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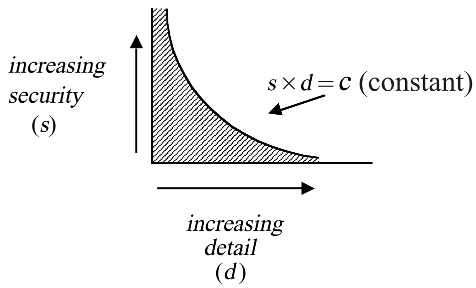
Asking for More Than Truth

Duhem's Law of Cognitive Complementarity

(1) Duhem's Law of cognitive complementarity holds that inquiry is subject to a complementary relationship between security and confidence on the one hand, and definiteness and detail on the other, so that $s \times d \leq$ *const. (2) Among other things, this relationship serves to characterize the difference between science and common sense, seeing that these two domains take a very different stance regarding security and definiteness. (3) Duhem's Law engenders an impetus to vagueness in matters where truth is paramount. (4) Moreover, security/detail complementarity has important lessons for the conduct of inquiry, and in particular means that knowledge is more than correct information as such.*

The Security/Definiteness Trade-off and the Contrast Between Science and Common Sense

It is a basic principle of epistemology that increased confidence in the correctness of our estimates can always be secured at the price of decreased accuracy. For in general *an inverse relationship obtains between the definiteness or precision of our information and its substantiation: detail and security stand in a competing relationship*. We estimate the height of the tree at *around* 25 feet. We are *quite sure* that the tree is 25 ± 5 feet high. We are *virtually certain* that its height is 25 ± 10 feet. But we can be *completely and absolutely sure* that its height is between 1 inch and 100 yards. Of this we are "completely sure" in the sense that we are "absolutely certain," "certain beyond the shadow of a doubt," "as certain as we can be of anything in the world," "so sure that I would be willing to stake my life on it," and the like. For any sort of estimate whatsoever



DISPLAY 1.1. Duhem's Law: the complementarity trade-off between security and definiteness in estimation. *Note:* The shaded region inside the curve represents the parametric range of achievable information, with the curve indicating the limit of what is realizable. The concurrent achievement of great detail *and* security is impracticable.

there is always a characteristic trade-off relationship between the evidential *security* of the estimate, on the one hand (as determinable on the basis of its probability or degree of acceptability), and on the other hand its contentual *detail* (definiteness, exactness, precision, etc.).

And so a complementarity relationship of the sort depicted in Display 1.1 obtains. This was adumbrated in the ideas of the French physicist Pierre Maurice Duhem (1861–1916) and may accordingly be called "Duhem's Law."[1] In his classic work on the aim and structure of physical theory,[2] Duhem wrote as follows:

> A law of physics possesses a certainty much less immediate and much more difficult to estimate than a law of common sense, but it surpasses the latter by

[1] It is both common and convenient in matters of learning and science to treat ideas and principles eponymously. An eponym, however, is a person *for* whom something is named, and not necessarily *after* whom this is done, seeing that eponyms can certainly be honorific as well as genetic. Here at any rate eponyms are sometimes used to make the point that the work of the person at issue has *suggested* rather than *originated* the idea or principle at issue.

[2] *La théorie physique: son objet, et sa structure* (Paris: Chevalier and Rivière, 1906); tr. by Philip P. Wiener, *The Aim and Structure of Physical Theory* (Princeton: Princeton University Press, 1954). This principle did not elude Neils Bohr himself, the father of complementarity theory in physics: "In later years Bohr emphasized the importance of complementarity for matters far removed from physics. There is a story that Bohr was once asked in German what is the quality that is complementary to truth (*Wahrheit*). After some thought he answered clarity (*Klarheit*)." Steven Weinberg, *Dreams of a Final Theory* (New York: Pantheon Books, 1992), p. 74 footnote 10.

the minute and detailed precision of its predictions. . . . The laws of physics can acquire this minuteness of detail only by sacrificing something of the fixed and absolute certainty of common-sense laws. *There is a sort of teeter-totter of balance between precision and certainty: one cannot be increased except to the detriment of the other.*[3]

In effect, these two factors – security and detail – stand in a relation of inverse proportionality, as shown in the picture of Display 1.1.

Note that the relationship at issue envisions the boundary of realizable information as set by a curve of the form $x \times y = c$, or equivalently $y = c/x$. Accordingly, the sum total of the area of accessibility lying under this curve is given by $\int y\,dx = c \int dx/x \approx \log x$. On this basis the overall size of the body of high-quality information that combines security and definiteness to an acceptable extent is given by a logarithmic measure. It will be useful to bear this in mind as the discussion proceeds.

Science versus Common Sense

Duhem emphasized that this relationship has important implications for the standing of the exact sciences where, after all, we always aim at the maximum of achievable universality, precision, and exactness. Thus in physics when we make the assertion, "The melting point of lead is 327.7 degrees Celsius," we are claiming that *all* pieces of (pure) lead will *unfailingly* melt at *exactly* this temperature. We certainly do not mean to assert that most pieces of (pure) lead will *probably* melt at *somewhere around* this temperature. (And in this regard, there would be a potential problem, should it turn out, for example, that there is no melting point at all and that what is actually at issue is the center of a statistical distribution.) In aspiration always and in practice generally, the theoretical claims of science involve no hedging, no fuzziness, no incompleteness, and no exceptions; they are strict: precise, wholly explicit, exceptionless, and unshaded. Here we operate at the lower right-hand side of the Display 1.1 curve.

After all, in intent and in aspiration science aims to characterize nature as it really is. And since (as we certainly believe) nature is fully definite and detailed, science endeavors to infuse these characteristics

[3] Duhem, *La théorie physique*, pp. 178–79. Italics supplied.

into the claims it stakes regarding the world. It scorns the very idea of claiming that matters stand roughly thus-wise or that things function something like such-and-such. Unlike everyday-life communication, the exact sciences stand committed not just to truth but to accuracy and exactness as well. And this, their seeming strength, is their Achilles' heel as well.

By contrast, the situation of ordinary life is very different; when we assert that "peaches are delicious" we are maintaining something like "most people will find the eating of suitably grown and duly matured peaches a rather pleasurable experience." Such a statement has all sorts of built-in safeguards on the order of "more or less," "in ordinary circumstances," "by and large," "normally," "when all things are equal," "rather plausible," and so on. They are not really laws in the usual sense, but rules of thumb, a matter of practical lore rather than scientific rigor. But this enables them to achieve great security. For there is safety in vagueness: a factual claim can always acquire security through inexactness. Take "there are rocks in the world" or "dogs can bark." It is virtually absurd to characterize such everyday life contentions as fallible: their security lies in their very indefiniteness and imprecision.

And there is good reason for adopting this resort to vagueness in everyday life, for protecting our claims to reliability and trustworthiness becomes crucial in personal interactions. We proceed in cognitive matters in much the same way that lenders such as banks proceed in financial matters. We extend credit to others, doing so at first to only a relatively modest extent. When and if they comport themselves in a manner that shows that this credit was well deserved and warranted, we proceed to give them more credit and extend their credit limit. By responding to trust in a responsible way, one improves one's credit rating in cognitive contexts much as in financial contexts. The same sort of mechanism is at work on both sides of the analogy: creditworthy comportment engenders a reputation on which further credit can be based; earned credit is like money in the bank, well worth the measure needed for its maintenance and for preserving the good name that is now at stake. Thus we constantly rely on experts in a plethora of situations, continually placing reliance on doctors, lawyers, architects, and other professionals. But they, too, must so perform as to establish credit, not just as individuals but, even more crucially, for their profession as a whole.[4] And much the same sort of thing holds for other sources of information. (The example of our senses is a particularly important case in point.) In everyday life, in sum, we prioritize correctness over accuracy.

However, while everyday-life common sense trades definiteness for security, science does the very reverse, with the result that its claims become subject to greater insecurity. As Duhem put it:

> A law of physics is always provisional and relative. It is provisional also in that it does not connect realities but symbols, and that is because there are always cases where the symbol no longer corresponds to reality; the laws of physics cannot be maintained except by continual retouching and modification. . . . One might be tempted to draw the strange conclusion that the knowledge of the laws of physics constitutes a degree of knowledge inferior to the simple knowledge of the laws of common sense.

Science decidedly prioritizes accuracy and detail over security. So as Duhem himself maintained, his principle both characterizes and explains the profound differences between the nature of our knowledge in science and in the matters of everyday life.

Further Ramifications

Duhem's Law of Security/Detail Complementarity has substantial implications for the modus operandi of inquiry. Thus one of its fundamental implications is represented by the following observation:

THESIS 1: *Insofar as our thinking is vague, truth is accessible even in the face of error.*

Consider the situation in which you correctly accept *P*-or-*Q*. But – so let it be supposed – the truth of this disjunction is entirely rooted in *P*, while *Q* is flatly false. However, you accept *P*-or-*Q* only because you are mistakenly convinced of the truth of *Q*, while it so happens that *P* is something you actually disbelieve. Nevertheless, despite your error, your belief is entirely true.[5] Consider a concrete instance. You

[4] Compare H. M. Vollmer and D. L. Mills, eds., *Professionalization* (Englewood Cliffs, NJ: Prentice Hall, 1966). This credit, once earned, is generally safeguarded and maintained by institutional means: licensing procedures, training qualifications, professional societies, codes of professional practice, and the like.

[5] Examples of this sort indicate why philosophers are unwilling to identify *knowledge* with *true belief*, even where belief is justified.

believe that Smith bought some furniture because he bought a table. However it was, in fact, a chair that he bought, something you would flatly reject because you believe he bought a table. All the same, your belief that he bought some furniture is unquestionably correct. The error in which you are involved, although very real, is yet not so grave as to destabilize the truth of your belief.

Ignorance is a matter of inability to answer questions properly. But one has to be careful in this regard. Answering a question informatively is not just a matter of providing a *correct* answer but also a matter of offering an *exact* answer. Thus consider the question "What is the population of Shanghai?" If I respond "More than ten and less than ten billion" I have provided a *correct* answer, albeit one that is not particularly helpful.

So the irony of it is that insofar as our ignorance of relevant matters leads us to be vague in our judgments, we nevertheless may well manage to enhance the likelihood of being right. The fact of the matter is that we have this:

THESIS 2: *By constraining us to make vaguer judgments, ignorance enhances our access to correct information (albeit at the cost of less detail and precision).*

For example, if I have forgotten that Seattle is in Washington State, then if "forced to guess" I might well erroneously locate it in Oregon. Nevertheless, my vague judgment that "Seattle is located in the Northwestern United States" is quite correct.

This state of affairs means that when the truth of our claims is critical we generally "play it safe" and make our commitments less definite and detailed. And in practical matters in particular, such rough guidance is often altogether enough. We need not know precisely how much rain there will be to make it sensible for us to take an umbrella. Nevertheless in those matters where exactness counts this pathway to truth is rather problematic.

Knowledge in Perspective

Duhem's Law of Cognitive Complementarity means that it is going to be a fact of life in the general theory of estimation that the harder we push for certainty – for security of our claims – the vaguer we will have to make these claims and the more general and imprecise they will become. And so if we want our scientific claims to have realistic import – taking them to provide an account of how matters actually stand – we have to reconstrue them loosely. Take the atomic theory. We should not – cannot – say that atoms are in every detail as the science of the day holds them to be: that the "Atomic Theory" section of our *Handbook of Physics* succeeds in every jot and tittle in characterizing reality as it actually is. But if we "fuzz things up" – if we claim merely that physical reality is granular and that atoms exist and have roughly such-and-such features – then what we say is no longer subject to (reasonable) doubt.

The complementarity of security and detail accordingly carries important lessons for the realization of knowledge. For one thing, seeing that informativeness is a pivotal factor here, it means that knowledge calls for more than mere correctness. And, for another, it means that knowledge is something difficult, something we do not achieve all that easily. For on its basis, knowledge qualifies as such not only through its claims to truth but also through its informativeness. The fact that quality is going to be a key factor here means that the quantity of information cannot be equated with the quantity of knowledge.

In the pursuit of knowledge we seek and demand more than the mere truth about things. For truth comes to us too cheap and easy when it is secured at the price of uninformativeness. Knowledge does not issue from trivial truth, it must contribute to our understanding of things. And so, both security and informativeness figure among the essentials for knowledge. But it lies in the nature of our human situation as finite inquiring beings that only so much can be accomplished along these lines. Duhem's cognitive complementarity law constrains us to make choices: we cannot "have it both ways." And just these considerations lead to a question that will set the theme for the rest of the book: Just what are the ramifications and implications that such limits pose for the development of knowledge?

2

Kant's Conception of Knowledge as Systematized Information

(1) Knowledge is not just a matter of information as such, but of information that is coherently and cohesively systematized. (2) This view of knowledge as properly systematized information – in effect, information as structured in an idealized expository treatise – goes back to Immanuel Kant. (3) Cognitive systematization is hierarchical in structure because a systemic organization of the exposition of the information at issue into successively subordinate units becomes paramount here. And, viewed in this light, structure will of course reflect significance with larger units dominating over subordinate ones.

Distinguishing Knowledge and Information

The interplay between knowledge and information is pivotal for the present deliberations. Actual information (in contrast with misinformation) requires little more than truth. But *knowledge* is something far more demanding: it calls for information that is organized, purified, systematized. It makes no sense to say "It is known that *p*, but it may possibly not be so (or . . . "there are considerations that lead to doubt about it")." From the cognitive point of view, knowledge is money in the bank. It must fit together coherently. The very concept of knowledge is such that what is known must be systemically consolidated: the matter of quality will also play a crucial role. For items of information are not created equal. Some are minute and trivial, others large and portentous. So there is little point to merely doing a nose count here. Only information that is scrutinized, verified, coordinated, and systematized can plausibly qualify to be regarded as knowledge. Whatever else it is, knowledge is information of substantial quality. And this leads to the question: How is knowledge related to information in strictly quantitative terms?

Since factual contentions are formulated symbolically, the quantitative assessment of raw information can be made by measuring expository text – that is, by looking to the amount of text expended in stating the matter. Information can thus be assessed – in a first approximation at least – in terms of sheer textuality, subject to the idea that the ampler and fuller its exposition, the more information this text account conveys.

Knowledge, on the other hand, is something very different, and mere information – unreconstructed textuality – does not do what is needed there. For knowledge does not consist in information as such but only in appropriately systematized information. And accordingly, knowledge is not a matter of the extent of text actually devoted to the issue, but rather requires an assessment of systemic enmeshment. To view knowledge in textual terms would require a radically different approach, one that looks not merely to sheer quantity of text but rather to the textual role of the information at issue.

But just how is this idea of knowledge and its systematization to be implemented?

Kant on the Systematicity of Knowledge

In the eighteenth century Immanuel Kant (1724–1804) had eloquently argued that the mission of rational inquiry is the systemic organization of knowledge: its coordination into one coherent structure under the guiding aegis of unifying principles.

> If we consider in its whole range the knowledge obtained for us by the understanding, we find that what is peculiarly distinctive of reason in its attitude to this body of knowledge, is that it prescribes and seeks to achieve its *systematization*, that is, to exhibit the connection of its parts in conformity with a single principle. . . . This unity of reason always presupposes an idea, (or plan), namely, that of the form of a whole of knowledge – a whole which is prior to the determinate knowledge of the parts and which contains the conditions that determine *a priori* for every part its position and relation to the other parts. . . . This idea accordingly demands a complete [organic] unity in the knowledge obtained by understanding by which this knowledge is to be

not a mere contingent aggregate, but a system connected according to necessary laws. We may not say that this idea is a concept of the object, but only of the thoroughgoing unity of such concepts, in so far as that unity serves as a rule for the understanding. These concepts or reason are not derived from nature; on the contrary, we interrogate nature in accordance with these ideas, and consider our knowledge as defective so long as it is not adequate to them. (*Critique of Pure Reason*, A645 = B673)

The paradigm of system that lay before Kant's eyes was that of science – of Euclid's systematization of Geometry, Archimedes' systematization of statics, and Newton's systematization of celestial mechanics. And his model of rational systematization was that exemplified in the work of the great seventeenth-century rationalist philosophers: Descartes, Spinoza, and also Leibniz as expounded by the subsequent members of his school, especially Christian Wolff.[1]

As Kant saw it, adequate understanding can be achieved only through the systemic interrelating of facts. The mission of human reason is to furnish a basis for the rational comprehension of what we know and this can be accomplished only by positioning these facts as integral parts of an organic whole. Kant developed his biological analogy of system in the following terms:

[O]nly after we have spent much time in the collection of materials in somewhat random fashion at the suggestion of an idea lying hidden in our minds, and after we have, indeed, over a long period assembled the materials in a merely technical manner, does it first become possible for us to discern the idea in a clearer light, and to devise a whole architectonically in accordance with the ends of reason. Systems seem to be formed in the manner of lowly organisms, through a *generatio aequivoca* from the mere confluence of assembled concepts, at first imperfect, and only gradually attaining to completeness, although they one and all have had their schema, as a original germ, in the sheer self-development of reason. Hence, not only is each system articulated in accordance with an idea, but they are one and all organically united in a system of human knowledge, as members of one whole.
(*Critique of Pure Reason*, A834 = B862)

[1] Leibniz's theory of cognitive systematization is detailed in the author's essay entitled "Leibniz and the Concept of a System" in his *Leibniz's Philosophy of Nature* (Dordrecht: D. Reidel, 1981), pp. 29–41. On the broader issues see the author's *Cognitive Systematization* (Oxford: Basil Blackwell, 1979).