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# The Experiment as Mediator of Object and Subject

*Johann Wolfgang von Goethe*

As soon as we perceive the objects around us we consider them in relation to ourselves—and rightfully so. For our entire fate depends upon whether they please or displease, attract or repel, benefit or harm us. This completely natural way of considering and judging things seems as easy as it is necessary. But it also makes us susceptible to a thousand errors that can shame us and embitter our lives.

Those human beings undertake a much more difficult task whose desire for knowledge kindles a striving to observe the things of nature in and of themselves and in their relations to one another. We no longer have the standard that helped us when we looked at things in relation to ourselves. We lack the measure of pleasure and displeasure, attraction and repulsion, use and harm. We must renounce these and as quasi-divine beings seek and examine what is and not what pleases. True botanists should not be touched by the beauty or the utility of a plant. They should investigate the plant's formation and its relation to the remaining plant kingdom. Just as the sun coaxes forth and shines on all plants, botanists should consider all plants with an even and quiet gaze and take the measure for knowledge—the data that form the basis for judgment—not out of themselves but out of the circle of what they observe.

The history of science teaches us how difficult this renunciation is. How we come to hypotheses, theories, systems, or whatever other modes of thought may exist through which we try to grasp the infinite, will be the topic of the second part of this short essay. In the first part I will consider how we proceed when we aim to understand the forces of nature. My current studies of the history of physics often provide the opportunity to think about these matters and give rise to this little essay. I strive to show in what way many great individuals have furthered, and also harmed, science.

As soon as we consider a phenomenon in itself and in relation to others, neither desiring nor disliking it, we will in quiet attentiveness be able to form a clear concept of it, its parts, and its relations. The more we expand our considerations and the more we relate phenomena to one another, the more we exercise the gift of observation that lies within us. If we know how to relate this knowledge to ourselves in our actions, we earn the right to be called intelligent. For any well-constituted person, who is by nature moderate or has been made moderate by circumstances, achieving such intelligence is not difficult because life itself guides us in every step. But when as observers we use our strict power of discernment to examine nature's hidden relationships; when we enter a world in which we alone can guide our steps and must take care to avoid all haste; when we keep our eye focused on our goal and do not allow any useful or harmful circumstance to pass by unnoticed; when we are our own most critical observer, controlled by no other and remaining skeptical of ourselves despite all inner engagement—in all these ways it is evident how strict the demands are, whether on ourselves or on others, and how little we can hope to completely fulfill them. But these difficulties and the hypothetical impossibility of surmounting them must not hinder us from achieving what is possible. We will come farthest when we become cognizant of the means that have allowed capable individuals to expand science. And we will also delineate the false pathways that have been taken, pathways that a great number of students, sometimes for centuries, have followed until subsequent experiences brought observers onto the correct path.

It goes without saying that experience, as in everything we undertake, has and should have the greatest influence in science, which is my present topic of consideration. Nor will anyone deny the high—and as it were creative and independent—powers of soul that apprehend, collect, order, and develop these experiences. But how these experiences are to be gained and used, and how we can develop and apply our powers is not generally known or recognized.

As soon as phenomena catch the attention of individuals with keen minds, they are inclined to observe and are also astute in making observations. I have often noticed this during my studies of light and color in conversations with people unacquainted with this topic that interests me so much. When their attention was stimulated they noticed phenomena that I either did not know or had overlooked. They corrected ideas that I had formed too hastily, allowing me to make faster steps and to step out of the limitations in which an arduous investigation often captures us.

It is true here as in other human endeavors that only the interest of many focused on a single point will generate

something excellent. The greatest obstacles for a researcher are the envy that would exclude others from the laurels of a discovery and the intemperate desire to consider and elaborate on discoveries only in one's own particular way.

I have been too satisfied with this method of working together with others to consider proceeding in any other way. I know exactly to whom I am indebted, and publicly acknowledging this in the future will be a joy to me.

If naturally attentive individuals can be of such help to us, how much greater the gain when those with training mutually aid each other. Any area of science is so vast that many individuals are needed to carry what one person alone cannot. We may notice that knowledge, like enclosed but living water, rises over time to a certain level and that the greatest discoveries emerge not only through people but also through time. We see this when important discoveries are made by two or more skilled thinkers at the same time. Just as we are indebted to society and friends, so are we even more indebted to the world and to the centuries. In both cases we cannot do enough to acknowledge how necessary it is that communication, mutual support, memory, and contradiction all play a role in keeping us on track and carrying us forward.

For this reason we should, as scientists, do just the opposite of artists: As artists we do well not to show our products to the public until they are completed, because no one can easily give advice or provide assistance. When the artwork is complete we can consider and take to heart praise or criticism, let them inform our experience, and then begin to develop and prepare a new work of art. In scientific matters, by contrast, it is useful to publicly communicate every experience, every conjecture. It is also advisable not to erect a scientific edifice until its plan and materials are generally known and have been judged and chosen.

We speak of an experiment when we take experiences of our own or of others, deliberately reproduce and present again the phenomena that arose, both those that came about fortuitously and those that appeared through the artifice of the experiment.

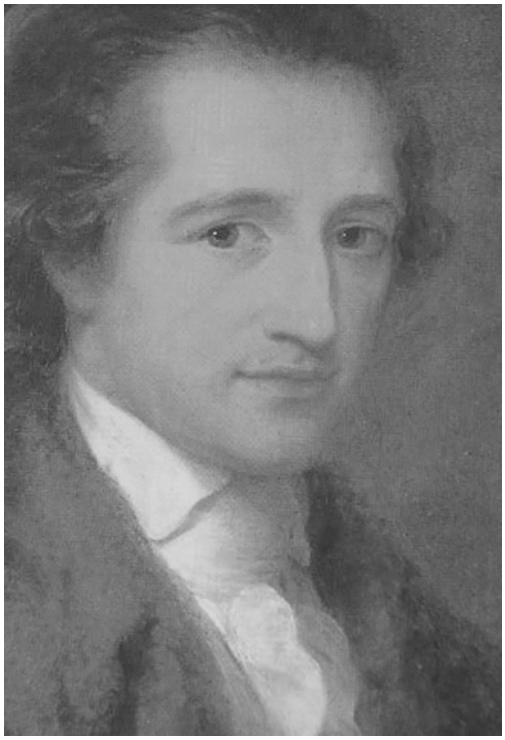
The value of an experiment, whether simple or complex, is that under certain conditions, with familiar apparatus and the necessary skill, it can be at any time reproduced as long as we re-create the same situation. Rightly we stand in awe of the human mind that can bring about the necessary constellation of circumstances and that is able to craft the instruments needed for experimentation. Such are being invented daily.

While we can praise a single experiment, it gains its true value only through its connection and unification with other experiments. Even to connect two experiments that are similar to each other demands more attention and vigilance than the keen observer might demand of himself. Two phenomena may be related, but not nearly as closely as we believe. Two experiments can appear to follow from one another and yet a whole series should lie between them to show the natural connections.

We cannot take great enough care when making inferences based on experiments. We should not try through experiments to directly prove something or to confirm a theory. For at this pass—the transition from experience to judgment, from knowledge to application—lie in wait all our inner enemies: imaginative powers that lift us on their wings into heights while letting us believe we have our feet firmly on the ground, impatience, haste, self-satisfaction, rigidity, thought forms, preconceived opinions, lassitude, frivolity, and fickleness. This horde and all its followers lie in ambush and suddenly attack both the active observer and the quiet one who seems so well secured against all passions.

To warn of these dangers, and to become more attentive to them, let me say something that may seem paradoxical. I dare to claim that one experiment, and even several of them, does not prove anything and that nothing is more dangerous than wanting to prove a thesis directly by means of an experiment. The biggest errors have arisen precisely because this danger and the limitations of the method have not been recognized. I need to express myself more clearly to avoid the suspicion that I am opening all doors to doubt: Every single experience, every single experiment through which we reproduce that experience, is essentially an isolated piece of knowledge and through carrying out the experiment a number of times we verify it as such. Within the same discipline we can know of two experiences and they can be closely related or can even be very closely related. Our tendency is to hold them to be more closely related than they are. This corresponds to human nature, and the history of the human intellect reveals thousands of examples and I myself have noticed that I make this mistake almost daily.

This mistake usually has its source in another, closely related one, namely, that we are often more delighted with the idea than with the thing itself. Or perhaps we should say: we take pleasure in a thing in so far as we form an idea of it and when it fits into our way of looking. We may try to raise our mode of thought so far above the everyday mode as possible and strive to purify it, but nonetheless it usually still remains only a mode a thought. It follows that we attempt to bring many phenomena into a certain graspable relation to one another that they may, looked at more closely, not have. And we have the tendency to form hypotheses and theories and to craft terminology and systems accordingly. We cannot condemn these attempts since they arise with necessity out of the organization of our being.



# Goethe the Scientist and Self-Critic

This essay by Goethe was written in the spring of 1792. It is remarkable how prescient it remains over 200 years later—more than enough reason to publish it in a new translation. It would be hard to find an essay that describes so many of the key elements of a rigorous, experience-based, and phenomenological scientific methodology in such a short space. In many respects Goethe elucidates what one could simply call "good science": The phenomena themselves should always be the focus of attention and the intent is to let the phenomena in their manifold relations come as fully as possible to expression. This is, as Goethe recognized, easy to say and all too difficult to achieve. Good science entails a wakeful and critical attitude towards oneself, and Goethe shows how vividly aware he was of science as a human activity. Since we are involved in every aspect of a scientific investigation, we need to attend to the many "inner enemies" that can color and distort our view of things. And while Goethe appeals to a "divine" attitude in which we "seek and examine what is and not what pleases," he is also clear that we cannot do this by detaching ourselves and trying to find a point of view that transcends all points of view.

No, we must engage. But the engagement is not one of theorizing and model-making, but rather one of achieving rich and manifold experiences, for example by creating a series of experiments that contain an array of variations so that we begin to unveil the phenomena through a many-sided consideration. In this movement through the phenomena and their variations, an order can begin to appear and patterns or relationships show themselves that Goethe calls experiences of a higher order in this essay. This is a seeing of relationships—inner lawfulness—that arises out of the engagement with the phenomena. It is not a theory or hypothesis that one formulates prior to engagement as the lens through which one views all the phenomena.

When Goethe wrote this essay, he was researching color. He had published a first essay on *Contributions to Optics,* and a second one followed soon thereafter. In these studies he carried out numerous experiments, so that when he writes of experimentation in the "Experiment as Mediator of Object and Subject" he is speaking out of direct experience. Moreover, he was also studying contemporary literature on optics and color, which were rooted in the work of Isaac Newton, so that he had keenly in mind a theory-driven approach to science that he believed gave a skewed view of the phenomena themselves. His work on color and optics continued over the next two decades, culminating in his *Farbenlehre*, which was published in 1810—200 years ago. (*Farbenlehre* is usually translated as *Theory of Color*, but might be more accurately rendered as *A Discourse on Color.*)

The idea that science should be theory-driven and all experimentation hypothesis-based still dominates science today. In science education students often learn theories and models as if they were phenomena, and experiments are largely carried out to substantiate an idea. A kind of indoctrination occurs. Thankfully, there is now a movement towards what is called "inquiry-based" learning whereby students experience science as a process of exploration. It is precisely undogmatic and self-critical exploration, carried out in careful dialogue with the phenomena at every step, that Goethe urges. This little essay belongs in the hand of every scientist and every science teacher.

Craig Holdrege

On the one hand, every experience, every experiment is by its very nature isolated. On the other hand, the power of the human mind seeks to unite with tremendous force all that it meets in the outer world. Considering all this, we can easily see the danger of connecting an individual experience with a preconceived idea, or of wanting to prove by means of individual experiments relations that are not altogether sense perceptible — that the creative power of thought has already formulated.

Through such efforts, theories and systems arise that do honor to the acuity of their author. But when they find too much acclaim and are maintained longer than they should be, they restrict and are harmful to the very progress of the human spirit they at first supported.

We can notice that a good mind is all the more artful the less data lie before it. To show its command, it selects a few flattering favorites from all the available data and knows how to order what is left over to show no contradictions. It knows how to confound, enwrap, and push aside the opposing data, and in the end the result resembles a despotic kingdom rather than a freely organized republic.

Such a master of high repute finds no lack of admirers, and students who learn the history of the framework are awed by it and try as far as possible to make the master's way of thinking their own. Such a teaching can dominate to an extent that anyone doubting it would be found disrespectful and audacious. Only later ages would dare approach this holy of holies and vindicate healthy common sense by remarking of the founder of the sect what a humorous mind once said of a great scientist: he would have been a great man had he not been so inventive.

It is not enough to point to such dangers and warn of them. It is only right that we disclose our position and show in what way we or others before us have avoided a mistaken path.

I said before that I hold the direct application of an experiment to prove some hypothesis to be harmful. I also stated that I acknowledge the experiment as a mediator. Since this is the crucial point, let me explain clearly: In living nature nothing happens that is not in connection with a whole. When experiences appear to us in isolation or when we look at experiments as presenting only isolated facts, that is not to say that the facts are indeed isolated. The question is: how do we find the connections between phenomena or within a given situation?

I have pointed out that we are subject to error when we try to directly connect an isolated fact with our faculty of thought and judgment. In contrast, we accomplish most when we never tire in exploring and working through a single experience or experiment by investigating it from all sides and in all its modifications.

It warrants a future and separate consideration to show how the intellect can be of help on this pathway. Let me say only so much here: since everything in nature, especially the more common forces and elements, is in eternal action and reaction, we can say of every phenomenon that it is connected to countless others, just as a radiant point of light sends out its rays in all directions. Once we have carried out an experiment, we cannot be careful enough to examine other bordering phenomena and what follows next. This is more important than looking at the experiment in itself. It is the duty of the scientist to modify every single experiment. This is the opposite of what a writer does whose aim is to entertain. Writers who leave no room for roaming thought bore their readers. Scientists must work ceaselessly as if the goal was to leave nothing for future generations to accomplish. Nevertheless, they will be reminded that our intellect in no way encompasses nature and that no one has the ability to exhaust any one field of inquiry.

In the first two of my contributions to optics I presented such a series of experiments that border on one another and that are directly connected with each other. When we attain an overview of all of them we see that they constitute, as it were, one single experiment, one experience presented from manifold perspectives.

Such an experience consisting of a multitude of others is an experience of a higher order. It is like a formula through which countless individual computations can be expressed. I believe it is the duty of a scientist to work toward such experiences of a higher kind. The work of the best scientists in the field shows us this. When we place one phenomenon beside the next, or rather, when we develop the subsequent step out of what preceded it, we advance with a thoroughness learned from the mathematician. And even where we do not venture into calculations, we must proceed as if a strict geometer looked over our shoulder.

The circumspect and pure nature of the mathematical method reveals every leap in assertion. Its proofs are simply the expanded explication of connections that are already implicit in the more basic parts, showing in the sequence of steps that the whole is correct and unshakable. Mathematical demonstrations are therefore more of the nature of expositions or recapitulations than they are arguments. Since I have made this distinction here, let me look back:

We can see the stark difference between a mathematical demonstration, which connects basic elements, and a proof that a clever speaker devises out of arguments. Arguments can contain wholly isolated facts and nonetheless, through cleverness and imagination, make a point and create the surprising semblance of right or wrong, truth or error. Likewise

we can compose individual experiments into an argument to support a hypothesis or theory, and generate a proof that, to a greater or lesser degree, deceives us.

If, by contrast, we want to work honestly with ourselves and others, we will attempt with great care to elaborate individual experiments into experiences of a higher nature. Individual experiments can be expressed in concise statements, placed side by side, and the more such statements we provide, the better they can be ordered and brought into a relationship that is as unshakable as that of mathematical statements. Higher order experiences are based on numerous individual experiments that can be investigated and tested by anyone. It will not be difficult to discern whether the parts can be expressed through a general principle, since there is nothing arbitrary here.

In the other method, however, in which we try to prove a claim using isolated experiments as if they were arguments, our judgments are often gained surreptitiously and may stand altogether in doubt. Once, however, we have brought together a series of experiences of a higher kind, we can apply intellect, imagination and ingenuity as we like. They will do no harm; rather, they will serve us. The first part of an investigation cannot be careful, diligent, strict and even pedantic enough, since the work is undertaken on behalf of the world and posterity. The materials should be ordered and presented in series and should not be arranged according to a hypothesis or used to serve a system. After that everyone is free to combine the material according to his manner and to create a whole that suits our way of thinking. In this way we will make the distinctions that are necessary and we are able to expand the array of experiences much faster and more purely than if we handle later experiments like extra bricks we cast aside and leave unused in face of an already completed structure.

The opinion and example of the best researchers give me hope that I am on the right path. I trust that this declaration will satisfy my friends who ask: what is the purpose of my work in optics? My purpose is to collect all experiences in this field, to conduct myself all the experiments, and to carry them out in their manifold variations. In this way they are easy to replicate and accessible to other people. Then I present the principles of the experiences of a higher order and wait and see if they let themselves be subsumed under even higher principles. Should the power of imagination and ingenuity at times speed ahead impatiently, the method itself will guide it back onto the right track.

*Translation by Craig Holdrege. Goethe wrote this essay in 1792, and it was published for the first time, in a slightly altered version, in 1823. Source of translation: "Der Versuch als Vermittler von Objekt und Subjekt," in* Goethe's Werke, Hamburger Ausgabe, Bd. 13 *(Munich: Verlag C. H. Beck, 2002, pp. 10-20).*

This lily shows something special. While a "normal" lily has six petals and six stamens, this one has six petals, five stamens, and one stamen that is also partially a petal. It is the curled structure at the center of the flower. Goethe arrived at many insights by paying attention to such unusual formations. (Photo Craig Holdrege)