



From Max Ernst to Ernst Mach: epistemology in art and science  
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## Introduction

'Epistemology' is about how we know things, and its study is part of what philosophers do. However, it has been suggested by Ken Wilber, polymath writer on science and religion, that philosophers suffer from not having a 'practice' to underpin their speculations. He says this in respect to the German Idealist philosophers in particular, that they lacked a 'yoga' or spiritual practice to give weight to their ideas <sup>1</sup>. In contrast both Max Ernst and Ernst Mach had practices, one in art and the other in physics, which formed the background to their speculations. Neither were philosophers as such, but had philosophical leanings, which make them useful starting points for questions on the contrasted epistemologies of art and science.

We are in a time where epistemological questions about art have resurfaced, perhaps due only to the rather mundane circumstance of a changed attitude to arts funding in the UK – it now hinges on art practice as 'research'. This presents both an opportunity and a danger – an opportunity to reframe art practice as an enquiry (or at least to make more explicit the questioning nature of art), and a danger of falling into a pseudo-scientific mode of investigation. In this context Ken Wilber again provides us with a useful terminology, that of 'epistemological pluralism,' to indicate that different domains of human activity or enquiry have different methods and different knowledges <sup>2</sup>. How then does the domain of art differ from the domain of science in its epistemology? We shall attempt to answer this by a close look at the practice of art, using the example of Max Ernst, and the practice of physics, using the example of Ernst Mach.

The choice of these two men to represent art and physics respectively grew initially out of wordplay, but an investigation of their lives, works, and legacies shows this to be a fortunate juxtaposition. Ernst Mach (1838-1916) was a Positivist physicist from Austria, whose work led to the Logical Positivists and their highly influential position in 20th century thinking. Max Ernst (1891-1976) was an artist and founder member of the Dadaists, who attended more philosophy lectures than art. Although Max Ernst is some 53 years Mach's junior, he is contemporary with the Vienna Circle of philosophers who built on the writings

of Ernst Mach. Max Ernst, working in Paris in the mid-1920s, bases his explorations on the unconscious and the irrational; the Logical Positivists, working in Vienna at the same time, base their philosophy on the rational and scientific. Ernst and Mach then certainly represent the juxtaposition of practices and philosophies that will guide our investigation, but we also find odd resonances between them. On the surface Ernst has a 20th century outlook, Mach a 19th century one; Ernst an artistic practice, Mach a scientific one; while Ernst is an antinomian maverick, Mach is a University professor. Yet behind these stark contrasts we find similarities that are useful to our discussion: both are profound thinkers about their practice, both have a questioning integrity, and we find that behind Mach's image of 19th century Viennese University professor there is also something of a rebel.

Returning to the idea of epistemological pluralism, we have in the two men exemplars of different fields of knowledge or 'epistemes.' But Wilber, rather disappointingly, does not develop the idea far enough, merely saying that scientists wouldn't accept the idea (and, as we shall see, the Logical Positivists certainly wouldn't). It has taken another polymath scientist, Stephen Jay Gould, to argue the case, though he uses a different terminology: 'non-overlapping magisteria' or NOMA for short <sup>3</sup>. Again he is arguing in the context of the science-religion divide, but this time makes a detailed and convincing case for the separation. Gould, as a scientist, is alarmed at the recent 'God-and-physics' debate, which has seen a succession of physicists arguing that physics proves mysticism or even the existence of God, and fears that it will discredit science. I have recently published a paper with the title 'Against Scientific Magisterial Imperialism' that makes a case, as Gould does, for the separation of epistemologies, but this time defending religion against the predation of science <sup>4</sup>.

The science-art debate is quite different from the science-religion debate however, partly because art does not seem to deal in the certainties apparently peddled by the other two. Hence we don't see science engaging with the kind of magisterial imperialism with art that it recently has with religion. However, the vague 'scientism' mentioned earlier, which is in no doubt partly due to the influence of the Logical Positivists, does threaten the debate on the epistemology of art with assumptions and methods unsuited to art practice. We shall see however that this is more to do with the philosophers of science than with the practice of science.

By contrasting the practice of art and the practice of science (before the philosophers get their hands on either), we can explore at least the context in which art as an episteme arises, and how it differs from science. One last word on religion however, as the science-religion divide serves as a contrasting case study to the science-art divide. If we can drop for the moment the externals of religion, and also the modernist and postmodernist hostility to its supposed truth-claims, then we can recognise that at its heart is a practice again, either of prayer or of meditation. I am going to suggest, and not in the least defend it here, that the pure practice of science and the pure practice of religion, when carried out with integrity and an open questioning, both lead to certain universals. However the knowledges thus attained, and we can use Einstein and the Buddha respectively as exemplars of these knowledges, are remote and seemingly inhuman. The pioneering psychoanalyst C.G.Jung famously called the Buddhist concept of nirvana an 'amputation' <sup>5</sup>. The general theorem of relativity, with its concept of curved space-time, is likewise divorced from our experience. But art, I would like to suggest, lives between the two extremes of science and transcendent religion, as a region of all that is human, compromised, dirty, warm and infuriating – a hall of mirrors. Its epistemology is therefore of direct relevance to us, but at the same time harder to pin down, harder to identify and

locate. Another way to say this is that physics is about the ultimately objective, nirvana is about the ultimately subjective, and art occupies the middle ground.

Leonardo da Vinci is often cited as the paradigmatic Renaissance man, because of his contributions to art and science. However I would suggest that art and science had not yet properly bifurcated at that point, and that Leonardo's practice is more homogeneous than we might recognise. I would place the proper date for the emergence of science as 1676, in agreement with Michael White, author of a critical biography of Newton 6. By the mid-1920s, Max Ernst and the Logical Positivists represent the complete sundering of the two mind-sets. However, culture is not uniform, and we find in the Russian Constructivists of the same period, and in the work of Naum Gabo in particular, an art that has its roots in science. In the period 1956 to 1986 we see the emergence of a group of artists, known as the 'algorists' working with the computer, and in some ways revisiting Constructivist principles. Later on we shall be exploring the idea that we can trace a bifurcation of art and science from the time of Leonardo, and a union again in the 'algorist' computer artists. In-between we find a clash of opposing epistemologies in the art of Ernst and the physics of Mach.

Before looking in a bit more detail at the lives and works of Ernst and Mach, a short discussion on science is in order. The term 'science' is a broad one, as is obvious from the many arguments put forward that Islamic and Chinese culture had 'science' long before the West. To focus the discussion here, I want to talk about physics instead, physics as a discipline that emerged in the West (I gave a date above of 1676 for its true birth), and transformed firstly the West, and inevitably the whole world. Physics is a focussed study of inanimate matter based on measurements of mass, length and time. It is glitteringly successful, both in its analytical and predictive power, and in the technologies it spawns, technologies that are incestuously and recursively used to refine its ability to measure. From the epicentre of physics all the other modern sciences radiate out, with diminishing claim to certainty, and, I would suggest, a proportional increase in relevance to human experience. Physics is inhuman and irrelevant to our subjectivity, to our lived realities, but its certainties are deeply attractive, an attraction that can be measured by the attempts to discredit those certainties. 'Physics envy' is the term that has been coined to describe how other disciplines have vainly attempted to ape its methods and successes, and is at the heart of the 'scientism' we have mentioned earlier. In fact I would suggest that the entire Enlightenment project can be understood in this way, as the shocked recognition (in the context of the Inquisition remember), that one can have a personal rivalry but none the less reach agreement on something, simply through the laboratory context. This realisation was a diffuse and slow one throughout Europe in the 17th and 18th centuries, leading to such oddities for example as Leibniz's conviction that political agreement could be reached by the same methods.

The reason for raising 'physics envy' is to point out that other epistemologies live in the shadow of physics, glancing at it in envy, feeling somehow 'other'. Our job is to change that, partly through a better understanding of physics itself (subject to so much mythologising), and through the more difficult task of identifying the epistemology of art.

### Ernst Mach and the Logical Positivists

We start with a look at the life and physics of Ernst Mach. Although he denied that he should be remembered as a philosopher, he is often referred to as 'Positivist Philosopher and Physicist'. In fact he was a deeply thoughtful man, and wrote extensively on the theoretical underpinnings of physics, a body of theory that can genuinely be called

'Positivist'. As we have indicated earlier, Mach was less conventional than his career would suggest, and as a child he was certainly unusual. At the age of three he was plagued with perceptual problems that led to his later interest in the physiology of perception, and was a weakly child. At the age of fifteen he read Kant's *Prolegomena to Any Future Metaphysics*, and in his twenties spent some time alone in a rented, ruined monastery, alone that is except for his horse which he quartered in an adjacent room. During his period of study at Vienna University he developed a popular reputation 'based largely on his peculiar manner of living and fearsome manly habits' 7, known also as a superior boxer and the best fencer in Vienna (so completing his transformation from delicate and educationally backward child).

Mach secured lecturing posts in Graz and Prague (where he carried out the bulk of the research that was to make his name), returning in 1895 to Vienna to a chair created specially for him, making him Professor of 'The History and Theory of the Inductive Sciences'. He was a gifted experimental physicist, contributing to the fields of ballistics and the physiology of perception, bequeathing his name to both disciplines. In ballistics the 'mach' number, which is a multiple of the speed of sound, is named after him, and in perceptual studies the 'mach' band, the striping effect in graduated tones, is also named after him. More important for our discussion perhaps is the 'Mach principle' in the philosophy of science, which we shall return to.

Mach studied Kant, Hume and Darwin, and 'thus learned to approach his beloved physics with a wary and sceptical eye.' 8. This gives us an insight into Mach's approach to physics, an approach that is complex and requires an understanding of both physics and the philosophy of science to appreciate. There is not space here to expand on this theme, other than to point out that the relationship between these two is problematic. The development of physics seems to require no support from philosophy at all, yet its best practitioners held all kinds of philosophies, all at odds with each other, and often, for periods at least, at odds with the very physics that the practitioners were discovering. Max Planck for example held certain views about thermodynamics which were philosophically at odds with Ernst Mach's published philosophy of science (and made known in a public attack on Mach). Yet Planck's experimental work, which gave him title of the 'father of quantum theory,' was in contradiction with Planck's philosophy and in agreement with Mach.

So what were Mach's philosophical ideas? In short, they were Positivist. 'Positivism' itself was a philosophy originated by Auguste Comte, also the founder of the discipline of sociology. Comte (1798-1857) believed that all sciences went through three phases, first theological, second metaphysical, and third 'positive', hence the name of his movement. Positivism denies metaphysics and states that the data of sense experience are the only object and the supreme criterion of human knowledge. Oddly, to our modern sensibilities, Positivism was also understood as a religion, and there exists to this day in Rio de Janeiro a 'temple of humanity' built for its sacraments and ceremonies. Of the latter Mach would have had no interest in, as he was generally anti-religious, recognising only late in life that perhaps his outlook had some common ground with Buddhism 9. It was the emphasis on sense-data that was at the heart of Mach's philosophy, and his great contribution was to recognise that the data of physics not only had their origin in the senses (regardless of the laboratory instrumentation and the types of 'reading' it produced), but that all the measurements were relative ones. This was the basis of his criticism of Newton's conception of absolute mass, space and time, and became known as 'Mach's principle', alluded to earlier. Einstein acknowledged Mach's importance on the development of relativity, even though not a direct contribution, furthermore Einstein characterised Mach's

writings as 'kind, humane and helpful'. Mach met both Einstein and the American pragmatist William James, whose account of their meeting paints Mach in an equally favourable light, both as a thinker and as a man. Mach's writings on science had in fact a wide impact, so much so that Lenin was forced in 1908 to insist that the Bolsheviks must choose between Mach or Marx.

But why should Lenin find Mach a threat? Surely the advance of the purest of sciences, physics, could only benefit the Revolution? The threat it poses relates to the spectre of solipsism that haunts the positivist world-view, and which on the surface of it should be implacably opposed to the objectivism of science. Once one accepts, as Mach does, the basic Positivist position about the primacy of sense data, then the next question arises, are the sense data in the mind or in the world? This is a brief way of raising the idealist / realist debate in philosophy, one that goes back to Plato and Aristotle, and which we cannot enter in any great detail here. It is to Mach's credit however that he keeps such an open mind about this issue, simply taking the data of sense experience and following it wherever it takes his curious but rigorous mind. This goes right back to his childhood where he suffered from the perceptual difficulties mentioned above, mainly visual. He apparently 'saw' the front and rear edges of a table, for example, as the same size, and complained about perspective paintings that foreshortened the geometries of such objects. Even later in life he objected to perspective art as a foolery. This might be a quirk of Mach's personality, but his method is based on observation, and he thought it essential to give weight to all his perceptions. This implies both a discipline and a freedom to 'take what one gets', an approach that Einstein pushed harder than any other theoretical physicist. (Einstein's genius was to say that as we cannot distinguish the acceleration due to gravity and due to inertial changes, let us 'take what we get' and say that they are the same in physics – a revolution in science that reverberates to this day.) But if we give credit to our senses as an individual, how can an outside ideology be imposed? If we trust in 'what we get' from our senses instead of what is imposed by authority, how can we be manipulated? Lenin was right to fear Mach. And we are right to pay him attention, because Mach's insistence on observation is also Leonardo's, and also, as we will see, Max Ernst's.

A careful reading of Mach's work is an education in physics and the philosophy of science. Although his physics is simply absorbed into the greater impersonal structure of the subject, an episteme of ultimate remoteness, his personal encounter with the obduracy of the manifest sensorium that was his life is engaging. He often reflects on the 'ego' as his pre-Freudian terminology had it (Freud's work only enters European thought in the 1920s, after Mach's death), finding it of 'only relative permanency' or 'as little absolutely permanent as the bodies' 10. He dismisses the Kantian 'thing-in-itself' as unnecessary, saying that 'the world consists only of our sensations', 'we have knowledge only of our sensations', and that the 'antithesis between ego and the world, between sensation (appearance) and thing, then vanish'. None of this is physics, but all of it has to do with the epistemological conditions in which the 'knowledges' we term physics appear. And none of it would appeal to Lenin.

This can only give a flavour of the intellectual legacy of Mach, a legacy turned into a philosophical movement by the Vienna Circle in the 1920s. Their ideas are distinguished from Mach's by the term 'logical' positivism, though some prefer 'logical empiricism' or other variants. The Vienna Circle was founded by physicist Moritz Schlick around the time he took up Mach's chair at the University. In fact this appointment had a curious and tragic history: Mach was the first occupant but lived through the suicide of his second son Heinrich, just seven days after Heinrich's 20th birthday and his graduation in chemistry. Mach himself suffered a stroke that paralysed half his body, and was forced to resign the

chair, making it available to his intellectual rival, a physicist called Ludwig Boltzman. Boltzman had a distinguished career, though showing an intemperate side to his nature in a public lecture with the title 'Proof that Schopenhauer was a Degenerate, Unthinking, Unknowing, Nonsense Scribbling Philosopher, Whose Understanding Consisted Solely of Empty Verbal Trash' 11. He also changed the title of Mach's chair to suit his own philosophy of science. After his sight failed in 1906 Boltzman hanged himself, freeing the chair for its later occupation by Schlick, who restored the title that had been created for Mach. Schlick himself was murdered in 1936 by a Nazi student sympathiser, though not before the Vienna Circle had made an impact on the world of ideas. Middle-Europe through this period had its dark side, one we also know through Freud's analysis of Viennese society.

Schlick's circle included two other principle members, Otto Neurath and Rudolf Carnap, along with a host of lesser-known figures, and one more prominent one, the mathematician Kurt Gödel. Their major initial influence was Mach, but Wittgenstein, through his *Tractatus*, also came to dominate their thinking, to the extent that by 1926 'the circle was reading the book aloud sentence by sentence and analysing it in detail' 12. Wittgenstein himself never joined the circle, met only selected members on certain occasions, and refused to enter into any debate on his philosophy. Later on Wittgenstein became increasingly dissatisfied with the *Tractatus* and the Vienna Circle's interpretation of it; in turn they drew closer to Mach's ideas again. In fact the more mystical elements of the *Tractatus* had worried many in the Circle, though it may well be that these explain the wide popularity of the text in the first place.

Let us return to the central propositions of the Vienna Circle, those that appeared in their manifesto and were agreed to by the principle founders. Like Mach they were unanimous in their rejection of metaphysics, and in a more technical sense philosophically they also rejected one of Kant's propositions, that there could be a synthetic a priori knowledge. Their third important idea is known as the 'verifiability principle', that a statement is meaningful if and only if it can be proved true or false, at least in principle, by experience. The 'verifiability principle' and the rejection of metaphysics may be clear enough, but the point about synthetic a priori knowledge requires explanation. Kant (1724-1804) had invented this category of knowledge as part of a larger scheme, which in turn was based on a rejection of ideas put forward by David Hume (1711-1776). In examining the Enlightenment philosophers of this period, we can use a rough guide to their ideas which goes as follows: Descartes, Spinoza and Leibniz are 'rationalist' philosophers, while Locke, Berkeley and Hume are 'empiricist' philosophers. Kant attempted to achieve a synthesis of these opposing views. Or so the story goes. The reality is much more complex, and I will tease out only one small strand, that is how they responded to the emerging discipline of physics.

I mentioned earlier, that science was born in 1676, on the 27th April at the Royal Society. The event in question was Robert Hooke's demonstration of Newton's 'Theory of Light and Colours,' and it cemented in place a revolution in thought that underpinned the Enlightenment, gave rise to the philosophies we are discussing, and ushered in the modern age. We may find it hard to accept, but the context for Hooke's demonstration was an age of intellectual repression, with the Inquisition a part of daily life throughout Europe; and in England, though relatively tolerant, there existed fanaticism and suspicion of heterodoxy in all forms. In this atmosphere we find that Hooke is actually Newton's arch-rival, and that a bitter feud and jealousy existed between them, that in any other sphere of thought at that time could have led to physical violence. That Hooke could verify the theorems of a detested rival through laboratory demonstration, in such a way as to

convince a group of sceptical and quarrelling thinkers of the day, was a completely new phenomenon. The scientific method as we now know it depends on such verification, but at the time the European mind had experienced consensus more usually at the point of a sword. In our present day context it would be like the Pope carefully reading the Islamic theories of Mullah Omar, one-time spiritual leader of the Taliban in Afghanistan, and announcing to the world that point by point they were all correct.

This one experiment on its own changed nothing, but the thinkers of Europe were waking up to the new possibility for consensus with relief and hope, Leibniz for example, as mentioned before, believing that it could be a model for other spheres, such as politics. The problem was that such thinkers, in fact almost all the Enlightenment philosophers, failed to grasp how physics worked, and at the heart of that failure was the absence of a practice. Descartes for example created a mechanics that was wholly wrong, because he took no trouble to verify it in a laboratory, and even the eminent physicist Huygens was slow to understand that his disagreement with Newton on the theory of colours could only be resolved by experiment. Spinoza engaged with physics more directly, as builder of microscopes and telescopes, and we even know of an amusing incident where he attempted to reproduce an experiment by Robert Boyle, which required a high-quality oil to provide a seal. The wealthy Boyle used olive oil, whereas the impoverished Spinoza could only afford butter and milk, with the result that the experiment failed<sup>13</sup>. Hume and Kant however never set foot in a laboratory, and so never engaged with physics as a practice.

Hume's highly influential criticism of science was therefore without foundation, but fell on willing ears. He attacked the method of science for using induction to derive knowledge, saying that just because we observe a result from a given condition many times, there is no logical derivation that can prove the result will take place in the future. There is no absolute certainty about a method that uses induction. But Hume had misunderstood the working methods of physics, which do not in fact rely on induction. Yes, if Hooke had merely shown the Royal Society that he could reproduce the laboratory findings of Newton, then it would not mean a great deal, but behind the data was a theorem, expressible in a mathematical form. In fact five elements make up the method in physics, which are as follows:

- 1) a technology for measuring data
- 2) the data itself
- 3) a hypothesis or theorem guiding the experiment
- 4) a mathematical model expressed in algebra, the differential calculus, etc
- 5) consensus: verification by the community

There is not space here to expand too much on these components, other than to say they are not in a particular order, except perhaps that verification, like the one carried out by Hooke, would come last. Each component needs careful consideration and development, and it was pure chance that all five fell into place that fateful day in seventeenth century London. To try and characterise the complex activity summed up by these five components in a single term 'induction' is quite misleading however, though Hume set in train a philosophical journey that takes us through the Vienna Circle and beyond to Popper and Khun. The history of the philosophy of science is an odd one, reminiscent of those biographies where one gradually realises that the author is ambivalent about the subject,

or even hostile. Karl Popper was close to the Vienna Circle, though not part of it, and wrote an influential book on the philosophy of science called 'the Logic of Scientific Discovery'. It rejects the 'verifiability principle' in favour of 'falsifiability' and in the introduction says of science: 'The philosopher --- does not face an organised structure, but rather something resembling a heap of ruins' 14. Popper is however the first to question Hume's assumption that induction is the basis of science, though A.J.Ayer, an English disciple of the Vienna Circle, ridicules Popper on this. In turn Khun rejects Popper's emphasis and describes science in terms of 'paradigm shifts'.

What then are we to make of the philosophy of science? Is it just a causal, though sometimes circular, chain of disagreement, with no hope of giving us a real epistemology of science? Probably. And we have identified a possible reason for this state of affairs: – that the philosophers of science did not have a practice. What they do have is a curious blend of interest in the subject and hostility towards it, what we identified earlier as 'physics envy'. The hunger of the Enlightenment period for consensus made the glittering success of physics very attractive, but at the same time the investment required to participate (not just olive oil) and the remoteness of its episteme, create ambivalence. Nevertheless the work of the Enlightenment philosophers and groups like the Vienna Circle have ensured that a kind of 'scientism' pervades the intellectual climate of today, and which will impact on the epistemology of art if not resisted. It is almost the definition of a philosopher that they would not accept 'epistemological pluralism', because they see their job as the unification of knowledge, and certainly the Vienna Circle attempted this. But if we return to Ernst Mach, we find a physicist with a strong laboratory record, whose philosophy is much less strident than we might expect, a philosophy that represents a thoughtful approach to sense experience. By denying that he was a philosopher, he made it clear that his writings were about physics, but, because of their originality and clarity, they became part of a movement that insisted on seeing all human experience through a narrow scientific worldview.

We can conclude this section by saying that physics is an episteme in its own right, and that to understand the kind of knowledges that it deals with requires a direct engagement with it. The attempt by philosophers to make a logical reconstruction of it does not help us understand its epistemology at all. At its heart there is a practice which is not generalisable, though as a practice, we can fruitfully compare it to the practice of art, as we shall see next. We are in a position to say something about what a 'practice' is, perhaps we can say that it is an engagement with an obdurate and bounded domain of human experience. Mach demonstrates this well, with another quality, that of humility before the given. He certainly does not regard the domain of physics as a 'heap of ruins'.

## Max Ernst and Freud

Turning to Max Ernst now, we have already noted that on the surface of it he represents the antithesis of Ernst Mach, if only in the gulf of practice and years. Max Ernst was born in 1891, some 53 years Mach's junior, and exposed to two cataclysms in Western experience that Mach was almost untouched by: the theories of Freud and the horrors of World War One. Mach's later life and legacy was centred around Vienna, while Ernst's artistic development took place in Paris. But Ernst was born in Germany, mid-way between Cologne and Bonn. His father was a teacher in a school for deaf-and-dumb children, and part-time painter of landscapes or religious works. The young Max found his authoritarianism hard to bear and recounts several formative events in his childhood relating to his father, including an episode where his father began to paint from nature in their garden. A tree did not fit the composition he had in mind, so rather than just leave it



out of the painting he took an axe to it, leaving the child with some interesting conclusions, that conventional painting was firstly mimetic, and secondly dishonest. Much later Ernst says of this episode:

‘To my mind that was a real crime against the imagination, a crime committed in the name of the authoritarian principles of an art that is false because it is limited by the blinkers always at the disposal of those specialists we honour with the title of academicians, in order to maintain the established order and a proper seemliness in their domain. My revolt took the form of a deep faith in the powers of sedition, of instinct, of inspiration, and even of an anarchic yet creative disorder which every established society tries to restrain, repress or ignore.’ 15

Ernst’s revolt against his father took a deeper turn after the First World War. Young Max had an imaginative childhood by any standards, including the strange conflation in his mind between the death of his pet parrot and the birth of his sister Apollonia, and the later studies at Bonn university where he ‘carefully avoided any kind of studies that ran the risk of degenerating into gainful employment’ 16. He was also deeply influenced by a visit to a mental hospital near Bonn where he saw the sculptures and paintings produced by the inmates. He then met August Macke, and through him the works of ‘Der blaue Reiter’ and other radicals who were followers of Hegel, Husserl or Nietzsche, and for whom ‘spontaneity was the order of the day’ 17, and finally Jean Arp. It was Arp who broke the news to Ernst that war was looming, and what was for Ernst a dead or missing period of his life, four years of blood and mud, in which he mused over the deaths of Appolinaire and Macke, idealist fighters on opposing sides of what Ernst saw as utter futility.

Paul Eluard, who was to become Ernst’s friend and artistic collaborator in Paris after the war, wrote in 1936:

In February 1916 the Surrealist painter Max Ernst and I were in our respective front lines, barely a kilometre from each other. Corporal Ernst, of the German artillery, was shelling the trenches in which Private Eluard, of the French infantry was mounting guard. Three years later we were the best of friends in the world, and since then we have fought together stubbornly for the same cause: the total emancipation of mankind 18.

Ernst returned from the war and showed in the ‘Dada House’ in Cologne, a shock to his father, both artistically and politically. After absorbing the assault on traditional values mounted by the works in the exhibition, his father’s pride in his son as patriot and soldier turned to disgust, saying that Max had brought dishonour on the family name 19. Max Ernst was however to encapsulate for a whole generation the revolt against authority that would be pursued as art, as a response to the carnage of the war, and as an embodiment of Freud’s new theories. Ernst had read Freud’s *Wit and its Relation to the Unconscious* and *The Interpretation of Dreams* while studying in Bonn. It has been suggested that while Ernst’s two major artistic styles, Dada and Surrealism, can be traced in their influences to these two works of Freud respectively, it is a mistake to subject Ernst’s work to a Freudian analysis 20. Elizabeth Legge in her examination of the ‘psychoanalytic sources’ for Ernst says "The extent of the relationship of Ernst’s paintings to Freud, ---, is difficult to define, and depends on arguments based on internal resemblances." 21. Elsewhere she adds: "As a Surrealist, Ernst would disallow the therapeutic aim of psychoanalysis, attaching little value to enabling a neurotic to function in a more socially normal way" 22. Legge also points out that Ernst had by no means accepted the psychological ‘project’ as a whole, for example he was highly critical of the type of German experimental psychology practised by

Emil Kraepelin, seeing it as repressive of the creative unconscious. (Ernst used Kraepelin's illustrations in his collages to subvert and ridicule the 'scientific' work done in asylums of the period.)

The ambivalent attitude of the Surrealists to the new science of psychology is shown in a critical account that André Breton published in 1922 of his meeting with Freud. (Note that this was the same year that Schlick took up his chair in Vienna and which marked the beginnings of the influence of Logical Positivism.) By the time of the issue of the First Surrealist Manifesto in 1924 the tone was more approving. Ernst had by this time established himself in the household of Paul and Gala Eluard in Paris, having abandoned his first wife and child in Germany, where he developed his two great innovations in artistic technique: frottage and collage. His overall aim in art had already taken shape in his rejection of tradition and convention; his disgust with the war and his father's authoritarianism; his embracing of the creative power of the unconscious. All this manifested outwardly by his abandonment of wife and child to live in a ménage-à-trois with the Eluard's, at the same time beginning the most fruitful collaborations of his early artistic life.

That Freud's ideas were an influence on the Surrealists is beyond doubt, but we find in Ernst's own accounts that his art practice was shaped by many forces, some of which were quite consistent with the conventional history of art. In *Beyond Painting* he cites a passage from Leonardo da Vinci, apparently written as an admonishment to Botticelli, which recommends 'gazing fixedly at the spot on the wall, the coals in the grate, the clouds, the flowing stream,' where 'genius becomes aware of new inventions' 23. Ernst explains how he developed the 'lesson of Leonardo' in his frottage:

The procedure of frottage, resting thus upon nothing more than the intensification of the irritability of the mind's faculties by appropriate technical means, excluding all conscious mental guidance (of reason, taste, morals), reducing to the extreme part of that one whom we have called, up to now, the "author" of the work, this procedure is revealed by the following to be the real equivalent of that which is already known by the term automatic writing. It is as a spectator that the author assists, indifferent or passionate, at the birth of his work and watches the phases of its development 24.

The 'death of the author' that Ernst is describing here becomes an essential part of the art narrative in the 20th century (though Ernst's adherence to this idea does not mean a retreat into modesty and self-effacement – far from it). In this and in his oppositional stance Ernst is intimately part of contemporary art practice, even if, like in the philosophy of science, we have a causal, sometimes circular, chain of disagreement as art movements react against and contradict their antecedents, thus rendering Ernst's work merely a part of history. Yet Ernst shows universals in his thought and workshop practice from which we can extrapolate an understanding of the epistemology of art, as we can an epistemology of science from Mach.

Ernst is serious about art, as Mach is about science. His early works, prior to his move to Paris, demonstrate an energy and an eclecticism showing a great variety of influences, including August Macke, Van Gogh, and an anticipation of Futurism. Once he had established his own workshop practices of frottage and collage, joined the Surrealists, and settled into his own unique oeuvre, he worked his field as earnestly and with the same integrity as any physicist. He never succumbed to the anti-art philosophy of Duchamp, and undertook a training in the techniques of sculpture when he turned to that medium later in life. We even find an extraordinary anticipation of the digital art pioneers in an invention of

his combining drip painting with the Lissajou figure (a mathematically-generated form at the heart of much of early computer art.)

The art of Ernst may live in opposition to science, but his odd invention for painting Lissajou's figures, comprising a tin hanging from a string about four or five feet long, filled with paint that leaked from a hole in the bottom and set swinging, showed a fascination for the analysis of movement 25. This technique was used in paintings such as *The Bewildered Planet*, *Young Man Intrigued by the Flight of a Non-Euclidean Fly*, *Surrealism and Painting* in 1942, and *the Green Zone* in 1970, and may have been a precursor to Pollock's drip paintings. Ernst kept the algorithmic quality of these images in his paintings, unlike Pollock, a visual quality related to planetary orbits. On a similar theme he completed a series in 1964 devoted to the memory of Wilhelm Leberecht Tempel, and untrained astronomer whose genuine findings were rejected by the scientific establishment 26.

These examples are given just to hint at the breadth of Ernst's interests and lifelong ability to innovate, both in ideas and their realisation in his studio practice. We have earlier placed an emphasis on practice and initially defined it as an 'engagement with the obduracy of a bounded domain', in Ernst's case that of the visual arts, primarily painting and sculpture. 'Obduracy' is an important term here, in that it indicates both the obduracy of the art medium, whether paint on canvas, or sculpture in marble, and the obduracy of the medium as a method of communication. The simple rectangular canvas represents a small arena of the most ferocious kind of struggle, and even if the artist may roam freely as regards subject matter, the act of painting, of 'arting' takes place within a bounded epistemological domain.

### Digital Art Pioneers and Constructivism

We will complete this meditation on the epistemology of art, as exemplified so far by the single oeuvre of Ernst, with a brief mention of the digital art pioneers. They are included here simply to round off a process that is interesting to consider: a bifurcation of art and science since the time of Leonardo da Vinci, shown in the polar extremes of the life and work of Mach and Ernst, and a reunion in the relatively obscure artistic practice of the early digital artists. These artists, often painters, who took up the use of the computer during the period 1956 – 1986, can be thought of as following through a Constructivist 'impulse', one shown for example in the work of Naum Gabo. I have written elsewhere on this phenomenon 27, but for now it is just worth saying that the imagery is based on algorithms, that is a mathematical basis for a relatively compact software programme, and output via a plotter, which drives a pen or brush over paper. These pioneers of digital art include Herbert W. Franke and Manfred Mohr from Germany, and Roman Verostko and Jean-Pierre Hebert in the USA 28, also the 'father of computer animation' John Whitney Sr., whose artistic goal was a 'new abstract cinema' based on the synthesis of images and sound 29. He built extraordinary machines based on pendulums, reminiscent in principle at least of Ernst's swinging drip-bucket, and produced a series of seminal films alongside his commercial cinema digital effects (for example in 2001 *Space Odyssey*).

All these digital art pioneers had to learn to programme their computers, an activity that is logical, mathematical and rational, more in the tradition of Mach than Ernst. Yet the best of their works, which often find their way into reputable national and private collections, also contains the emotional, and the serendipitous. The digital art practice represented by these works includes both halves of what was one in Leonardo and seemingly sundered in our Mach / Ernst juxtaposition, a practice that is both an enquiry and an engagement.

## Epistemology

Having presented some observations regarding the practice of physics and of art, perhaps initially summed up as enquiry and engagement, we can investigate what an understanding of this juxtaposition can yield. First of all we note that while it might seem obvious to go to the philosophy of science to understand the epistemology of physics, we caution against it, as the philosophers are not engaged, at least not in the way we define it here. Likewise the temptation to say that art has moved on since Ernst, throwing up radically new ways of understanding its epistemology, should be resisted. Of course the philosophy of science and the history of art criticism cannot be ignored, but we prefer here to focus on practice. What does Ernst Mach do, that sheds light on the way we can understand Max Ernst, in epistemological terms? And what might a crude scientism, one that no doubts exists today as a legacy of Mach, through Logical Positivism, what might this impair in our investigation of the epistemology of art?

First of all, Mach has a tentative approach to science. Ideas and theories are provisional, always subordinate to sense-data, always located with respect to his sensorium, rather than to his preconceptions. This was the basis of his stand about observations of mass, length and time being relative rather than absolute, and which prepared the ground for the relativity theories of Einstein. Mach also promoted an economy of description, wanting theories to 'wither away like leaves' <sup>30</sup>. All this is natural to physics, in particular the brevity of its descriptions. What Mach also did was to show that a 'humility before the given' does raise questions of solipsism (these become ever more difficult to avoid in modern quantum theory and in relativity). In other words, despite the rigour of his enquiry and the desire to go beyond ego, Mach conceded that all his science took place in his own subjectivity.

Where Ernst differs from Mach is in his intentionality, and in how he relates to his sensorium. Where Mach narrows it down to measurable quantities, Ernst opens it up to include the emotional and further still: to embrace the products of the unconscious. Like Mach he wants 'to get out of the way', to allow his engagement with the obduracy of his discipline to unfold in its own telling. Above all Ernst is an artist, a painter, and his enquiry contains within it a remit to embody his findings in art.

What the populist, unthinking promotion of Logical Positivism has tended to achieve in the 20th century is to take Mach's methods and intentions, the sense-data and enquiry appropriate to physics, and to insist that these data and this method be applied to all areas of human experience.

## Conclusions

We have seen that there is common ground between an artist like Ernst and a physicist like Mach, a commonality of engagement, of integrity and of humility before the given. Mach's legacy, as a thoughtful writer on the method of physics, has been, via the Logical Positivists, to create a 'scientism' that has skewed epistemological understandings of non-scientific disciplines such as religion and art. However, by focussing on the practice of physics, and taking a sceptical stance to the theories of the philosophers who do not engage with the obduracy of such a practice, we can arrive at a better and less arrogant epistemology of science. In turn, by granting that the practice of the artist is an equally rigorous engagement, against the obduracy of a quite different domain, we can begin to investigate its own epistemological contours and boundaries. This approach, called 'epistemological pluralism' by Ken Wilber and 'non-overlapping magisteria' by Stephen Jay

Gould resists the trap of scientific magisterial imperialism that much 20th century thinking has fallen into.

If we say that physics is knowledge tested against sense-data (the verification principle of the Logical Positivists), while art is knowledge tested as sense-data (in the visual or other sensory works of its studio outcomes) then the following provisional definitions might serve to sum up the epistemological differences of the two domains:

Physics: a knowledge embodied in its statements and mathematical formulae, tested against sense-data, based on principles of economy, rationalism and objectivism.

Art: a knowledge embodied in its works, tested as sense-data, based on principles of profligacy, the irrational and the unconscious.

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