THE PRECURSORS OF THE EUREKA MOMENT AS A COMMON GROUND BETWEEN SCIENCE AND THEOLOGY

by Michael Cavanaugh

Abstract. "Eureka moments" can be said to be based on intuition, but their deeper foundations are phylogenetic evolution and subconscious gestalt processes, as analyzed by the late Nobel laureate Konrad Lorenz. By incorporating Lorenz's findings, modern epistemology could avoid three common errors which have crept into the discussion. Those errors are: (1) that epistemology is language-dependent; (2) that epistemology is primarily subjective; and (3) that epistemology is creative and not methodological.

Keywords: creativity; discovery; epistemology; Eureka moment; Konrad Lorenz; objectivity.

Current studies in epistemology (the nature and processes of knowledge) are particularly sensitive to the interplay between science and the humanities. For example, a recent article by Morris Shames (1991) sought to show that both disciplines (and all others) arise from the same epistemology because they depend on intuition-based insight, beginning in the well-known "Aha!" or "Eureka" moment of discovery.

Shames's conclusion would be inescapable if it rested on a better scientific foundation, but three significant errors in his precepts threaten to undermine recent progress in the theory of knowledge. This article will strive to correct those errors by reviewing the contributions of Nobel laureate Konrad Lorenz on the same subject and by citing research that supports his conclusions.

1859 TO 1959: FROM DARWIN TO LORENZ

Although *The Origin of Species* (Darwin 1859) did not discuss human evolution or mental processes, its final chapter alluded to both and

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predicted the current research program in evolutionary epistemology. At page 488 Darwin wrote, "In the distant future I see open fields for more important research. Psychology will be based on a new foundation, that of the necessary acquirement of each mental power and capacity by gradation." In the storm that followed Darwin, this provocative sentence took a backseat to the other implications of his theory, and thus the prophesy is only just now beginning to come true.[1]

Yet those early disputes set the stage for the modern controversy by resurrecting and reworking concepts like reductionism and vitalism.[2] When one group began to emphasize the animal roots of knowledge early in the twentieth century, it was promptly accused of reductionism. The rival group was accused of vitalism when it strove to show how completely different human epistemology is from animal epistemology, primarily because of language and culture.

From within this latter group Bierens de Haan constructed a concept in 1935 called "the anticipatory explanatory principle," which partly foreshadowed what is now being called intuition-based insight or hermeneutical preknowledge, but in explaining the concept, he chose to attack Konrad Lorenz, who responded with a devastating counter attack (Lorenz 1942).

Later, however, Lorenz wrote a fascinating paper that was somewhat more conciliatory (Lorenz 1959). Interestingly, it came to the same conclusion as the 1991 Shames paper does, but it did so on radically different grounds. Lorenz agrees that all discovery has the same origin, but he denies the metascientific basis of that epistemology implied in Shames. Instead, he gives an entirely causal and biological basis for both scientific and literary insight. I will summarize his argument and contrast it to Shames's and then draw conclusions relevant to the contemporary search for common ground.

The Biology of the Eureka Experience

Lorenz's 1959 paper is entitled "Gestalt Perception as a Source of Scientific Knowledge." In it he searches for processes that might explain the foundations of reasoning and deduction, with special attention to the process of discovery that produces the Eureka experience. Thus he and Shames are writing on exactly the same topic, but whereas Shames treats the Eureka experience as the *beginning* of discovery, Lorenz spends most of his paper exploring its *precursors*. As one might expect from the founder of ethology (the study of comparative animal psychology), Lorenz states that epistemology can be

understood only by observation and comparison and by thinking about its evolutionary and developmental roots.

Lorenz begins by chiding his fellow scientists for their preoccupation with measurement and statistics to the exclusion of disciplined observation. He chuckles at Metzger's witty statement that "there are some people who are incurably prevented, by theoretical considerations of cognition, from using their senses for the purpose of scientific understanding." And he cites a paper by Max Planck, which argued that a scientific worldview arises primarily through basic perceptual functions, so that knowledge processes in children and primitive peoples are essentially similar to the methods of science.

The role of perception is underlined when Lorenz considers the operation of subconscious gestalt processes.[3] Day by day our senses observe and our subconscious brains store data. In the subconscious brain, data are shuffled and sorted into working hypotheses and categories. Later, some of those tentative subconscious conclusions rise to the surface for further processing. Lorenz's young daughter supplied a simple example of the process at work when he took her to the zoo. Although unfamiliar with the birds there, she was able to place them in correct taxonomic categories based on her previous knowledge of local birds. Lorenz argued that she was comparing present looks and behavior to subconsciously constructed categories based on prior perception. He was especially impressed when she identified a difficult bird as gallinaceous (chickenlike) , exactly echoing the opinion of the most qualified systematists.

The small son of a colleague provided an even more charming example, one that reveals the innate nature of such category construction. The little boy persisted in calling many different animals "bow-wow," including even his infant sister. This distressed his zoologist parents greatly, until they realized that he consistently applied "bow-wow" to all mammals, and only to mammals. The confusion was about word usage, not about perception or category construction; the boy had competently performed *those* functions even before he could talk, and it was easy to change his words once his underlying perceptions and subconscious category constructions were appreciated.[4]

Young children are not the only creatures that can construct such categories. Animals do it routinely, easily ascertaining (for example) which creatures to pursue as prey and which to avoid as predators; they can even ascertain whether their predator is hungry or full (Light 1989). In learning experiments, animals routinely touch computer screens with their noses to show that object A is in the same category as object B.[5]

Lorenz later worked out a general epistemology (Lorenz 1977) that

tied all of these observations together, but the 1959 paper was not so much concerned with general questions. It focused on the interface between subconscious and conscious processes. This interface operates like underground water coming to the surface. Usually it seeps slowly into springs of consciousness, but sometimes subconsciously constructed conclusions burst suddenly into our awareness like a geyser, and we exclaim, "Eureka, I have found it!" Before Lorenz, such sudden inspirations seemed so mysterious that most philosophers believed they came from supernatural sources like God or an oversoul or a vitalistic fluid or a supervening karma. For the first time, Lorenz provided a cohesive and comprehensive natural explanation for such insights.

He did so by building on Freud. Although Freud had not originated the idea of the subconscious (Whyte 1978), he certainly brought it into popular conversation and stimulated researchers like Lorenz to consider it further. Lorenz marshalled dozens of animal and human examples to show the evolutionary history of subconscious processes. He legitimized hunches and other "mystical" flashes of insight by arguing that they arise from the same subconscious storing and sorting of data already discussed. Thanks to him, we now understand that sending subconscious conclusions into consciousness is a normal brain function. It is fundamental not only to our brain biology, but to the brain biology of all higher animals. A chimpanzee stares at a maze for a time proportionate to the maze's difficulty and gets an "Aha!" look just before working the maze (Rensch 1971, 221–24). Its body language identifies the moment it *discovers* how to use a box to reach a suspended banana.

Trained as a physician, Lorenz took the underlying neurology of subconscious processes for granted. He often encouraged efforts to investigate that neurology, but his own research focused on more readily accessible evidence, especially animal behavior. He was a cofounder of the influential journal *Ethology,* but before he died several new journals had begun investigating the neurological foundations of thought and behavior, and I will cite some of them below.

Distinctions between Lorenz and Shames

Shames's stream-of-consciousness style produces some currents that seem to flow parallel with the analysis above. Yet three of his concepts seem clearly inconsistent with Lorenz, and those concepts must be clarified if they are to offer firm common ground on which both scientists and humanities scholars might stand.

The first inconsistency concerns the question of whether epistemology is language-dependent or not. Shames unequivocally states (1991, 346) that it is. Of course, that is true if epistemology is thought of as "the *study* of the nature of knowledge," because it is hard to imagine how one could study the nature of knowledge without language.[6] But since epistemology usually means "the nature and processes of knowledge," the statement is not easily accepted by evolution-literate thinkers precisely because of the many examples of knowledge that do not depend on language. In addition to those already cited, Lorenz supplies others in his 1963 article "Do Animals Undergo Subjective Experience?"

More ethological evidence has accumulated since Lorenz,[7] reiterating and expanding his claim that many animals display sophisticated epistemological processes without language. But even apart from animal studies, other disciplines also explore human knowledge processes that operate independently of language. Modern psychology calls perception-based knowledge "veridical" thought, and it is well supported by the researches and philosophy of Donald Campbell (1960).[8] Indeed, it now appears that children acquire language as the end product of epistemological processes that precede it; words are themselves learned as a sudden Eureka experience (Cromer 1983).

Neurology also supports the existence of nonlinguistic epistemology, both in animals and humans. For example, studies of prosopagnosia (the inability to recognize faces) demonstrate that some parts of the human nervous system can recognize a face even if language centers cannot (Bruyer 1986; Deltaan and Newcombe 1991). Since certain neurons in the monkey's brain have been positively correlated with facial recognition (Bruyer 1986, 151), it must be presumed that human brains contain similar neurons. In a healthy human brain those neurons undoubtedly communicate with language centers, but they are not dependent on them. The contrary is probably true; greeting a person by name requires us to first recognize him or her.

Does any of this mean language is unimportant? Of course not. Once one accepts the biological and neurological foundations of knowledge, language takes its rightful place as a powerful though latecoming component in the epistemological milieu. With language, we can construct a much richer understanding of our own experience and learn from the experience of others, but we can adequately appreciate how profound those abilities are only by seeing them as the result of a phylogenetic and developmental history that requires us to acknowledge the prior impact of nonlinguistic epistemology.

Incidentally, Lorenz's emphasis on prelinguistic epistemological processes does not mean that he denied the impact of hermeneutical preknowledge.[9] On the contrary, he agreed that our perceptions are biased, not only by language and culture, but also by something even more basic. In an important footnote to the 1959 article (no. 73), he reminds us that evolution itself produced hypotheses which are preserved in our genes. Time has validated most of those hypotheses for the conditions under which they evolved, but whether valid or not they clearly bias our perceptions even more profoundly than language does.[10] Our biases, however, do not mean that reality is itself subjective, as can be seen by examining the second inconsistency between Shames and Lorenz.

The second inconsistency concerns the question of whether reality is subjective or objective. Actually, Shames is a bit murky on the question, but his usage of Gadamer seems to settle the issue in favor of subjectivity.[11] As usual, Lorenz is far from murky and gives three kinds of evidence to support a humble but definite objectivity:

1. Widely different kinds of consciousness react to *something* in ways that cannot be understood except by reference to an objective[12] reality. Plants and animals were reacting to this outside reality long before human consciousness evolved to somehow "create" reality with our metaphors.[13] Humans were too, as is made clear by MacLean's recent (1990) explication of the growth and structure of our triune brain.[14]

2. Each of these different kinds of consciousness is or was reacting to the *same* outside reality. The evidence for this claim arises from the fact that our notions of reality are frequently challenged by anomalies encountered in the field or laboratory. When that happens we could either stubbornly insist on our current view of reality, or we could try to resolve the apparent inconsistency. When we do the first, it might fairly be argued that we are imposing our subjective notions of reality on other beings. Often, however, we take the second route, and thus far we have only been able to solve the epistemological puzzles presented by further explorations of a single reality, rather than by abandoning it or by perceiving it as somehow divisible.[15] It is vastly more likely, for example, that pigeon homing will be explained as a response to objective cues than by postulating intuitionism.[16]

3. The many mistakes we make might seem to challenge the existence of a unified objective reality, but actually they support it, provided we understand how evolution works. Organs and behaviors evolved to work "well enough" for survival, but not flawlessly. As Lorenz's student Franz Wuketits explains (1990, 92–93), we evolved

to participate in a limited sector of reality (the "mesocosm"). Yet our elegant brain and its feedback mechanisms permit us to learn from our mistakes and to fine-tune our responses over time; thus we can range far beyond our mesocosm and comprehend greater and greater portions of reality. Humility is required, but there are solid clues as to the existence and nature of reality (see also Feinberg 1985, part 1).

The third inconsistency between Shames and Lorenz arises when Shames claims that the Eureka moment is primarily creative and not methodological. Creativity can happen without formal training or method, but Lorenz showed why they are critical to encouraging creativity. By engaging in long-term study or observation, one methodically feeds the subconscious, and that is why the Eureka moment is much more likely to arise in the prepared person than in the unprepared. To say that genius is 99 percent perspiration and 1 percent inspiration is a poetic but accurate way to say that hard mental work furnishes most of inspiration's raw material (Lorenz 1954). By imposing a rigid dichotomy, Shames denies the intimate interaction between method-programmed subconsciousness and creativity. What is needed today is more research into *how* method operates to create insight, both from a neurological viewpoint[17] and from the viewpoint of education theory.[18]

Shames might say that none of this disturbs his basic argument because rudimentary knowledge processes don't amount to an epistemology. A respectable epistemology of discovery requires sophisticated knowledge of the kind scientists and humanities scholars possess. The legitimate question is whether *that* kind of knowledge is all of a piece, arising out of identical Eureka experiences. I think Lorenz would agree that it is all of a piece, but his explanation would incorporate both simple and sophisticated knowledge processes, thusly: Like other nonprecocial beings, we begin our lives in dependency on our elders. Indeed, our species made such a great investment in cognitive processes that we need conceptual orientation almost as much as we need food. Early dendritic development predisposes us to learn concepts from the group, but with age our dependency diminishes. We can supplement and even supplant social learning with individual learning. We are able to modify the group's concepts, and we can even imagine entirely new concepts.

These new concepts (like their predecessors) are based on observations made with our evolved senses and on conclusions derived from processing those observations using evolved thinking patterns. Constructing subconscious trial groupings is the most relevant example

of those evolved thinking patterns. And the Eureka moment is the biologically predictable result of constructing subconscious trial groupings.[19]

The Middle Ground

Shames's conception is not beyond salvation because it does try to incorporate evolutionary concepts even while granting them merely an analogical or metaphorical role. Indeed, a two-step merger of Shame's views with Lorenz's clears some fertile new ground for epistemologists to plow.

First, the merger must accept the evolutionary and biological foundations of epistemology. Establishing that beginning place implies the existence of at least six precursors to the Eureka moment, which can be listed in the order they emerged in history. They are: (1) evolution in general; (2) the evolution of a brain complex enough for subconscious gestalt processes; and (3) human evolution. Human evolution was either immediately followed or preceded by (4) culture and (5) language. Presumably (6) metaphor developed after language did.

The order of the last four precursors requires some elaboration. They emerged rather quickly, acting as dynamic feedback loops on one another and on other elements of evolutionary change. For example, standing upright was a significant event in our evolution, with several relevant consequences. First, it caused our vocal chords to migrate lower, permitting new vocalizations that led to language. It also freed the hands, which accelerated the development of cultural artifacts like tools, and also permitted the metaphorlike hand signals that probably preceded language.[20]

Impressive as these four later developments are, Lorenz emphasizes the importance of the first two because they are true precursors to all Eureka moments, animal and human. To elucidate the later precursors in the human version of Eureka experiences, and to establish the second stage of the merger, we look to Shames. We rely on him to show how profoundly language and especially metaphor build upon the basic biology of thought processes. He shows how dynamically our cultural and religous concepts depend on metaphorical structures against which we test our imaginations and experience. And, finally, he identifies the Eureka moment's role in the formulation of myth and other complex theological structures.

Lorenz and Shames agree that the entire process of discovery, and especially the Eureka transition from subconscious to conscious, applies whether one is doing science or writing poetry. Granted,

science may ultimately result in more easily testable conclusions than a poem does, especially a poem which playfully shares ideas only barely bubbled out of the subconscious, but science can (and does) also explore its aha!s while they are still barely out of the subconscious,[21] and literature can be highly developed and far removed from its subconscious origins. Whether we call the result science or literature depends on what happens to it after the Eureka moment. Biologically and conceptually, the earliest phase of each discipline is the same.

THEOLOGICAL IMPLICATIONS

Several theological implications grow out of a combined Lorenzian/Shamesian epistemology. One is that we have a new basis for understanding the growth of theological ideas. That basis was expressed well by the University of Chicago's Dean Shailer Mathews in his 1931 classic *The Growth of the Idea of God,* and it finds more recent expression in books like Gordon Kaufman's *The Theological Imagination* (1981). The first book constructed a sophisticated social epistemology, and the second one emphasizes the subconscious and linguistic dynamics that cause theological concepts to change over time. Neither book, however, correlates completely with the Lorenzian/Shamesian epistemology presented above, and some updating would render both all the more powerful than they already are. For example, both books imply that "God" is a metaphor encompassing our deepest and profoundest experience, though fundamentally like other metaphors. Now we are in a position to extend that observation by exploring the probable origins of the metaphor and its related doctrines. The exhilarating sensations that felt so supernatural may now be reasonably identified as dramatic "higher-level" Eurekas; through them the subconscious brain produced conscious concepts and systems of concepts that gave meaning to mysterious and terrifying events.

A second implication concerns prayer. The old Protestant song admonishes, "Take your burdens to the Lord and leave them there." To paraphrase Lorenz and to expand upon Shames, we might change the image to say, "Take your burdens to the subconscious and leave them there." As thus conceived, "burdens" are unsummarized accumulations of dissonance and discouragement. They hang heavily in our mental recesses until the load is lightened by the consolidation and delivery provided by a Eureka realization. The conscious assignment of problems to the subconscious and the delight in the Eureka moment of receiving answers (and potential answers) to them have much in common with traditional concepts of prayer.

Such a proposal would doubtless sound impious to conservative theologians, but even they might strengthen their concept of prayer by defining the subconscious as a way station for burdens on the way to and from God. Certainly they would agree that the conscious end of the dialogue, where problems and answers are articulated in words, is identical with classical prayer, unless prayer is held to require magical incantations of specific words and names.[22] As a trade-off for the liberalization of the prayer concept, these notions might empower more scientists to "come out of the closet" and acknowledge the prayerlike nature of their own discovery processes.

Other implications of the Eureka process for theology include the construction of personal faith from one's culture and experience; revelation (including especially the overarching revelation embodied in new paradigms) ; and a new explanation of visions as particularly dramatic Eureka experiences.

CONCLUSION

As Shames has demonstrated, discovery can be conceptualized purely in terms of linguistic and metaphorical constructions. Theological concepts, such as the five examples given above (the growth of theological ideas, prayer, faith construction, revelation, and visions) may likewise be expressed in linguistic and metaphorical terms standing alone. But an adequate epistemology of discovery, one which more fully explains these and other theological concepts, must include not only metaphorical foundations of discovery, but also biological ones.

The concepts introduced by Konrad Lorenz offer great hope for adding biological foundations to current epistemologies. Lorenz is not often cited in *Zygon,* perhaps because his major technical writings do not address the issues that are precious to its readers (but see Hoagland 1967), yet several of his articles and books, including the ones discussed above, offer firm common ground upon which both scientists and humanities scholars could stand. In some ways he was a controversial figure, inspiring such modern disciplines as sociobiology (see Ruse 1979) and evolutionary epistemology (see Bartley and Radnitzky 1987 and Wuketits 1990). He was also very modest and cautious in his conclusions, and that assures his lasting significance. Now that he is gone—he died 27 February 1989—more objective appraisals of his work will be produced, and I predict that his writings will become markedly more valuable to philosophers and theologians in the next few years, just as the value of a painting grows once the artist is dead.

NOTES

I am indebted to an anonymous referee of this journal for three phrases, namely the description of certain sensations as "higher-level" Eurekas; the descriptions of burdens as "unsummarized accumulations of dissonance and discouragement"; and the idea that scientists might "come out of the closet."

1. The quoted sentence was edited in later editions to acknowledge that Herbert Spencer had already suggested the same thing. Darwin's biography disclaimed any conscious influence by Spencer, but it is noteworthy that one great mind was already grappling with an evolutionary conception of epistemology, even before Darwin.

2. For an instructive (and thoroughly provitalistic) view of the arguments at the turn of the century see Driesch (1914), especially pp. 137–48.

3. One doesn't hear much about gestalt psychology nowadays, at least not in America. That is not because it has been abandoned or overruled, but because most of its insights have been thoroughly assimilated into mainstream psychology (see Rock and Palmer 1990; Smith 1988).

4. Elsewhere Lorenz eloquently expands this theme, drawing an amazing amount of insight from the single case of Helen Keller (Lorenz 1977, 184–91). Essentially, he demonstrates that Keller already had the innate ability and motivation to construct and use symbols, which only awaited the elucidating skills of Anne Sullivan.

5. The behaviorist psychologists were Lorenz's sworn enemies, and even he accused them of reductionism (for example in Lorenz 1971). He did not dispute their results, but he argued that those results are trivial, demonstrating only that there are some cognitive processes common to humans and rats and pigeons. That is nonetheless an important insight; realizing that pigeons and other animals can perform amazing epistemological feats (see Staddon 1970) makes it easier to imagine the evolution of human neurology from the simpler brains of our distant ancestors. For two articles very sensitive to the lack of any meaningful ethology/behaviorist interchange, see Burghardt (1988) and Hailman (1988).

6. It might also be true if we defined epistemology as "accumulated knowledge," because even though some animals can accumulate knowledge and pass it down, their abilities pale in comparison with those of humans (see Lorenz 1970, 225). That unusual usage, however, would make epistemology a synonym for culture and would render the present point tautolological.

7. In addition to the journal founded by Lorenz and his colleagues (*Ethology*), many journals now publish articles about animal behavior. Several of them merge imperceptibly with the various neurological journals, but they bear names that reveal their ethological orientation, names like *Psychobiology, Neuropsychobiology, Behavioral Neuroscience, Behavioral and Brain Sciences, Physiology & Behavior, Progress in Psychobiology and Physiological Psychology, Psychophysiology,* and *Neuroscience and Biobehavioral Review.* Almost every issue of these journals provides one or more animal studies supporting Lorenz's argument that knowledge is a biologically based phenomenon with an evolutionary history.

8. Incidentally, Campbell is no stranger to Lorenz. His paper "Reintroducing Konrad Lorenz to Psychology" and Lorenz's response are a model of scientific dialogue. See the exchange in Evans (1975). Neither does Campbell deny that perception can be influenced by language and culture; indeed he and his colleagues have identified and quantified some of the cultural influences on veridical thought, without making epistemology itself a cultural artifact (Segall, Campbell, and Herskovits 1966).

9. For a well written explanation of hermeneutical preknowledge, see Stent (1985).

10. This observation leads Lorenz to a very sensible argument, and yet it is one that even philosophers of science often overlook. "Popper's denial of induction," he says, "would be entirely correct, if human cognition were forced to start on the basis of unprocessed sensory data, which it not only does not but *cannot*" (emphasis Lorenz's). The argument is mentioned in footnote 73 and developed in the 1977 book *Behind the Mirror.* Although some Popper scholars may consider the two views on induction irreconcilable, Donald Campbell comes close to harmonizing them in his contribution to a volume celebrating Popper (Campbell 1974).

11. By quoting a passage that focuses on knowledge as a kind of mutual agreement, Shames is apparently interpreting Gadamer in the way popularized by Richard Rorty. For a delightful argument against that interpretation, see Munz (1987). For a book-length treatment of the same issues, see Warnke (1987).

12. In the 1959 article Lorenz uses the awkward phrase "non-subjective" instead of the bolder "objective," but there is no doubt where he stands on the issue, either in this essay or in any of his other writings. See especially Lorenz (1962 and 1970, 224–26).

13. Shames does not explicitly argue that there was no objective reality until we invented it, but some current epistemologists (especially Rorty) use arguments similar to his to fashion this unjustified piece of human chauvinism.

14. One may argue that MacLean supports a subjective view of reality, but at the very least his massive accumulation of neurological evidence demonstrates how physical brains interact with physical environments to produce objectively observable subjective states.

15. Although Thomas Kuhn is usually cited in support of subjectivism, he also argues that anomalies prompt us to further explorations of a single reality, and he is frustrated that he has been interpreted as an apostle of radical relativism. Fifteen years after *The Structure of Scientific Revolutions,* in a chapter entitled "Objectivity, Value Judgment, and Theory Choice," he said, *"My point is, then, that every individual choice between competing theories depends on a mixture of objective and subjective factors, or of shared and individual criteria. Since the latter have not ordinarily figured in the philosophy of science, my emphasis upon them has made my belief in the former hard for my critics to see."* (1977, 325).

16. For the latest in the fascinating search into pigeon homing mechanisms, see Papi, Gagliardo, Fiaschi and Dall'Antonia (1989).

17. While it is not a goal of this article to propose specific research, a testable hypothesis might be possible on this point. For example, suppose competent researchers took a well-known invertebrate like *Aplysia* with its 24-neuron brain (see Davis 1986) and began to train it to do some task. If neurological changes could be demonstrated *before* the snail has finished learning the task, it would be reasonable to assume that changes also happen in human brains before we become conscious of them. That would further support Lorenz's concept of the biology underlying Eureka experiences.

18. In his work on imprinting, Lorenz discovered that *timing* is important to learning because the neurology of any species develops on an innate schedule. Recently it has been shown that children learn to distinguish between hypothetical beliefs and substantiated beliefs in the interval between first and second grades (Sodian, Zaitchik, and Carey 1991). This kind of finding will and should increasingly influence educational theory and practice.

19. I hope this summary paragraph does not take too many liberties with Lorenz. I believe it is a reasonable inference from his principles and conclusions, based primarily on his book *Behind the Mirror* (1977). See also Bayliss and Halpin (1982), Campbell (1980), and several of the other articles in Stent (1980) and Hess (1973). The latter reference includes an enthusiastic foreword by Lorenz.

20. This observation leads to another argument which could conceivably support Shames's statement that all epistemology is language-dependent. Since all knowledge processes require some degree of communication (if not vocalizations or hand signals then surely chemical messages, even within the cell's internal environment), we might call any system of communication a language, and therefore it is true that all epistemology is language-dependent. That would be an odd definition of language and would confuse more than it clarified—in biblical language it would be straining at a gnat while swallowing a camel.

21. Wagener (1979) gives several examples of Eureka moments in science, including Poincaré, Koestler, Gauss, Kekulé, and Tesla, and he also recounts the original Eureka, which happened when Aristotle suddenly saw the answer to a problem while in the bath. (I suppose, however, that the earliest recorded Eureka was that of Adam and Eve when they realized they were naked.)

22. The text only mentions prayers of supplication, but obviously prayers of thanks-

giving and praise are also most authentic when combined with a conscious commitment to a positive outlook on life, and not when they are simply directed at God without that programming. Ritualistic repetition is not necessarily in vain, however, because it can be an effective way to program the subconscious, both for supplication and thanksgiving.

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