

TOWARD AN UNDERSTANDING OF INTUITION AND ITS IMPORTANCE IN SCIENTIFIC ENDEAVOR

LOIS D. ISENMAN*

When I asked a number of my scientific colleagues their view of the role of intuition in science, their answers ranged from “intuition is for poets, not for scientists” to “it’s all intuition.” Intuition can thus be viewed as something entirely apart from scientific inquiry, or as one of its most essential components. At least in part the problem is what we mean by the word *intuition*. The word is applied to a range of different events or processes, some of which call forth conflicting connotations.

What is intuition? In order to begin to answer this question, we will explore the range of meanings the word *intuition* has accrued. We will then look beyond the specific usages to the common threads and from **these** craft a definition. Using this definition we will then examine the roles intuition plays in inquiry in general and in scientific endeavor in particular.

Multiple Usages of the Word Intuition

When physicists, for example, say that something is intuitively evident, they mean it is self-evident, clear by inspection, and not requiring further proof. In common speech as well, *intuitive* can be used to imply that something is clear and obvious, or easily accessible, that the argument is straightforward and unchallenging. In a similar vein, the word *intuitive* is often used in reference to habituated thought or action. Occasionally it is even used interchangeably with the word *instinctive*.

The word *intuition* also is often used synonymously with the word *hunch*. In answer to a question, it is common to say, “**My** intuition is such and such,” meaning that such and such comes to mind with only cursory reflec-

The author wishes to thank Andreas Koehler, J. Fred Dice, Paul Isenman, and Kate Elgin for critical review of the manuscript, and to Leslie Brody, John Katz, and Ted Kauffman for helpful discussion. Thanks also to Florence Ladd and the 1994–1995 Bunting Fellows for support and encouragement.

*Department of Physiology, Tufts University School of Medicine, 36 Byfield Road, Newton, MA 021683.

© 1997 by The University of Chicago. All rights reserved.
0031-5982/97/4003-1013\$01.00

tion. The speaker may have no idea why such and such came to mind. Other hunches are backed by partial data or analysis. The word *intuition* used in this way implies that either all or certain of the pertinent information is unavailable or shrouded. Thus, *intuition* signifying *hunch* connotes something antithetical to the use of the word, meaning clear and completely independent of further analysis.

We also use the word *intuition* (or *intuitive*) to imply that a pattern, logical sequence, or understanding appears to the mind as a whole, that the whole is seen in a single instant. For example, when Linus Pauling, who had studied the hemoglobin molecule extensively, first heard about the behavior of red blood cells in sickle cell anemia, he immediately predicted that the disease resulted from a simple genetic mutation that caused hemoglobin to aggregate at low oxygen tension in a manner so as to both distort and rigidify the red cell membrane [1]. Intuition as a sense of the whole contrasts with the idea of intuition as a hunch, in which parts of the argument (or data) are shrouded or unavailable.

Intuition as a sense of the whole is closer to the more trivial use of the word, in that the perception is clear and complete, a package deal as it were. However, except that such intuitions just seem to appear in awareness, there is generally little that is self-evident, obvious, or even consensual about these insights. Quite to the contrary, as the above example illustrates, they are often completely novel and involve multiple levels of interrelated understanding. Indeed, what is often so surprising about such insights is that such complexity can spring forth so well formed from the mind.

Sometimes the phrase “an intuitive leap” is used to imply that a conclusion a number of steps beyond where the issue stood appears in awareness, but the intervening steps are inaccessible. One knows the conclusion, but doesn’t know how one got there. When it is possible to recapture the instant of intuition, it may become apparent that the whole sequence actually appeared fully formed in consciousness as described above; however, awareness focused on and was able to hold only the conclusion.

A common folk usage of the word *intuition* is to mean “natural knowing,” a knowing that is independent of the usual logic of evidence. Instead, other qualities inherent in or accompanying these insights confirm their validity to the knower. The existence of such a process is of course highly controversial. *Intuition* used in this way is synonymous with *truth*; however, from the point of view of another person it may be at best subjective truth. In contrast to natural knowing, hunches, intuitive leaps, or intuitions in the sense of an understanding of the whole, may rest on logical or rational processes (see below). Moreover, with more information the perceiver may find these other processes to be either true or not true, whereas natural knowing carries its own validation. Direct religious experience, as implied by the account of Moses’s experience in front of the burning bush, or the conversion

of Saul to Paul on the road to Damascus, can be seen as a particularly meaningful example of natural knowing.

Common Threads

These different meanings of the word *intuition* all share the idea that the events or processes referred to occur in the absence of conscious mental will. We can go further toward crafting a useful definition of *intuition* by eliminating any meaning that is irrelevant or inappropriate to the present discussion. Certainly it seems that cognitive experiences that are intuitive in the sense of the obvious, clear by inspection alone, and consensual, are not relevant to the role of intuition in scientific and other inquiries—although indeed, this quality of understanding may well be the goal of a given inquiry. Many would also argue that intuition as natural knowing or perceived truth also has no place in a discussion of inquiry. We will, however, for now retain natural knowing on the list, and postpone discussion of this controversy until later.

What ties together the remaining meanings of the word *intuition*? In each case the information content of intuition is originally outside of consciousness and beyond voluntary recall, yet has the potential to impact thought or action significantly. The process of intuition can then be seen as a bridging function that brings this information into awareness in the absence of directed mental activity.

The contents delivered into consciousness come from layers of the mind that are hidden from ordinary awareness. We will assume that the source of this information is the unconscious mind spoken about by psychologists. This definition is particularly fruitful, as it highlights the potential power of intuitive processes in inquiry. Intuition as a bridging function brings the power of the unconscious into conscious thought. Through intuition, the unconscious with its vast memory banks, its associative accessing system, its speed, and its ability to process multiple items in parallel, greatly enriches the ability of conscious mental activity to manipulate logic and construct empiric tests [2–4].

Role of Symbols in Intuition

As dreams demonstrate, the unconscious frequently communicates in the language of symbols. In symbol formation, each object can be represented by multiple associative categories. In symbolic expression, any one of these aspects can stand for the whole item; however, symbols often simultaneously encode a number of different levels, presenting a richly textured and very often surprising understanding of the object under consideration. In the unconscious, in effect, each item is categorized by all its different

component parts, as well as its descriptive, situational, and affective associations [5]. Intuitions very frequently come through to awareness in symbolic form and tend to share in the rich and unexpected quality that characterizes unconscious mental processes. The description of intuition in the following vignette highlights the symbol-forming facility of the unconscious:

Early in my investigation of intuition, a colleague surprised me by asking for an impromptu definition of intuition. After a moment of searching, the phrase "a blink of the eye" unexpectedly came to mind. This didn't seem to answer the question, so I looked again. This time a subliminal physical sense of the experience of intuition as a rapid closing and opening somewhere in my chest accompanied the mental experience of seeing a generic signal go down and then up on a graph.

In hindsight it is clear that my unconscious had offered "a blink of the eye" as a symbol for intuition. The process of intuition was highlighted as an instantaneous closing down of ordinary vision which allows for, or accompanies, a simultaneous opening of internal vision. Moreover, with both intuition and a blink of the eye, one may be aware that something has happened, yet the experience tends to remain just below the threshold of ordinary consciousness. In addition, of course, the metaphor of a blink of the eye highlights the fact that internal vision tends to remain open only for an instant. Finally, and on a more personal note, the image also appears to encode my first intuition as a biologist. [6]

But isn't the language of symbols, as my scientific colleague in part implied, a language for artistic expression, not scientific and other empiric inquiry? Even if intuition may play a role in certain "soft" inquiries such as the present investigation, does it really have a role in "hard" science or other empiric pursuits? At least several important scientific discoveries have been inspired by dream-like symbols [7]. For example, Dmitri Mendeleev apparently first saw the periodic table in a dream, and the German chemist August Kekulé reported that his two most important contributions, the idea of atoms combining relative to their valence and the structure of benzene, both first appeared to him in waking dreams:

. . . As usual I was sitting "outside," on the roof of the omnibus. I sank into reverie. Visions of the atoms flitted before my eyes. I had always seen them in movement, those little creatures, but I had never succeeded in overhearing the secret of their movement. Today I saw that often two smaller ones would join to form pairs; larger ones would embrace the two smaller ones, and even larger ones would seize hold of three and even four, the whole circling in a swirling round dance.

It was similar with Benzol theory . . . I sat there writing in my textbook, but it was not going well; my mind was on other things. I turned the chair to the fireplace and sank into half-sleep. Again the atoms played before my eyes. This time the smaller groups kept modestly in the background. My mental eye sharpened as a result of repeated visions of a similar kind, now discerned larger structures of manifold formation. Long rows, often put together more closely; everything in motion, twisting and moving around in a snake-like manner. And behold, what was that? One of the snakes got hold of its own tail, and tauntingly the whole structure whirled before my eyes. [8]

Another fantasy that played a central role in contemporary scientific understanding is Einstein's reverie at the age of 16 of riding a light wave. This image structured much of his early thinking that led up to the special theory of relativity and, like Kekulé's ring of snakes, can be seen as an image presented from the unconscious.

Role of Analogies in Intuition

Associative processing, an important component of symbol formation, plays a central role in intuition whether or not intuition is expressed in consciousness in symbolic form. Thus intuition perhaps more frequently brings the power of the unconscious processing into the arena of rigorous inquiry by using associative processing to facilitate analogies to other events or systems. Analogies, defined as "a partial similarity on which a comparison may be based" [9], can be seen as symbols, although not necessarily of the dream-like variety exemplified by Kekulé's snake biting its tail [5]. Intuition uses associative processing to rapidly check for similarities between different situations and/or data. Often the novel is compared to the more familiar, becoming more approachable or knowable by being framed in relationship to what is already known. Analogies play an important role in science [10]. For example, the concept of a wave was analogized first from water to sound and then to light.

Intuition can also focus attention on similar patterns in diverse (novel) circumstances or data which appear unrelated by more superficial criterion. Einstein was pointed to this capacity of intuition to uncover similar underlying patterns in diverse phenomenon when he said, "To these elementary laws there leads no logical path, but only intuition, supported by being sympathetically in touch with experience" [11].

Intuitive Logical Processing

Although intuition is independent of conscious rational activity, it appears to have access to logical as well as associative processing modes. Those of us who use it as a default or preferred mode of cognition can readily confirm its ability to generate rigorously structured insights when required, as well as its ability to monitor itself for consistency with other information (see below). It is tempting to say that intuition as a bridging function has access to both the associative processing capacity of the unconscious and the logical processing capacities of the conscious mind. However, it is not clear that the capacity for logical construction is inherent only to the conscious mind. Often, aside from the "received" quality of intuition, the only difference between intuitive processing and conscious rational processing of information is that intuitive processing is much faster. The observation that a novel logical chain can appear fully formed in awareness, rather than

undergoing sequential construction by conscious mental activity, suggests that the capacity for logical processing also exists within the unconscious.

One surprising possibility is that what we experience in conscious awareness as feeling may function alone or in conjunction with thought in the structuring and retrieval of unconscious contents by intuition (see below). This is an appealing hypothesis because feeling is a much faster processing mode than thought [12]. Feeling here is not necessarily synonymous with emotion. It refers instead to a nonrational capacity for fine discrimination, an underlying current registering mental harmony or discord, a sense of being on or off beam. The following vignette illustrates that complex processing of conceptual information may go on outside of awareness and suggests that at least in some cases, feeling may play a role in such processing:

I had been struggling for a while to understand an issue tangentially related to my work [13, 14]. At different times I had small insights about various aspects of the problem, but a unified sense of the issue kept eluding me. In the course of a discussion one day I had an insight that I recognized as much more penetrating than any of my other bits of understanding. I remember wondering to myself if the new insight were consistent with my other insights on the topic, but for some reason I could not bring the specific content of these other insights to mind. Then without consciously willing it, and at a level below my awareness, I found myself checking this new insight to confirm its consistency with the other information stored in memory. My link with this process was a feeling trace at the threshold of awareness that recorded a continuous sense of harmony at the absence of contradiction that marked the transition from one piece of stored information to the next. At one point I sensed that I could bring the whole process completely to consciousness had I wanted to, however the experience accessible to me was much too compelling to stop. At the end, nonetheless, I found I had available a fully integrated, multi-leveled understanding of the whole issue.

When Do Intuitions Appear?

Although intuitions are not the product of conscious will, they can be stimulated by ongoing conscious mental activity, as the example above demonstrates. However, as the image of “a blink of the eye” suggests, often it is necessary to quiet the logical mind to encourage the intuitive mode. Thus after an unresolved struggle with an idea, the solution will often appear unexpectedly in a relaxed moment. However, this is not always the case. Intuitions are also especially likely to occur when concentration on the object of inquiry is so complete that one’s sense of self as a frame of reference seems to disappear.

Intuition is not limited to finding solutions, or completing incomplete *gestalts*. Sometimes, either during relaxation or in the midst of intense mental activity, the shadow or corner of an entirely novel idea may emerge into consciousness more or less uninvited and have a strong power or draw on the conscious mind. Much time and work may be required to clarify such intuitions to the point that they can be reasonably communicated to others.

Very often these sketchy ideas initiate completely new and very powerful areas of investigation.

Intuition as a Processing Mode vs. Intuition as a Source of Primary Information

To talk further about the role of intuition in scientific and other empiric inquiry, it is helpful to distinguish clearly between two different categories of intuition implied throughout the above discussion. Intuition may function either as a processing mode or as a source of *de novo* knowledge about the world. Presumably either type of intuition could function without the inquirer's awareness. This dual aspect of intuition no doubt accounts for some of the controversy about the potential role of intuition in science.

Without question, intuition as a processing mode plays an important role in the process of scientific inquiry for most investigators. Because of its access to unconscious content and its capacity for associative data management, it brings creativity and speed to the process of inquiry. Moreover, intuitive processing within the context of inquiry is often rigorous in the sense of being logical; this, however, is not to say that all hypotheses or insights generated by intuitive processing are correct. This is an extremely important point: as all researchers know, the creative and elegant hypotheses one's intuition provides to explain accumulated data can easily be overturned by tomorrow's experimental results.

In contrast, the role of intuition as a source of primary information or understanding about the world is more problematic. One position is that it is not possible to intuit fundamental information about the world. What seem to be primary intuitions are in fact just examples of intuitive processing. To people holding this view, for example, Kekulé's reveries represent good solutions that the symbol- or analogy-forming capacity of his unconscious provided to problems in which he was engrossed, and these solutions happened to be right. What appear to be primary intuitions are at best very good guesses, honed by experience and a very subtle intuitive integration of every available clue.

Others support the view that reception of even complex information or understanding about the world unmediated by conscious experience is possible. Thus far, however, it has proved difficult to design definitive tests to resolve the series of controversies suggested by this statement. Fortunately, within the context of this discussion it is not really necessary to do so. For the sake of argument we will assume that direct intuition about the world is possible, and then consider the potential role of such intuitions in empiric inquiry. Irrespective of its origin, any piece of information that can be subjected to empiric confirmation is appropriate input for scientific inquiry. Thus, Mendeleev's dream showing him the periodic table, quite indepen-

dent of its source, served as an important way station in the empiric search for the structuring principles of matter.

No “Front Door” Role for Natural Knowing in Science

Intuitions as hunches, images or analogies, and more complete understandings guide our thinking, and their role in scientific inquiry is clear, even when their source is not. A more complex, but related issue is the role of intuition as natural knowing or perceived truth in scientific inquiry. As opposed to intuition as a source of ideas, intuition as natural knowing by definition is always correct to the knower. Scientific inquiry, in contrast, is structurally antithetical to the idea of perceived truth. Indeed, the immediate goal is not truth, but rather reproducible empiric verification of understanding. Thus the scientific method sidesteps the issue of truth, and theories cannot be proved, only disproved, although over time consensual validation is taken as proof. Natural knowing is certainly not allowed in the “front door” of empiric endeavor.

This is somewhat different than saying that scientific inquiries do not have experiences of natural knowing around their subject matter. However, this question lies outside the domain of science, and interested investigators can probably best approach it by careful examination of their own experience. The pitfall on one side is that the healthy skepticism of science will rigidify into a belief system that functions to limit experience, while the pitfall on the other is that apparent experience will be accepted in the absence of sufficiently skeptical analysis.

The more important point for our discussion is that those involved in scientific inquiry would not be satisfied to hold any intuition about the natural world simply as a perceived truth. Again, for argument’s sake, let’s say a researcher could intuit the mechanism to account for a specific phenomenon in the presence of little or no supporting data, and because of certain subtle qualities, independent of goodness or fit, be entirely confident it were correct. Nonetheless, the nature of scientific endeavor dictates he or she hold the intuited mechanism as a provisional model until the required evidence appears.

Conclusion

Intuition can play an important role in all facets of scientific inquiry. It can orient the researcher, providing him or her with a fruitful conceptualization of the problem, supplying a productive method of attack, and reconfiguring the raw data into a meaningful pattern. Intuition harnesses the unconscious with its large data capacity and speed, thus allowing both logical and associative connections to be made very quickly between recent observations and other stored information, as well as between different lev-

els of observation. With the support of the unconscious, the intuitive scientist weaves his or her observations into a rich web of understanding; this web in turn functions as a fine apparatus with which to capture even more subtle and compelling levels of understanding.

A quote from Barbara McClintock, the Nobel laureate corn geneticist illustrates this forcefully:

But why was I so sure they were ring chromosomes? I could convince anyone to call them ring chromosomes before anyone had seen them. That was, God knows, true confidence. I was not trying to convince anybody, but I was convinced. Why was I so convinced that the thing had to be, that it couldn't be anything else but that? . . . The logic was compelling. The logic made itself, the logic was it. What's compelling in these cases is that the problem is sharp and clear. The problem is not something that is ordinary, but it fits the whole picture, and you begin to look at it as a whole

REFERENCES

1. JUDSON, H. F. *The Eight Days of Creation*. New York: Simon and Schuster, 1980.
2. KIHLMSTROM, J. F. The cognitive unconscious. *Science* 237:1445-1452, 1987.
3. LEWICKI, P.; HILL, T.; and CZYZEWSKA, M. Nonconscious acquisition of information. *Am. Psychol.* 47:796-801, 1992.
4. EPSTEIN, S. Integration of the cognitive and psychodynamic Unconscious. *Am. Psychol.* 49:709-724, 1994.
5. EPSTEIN, A. W. Categorization: A fundamental of unconscious mental activity. *J. Am. Acad. Psychoanal.* 20:91-98, 1992.
6. ROTHMAN, S. S., and ISENMAN, L. D. The secretion of digestive enzyme derived from two parallel intracellular pools. *Am. J. Physiol.* 226:1082-1087, 1974.
7. HARMON, W., and RHEINGOLD, H. *Higher Creativity: Liberating the Unconscious for Breakthrough Insights*. Los Angeles: Jermey Tarcher, 1984.
8. ROTHENBERG, A. Creative homospatial and Janusian processes in Kekulé's discovery of the structure of the benzene molecule. In *The Kekulé Riddle*, edited by J. H. WOTIZ. Clearwater, FL: Cache River Press, 1993. 293.
9. *Random House Dictionary*. New York: Ballantine, 1978.
10. HOLYOAK, K. J., and THAGARD, P. *Mental Leaps*. Cambridge, MA: MIT Press, 1995.
11. HOLTON, G. *The Scientific Imagination*. Cambridge, MA: Harvard Univ. Press, 1978. 95.
12. DAMASIO, A. R. *Descartes' Error*. New York: Avon Books, 1995.
13. ISENMAN, L. D., and DICE, J. F. Selective release of peptides by lysosomes. *J. Biol. Chem.* 268:23856-23859, 1993.
14. ISENMAN, L. D. Peptide release by lysosomes. In *MHC Molecules: Expression, Assembly, and Function*, edited by E. R. CHICZ and R. G. URBAN. Austin: R. G. Landes, 1996. 73-81.
15. KELLER, E. F. *A Feeling for the Organism*. New York: W. H. Freeman, 1983. 67.