Foreword

My father was a quantum physicist, not an art historian. What in Dürer's engraving so captivated him? He contextualized his own work within a long history of scientific thinking, within a long legacy of thinkers changing the meaning of knowledge. This historical view meant that, where Newtonian physics was the way to understand God's rules for the world, modern quantum physics challenged the very existence of such rules and therefore the very nature of knowledge. Following Francis Bacon's understanding that scientific thought often reveres false 'idols,' my father worked to identify and then smash the idols of physics. In an unfinished manuscript, he explains quantum theory as 'the theory of what it means to know.' He writes,

> In quantum physics we no longer imagine that it is possible to describe any physical process completely and precisely, as (say) Descartes imagined. Instead we describe the most detailed possible input and output actions of experimenters and give the probability that a given input will be followed by a given output. This input-output philosophy makes quantum theory more like a cook-book or a computer-programming manual than a traditional book on celestial mechanics.

Even before the hidden faces in Melencolia§I began to emerge, my father was pulled into the engraving as an exploration of what it means to know. One never sees the back of the Dürer solid. 'The Octahedron is a puzzle that is intentionally unsolvable,' he writes. '[Dürer's octahedron] declares that the Intellectual World has a mathematical design, but that this design is inaccessible to us.' In his youth my father would have agreed, that it is not accessible to us *yet*. But what he learned from quantum physics was that we don't look through the language to find its meaning, through the picture plane to find the solid, or through numbers to find the physical truth.

For a time, whenever I saw my father he would announce a new face in *Melencolia§I* and ask me if I could see it or not. Was it really there? His rubric was that if he couldn't find three justifications or explanations for a potential face to exist, it didn't. Without such a rule, once you start hunting for hidden faces, you start finding them all over the place. Dürer's engravings in particular: there is something about how they are drawn, maybe an excess of detail or texture, that makes you feel certain that if you look at them correctly the face will emerge. Occasionally it does, but often it doesn't. It's just that there's a face-ness to Dürer's naturalistic style. My father and I wondered about this quality, and it occurs to me now that it is in the spirit of the Dürer solid. A hidden face is a ripple on the surface of the picture plane. One cannot see both the Dürer solid and Dürer's mother at the same time. Likewise, the emerging face disrupts one's visual world and replaces it with another, drawing attention to the engraving as an object.

doi:10.1088/978-1-6817-4090-4ch1a

While Dürer found melancholy in his solid, this 'subtler, more self-conscious epistemology' of quantum theory was my father's joy. The quantum epistemology, in his own words:

> This is the kind of section I would skip when I was starting out in physics. I wanted hard mathematical facts, not philosophical chit-chat. 'Number is the language of science,' Pythagoras tells us across the centuries. Number, not words. Is that not a thrilling idea? Mathematics, an almost secret language that Man has created in just the last few thousand years, completely captures all of nature! Are we not like gods?
>
> Pay attention to that feeling. It is hubris, the arrogance that precedes disaster. For some it blocked the understanding of relativity, and now it blocks the understanding of quantum theory for many.
>
> Mathematics is not the language of science.
>
> Eavesdrop in a science laboratory. Are they speaking in mathematics? Are there mathematical terms for funding salaries and equipment, blowing glass, purifying silicon, swinging pendulums, publishing? Physics is a social science, as [Victor] Weisskopf used to say. Mathematics refers only to mathematical experience, a small part of physical experience, though an indispensable part.
>
> Quanta are so different from symbols, including mathematical ones, that no exact map of one into the other is possible. The key difference is that our observations of mathematical objects are usually complete while our observations of physical ones are never. Predicates about a mathematical system are assumed to commute, while physical observations are observed not to commute. Non-commutativity describes how observation changes the observed system, and this kind of change is ignored in the works of fiction that make up mathematics: 'In a far-away land lives an intelligence that can add 1 to 0 any number of times without end.' The quantum non-commutativity is experimental; the Boolean commutativity is axiomatic.
>
> That quanta have no exact descriptions does not mean that quanta do not exist. We live our daily lives with no exact descriptions of anything.
>
> Theoretical physicists left normal thought behind in the heyday of classical mechanics. Some natural philosophers thought that they made complete mathematical models of nature, or at least could do so in principle. In quantum theory, physicists return to the human predicament.
>
> Another example of such a radical change in physical thought is the special theory of relativity. This relativized our concept of 'the present.' Quantum theory does much the same for our concept of 'the state of the system.' Quantum theory is the most successful physical theory in history. Nevertheless, much confusion envelops it. Many who practice it most productively claim that no one understands it, certainly not themselves.
>
> Much of this confusion arises from deep, ancient, and usually tacit magical beliefs about how one knows anything about natural objects, ideas that conflict with how we actually learn about Nature.

The process by which we see the world around us is invisible to our ordinary senses, as though it were magical. One old idea is that we just know, as by direct contact between knowing spirit and known object, or as one knows the Logos according to Parmenides. The great natural philosopher and mathematician Leibniz proposed that God preordained this puzzling harmony between the world and our mental images of the world.

Also old, however, is the alternative notion that we see an apple when small particles of light fly from it to our eyes. We did not see them in flight or perceive the intricate neural processes that they trigger when they reach our eyes. We experience only the results. Nevertheless, perception is not magic but a chain of subtle causes and effects, in which the apple, light, and our mental image of the apple are all equally physical.[1]

Aria Ritz Finkelstein

[1] Finkelstein D 2013 *The Idea of the Quantum* unpublished manuscript.

Editor's note

The following manuscript is one that David Ritz Finkelstein began working on in the early 2000's. It went through several drafts, an early one of which was published in 2004 as an article in *The Saint Ann's Review*. The spirit of the work and its conclusions have changed little, but its order and several of its specific insights have evolved. Some of the earlier iterations flow more smoothly, but this manuscript reflects Finkelstein's latest thinking. Accordingly, it displays some of the jagged seams of its construction, as befits an ongoing and thus imperfect conversation.