

## **Personal Wonder**

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## **Abstract**

Plato placed wonder at the beginning of any philosophical striving  
FW Zeylmans van Emmichoven FW (1964)

## **Wonder**

All his life, Heinz von Foerster was a magician. Formally, as he recounts in his paper “On Natural Magic,” (von Foerster 1993b) he was a member of the Vienna Magic Circle (as well as attending lectures of the Vienna Circle). He acquired this distinction, working as a teenager with his cousin Martin Lang (who became a distinguished actor), to pay for his skiing and rambling holidays.

Those who heard him talk soon became aware of that part of being a magician that is involved in presentation. He was a consummate presenter: in lectures, where he could captivate and hold in his hand a whole audience no matter how difficult the topic; in conversation, for which he prepared for hours in advance; and in his writing which is particularly and beautifully formed (Glanville 1996a). But this quality was, or became, natural. He needed no preparation. If you dropped in on him, he behaved just the same. He was a man who responded to an audience, and it is no surprise that he wrote of himself “Through the Eyes of the Other” (von Foerster 1991).

There is a danger in trying to relate too closely the personal and work lives of scholars. All too often we can find extraordinary mirrors that we treat as causalities but which would not be recognised or accepted by the person in whose behaviour we believe the mirror to be. Yet there can also be a strength, specially when undertaken carefully and always remembering that the mirror is understood to be in the mind of the relator—as, indeed, is all analysis!

As von Foerster reached the end of his life, it occurred to me that this matter of magic might have been very important to him: more important than we had realised, maybe more important than he had realised, perhaps more important than his paper “On Natural Magic” implies. So I decided to examine this sense of magic in his work, and especially to see if I could find magic in his cybernetics.

## **Magic and Wonder**

In "On Natural Magic" von Foerster tells us something of how magic works. For him, it is important that it attends to the laws of physics, and his curiosity is aroused when he sees what seems physically impossible appearing to happen. "How does it work?" is his question.

But I think that to an audience, or at least to me-as-audience, this may not be the response we have. From my point of view, what I gain is a terrific sense of wonder. I am not interested in the physical question of how: I am much too happily absorbed in the experience of incredulity and amazement, which, the moment I ask "How?" is lost. It is this sensation, the sensation of wonder, that is what I love about magic.

In English, wonder is (as are so many words) ambiguous. There are two main senses in which the word is used that are of relevance here. The first is the verbal form, wonder, in the sense of enquiring; the second is the noun, wonder, in the sense of amazement. Both of these are relevant: the verb to von Foerster's interest in how magic is done, the noun to my experience of magic. (I quote Merriam Webster's definition, from Encyclopaedia Britannica, in the appendix.)

The sense in which I experience wonder when in the presence of magic is a very special experience not restricted to "magic tricks," unless one accepts a very broad interpretation of what such magic tricks are. I often find myself in a state of wonder (awe, amazement, speechlessness, which I think of more or less as synonyms). It is, perhaps, the experience I think of as the best I ever have. I can experience it with people, in conversation and sharing, in performance, in landscape, in art, and in the beauty of thought, for instance. Indeed, it is often associated with beauty. It is also associated (in my mind) with a loss of self, possibly what makes it so captivating and yet so very difficult to capture. To me, it is, therefore, very special and I greatly value my seemingly great gift to enter into wonder.

I asked von Foerster about this shortly before he died. In one of those rare moments when it seems permissible to ask anything, and as I left him, I suggested to him that what he had been most interested in was wonder: and that magic could create the experience of wonder while wondering could explain the mechanism of magic. He agreed. For this reason I claim that wonder was as important to von Foerster as it is to me. He liked to create for us the possibility of the sense of wonder, for wonder is perhaps the most essentially human experience there is. (This is why his dictum that only we can decide the undecidable is so significant, grounded, as it is, in wonder.)

## **Cybernetics and Machines**

Cybernetics has always been concerned with machines, both physical and conceptual. In a recent paper ("A Gallery of Monsters: cybernetics and self-organisation, 1940-1970"), Andrew Pickering (in press) argues that cybernetics is unique in coming from the actual making of astonishing machines (the monsters

of his title), rather than theoretical considerations which are then illustrated in machine embodiments. He cites, in particular, Wiener's predictor and Ashby's homeostat.

Von Foerster was not known (somewhat inaccurately) for making actual machines. He had researched microwaves. Anecdotally, I have heard him credited with the invention of the microwave oven. In the late 1940s, he explored systems such as the power supply distribution network in Vienna, when it failed. In the 1960s he built parallel computers and extremely effective pattern recognition devices. This is not, however, the way of working with machines that Pickering is getting at. But von Foerster was a cybernetician, and, specially in the earlier days, cyberneticians were concerned with machines. Indeed, Wiener's well-known characterisation of cybernetics as "communication and control in the animal and the machine" makes this preoccupation clear, for his cybernetics treated the animal through the metaphor of the machine.

A reasonable question would, therefore, concern von Foerster's use of the machine metaphor, the cybernetic machines he was interested in and/or developed; and whether these machines have about them a sense of magic that might offer us the opportunity to wonder.

### **Von Foerster's Machines of Wonder**

I shall discuss three magical machines with which von Foerster is clearly and explicitly associated, which lead to wonder. They are:

Maxwell's Demon  
Eigen Forms  
The Non-Trivial Machine

#### **Machine 1: Maxwell's Demon**

Von Foerster (1960) introduces us to Maxwell's delightful Demon in his paper "On Self-Organising Systems and their Environments."

The paper is important in a number of ways. It reminds us most clearly of von Foerster's background as a physicist. The theme of the paper is that self-organising systems are subject to the Laws of Thermodynamics, and are therefore, in a profound (but physical) sense, impossible. This was considered surprising, a strange conclusion for a man who had spent time and effort organising the conference on self-organisation at which the paper was delivered!

More to the point, here, is the introduction of Maxwell's fabulous Demon, which makes further (and longer) appearances in "Responsibilities of Competence" (von Foerster 1972b), where von Foerster argued that Maxwell's Demon is an isomorph of the Turing machine, an idea he repeated in "Disorder/Order: Discovery or Invention?" (von Foerster, 1984).

What is Maxwell's Demon? Maxwell's Demon is a thought (conceptual) device

intended to counteract the operation of the Second Law of Thermodynamics. The idea is that this little Demon exists inside a box of two halves, one hot, one cold, separated by a division in which there is a small hole with a door. The Demon notes when low energy (speed) particles try to move from the lower energy half to the higher, and those of high energy (speed) try to move from the higher to the lower half, and acts (by opening and closing the door) to keep the hot with the hot and the cold with the cold, while allowing misfits to cross into their more suitable halves. Energy is indicated, here, as temperature, and the (temperature) differential may actually increase.

The point von Foerster develops originates in Szilard (see Umpleby 2004): energy is required for the Demon to recognise the particles as hot or cold, and then to act to open or close the door, which dissipates the energy (temperature) differential regardless of the Demon's conservatory efforts and antics. This means Newton's Laws still hold, in spite of the Demon. Szilard calculated the Demon would use more energy to operate than it could ever possibly save by maintaining or increasing the temperature differential.

What, then, is interesting about Maxwell's Demon? After all, it's just a thought experiment and it's neither real nor (within the real world of physics that it is intended for) will it work.

The answer is that the invention of Maxwell's Demon can be seen as recognising the need to create and maintain distinction (long before Spencer Brown's imperious command that brings our worlds into order and pattern: "Draw a Distinction!" (Spencer Brown, 1968)). The mechanism of Maxwell's Demon creates and maintains distinction, and without distinction it is not possible for us to develop understandings by placing boundaries that contain and exclude. Distinction makes possible our amazing ability to see (perceive) and then to explain—and that is wondrous. Even more, it allows us to understand that difference (and thus multiplicity)—is wondrous. In the world of physics, it also maintains order, and without order in our world there is nothing but a uniform entropic mud. But perhaps that's just another way of talking of distinction!

## **Eigen Forms**

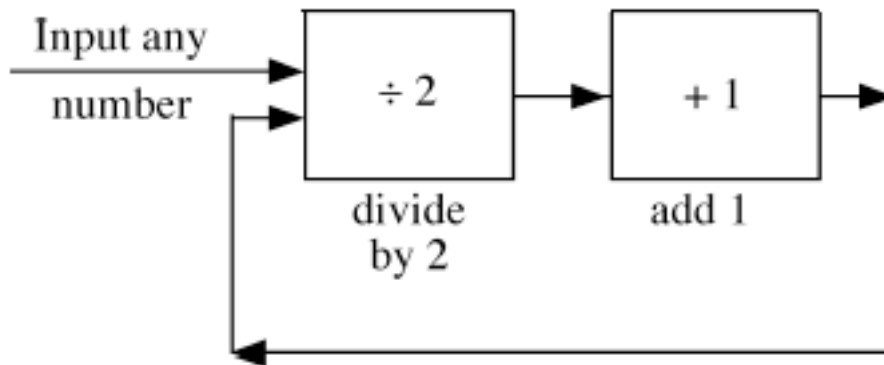
Most who know of von Foerster's more philosophical work will know of his fascination with Eigen Forms, introduced in his paper "Eigen Objects—Tokens for (Eigen) Behaviours" (von Foerster, 1977) in which he explores the notion of recursive mathematical processes that yield a fixed, self-reproducing value regardless of the value of the initial input. Yet some people question the value of this fascination with Eigen Operations, Eigen Values, etc. They refer, in particular, to von Foerster's tendency to use the one example:

*Take any number and apply the following action to it:*

*Divide it by 2 and add 1 to the result.*

*Then repeat this process on this result—that is, use the output (result) of this operation as its next input.*

The output of this iterative process always progresses towards 2. When it reaches 2 it retains that value. This operation can be expressed in the diagram shown below:



*An Eigen Form that computes an output that recursively approaches the value 2.*

The general criticism I hear is that this example doesn't say much: that what von Foerster offers is a far too restricted reading based on this one example taken from what is a much more extensive area. And, indeed, it is restricted—for this example is intended, I believe, as a metaphor for a process by which repetitive actions can lead to stability (which I also proposed, in a different form, in the Objects I invented in my doctoral thesis (Glanville 1975): the reproduction of a state recognised as the same. As Kauffman (2003) shows, Eigen Behaviours (and similar functions) are much more common than we might imagine.

Why was von Foerster fascinated with Eigen Forms? While Kauffman provides an extensive answer, there is a simple root to von Foerster's fascination. The key is to be found in a connection he proposed (when he first paraded his interest) with Piaget, and, in particular, with Piaget's concept of object constancy—the mechanism by which, Piaget proposed, starting as newborn children we learn to identify stable-under-change objects that we propose as the embodiment or progenitor of different percepts (Piaget, 1955). Thus, many different sensations that we eventually come to categorise as views, sounds, smells etc. and which we encounter on many different occasions, eventually come to form our notions of the objects with which we populate our worlds such as "Mum," "concept," "football," "physics" or "red." Piaget derived this as what he thought of as a necessary behaviour. In his Eigen Forms, von Foerster gives us a model of a mechanism that can generate this behaviour: a machine to stabilise.

This is, I believe, where he found magic in the operation of Eigen Forms. They provide a metaphor for a means by which we might generate, from any random selection and out of nothing, a constant, recurring something: the stable concept of a stable object. This operation shows us a way in which we might understand how (and that) we may develop constancy in our experience: how, from a world of no-form (no-world), we can generate a form or object—which we can attach to

objects in the world (the world itself being such an object). Do we not respond to this amazing phenomenon with wonder? (Of course, these objects are now the consequence of computations we carry out on our percepts, as von Foerster argues first in "On Constructing a Reality" (von Foerster, 1973), a paper that became a clarion call to those concerned that the observer's presence in his/her observations should be explicitly demonstrated and who wanted to understand what this might mean.)

Von Foerster considered this way of looking as a means of bridging between experience and the world described in physics. As he often insisted (e.g., von Foerster & Poerksen, 2001), he was not a constructivist: but, then, he was not really any sort of -ist at all: he hated categorisation because it reduces our freedom to be what we need to be as we need to be, and it places limitations on what is imaginable, making it difficult for us to see outside the bounds of the categories we use—regardless of whether what we were seeing came from the (rest of the) world, or came from us. As he is quoted by Poerksen (2004) "At each and every moment I can decide who I am."

### **The Non-Trivial Machine**

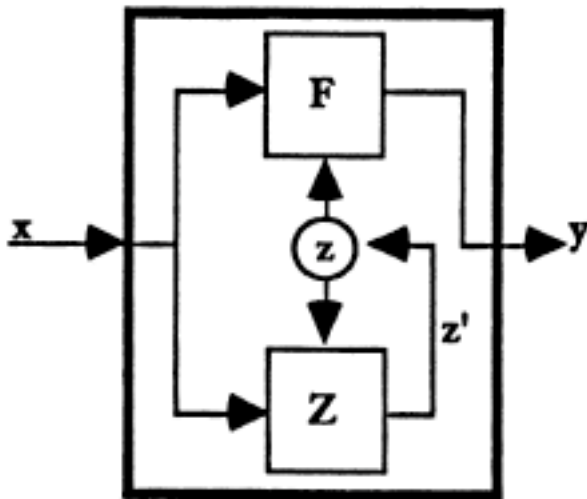
Von Foerster would often talk of the extraordinary processes of trivialisation that humans resort to. A friend of Ivan Illich, he regarded most education as a form of trivialisation (as he insists in, for instance, von Foerster and Poerksen (2001)). By trivialisation, he meant that variety and difference were removed so that the outcome of any input entered into a "trivial" machine is known (that is, it is perfectly predictable). Thus, the trivial machine makes for flatness and uniformity. This offended him greatly, for (amongst other things) it offended against his dictate that "only we can decide the undecidable" by removing the undecidability through a conceit.

A traditional input/output machine converts an input signal or behaviour into a totally predictable output signal or behaviour. The machine is trivial because this behaviour is trivial: there is never anything to learn and no behaviour has any great significance in the sense that it challenges the observer or requires any modification in understanding. Once you know one input/output relation you know that you know the resultant outputs deriving from all inputs.

Von Foerster held that if, in some system, you know the output that results from any input, that knowledge is trivial. As he wrote "A trivial machine is defined by the fact that it always bravely does the very same thing that it originally did" (von Foerster, 1993b).

In contrast, the Non-Trivial Machine, as von Foerster draws it, contains another, strangely connected input/output machine within it, which has a feedback loop generating internal states. As a result, the behaviour (to the observer outside, who cannot see this second, internal machine) is simply not predictable: the possibilities are so vast that they cannot be examined. And, while there may be times when the observer (that is, we) believe(s) (s)he has made a predictable model, there never is, and never can be, the certainty associated with the Trivial

Machine. At some time the behaviour may change: we cannot know whether this will happen and, if so, what the result will be. In this respect, the Non-Trivial Machine is a variant on the Black Box (see Glanville 1982) and follows Wittgenstein's (1961) insistence that because something has always happened does not mean it always will: historic constancy is not causal connection. See below:



*A Non-Trivial Machine: note internal secondary machine and feedback loop.*

It is the unpredictability of the Non-Trivial Machine that is significant to von Foerster, and that makes it non-trivial. What he values is precisely the unpredictability, which can be seen as an amplification of variety (whereas the Trivial Machine destroys variety). Why?

Because this unpredictability means we can anticipate that we will face surprise: all will not be as we had thought it would be. In other words, we have a model for a world in which what we observe may change in ways we cannot imagine. And that means we are never truly in control, that we can and must keep learning (remember Pask's definition of the human as a machine that needs to learn)—maintaining our involvement (and interest). The world of the Non-Trivial Machine, as if by magic, creates surprises and cannot be tamed by us, bringing us wonder at its output.

## Conclusions

The Eigen Form generates constancy (pattern) out of disorder and allows us to create objects in our experience.

The Non-Trivial Machine breaks these patterns, allowing us to discover the new, anew: it disorganises our ordering. And it is difficult to imagine something more certain to generate a sense of wonder than surprise at the new.

And Maxwell's Demon allows us to find and maintain boundaries in the continuum.

And here we have it. Wonder. We can think about and reflect on these three machines, which is to wonder about them.

All three concern, in some way, the making and maintaining of the new. The Non-Trivial Machine gives us a mechanism that will surprise us by its unpredictability and novelty. The Eigen Forms allow us to form the new within the unformed and then to maintain what we make. And Maxwell's Demon gives us permission to maintain difference, without which the new cannot be other than the old.

But we can also consider our response to how we respond to the behaviours of these three machines: and that is with awe and surprise and astonishment. We can be amazed at the sort of wondering that gives us these machines and at how they appear to us; but, even more, we can look at what they do and our responses to this, I will speak only for myself, but in the conviction that what I say will resonate with others: my experience is to be awed and astounded—and that I call wonder.

And I can wonder at this wonder: both in questioning it and in being, once again, amazed at my amazement; my wonder at wondering. This is my wonder of wonders.

It is this sense of wonder that von Foerster most wanted to create and share, to bring forward in our attention as the essential human quality. In his dictum "only we can decide the undecidable," this is what he is saying. To be human is to be able to decide. In that ability lies wonder. To be human, then, is to share in the experience of wonder. At our wondering, at what is wonderful, at being lost in the awe and amazement that is wonder.

I know this because he and I shared this wonder shortly before he died.

And that brings us back full circle.

## References

[References with a bracketed message at the end in square brackets indicates the paper is reprinted in Foerster, H von (2003) *Understanding Understanding*, New York, Springer, a collection of papers made and introduced by von Foerster before his death.]

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## Appendix

I have highlighted, below, the meanings of wonder I refer to in this paper, as seen through *Merriam Webster's Collegiate Dictionary* (cited on the Encyclopaedia Britannica web site: [www.eb.com](http://www.eb.com), accessed 15 September 2004.):

Main Entry: **<sup>1</sup>won·der**

Pronunciation: 'w&n-d&r

Function: *noun*

Etymology: Middle English, from Old English *wundor*; akin to Old High German *wuntar* wonder

Date: before 12th century

**1 a** : a cause of astonishment or admiration : **MARVEL** <it's a *wonder* you weren't killed> **b** : **MIRACLE**

**2** : **the quality of exciting amazed admiration**

**3 a** : **rapt attention or astonishment at something awesomely mysterious or new to one's experience** **b** : a feeling of doubt or uncertainty