphasis on the nineteenth century when key aspects of modern science were emerging. It is not intended to be a definitive history of the concepts of correspondence and coherence as they have been used across the centuries in the field of inquiry that we now call science. Rather it is a brief history that highlights the apparent origins of the concepts and provides a discussion of how these concepts contributed to two important science related controversies. The first relates to aspects of evolution in which correspondence and coherence, as competing theories of truth, played a central role. The controversy about evolution continues into the beginning of the twenty-first century in forms that are recognizably similar to those of the middle of the nineteenth century. The second controversy relates to the etiology of blood-born infections (sepsis) during childbirth (childbed fever). In addition to correspondence and coherence, the authors introduce other theories of truth and discuss an evolutionarily cogent theory of truth, the pragmatic theory of truth.

Keywords: coherence, correspondence, history, science, evolution, childbed fever.

1 Theories of truth

Correspondence and coherence, perhaps the most popular notions of truth in modern day philosophy, both have deep historical roots as conceptions of truth.

1.1 Truth as correspondence

Correspondence can be traced at least to Plato and Aristotle in the third and fourth centuries BCE. Plato believed that reality comes from the mind of God and as such is both rational and understandable, assuming that we are clever enough. The Platonic ideal, in the words of Isaiah Berlin, is that "as in the sciences, all genuine questions must have one true answer and one only, all the rest being necessarily errors" (quoted from *The Crooked Timbers of Humanity* in Gregory, 1992, p. 19). Aristotle emphasized the importance of observation to our comprehension of natural phenomena and provided a definition of correspondence that holds that a true statement or proposition reflects reality itself: "... it says of what is that it is; and of what is not that it is not" (Blackburn, 1994).

The correspondence notion of truth is commonly viewed as the traditional and common sense understanding of truth. This characterization of reality as being both understandable and rational is generally held to be a key feature of correspondence. If our beliefs need to square with reality and also not be self-contradictory, then, because we experience one reality, this implies that only one truth exists. Further, it implies that whether viewed from a religious or scientific perspective, truth needs to be one and the same. The other common sense aspect of the correspondence notion is that truth about nature is knowable. Albert Einstein, whose work in the early 1900's was clearly tied to the advances science made in the mid to late 1800's, stated this common sense notion well. He remarked that "The Lord God is subtle, but malicious he is not," which is to say that God may be stubborn in making the laws difficult to find, but He would never make a universe that could not be understood because nature at its bottom would then be irrational. (Einstein made this remark at a Princeton reception in May of 1921 in response to a report that the famous Michelson-Morley experiment had been shown to be invalid [Fölsing, 1997].) That nature is understandable would seem to suggest that Einstein perhaps considered both correspondence and coherence to be important. However, coherence alone may be seen as having been troublesome for Einstein. Although quantum mechanics is a coherent theory, it was not compatible with Einstein's sense of reality.

In summary, from the common sense (correspondence) view, reality is rational, and knowable.

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1.2 Truth as coherence

The coherence theory of truth emerged in the work of Immanuel Kant at the end of the eighteenth century. Kantian philosophy became increasingly well known and popular during the late 1700's and 1800's. In his 1787 edition of *Critique of Pure Reason*, Kant set limits on human knowledge of the world. He believed that the world was only knowable through the mind and that the perceived regularities that we note are due to aspects of the mind itself. Drawing on Kant, his disciple, Jakob Fries, observed that truth was not the correspondence of a representation with an object. Humans cannot get outside of themselves to make such a comparison. According to Fries, "the truth of a judgment is its correspondence with the immediate cognitions of reason in which it is grounded." He called this an "inner truth." (Gregory, 1992, p. 20). Within this representation, the best one can hope for is a coherent view of nature since one can never be sure that perception and reality are concordant. This view implies that more than one truth is possible in our attempts to know the world. A consequence of Kant's position is that knowledge is confined to the realm of the senses, the realm dealt with in science. Religion is directed to the realm beyond sensual knowledge and is apprehended by faith. Science and religion, then, are separate aspects of human experience that do not overlap.

For coherence, a statement or proposition must be consistent with a suitably defined body of other propositions, and this body needs to be consistent within itself. A less formal view of coherence requires that a statement or proposition be consistent with an existing body of beliefs.

1.3 Other theories of truth

Other theories of truth include three that are variations on a theme: identity, redundancy/disquotational, and semantic theories (Blackburn, 1994). The theme represented by these theories is that a true proposition and the facts that make it true are the same things, whether expressed in words, formulae, or aspects of language. Not discussed here is the tack taken by adherents to radical skepticism in which the very existence of any aspect of the world is questioned.

1.3.1 Pragmatic theory

The last theory of truth we will consider is the pragmatic theory. This theory is attributed to the American physician, psychologist, and philosopher, William James, whose writings extend from the late nineteenth through the early twentieth century. The pragmatic theory states that the truth of a statement can be defined in terms of the utility or desirability of accepting it. The central feature of this belief is that "... the meaning of a doctrine is the same as the practical effects of adopting it" (Blackburn, 1994, p. 297). Early criticisms appropriately included the observation that many things that are desirable are demonstrably not true. It should be appreciated that the "driving motivation of pragmatism is the idea that belief in the truth on the one hand must have a close connection with success in action on the other" (Blackburn, 1994, p. 297). More recent characterizations include the observation made by Blackburn (1994, p. 297) who notes there are "deep connections between the idea that a representative system is accurate, and the likely success of projects and purposes formed by its possessor." A natural example of this connection would seem to be the "accuracy" of evolutionary adaptations such as perceptual systems (where the accuracy is the fit between an adaptation and successful functioning within a given environment). At the level of cognition, one would expect similar connections to be discernable; accurate beliefs about the environment should lead to higher rates of success for the cognizant organism — beliefs have effects.

2 Science in the 18^{th} and 19^{th} centuries: Context and controversy

Having examined some notions of truth, we now turn to controversies that centered on notions of correspondence and coherence and were embedded in the science-related transitions occurring in the eighteenth and nineteenth centuries. To better understand these controversies, we will step into the world of the nineteenth century natural philosophers, early scientists, and medical practitioners. After reviewing two controversies in some detail, we will summarize what may be gleaned from a better understanding of these controversies.

2.1 Controversy over evolution

2.1.1 Context

Let's begin our task by reviewing a key aspect of the context within which the controversy about evolution occurred. First we need to recall the central role that religious beliefs played in the development of Western science and in its early history. As Gregory has noted, "Ultimate questions about the meaning and nature of human existence are the crux of the relationship between natural science and religion" (Gregory, 1992, p. 3). Prior to the eighteenth and nineteenth centuries, activities in natural philosophy, the predecessor of the practice of science, were based on the premise that God provided laws for the universe and man's uncovering them was a way of bringing glory to God. Natural philosophy was often described as being the "hand maiden" to religion.

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2.1.2 Controversy

The notion of evolution by natural selection was presented by Charles Darwin in his 1859 book, *Origin of Species*, in which he suggested that random changes in inherited characteristics could lead to a survival and reproductive advantage and thus be selected within an environment to be transmitted to future generations. Random changes do not imply progress and are not consistent with the notion of God-directed evolution. Even nonreligious minds objected to evolution based on chance because it seemed to rob evolution, and the history of nature, of direction and intrinsic meaning. The German scientific materialist Ludwig Büchner, for example, said that "It is a great weakness and inconsistency in Darwin that individual or random change ... should be the forerunner of new species" (Büchner, 1900, p. 349). Natural selection was thus a major source of controversy. As we will soon discuss, reactions to this controversy can be seen to be associated with differing conceptions of truth.

2.1.3 Dimensions of the controversy: A theological example

The dimensions of this late nineteenth century science-related controversy can be most starkly presented from a late nineteenth century theological viewpoint. The controversy can be seen to include two conceptions of truth (correspondence and coherence) and three types of theologians (conservative, liberal, and radical). The controversy will be briefly examined from each type of theologian's point of view.

Conservative theologians. The conservative theologians can be seen as adherents to the correspondence theory of truth. Those who adhered to a strict interpretation of the Bible saw the opportunity for only one version about evolution to prevail. From their perspective the decision space was small and simple: the Bible was correct, the evolutionary scientists were wrong — any theory that replaced God with random changes was clearly both atheism and wrong. The Princeton theologian Charles Hodge, in his book of 1874, *What is Darwinism?*, wrote that he had the right "to reject all speculations, hypotheses, and theories which come into conflict with well-established truths." Regarding Darwin's theory he said: "The conclusions of the whole matter is that the denial of design in nature is virtually the denial of God" (Hodge, 1874, pp. 139, 173). Other conservative theologians emphasized the importance of the Bible but held that, since God directed evolution, perhaps this controversy was overblown. Baptist theologian Augustus Strong accepted that humans had evolved. Of Jesus turning water into wine at the miracle of Cana, Strong said in 1907, "The wine in the miracle was not water because water had been used in the making of it, nor is man a brute because the brute has made some contributions to his creation" (Strong, 1907, II, p. 472). It seems these theologians failed to appreciate the version of evolution expressed by Darwin and perhaps were holding onto older notions of evolution.

Liberal theologians. The liberal, mainly Protestant, theologians also believed in the correspondence theory of truth. As a result, when faced with new facts they concluded that their theology should be updated to be consistent with new scientific truth. The first of three questions that framed David Friedrich Strauss's *Old Faith and the New* in 1872 was: "Are we still Christians?" No, Strauss declared, we are not. But we do still have religion. It was order and law, reason and goodness "to which we surrender ourselves in loving trust" (Strauss, 1872, pp. 140–141). Many in this group of theologians also maintained that God controlled nature and history, a view similar to those expressed by some deistic natural philosophers. Frederick Temple asserted in 1885 that the doctrine of evolution left the argument for an intelligent governor of the cosmos stronger than before; however, the execution of God's purposes resulted from the original act of creation than it did from God's interventions since (Temple 1885).

Radical theologians. The term radical theologians applies here because they abandoned the common sense notion of correspondence truth and adopted the Kantian notion of coherence in which more than one truth is allowable. Hence science should not claim to give final truth since to do so repeats the dogmatism of earlier theological systems. The German neo-Kantian theologian Wilhelm Herrmann wrote, "The possibility of discovering new characteristics of nature goes into infinity. ... If the knowledge of nature is directed to determining objects and the changes of their states as completely as possible, no definite limits can be imagined for this activity" (Herrmann, 1879, p. 24). Religion must grant science freedom to construct whatever theories are coherent about the sensed world since its purview lies elsewhere. Religion should focus on what is "the truly real" (das Wahrhaft reale): ethics, morality, and aspects of an authentic life (Herrmann, 1876, p. 14).

2.2 Controversy over childbed fever

2.2.1 Context

Key contextual features of the controversy regarding the etiology of childbed fever (systemic infection, i.e., sepsis, associated with childbirth) were the common mid-nineteenth century beliefs about the causes of illnesses

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and the longstanding conservatism of medical practitioners regarding etiologies of illness. Although some observers as early as the first century CE had expressed a belief in "... certain minute animals, invisible to the eye ..." and "seeds" in the environment that could reproduce in the body and cause disease (Lyons, 1978, p. 549), these ideas were not widely accepted until late in the nineteenth century. In the seventeenth century, von Leeuwenhoek had invented a useful microscope, however the bacteria routinely seen in sour milk and in spoiled meat were understood to be the result of chemical processes associated with fermentation and putrefaction (spontaneous generation) (Lyons, 1978). In the eighteenth century, there had been heated controversy between those who believed that diseases were definitely contagious and those who believed that derangements in the internal organs and environmental changes were responsible (Lyons, 1978).

2.2.2 Transitions/dynamics

In 1829, Robert Collins of the Dublin Lying-in Hospital in Ireland was able to greatly reduce the occurrence of childbed fever by using chloride of lime (calcium hypochlorite) for cleaning and heat to sterilize blankets (Mettler, 1947). However, these practices were not continued after Collins' departure and rates of childbed fever cases again increased. Early in his career in the United States in 1843, Oliver Wendell Holmes attributed childbed fever to contagions carried to new mothers by physicians from other infected patients based on his assessment of earlier literature. His conclusions were severely criticized as theorizing without proof by his senior colleagues (Garrison, 1929; Lyons, 1978).

2.2.3 Controversy — Semmelweis

In 1846 at age 28, Ignaz Semmelweis, with degrees in Medicine and Midwifery, was appointed an assistant physician at the lying-in hospital in Vienna, Austria. Just prior to his arrival, death rates associated with childbirth were about 7.8% per year (Yates, 1966). Upon his arrival he noted childbed (puerperal) fever to have greatly differing rates depending on which service he examined. Mortality rates on the ward where medical students were trained were 9.9% per year whereas on the ward where midwives received instruction, rates were 3.3% (Yates, 1966; Lyons, 1978). He made detailed observations and kept detailed records of his data. Among his general observations were that physicians and students on the medical student service would spend part of the day studying cadavers and performing autopsies. Examination of women in labor would be performed after the autopsy room sessions with little or no clean-up between examinations of the dead and the living (Garrison, 1929; Lyons, 1978). On the midwife instruction service, training on cadavers and attending autopsies did not occur. In addition, there was considerably more attention to general cleanliness on the midwife ward (Garrison, 1929). A tragic mishap involving one of his colleagues solidified the association between autopsies and childbed fever in Semmelweis' mind. An assistant physician became ill and died after receiving a wound during an autopsy of a fatal case of childbed fever. Semmelweis attended his colleague's autopsy and saw pathologic changes in the internal organs that were the same as were routinely seen at the autopsies of cases with fatal childbed fever.

Although the true mechanism of transmission of childbed fever (bacterial inoculation leading to sepsis) was missed by Semmelweis ("... the cause of disease was cadaveric material carried into the vascular system." (Yates 1966, p. 116) — which was thought to be the resorption of poisonous material), he recognized that the hands of his staff and their students were transferring some type of deadly material from the autopsy room to the delivery area and the women examined there (Yates, 1966; Mettler, 1947). Based on these observations, Semmelweis instituted a change in practice that included using chlorinated lime water to wash hands after attending autopsies and after each patient examination. The rates of mortality from childbed fever plummeted to just over 1% per year (Garrison, 1929; Lyons, 1978).

Just as had occurred with Holmes in the US and Collins in Ireland, Semmelweis' results were severely criticized and were not continued after his departure (Garrison, 1929; Lyons, 1978). Ironically, Semmelweis died at age 47 after a finger wound became infected.

2.2.4 Correspondence and coherence

Aspects of both correspondence and coherence can be seen in the example of Semmelweis and childbed fever. A correspondence perspective is clearly present in the link between his observations, his changes in the processes of care, and in the subsequent dramatic drop in mortality rates associated with childbed fever. The lack of a coherent explanation of the results of Semmelweis' actions can be seen as a potentially important factor in the lack of acceptance of his results. Without a coherent theory of bacteria as a cause of disease (sepsis), many physicians found it impossible to discount other more traditional, competing explanations of his results. There was no coherent set of concepts for the disbelieving physicians to use to characterize what had happened. Lacking such an explanation, it was easy for many physicians to discount and criticize the results.

3 Implications for judgment and decision making research: Context, dynamics, and theories of truth

What can this historical foray into two nearly century-and-a-half old controversies hold for modern day cognitive scientists? The key take-home concepts can be comfortably discussed within a framework familiar to Egon Brunswik and his followers, the lens model (Hammond, 1996, p. 87). The lens model identifies an organism (decision maker or judge), an environment, and information (cues) that links them. First, we should consider key aspects of the specific environment within which information is available and perceived, decisions are made, and consequences occur. Second, we should consider cogent aspects of the organism under study which perceives, decides, and enjoys or endures the consequences of those decisions. As will be discussed shortly, a deeper understanding of these concepts can provide opportunities for us to do better modern day science.

3.1 Context and dynamics

Both evolution and sepsis involve primarily biological processes. This is the general context within which these controversies must be considered. Biology tries to understand phenomena within "... actual, historical, particular time (in which the context is crucial)" (Alanen, 2004, p. 44). This is contrasted with physics which seeks unchanging natural laws for which there are no favored locations in the universe, i. e., the laws of physics are the same everywhere. Physics deals with understanding phenomena within a "... hypothetical, generalized, theoretical and universal time scale (from which all local, particular, context has been rigorously abstracted" (Alanen, 2004, p. 44).

An appreciation of the specific context within which the evolution-religion controversy (the nineteenth century within which several religious perspectives were in play and natural philosophy was transitioning toward natural science) and the etiology of childbed-fever controversy occurred (the mid-nineteenth century before the germ theory was widely accepted and used and a time when progress in the prevention of childbed fever was haphazard and halting) was essential to a more complete understanding the nature of these controversies.

Within the lens model framework, concerns about context require considerations of a specific organism within a specific environment. These context considerations also inform aspects of the judgment task characteristics and ultimately the generalizability of the lens model results. Common sense notions of truth (correspondence) are clear in our attempts to capture the "true" relationships (probabilistic ecology) between the cues (fallible indicators) and the judgment target (outcome or state). Additionally, correspondence concerns occur in our assessments of the accuracy of judgments. Expectations of coherence are evident in our attempts to capture systematic relationships between cues and judgments within a group of sufficiently similar judgments.

For ecologically salient judgments (e.g., survival and reproduction) within naturalistic settings, the intentionality of the organism (Hammond & Stewart, 2001) is expected to be associated with judgmental correspondence and with judgment related coherence (hypothesized cue patterns, associational or causal hypotheses between cues and outcomes, or other mental models of such relationships among nonhumans) as a result of selection pressures applied across evolutionarily cogent time periods (Donald, 1991). Viewing current humans as products of ancient selection processes also provides an opportunity to better understand how perceptual, cognitive, or behavioral adaptations that were key to successful functioning in the ancient past may continue to serve us well or may lead to inaccurate perceptions and troublesome behaviors within our 21st century environment (Pinker, 1997; Pinker, 2002).

3.2 Lens model: Human judges and human diseases

Thinking about the physical depiction of the lens model (Hammond & Stewart, 2001) provides an opportunity to more comprehensively characterize the interrelationships of the ecology/environment and the organism/decision maker/judge. Although Brunswik's interests were broadly focused to include questions about organisms generally, we will limit our remarks to investigations of human decision makers. For the individual human, the environment provides information (cues) which is used to evaluate the environment relative to desired goals or actions (intentionality). This reflects the way the lens model is generally viewed and used by current JDM researchers

3.3 Understanding the environment

As we strive to understand the environment, we need to think about contexts and related dynamic issues and make those considerations explicit in our methodological and analytical approaches. Requiring ourselves to provide explicit characterizations of the environment will help us to consider avoidable problems associated with ignoring the ubiquitous and often unstated characteristics of our environments that may none-the-less be important to judgment and decision making processes.

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We will use two examples of correspondence related issues from present day routine medical activities to highlight how thinking about context may influence our approaches to research problems.

Illness history. The presentation of symptoms (that is the cues from the patient history) of something as seemingly straightforward as appendicitis has been shown to vary by geographic area (Staniland, Clamp, deDombal, Solheim, Hansen, Ronsen & Helsingen, 1980; deDombal, Staniland & Clamp, 1981; Wigton, 1996). The disease entity is the same across borders but the diagnostic value (correspondence) of verbal descriptions used by people from different countries has been shown to vary. This occurs because the prior probability of appendicitis and the conditional relationships between the presence (or absence) of symptoms given the presence (or absence) of appendicitis (sensitivity and specificity, respectively) co-vary. Appendicitis is more common among the young and in men. In addition, women and older patients of both sexes have a longer list of competing potential diagnoses with symptoms that overlap with those of appendicitis (Laurel, 2006). This general phenomenon has been labeled "spectrum" in the diagnostic medicine literature (Ransohoff & Feinstein, 1978; Lofgren, 1987). Thus the apparent ecology of the diagnostic cues from the history would be expected to be different across sociodemographic contexts.

Physical examination. The performance of physicians in using physical exam findings in the diagnostic process may vary among contexts that are associated with markedly differing occurrence rates (or prior probabilities) of the disease or diseases of interest. The ability of physical exam findings from the chest exam (and thus the cue weights from the ecology) to predict acute diseases may vary depending on whether the context for the study was a pulmonary disease clinic or a student health or primary care clinic. For example, dullness on percussion of the chest would be expected to have more false positives (thus lower specificity and predictive value positive) in predicting acute disease in the pulmonary clinic compared with the primary care clinic. This is because more patients in the pulmonary clinic would have had prior inflammatory lung diseases and these inflammatory diseases are associated with thickening of the lining of the chest cavity which is associated with dullness to percussion on physical exam.

Systems as context. These variations across sociodemographic contexts should enhance our thoughtfulness about system membership and should remind us that many contextual considerations are not simple, isolated entities. The importance of systems to better understanding observable phenomena has been recognized in physics (phase transitions) (Barabasi, 2003), biology (sub-cellular systems, cells, organs, individuals, social groups) (Barabasi, 2007), computer science (the internet) (Barabasi, 2003), and social aspects of diseases (obesity rates in social networks) (Christakis & Fowler, 2007). Consideration of systems (or more appropriately, hierarchies and networks of systems) should lead to non-traditional considerations of what are adequate analyses and causal models. Why should we be interested only in the independent contribution of individual variables (e.g., simple multiple regression of the judgment target or judgments on the cues) when the variables are part of a system of functionally inter-related variables (Kraemer, Stice, Kazdin, Offord & Kupfer, 2001)? A more informative set of analytic goals would seem to include understanding the overall association or predictivity of the entire subsystem (correspondence) relative to the outcome of interest and the mechanisms underlying the associational and causal connections between the cues and the outcome and the cues and the judgments. Understanding phenomena at this level would not only provide more meaningful research results, it would facilitate the creation of interventions that are based on (one or more) mechanisms of change within the systems being studied (coherence).

3.4 Understanding the organism

We propose that two perspectives or organizing principles are key to developing a deeper understanding of the function of organisms in their respective environments.

The first perspective or organizing principle is the pragmatic conception of truth as articulated by Simon Blackburn (Blackburn 1994). This notion holds that there are "deep connections between the idea that a representative system is accurate, and the likely success of projects and purposes formed by its possessor (Blackburn, 1994, p. 297)." Excellent examples are the evolution of functional units within living systems. The evolutionary adaptation of perceptual systems seems to provide a particularly cogent example of system accuracy (correspondence) being the fit between an adaptation and successful functioning within a given environment. One can give this perspective a more cognitive thrust by hypothesizing probabilistic relationships along the path from perceptions to beliefs to actions to outcome (positive or not). Which is to say that beliefs have effects!

This conception of pragmatic theory shares with classical correspondence theory the notion of the determining role of external reality, although it does not require that what is real has to be rational. In this regard, it is similar to coherence theory.

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The second perspective or organizing principle is explicitly considering the dynamic processes that affect the organism and the environment and are central to understanding performance. This perspective leads to inquiring about key issues such as how learning by the organism and/or changes in the environmental affect the performance of the organism within that environment.

4 Correspondence or coherence?

Lastly we return to the question of whether coherence or correspondence is more important to our scientific endeavors. "Science is devoted to the ideal of system . . . " (Cohen, 1931, p. 106). An essential part of a system is the connectedness of its parts. We can start with observations about what works (in the pragmatic theory sense), then seek evidence about the functional relationships or mechanisms that allow the observed outcomes to occur (thus providing a link to correspondence). Multiple verifiable "facts" are insufficient, however. "We need some guiding principle to explore and take account of all possibilities and to introduce order into the chaos of unconnected facts" (Cohen, 1931, p. 108). This provides the need for coherence. "When we prove or give evidence for a proposition we connect it with other propositions according to some logical or rational order so that the various propositions support each other. . . " (Cohen, 1931, p. 106).

Our position about the choice between correspondence and coherence is clear. Both correspondence and coherence are essential to our goals of better understanding the environment and organism. Both should be part of our bag of methodological approaches. And both are essential to the modern iterative process of formulating a coherent theory from currently available knowledge, testing its correspondence with reality, synthesizing the results of the study with other information to create a more comprehensive and coherent theory which is then tested and the results further synthesized, etc. Links to reality (correspondence) are essential for progress within the 'real world' (the specific aspects of which need to be clearly identified) (Hammond, 2007). Links among our concepts/theories (coherence) are essential for deeper levels of understanding of our world.[1]

[1]This is contrasted with links (coherence) within abstract, hypothetical, or metaphysical contexts which may provide insights only within those contexts. Generalization of these insights depends entirely on the sufficiency of key similarities between the abstraction and reality (consistent with Blackburn's characterization of the pragmatic theory of truth) (Blackburn, 1994).

References

Alanen, P. (2004). The problem of knowledge in medicine. In M. Evans, P. Louhiala, & R. Puustinen (Eds). *Philosophy for Medicine: Applications in a Clinical Context* (pp. 17–46). San Francisco: Radcliffe Medical Press.

Barabasi, A-L. (2007). Network medicine — from obesity to "diseasome." *New England Journal of Medicine, 357*, 404–407.

Barabasi, A-L. (2003). *Linked: How everything is connected to everything else and what it means for business, science, and everyday life*. New York: Plume.

Blackburn, S. (1994). *The Oxford dictionary of philosophy*. New York: Oxford University Press.

Büchner, L. (1900). *Im Dienst der Wahrheit*. Giessen: E. Roth.

Christakis, N, A,, & Fowler, J, H. (2007). The spread of obesity in a large social network over 32 years. *New England Journal of Medicine, 357*, 370–379.

Cohen, M, R. (1931). *Reason and Nature: An Essay on the Meaning of Scientific Method.* New York: Dover, (1978).

deDombal, F. T., Staniland, J. R., & Clamp, S. E. (1981). Geographical variation in disease presentation: Does it constitute a problem and can information science help? *Medical Decision Making,1*, 59–69.

Donald M. (1991) *Origins of the modern mind: Three stages in the evolution of culture and cognition*. Cambridge, MA: Harvard University Press.

Darwin, C (1859/1967). *Origin of species.* New York: Atheneum.

Fölsing A. (1997). *Albert Einstein*. New York: Penguin.

Gregory, F. (1992). *Nature lost? Natural Science and the German theological traditions of the nineteenth century*. Cambridge, MA: Harvard University Press.

Hammond, K.,R. (1996). *Human judgment and social policy: Irreducible uncertainty, inevitable error, unavoidable injustice*. New York: Oxford University Press.

Hammond, K. R. (2007). *Beyond rationality: The search for wisdom in a troubled time*. New York: Oxford University Press.

Hammond, K. R., & Stewart, T. R. (Eds). (2001). *The essential Brunswik*. New York: Oxford University Press.

Hermann, W. (1876). *Die Metaphysik in der Theologie*. Halle: Niemeyer.

Herrmann, W. (1879). *Die Religion im Verhältnis zum Welterkennen und zur Sittlichkeit*. Halle: Niemeyer.

Hodge, C. (1874). *What is Darwinism?* New York: Scribner.

Kant, I. (1787/1929). *Critique of pure reason*, 2nd ed. New York: St. Martin's.

https://doi.org/10.1017/S1930297500002552 Published online by Cambridge University Press

Kraemer, H. C., Stice, E., Kazdin, A., Offord, D., & Kupfer, D. (2001). How do risk factors work together? Mediators, moderators, and independent, overlapping, and proxy risk factors. *American Journal of Psychiatry,158*, 848–856.

Garrison, F. H. (1929/1960). *An introduction to the history of medicine.* Philadelphia: Saunders.

Laurel, H. (2006). Acute Abdominal Pain. Acta Universitatis Upsaliensis. Digital Comprehensive Summaries of Upsala Dissertations from the faculty of Medicine,from http://urn.kb.se/resolve?urn=urn:nbn:se:uu:diva-7161

Lofgren, R. P. (1987). The dynamic nature of sensitivity and specificity. *Journal of Geneneral Internal Medicine, 2*, 452–453.

Lyons, A. S. (1978). Infections. In Lyons, A. S,, & Petrucelli, R.J, (Eds.), *Medicine: An illustrated history*. New York: Harry N Abrams Inc.

Mettler, C. C. (1947). Obstetrics in the nineteenth century: Puerperal fever. In Mettler, F. A. (Ed), *History of Medicine*. Philadelphia: Blackiston.

Pinker, S. (1997). *How the mind works*. New York: Norton & Company.

Pinker, S. (2002). *The blank slate: The modern denial of human nature*. New York: Penguin.

Ransohoff, D. F., & Feinstein, A. R. (1978). Problems of spectrum and bias in evaluating the efficacy of diagnostic tests. *New England Journal of Medicine, 299*, 926–930.

Staniland, J. R., Clamp, S. E., deDombal, T. F., Solheim, K., Hansen, S., Ronsen. K., & Helsingen, N. (1980). Presentation and diagnosis of patients with acute abdominal pain: Comparisons between Leeds UK and Akershus county, Norway. *Annales Chirurgiae et Gynaecologiae, 69*, 245–250.

Strauss, D. F. (1872). *Der alte und der neue Glaube: EIn bekenntniss*. Leipzig: Hirzel.

Strong, A. (1907). *Systematic theology*. 3 vols. Westwood, NJ: Fleming Revell.

Temple, F. (1885). *The relations between religion and science*. London: Macmillan & Co.

Wigton, R. S. (1996). Social judgment theory and medical judgment. *Thinking and Reasoning, 2*, 175–190.

Yates, E. L. (1966). Semmelweiss — saddest figure in modern medicine. *American Journal of Practical Nursing, 2*, 114–117.