Music of Light & Colour

Professor Milton Mermikides

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Windows to the World

"Behold! human beings living in an underground den […] and they see only their own shadows, or the shadows of one another, which the fire throws on the opposite wall of the cave […] In every way, then, such prisoners would recognize as reality nothing but the shadows of those artificial objects."
Plato, Republic 514a–520a, Book VII

This lecture continues *The Music of Nature* series, which examines the meeting point between our internal musical experiences and the wider natural world. The first lecture in this series *The Music of Animals* considered how the animal kingdom engages with the making, perception and underlying patterns of music. Here we turn to something even more fundamental in the cosmos: light and colour, and the ways the visual domain (including visual art) overlaps with the sonic domain (including music). Vision and hearing are two of our many senses[1], yet each is remarkably narrow in scope, a tightly filtered channel rather than a full picture of reality. This view connected with Plato's ancient allegory, where prisoners trapped in a cave mistake the shadows on the wall for reality itself. Our senses are much the same: narrow windows onto the external world, each providing fragile reflections of the vivid world – the higher reality Platonic 'forms' – outside: "Nothing but the shadows of artificial objects". If Locke's belief that senses are the basis of knowledge, then we should question how perception contributes to experience allowing us to gain brief glimpses of the 'real world' outside our caves. And in particular how the royal pair of senses; sight and sound, relate to one another, interplay, and shape our experience of music.

Sight and sound are often treated as the royal senses, but they are also profoundly limited. Each offers a narrow, highly filtered view of reality, shaped by biology, habit, and culture. Plato's cave remains a powerful metaphor: we mistake shadows for the thing itself, not because we are foolish, but because our access to the world is constrained. Our senses are windows, not the landscape.

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[1] Rather than the Aristotelian – and commonly held – view of five senses (sound. sight, taste, touch and smell), modern neuroscience now recognises that we possess, depending on definition. anywhere between seven and over thirty distinct senses. Without the need to evoke the supernatural these include *thermoception* (sensing heat or cold), *nociception* (pain). *vestibulation* (balance), *proprioception* (position), *interoception* (internal state), the passage of time and so on.

Hidden Rapports

“This secret analogy between light and sound leads one to suspect that all things in nature have their hidden rapports, which perhaps some day will be discovered.”
Voltaire, Éléments de la philosophie de Newton (1738)

Voltaire suggested that there is a “secret analogy”, and “hidden rapports” between light and sound. Is this true? There are indeed some ways in which vision and hearing are related: Light and sound are both wave phenomena, yet their physical and perceptual realities could hardly be more different. However, sound travels as pressure through air, unfolding over time. Light moves as electromagnetic radiation, unimaginably fast, and overwhelmingly spatial in its effects. The ear gives us access to a vast range of frequencies with exquisite temporal resolution. The eye samples only a tiny sliver of the electromagnetic spectrum, roughly an octave of wavelengths, filtered through cones and rods into a fused percept we call colour. When we hear a musical sound, we can often unpack it: individual notes within a chord, instruments within a texture, harmonics within a single tone. Colour arrives already mixed. We perceive blue-grey or amber as whole experiences, without any intuitive awareness of their constituent wavelengths. By the time colour reaches consciousness, the blending has already happened. Evolution shaped these sensory systems for different tasks. Hearing excels at parsing events in time; vision at detecting edges, motion, and spatial relationships. They are mismatched apertures onto the same physical universe.

And yet, despite this mismatch, we persistently link them. We chose words not just because of their dictionary definition, but for how the sound of them conjures a vision. Writers will find the perfect word – *le mot juste* – which marries meaning with visual connotation. Lewis Carroll’s *Jabberwockian* invented words: *frumious, snickersnack, slithy* and *galumphing* perform this feat. We know what they mean visually without knowing their dictionary definitions. Some of these neologisms work so well – like *chortled* – that they have entered the lexicon *slithing* their way in by the back door.

A particularly vivid example of such sound symbolism is the *Bouba–Kiki* effect. With experiments originating over a century ago, this set of studies shows that we humans tend to agree with remarkable consistency what sounds are associated with abstract shapes. When subjects are shown a rounded shape and a jagged one, people overwhelmingly label the rounded form ‘bouba’ or ‘maluma’, and the jagged one ‘kiki’ or ‘takete’. Such intuitions hold with impressive robustness across ages and cultures, and appear independent of anchoring defining words.

Some suggest that when we choose, for example Bouba for the rounded shape, we are intuiting a link to the rounded mouth shape necessary to speak its name. And perhaps the jabbed spikes of Kiki read as sharp audio transients. Or more simply there’s a smooth or spiky general sense that appears in each of these domains. These are compelling explanations, however with an experience in sound synthesis I happened to notice how these shapes resembled the circular waveform presentations found in wavetable synthesis. That is when we wrap a sound wave into a circle, like a snake eating its tail, an appropriate thing to do with a looping sound. So, out of curiosity, I forged similar shapes as circular waveforms and played them through a synthesiser. The results are convincing. The rounded shape produces a smooth, gentle sound; the jagged one a bright, abrasive texture. Seeing becomes hearing. The effect suggests that, even without conscious awareness, our brains are sensitive to shared structural features across senses. There’s a natural correspondence between the look of these objects and their sonic identities they produce from simple to complex, familiar, beautiful to silly (see Fig.1). Here we are putting shape into sound, but the physical universe allows us to reverse the process: the field of cymatics (from the Ancient great for ‘wave’) draws visual shape from sound. Vibrations from bow strokes, played tones and music when imparted to freely moveable particles (e.g. sand on a vibrating plate) can produce stunning appropriate and somehow appropriate patterns from sound.

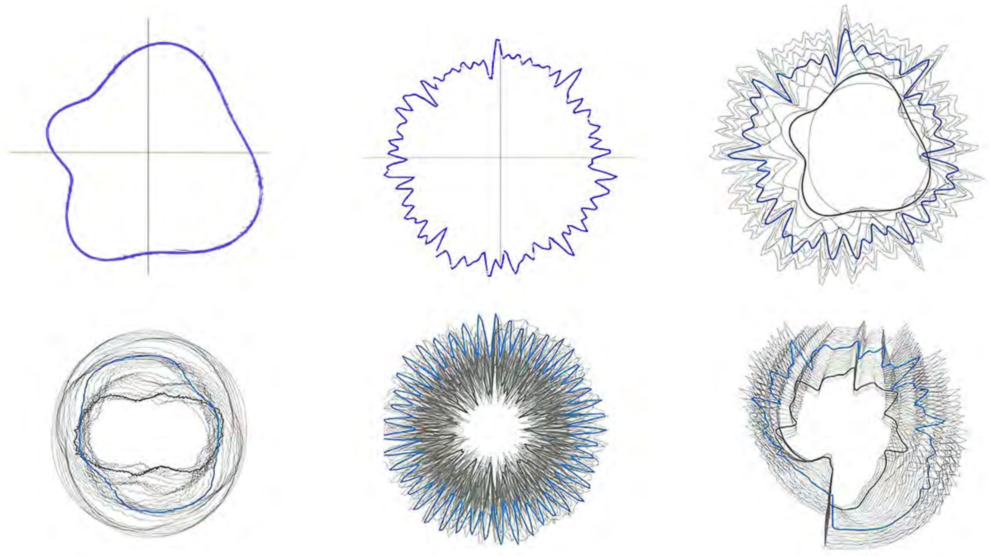

Figure 1: Bouba–Kiki inspired circular waveforms. Clockwise from top left: *Bouba, Kiki, Bouba–Kiki offspring, Flower, Superkiki* and *UberBouba.*

Music, Seen

Sound and sight relate through the physical universe, simply by translating the corresponding patterns of energy, but there is also remarkable correspondence, particularly in the field of music, between these domains: how we see music in our mind's eye.

The tendency to map pitch onto vertical space, speaking of 'high' and 'low' notes (with fast and slow frequencies) is innate in our culture; it is unquestioned and automatic. The concept of high and low pitches just seems obvious, despite pitch having no inherent spatial position. When height is used to denote pitch, the overwhelming majority of cultures map them in this way. However even when cultures do not use the concept of pitch-height, we can often guess the direction. In Turkey, pitches may be thick or thin'. The Amazonian Suyá speak of ''old' and 'young', Ancient Greeks used 'sharp' and 'heavy' and the *Bashi* of Central America 'strong' and 'weak''. You might guess these mean low and high respectively. Even when the descriptions appear at first abstracted – like the Shona peoples's (Zimbabwe) description of low and high notes as 'crocodiles' and 'those that follow crocodiles' respectively, we can picture it. Beyond actual usage, we can pick antonyms e.g. "sleepy" and "alert" and map them quite consistently. Even nonsense questions like "are lemons higher pitched than apples?" or "is red lower than blue?" are answered with undeserving consistency.

Of course there are (many) more musical parameters than pitch, and (many) more visual dimensions than height. However, again we see general correspondence between the sensory domains. Time tends to run left-right, but as this seems to be affected by the text reading direction of the subject, this is more culturally malleable than pitch-height. Loudness shows a strong correlation to the size and brightness of internal visualization, while pitch height tends to be positively correlated with opacity, saturation and brightness. There are many more such mappings in regards to tempo, density, timbre etc (and sometimes these parametric mappings 'compete') forming a rich and complex inner visual landscape.

There is another form of harmonic 'brightness' – an emotional one that seems to correlate with tonality such as major and minor keys. Although this is far more music-culturally mediated than pitch-height and loudness, there is a remarkable consistency and elegant hypothetical explanation: The perfect 5th – an intervallic relationship where 2 pitches are in an approximately 3:2 frequency relationship – is often intuitively (and overtly articulated) associated with brightness or light. This experience is not just about ascent, as it is preserved across octaves. Descending fifths (the same as ascending 4ths) conversely are more 'muted'. If we arrange the 12 chromatic notes in a circle of 5ths we can quickly map out how various collections sit on this circle of harmonic brightness. A major scale sources its notes largely from ascending 5ths – other than the root, five of the remaining six notes are on the 'bright' side of the circle. A minor scale on the other hand (and other side) has four of its six scale degrees as descending 5ths. The modes: Lydian, Ionian, Mixolydian, Dorian, Aeolian, Phrygian. Locrian represent incremental turns of a 'dimmer switch' on the circle of 5ths.

Hindustani music, with its highly sophisticated library of hundreds of *ragas* (musical templates including scales, rhythmic, thematic and stylistic features) demonstrate the brightness of the 5th beautifully. Associated with brightness and the sun, It is found in almost all of the scales, but the exceptions are illuminating. We get no 5th in the scales of the deepest contemplation, prayer and piety, but also in scales associated with the dead of night. The beautifully haunting *Raga Lalit* associated with the moments before the break of dawn, has a highly unusual cluster of notes around the 5th (the 4th *and augmented 4th* and minor 6th) creating an exquisite tense that is released at dawn with the emergence of the bright 5th.

Such correspondences between sight and sound might explain why different art forms when depicting similar moods and subjects for example Monet's *The Magpie* and Debussy's *Footsteps in the Snow* respective impressions of a winter scene marry so well. They are different ways of saying the same thing.

From Correspondence to Synaesthesia

Cross-modal correspondence is something we all share. However, we should not confuse this tendency to associate sound and vision with the diagnostic definition of *synaesthesia*. Synaesthesia involves the stimulation of one of our 'world-modelling' senses (auditory, visual, gustatory, olfactory, tactile) induced by another sense, or even ideas. Such a mapping is involuntary and automatic. It's not something the synaesthete decides upon or can stop, it just happens. The mapping is individualistic and idiosyncratic (not to say that synaesthetes don't share mapping, it's just that they are discovered rather than expressly learned or inculturated). These mappings are repeatable and stable, even though they may develop and transform over time, they are generally remarkably stable, often lifelong. Crucially the experiences are genuinely experienced, it's not "as if" – for example F# is blue, it is consciously seen (either in the mind's eye or 'projected' in front of the subject.). It seems synaesthesia is a cross by the cross-activation of cortices (caused by genetics, and sometimes caused by trauma or induced by psychoactive drugs). Fascinatingly, it is hypothesised that we all have it as infants, but most of us grow out of it, dutifully separating our windows to the world.

Synaesthesia appears in many forms, people might taste words, see sounds, hear colour, smell names, colour the sequence of days, and even cross multiple senses. Marilyn Monroe could see tastes, Richard Feynman saw colours in mathematical symbols, and the extraordinary Russian mnemonist Solomon Shereshevsky had cross-activation in all senses. He could even change his heart rate at will by visualising running.

The most common form of synaesthesia is 'grapheme-colour' where symbols like letters and numerals are associated with colours (1–2% of the population have this to some degree). Here we will look at the next most common – and the most studied – type of synaesthesia: chromesthesia where sound automatically produces the sensation of colour and shape.

Composers, musicians, and artists are disproportionately represented among synaesthetes, perhaps because long-term attentional training strengthens cross-activation between sensory regions. However even when it occurs, mappings are rarely agreed: In a 1907 post-concert dinner in the Cafe de la Paix, the composers Scriabin and Rimsky-Korsakov agreed on the colour of D major (gold-yellow) but disagreed on the colour of Eb major (red-violet and blue respectively). Rachmaninoff did not associate colour with either, but because he had used D major for a treasure scene in the *Miserly Knight* Scriabin and Rimsky-Korsakov felt vindicated by his intuitive agreement of such a mapping.

Accounts range from Duke Ellington's descriptions of specific instrumental tones (by instrument and player) as textured blues and satins, to Michael Torke's clearly defined colour associations; like rooms he can walk in and out of with his compositions. For many historical composers it is hard to tell what is correspondence, imagination or synaesthesia, but perhaps the clearest, most documented and extensive case of chromesthesia in a composer is that of Olivier Messiaen (1908–1992), an extraordinary musician whose output spanned modernism, electronic music, global music forms, inventive rhythmic and scalar forms, a deep study and influence of bird–dong (see Lecture One: The Music of Animals). Messiaen had perfect pitch in parallel with a vibrant, highly specific and expansive chromesthesic language. He had specific colours for pitches and keys, but a particular reaction to a collection of pitches. There is footage of him explaining the dazzle of colours emerging from Debussy. However he was not just reactive in his responses, but devised entire systems to exploit these mappings. His modes of limited transposition - a library of scales he invented which share a particularly rotational property[2] Figure 2 shows his reaction to one of the modes and its harmonies. His synaesthesia reacted differently not just with scale type and transposition, but also the structures their inversions produced. Messiaen's musical language was deeply embedded with his synaesthesia, as if he was composing with colour and sound equally: "The music of *Trois Petites Liturgues* is above all a music of colours… These inexpressible ideas are not expressed – they remain in the order of a dazzle of colours."

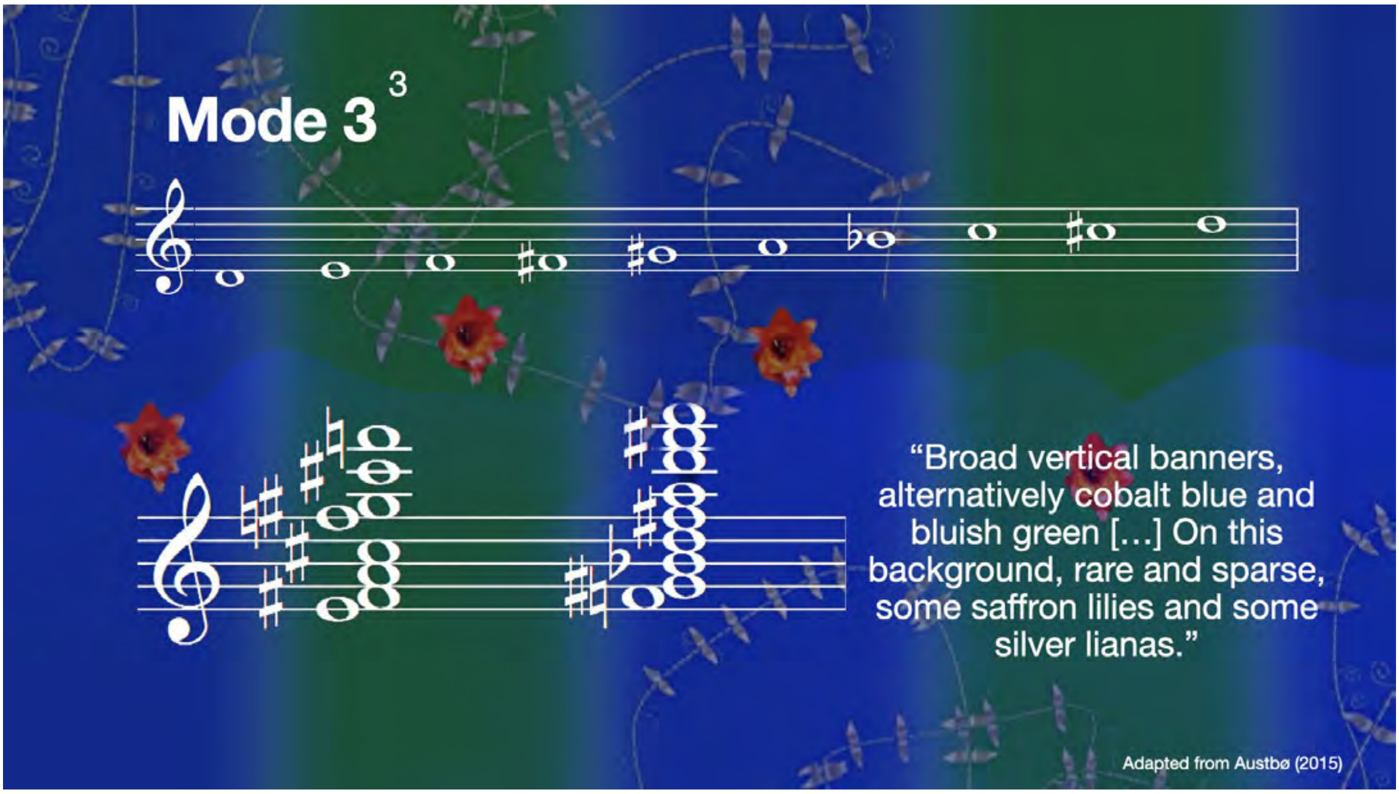

Figure 2: Messiaen's synaesthetic response to the third transposition of Mode 3. Adapted from Austbø (2015)

Newton Unweaves a Rainbow of Notes

Cross–modal correspondence and chromesthesia form intuitive and/or automatic bridges between the visual and audio domain. However it is also possible to make systematic translations between these domains, unmediated by human perception. The idea of translating light spectrum down to the audible spectrum is not so fanciful when one considers that sufficiently slowed down pitches and harmonies are (without poetic licence) rhythmic patterns, and conversely accelerated rhythms are experienced in the pitch domain. There is correspondence also in that simple rhythms (e.g. quavers against crotchets) are experienced as simple consonant harmonies (in this case an octave), while the complexity and degree of dissonance is preserved across the domains. What happens if light is heard?
In the summer of 1666, while sheltering from the plague at his family home, Isaac Newton transformed our understanding of light by passing a white beam through a prism; he distinguished pure from composite colours and showed that white is a mixture, not a fundamental. Before Newton, colour was thought to belong to objects. After him, it belonged to light itself. In *Opticks* (published in 1704 long after his discoveries aged just 23), he also provided a beguiling metaphor between light, colour and music. In his

[2] These modes have an intervallic pattern that repeats so that if you transpose them they 'find themselves' again. Unlike the major key which has 12 distinct versions, these as the name suggests are limited in transpositions. Each mode then can be identified by a number (the pattern) and what transposition: 3^2 is mode 3 in its second transposition, for example.

Figure 11 (see our Figure 3), and its accompanying text, Newton used the analogy of musical intervals to describe the circular arrangement of the colours. Newton's scheme was speculative, but remarkably prescient. He ordered colours correctly by spectral sequence without knowing wavelength, identifying the warmer colours with lower notes. His circular model of colour perception, despite the linear physics of the spectrum, marries beautifully to the circular nature of a musical scale. Newton chose D Dorian[3] (and not a major scale) as his scale, using the proportions to carve out the colour positions. As it happens the spectrum of visible light is just shy of an octave (Newton had no way of knowing this). If you transpose light down by 41 octaves it becomes a scale starting around F# and ending around F (or E# if you prefer) spanning middle C. Though the order of colours are correct the gaps aren't quite how Newton identified them, however there is so much that is intuitively right and artistically motivating about his vision. Many analogies emerge: close clashing notes/colours, white noise and white light, colour mixture, pure vs composite tones and harmonies, circularity of experience etc. In short, Newton's colour–music concept though (understandably) not without fault, is remarkably prescient, and to many, deeply inspiring.

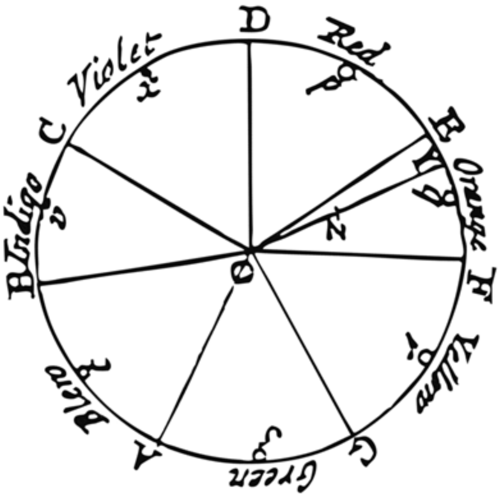

Figure 3: Newton's colour wheel hypothesising a correlation between the spectral colours and a musical scale from *Opticks, Book I, Proposition VI, Problem II* (1704)

Colour Scales and Palettes of Pitches

"One day I must be able to improvise freely on the keyboard of colours: the row of watercolours in my paintbox."
Paul Klee

Others followed from this concept, Figure 4 shows a sampling of colour scales proposed by composers, artists and natural philosophers since Newton. Some of these are linked to the rainbow order, others informed by synaesthetic anchoring, theosophic musics or artistic motivations. Some were even inspired to build appropriate tools, such as Castel's 1734 *Ocular Harpsichord* – a device that would shine lights through a collection of glass panels when the appropriate key was played, a predecessor of contemporary audio-reactive visuals. The concept of a colour scale also reveals that we place handy but rather arbitrary human-centric convenient markers, stepped discrete jumps in colour and sound, when in reality both are a smooth continuum. The Spectralist movement of the 1970s and 1980s exploited such a liberated vision of the audio spectrum, embracing the full palette of colours

[3] The choice of Dorian (with Red starting on D) is over the normative major scale is musically and mathematically satisfying, given its balance of major and minor intervals and mirror symmetry. It is also quite fitting if you know anything about Pink Floyd who use the Dorian mode extensively, and D Dorian specifically (although I don't think intentionally) on *Any Colour You Like* from the Newton prism covered *The Dark Side of the Music* (see Lecture 6 from *Worlds of Music*)

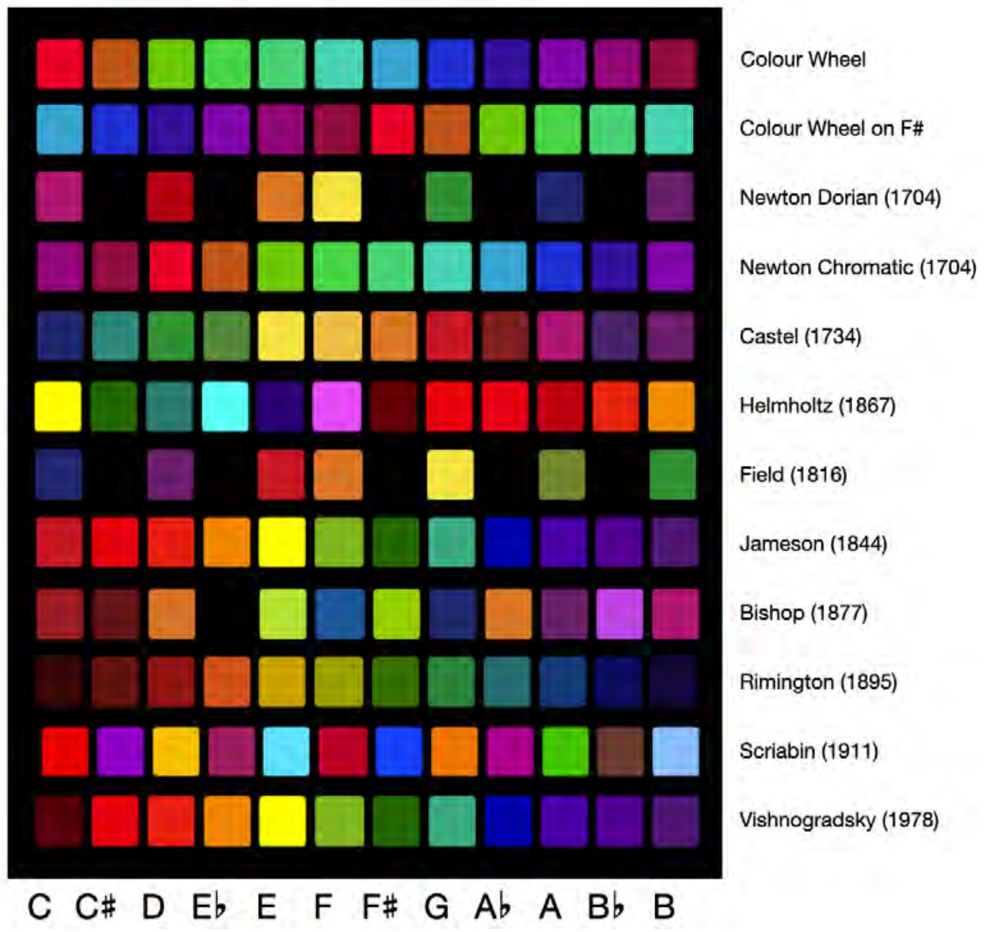

Figure 4: A sampler of historical colour scales, mapping notes (‘pitch-classes’) to hues.

Although many colour scales are born of conceptual or poetic motivations, an intriguing study of a cohort of synaesthetes’ automatic responses to these ‘pitch-classes’ suggested that – when colour responses were averaged out – a colour spectrum emerges. Cs were remarkably consistent as red, and Gs as blues, Ds leaned to a golden yellow (Scriabin and Rimsky-Korsakov were on to something) and Fs to green, Higher octaves used the same hues but progressively desaturated heading towards whites and greys (see Itoh et al. 2017).

Slow Light and Painting Music

The Australian composer and painter Phillip Houghton (1954–2017) told me in conversation that he conceived of his (and all) music as “slowed down light”, drawing inspiration from this “secret analogy”. Can music and sound return the favour to the visual arts?

Artists such as Wassily Kandinsky (1866–1944) and Paul Klee (1879–1940), both extremely proficient musicians, embraced this deeply. Kandinsky, who had deep (and likely synaesthetic) responses to sound, spoke of music as his "ultimate teacher” and that “colour is a keyboard” and “the soul is a piano”. Klee in both practice and his pedagogical writing approached painting through direct musical metaphors of foreground and background, rhythm and meter, polyphony, pitch sets, emergent structures and counterpoint.

Technology has expanded our toolkit, allowing us to visualise spectra, draw sound, and explore the bridge between these domains and a blended audio-visual artistic practice and expression. Daphne Oram’s *Oramics* and Iannis Xenakis – erstwhile Gresham Professor Music – allowed composers to paint (using ink and digital pencil respectively) audio signals and instructions. Contemporary digital technology allows the real time translation and mapping of practically any video to audio data (or the other way round. My own *Slow Light* project explores this idea by translating paintings into musical structures using custom software (originally titled the barely pronounceable *Synaesynthesizer*).. Colour becomes pitch-class or harmony (by using established or new colour scales), the relative levels of red, green and blue can be used as continuous controllers for musical parameters, and a painting can be read at any trajectory or tempo so that spatial arrangement becomes form. I never tire of, or will exhaust, the possibilities of converting visual artworks into music, nor photographs of my friends for their birthdays.

Prometheus and the Total Artwork

And to wrap up, let's discuss Alexander Scriabin's *Prometheus: The Poem of Fire* (1910), which stands as a seminal, ambitious and uncompromising attempt to fuse light and sound into a single artistic act..Scriabin had a colour scale anchored on the three notes: C (red) was associated with the human, the earthly point of origin, D (golden-yellow) represented transformation, F♯ (bright blue-violet) the transcendent and the divine. He found that the rainbow across the cycle of 5ths generated these colours, so filled in the rest to create a complete palette (see Figure 4, penultimate row). From this collection he developed a harmonic language centred on what is often called the mystic chord: a six-note collection representing the tension and transformation of the mortal to the transcendent.

Prometheus maps this trajectory by opening with a mystic chord, swirling though pitch collections (which he mapped out in the accompanying material to the score) and arriving at a triumphant F#major chord (the first instance of a conventional chord in the piece and representing the final moment of transcendence)

This harmonic – and spiritual ºtrajectory was mirrored visually with Scriabin's own invented instrument the *Luce* or *clavier à lumière*s. This colour keyboard is notated and performed by a musician in the piece but – unlike Castel's instrument – produces no sound at all. Rather its role is to bathe the hall in shifting colours aligned to the harmonic field. The ambition was staggering: a concert that would dissolve the boundary between senses, between performer and listener, between the human and the cosmic.

While technology lagged behind imagination, contemporary performances aided by modern technology do this extraordinary piece more justice. And Scriabin's vision of a total artwork[4], an "expression of the entire universe", in which sound and light are different manifestations of the same unfolding process and truth, remains beguiling. In this sense, *Prometheus* represents both the culmination of centuries of speculation about music and colour, and a prophetic glimpse of multimedia art to come.

Return to the Light

"Art does not reproduce the visible. It makes visible." - Paul Klee

In the ancient myth, Prometheus dares to steal fire – knowledge, light, technology, transformation – from the gods to illuminate humanity. One might see a parallel in how the artist devotes a life to carrying light into the cave, revealing the world not as shadow, but in its fullest colour.

Acknowledgments

Umut Eldem for the generous scholarly tour of synaesthesia, and Philip Houghton for introducing me to the slow light.

Bibliography and Further Reading

Please note that all the lectures are interlinked. *The Nature of Music* (2023–24) provides an overview of the fundamental building blocks of music; *Worlds of Music* (2024–25) gives a few examples of the countless ways these mechanisms are used in artistic practice; and *The Music of Nature* (2025–26), how music

[4] Not content on the totalness of this total work, Scriabin planned a follow up work to *Prometheus: Mysterium* to be performed on the foot of the Himalayas, together with music, light, dance and scents. See you there.

intersects with the natural world from subatomic particles to birds, mountains and the planets. All recorded lectures and accompanying essays are available at gresham.ac.uk.

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