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A Perfect Fifth of Blue and Red: Enlightened Harmonies of the Senses

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See table of contents

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In this article, I use Louis-Bertrand Castel's attempt to create a music of colours as a window into 18th-century debates on the inter-relationship between physics, physiology, and sense experience. In part one, I address Castel's original 1725 proposition to build an "ocular harpsichord," a musical instrument designed to play colour rather than sound. I argue that Castel's idea relied in equal measure on contemporary music theory, optics, and neurophysiology. In part two, I examine Castel's attempts to justify his new music experimentally. Though his purported demonstrations became more eclectic, the core theoretical principles behind his optical music remained the same. In part three, I turn to what should have been the triumph of Castel's career: his creation of a partially functioning harpsichord in 1755, along with the publication of two proposals for other sensorial musics in 1753 and 1755. The ostensible failure of Castel's idea points to the limitations — theoretical, experimental, aesthetic — of his original proposal. At the same time, their enduring power to inspire spoke to the appeal of music as an explanatory framework, encompassing both art and science, body and mind.

Résumé

Dans cet article, j'utilise la tentative de Louis-Bertrand Castel de créer une musique de couleurs comme fenêtre sur les débats du XVIIIe siècle au sujet de l'interrelation entre la physique, la physiologie et l'expérience sensorielle. Dans la première partie, je me penche ainsi sur l'idée de Castel qui proposait de créer , en 1725, un « clavecin oculaire » - un instrument de musique conçu pour jouer de la couleur plutôt que du son. Je soutiens que la notion de Castel s'appuyait sur la théorie de la musique contemporaine, l'optique et la neurophysiologie. Dans la deuxième partie, j'examine les tentatives de Castel de justifier sa nouvelle musique à titre expérimental. Bien que ses prétendues démonstrations soient devenues plus éclectiques, les principes théoriques fondamentaux de sa musique optique sont demeurés les mêmes. Dans la troisième partie, j'aborde ce qui aurait dû être le triomphe de la carrière de Castel : sa création d'un clavecin partiellement fonctionnel en 1755, ainsi que la publica-

tion de deux propositions pour d'autres musiques sensorielles en 1753 et 1755. L'échec apparent de l'idée de Castel met en évidence les limites — théoriques, expérimentales, esthétiques — de sa proposition originale. En même temps, leur pouvoir d'inspiration durable témoigne de l'attrait de la musique comme cadre explicatif, englobant à la fois l'art et la science, le corps et l'esprit.

When Louis-Bertrand Castel first proposed his ocular harpsichord in November 1725, he likely had little idea of the intellectual odyssey on which he was embarking, whose twists and turns would occupy a central part of his life for the next three decades until his death in 1757. The ideas behind the instrument, meant to play harmonies of colour and light, were by no means original to him. European natural philosophers had been insisting on the physical similarities between light and sound for almost a century — the most recent example, relative to Castel, coming in the form of the 1720 and 1722 French translations of Newton's *Opticks*, in which the famous Englishman compared the colour spectrum to a musical scale.[1] The principles of musical harmony, which Castel proposed to apply to light as well as to sound, were also well-trodden ground for philosophical inquiry, having inspired a flurry of attention in the seventeenth and eighteenth centuries. In this way, the harpsichord represented a variation on two pre-existing themes — one that played in the realm of physics, the other in the realms of music and art.

From the moment he first proposed the *clavecin pour les yeux*, Castel found himself enmeshed in complex eighteenth-century debates about sense experience, the body, and the soul. For Castel's contemporaries did not understand the ocular harpsichord as merely an optical curiosity or a new instrument of the fine arts.[2] Castel famously claimed that his harpsichord could "render *sound visible*," but what was really at stake was the possibility of a pan-sensory principle of pleasure, a *sensorium commune* based on harmony, which Castel attributed to the proportionate vibrations of all the sensory nerves.[3] Much of the controversy surrounding the optical harpsichord focused precisely on this musical reading of sensory physiology. Indeed, although few philosophers had much faith that Castel would ever succeed in composing his chromatic harmonies, many accepted the implications of his arguments: that the principles of sensorial pleasure could be derived from the material movement of the nerves. This article proposes a radically new conception of Castel's instrument by considering it within the field of eighteenth-century sensationist philosophy and materialism:

his ocular harpsichord was an analogy for the human being, illustrating the union of body and soul through music and harmony.[4]

I. The Metaphysics of Sensory Physiology: The Early Years of the *Clavecin Oculaire*

Castel first announced his plan to build an "ocular harpsichord" in a brief article published in the *Mercure de France* in November 1725. As the name of the instrument implied, Castel modelled the ocular harpsichord on an "auricular" harpsichord, with the crucial difference that each keystroke on his instrument would "render *sound visible*" by playing colours rather than musical tones.[5] To Castel's readers, it might have seemed that the philosopher was riding on the coat-tails of Isaac Newton, whose *Opticks* had appeared in French translation only a few years before.[6] Here, Newton set forth the theory of colours that would shape European optical research for the first decades of the eighteenth century: he argued that colours were not formed by the modification of white light (as Aristotle had taught), but rather constituted distinct parts of white light. This he demonstrated with his *experimentum crucis*, refracting white light into the colour spectrum and then reconstituting these coloured rays into a single ray of white light. Newton had also observed that the proportions of the colour spectrum appeared to correspond to the proportions of the diatonic scale, which suggested that the colour spectrum possessed the same harmonious structure as a musical scale (in particular, D Dorian).[7] Newton had not offered an explanation as to why that might be the case, although he did suggest, as had many seventeenth-century natural philosophers before him, that both light and sound were propagated through vibrations, and were therefore analogous phenomena.[8]

While Castel did indeed cite Newton's musical musings approvingly, his optico-musical theories were only loosely tied to contemporary research into the nature of light and colour. Castel himself subscribed to a vaguely Cartesian system of optics, according to which light was "propagated by perfectly equal, solid, and incompressible globules" that vibrated in a similar manner to sonorous air.[9] But in proposing his *clavecin oculaire*, Castel was ultimately only interested in the propagation of light insofar as it supported his analogy with music — that is, insofar as it allowed him to apply the principles of music theory to the domain of light and colour. He thus cited as his greatest influence not Newton, but the seventeenth-century Jesuit polymath, Athanasius

Kircher, who had called sound the "ape" of light, and suggested that "if anyone were to see these most subtle motions of the air, while a musical instrument was playing, he/she would certainly see nothing but a painting represented by the most extraordinary variety of colours."[10] That Kircher had little to say about the physical nature of light — and was hardly a scientific authority in the early eighteenth century — was almost irrelevant, since Castel was more concerned with the human experience of light, and with its similarities to sound and music.[11]

We can trace Castel's fascination with music to the early 1720s, when he met the composer Jean-Philippe Rameau. The two formed a stormy friendship that would last into the next decade, when arguments over Rameau's 1737 *Génération harmonique* drove a rift between them.[12] In his 1722 review of Rameau's *Traité de l'harmonie*, Castel expressed his agreement with the composer's vision of music as "a Science that must have certain rules," rules which "must be drawn from a clear principle," which itself could only be elucidated through "the help of Mathematics."[13] Indeed, for much of the medieval and early modern period, theorists of music and philosophers alike had believed that music was governed by mathematical proportion: the harmonies most pleasing to the soul were those played by strings whose lengths corresponded to simple mathematical ratios (1:2, or the octave; 2:3, or the fifth; 3:4, or the fourth). From the 1650s to the 1750s, French neoclassical philosophers of art frequently turned to musical harmony to illustrate the rational basis of beauty for this very reason — in some cases, even using the language of musical harmony to describe the principles of cadence in poetry and composition in painting.[14] Castel's approval of Rameau, who himself exemplified this trend of rationalizing and naturalizing the principles of harmony in the eighteenth century, thus placed the philosopher squarely within an influential trend of French aesthetics, which sought to bring matters of taste within the purview of reason.

When Castel first proposed his *clavecin pour les yeux* in December 1725, he was effectively combining contemporary optical theories with this tradition of French rationalist aesthetics. However, as he continued to develop his theory of ocular music, Castel took the principles of harmony in a new direction, pursuing the vibrations of sound and light inside the human body, first to the ears, then to the eyes and the other senses, and finally to the continual, tonic motions of the body's fibres.[15] Once again, Castel started from a well-worn position, in this case, the coincidence theory of consonance, which had been the dominant theory of the physiology of music since the early seventeenth century.[16] In his February 1726 "Démonstration géométrique du clavecin pour les yeux & pour tous les sens," Castel explained that, when a sound struck the "auditive membrane" in the ear, the membrane subdivided itself according to the frequency of the sound. Two sounds were consonant with one another when the quantities of these vibrations in the auditive membrane coincided according to simple mathematical ratios; when they did not, the sounds caused displeasure.[17] This was essentially a translation into bodily terms of what music theorists in the Pythagorean vein had long affirmed, that the mathematical simplicity of harmony was also the foundation of its pleasure.

The soul's appreciation of harmony, moreover, was also a consequence of the healthy physiology of vital bodily function. Every regular and moderate motion, Castel pointed out, was not only "always agreeable" to the soul, but also "agitated" the blood and "fortified" tonic movement, the continual oscillatory motion that characterized all of the body's solid parts.[18] Castel was likely referring to the influential work of the Italian physician Giorgio Baglivi, who had affirmed the importance of tonic motion for the maintenance of healthy bodily function at the turn of the eighteenth century, and whose ideas were quickly growing in popularity within the French medical community.[19] Castel was not alone in linking what was beautiful with what was good for the human body. In 1715, the Swiss philosopher Jean-Pierre de Crousaz had argued that the physical constitution of the body played a key role in the appreciation of music.[20] "Each passion," he suggested, "is maintained by a particular movement of the blood & the spirits, & each type of movement in the Spirits give themselves and the bodily fibres, which these spirits fill, a certain degree of tension, & consequently springiness. We are therefore in a manner of speaking *tuned* [*montés*] to make *consonance*, sometimes with some Tones, & sometimes with others."[21] In other words, the right music would quite literally resonate with the body, its spirits, and its fibres. Crousaz and Castel were in effect proposing, in the language of eighteenth-century physics and physiology, a corporeal re-interpretation of the ancient Pythagorean and Platonic idea of *musica humana*. Though European philosophers had traditionally expressed harmony in the language of mathematics, Castel insisted that vibration was its physical manifestation — which, when present in the body, corresponded to pleasant sensations and good health.[22]

While these observations of bodily vibrations served to legitimize Castel's rationalist aesthetics, they did little to support his claim that the pleasures of harmony could be experienced by means other than hearing. To justify his new optical harmonies, therefore, Castel drew from contemporary English and French theories of nerve function to argue that "each object of our senses excites the same sort of vibrations" in the sensorial organs, causing the sensory nerves to vibrate from their extremities toward the brain.[23] The mechanisms of pleasure that worked for the ear were also valid for the other senses, for "wherever in the body the soul feels moderate & commensurable vibrations [i.e., vibrations in numeric proportion], it must take pleasure, & in the contrary sense." The principles of harmony did not depend on the specific sense in question, but rather on the proportion of these vibrations. As Castel wrote, "pleasure and displeasure in all of our senses consist in the same type of vibrations, that is to say, vibrations in harmonic proportion."[24] Consequently, the idea behind the *clavecin pour les yeux* was compatible with all of the senses — precisely the argument made by Castel in an article published in the *Mercure de France* in March of 1726:

> 1. Put around forty different pots in a row, filled with different flavours, cover them with valves, and make it so the movement of the keys opens these valves: that is the harpsichord for the nose. 2. On a plate, arrange in a certain order different bodies able to make various impressions on the hand, and then pass the hand over these bodies: that is the harpsichord for touch. 3. Arrange in the same way bodies pleasing to the taste, and mix them with some bitterness.[25]

Since Descartes's first mechanist descriptions of the body, physiologists had argued that the corporeal basis of sensation lay in the physical movements of the nerves, which shook, oscillated, and vibrated as they transported sensory impulses from the organs of senses to the *sensorium commune*, or common sensory, in the brain.[26] In this cerebral organ (which anatomists located in various spots in the cerebrum and spinal cord, and most commonly at the cerebrum's centre, in the *corpus callosum*), the immaterial soul observed material sensible impressions, and in this act of observation, or perception, these impressions became sensations and ideas. This impression theory of sensation shattered the direct relationship that had existed in scholastic theories of cognition between the soul's perception of an external object and the object itself.[27] Natural philosophers simply could not conceive how the shape and movements of tiny material corpuscules could produce sensations that bore any similarity to the soul's experience of the world.[28] In the words of John Locke, there was "no conceivable connexion between any impulse of any sort of body and any perception of a colour or smell which we find in our minds."[29]

Despite these considerable philosophical difficulties, during the late seventeenth century natural philosophers across Europe began to develop physiological explanations of sensation that established a correlation between the movements of the natural world, the motions of the body, and the experience of the soul. This trend manifested itself most notably through the search for a common principle shared between the senses, one which could conceivably act as a bridge, both material and spiritual, between them. One idea, which became increasingly popular from the 1730s onwards (as will be more fully discussed below), was that all sense experience consisted in variations of touch. Another, albeit less well-known within current scholarship, was that the soul experienced and judged all sensations on the basis of the vibration of the nerves and the fibres of the brain. Just a few years before Castel had first described his *clavecin pour les yeux*, the Montpellier physician Jean Astruc proposed precisely this: that the brain acted as a sort of harpsichord, conveying ideas via the vibrations of cerebral fibres to the soul, which then judged the concordance of these ideas based on the proportions between the fibres' vibrations.[30] As the Chambers' *Cyclopaedia* put it, "If the Vibrations of the Fibre that gives the Idea of the Subject, and those of the Fibre which gives the Idea of the Attribute of Proposition, be *Isochronal*, or make an equal Number of Vibrations in the same Time, we are determin'd to the Affirmation of the Proposition; if *Eterocronical*, or their Vibrations be unequal, the Soul will be determin'd to a Negation, &c."[31]

In this context, Castel's claim that the pleasures of all of the senses were fundamentally analogous might not have seemed out of the ordinary. Indeed, in April 1726, a certain 'Rondet' published a letter in the *Mercure de France* in which he introduced a variety of medical and physiological evidence in support of Castel's physiology of the senses.[32] Rondet re-affirmed Castel's theory of the vibrating nerve, at least as it pertained to vision, citing the English anatomist William Briggs' *Ophthalmo-Graphia* (1686), which affirmed that "the sympathetic fibres of the optic nerve resonate with one another in a perfect harmony; [and] that these fibres were stretched over the optic nerve as if over the bridge of a violin."[33] Rondet added that ocular and auricular physiology were inter-linked, since both the ears and the eyes often suffered from disease together, and both diminished in function with the effects of age.[34] He related an anecdote from the English oculist, John Thomas Woolhouse, who had observed a blind man in Maastricht, the Netherlands, who was able to distinguish colours by touch, and moreover identified particular colours with particular sounds.[35] Rondet was so confident that the ocular harpsichord would produce a new and pleasant art form that he described in detail how it might be constructed. The philosopher proposed that a "dioptric box" be placed on top of an ordinary harpsichord, containing an interior light and coloured glass corresponding to each note of the keyboard. Each glass would be covered with a small curtain, to be pulled by a complicated system of ropes and pulleys when the musician played the appropriate key.[36] In Rondet's design, each colour would be accompanied by a musical tone, such that the ocular harpsichord would create harmonies of both light and colour.

But not all of Castel's contemporaries were convinced by his arguments for the senses' common appreciation of harmony. In May 1726, an anonymous author, who went by the pen name "un Philosophe Gascon," objected in the *Mercure de France* that Castel's hypothesis of nervous vibration risked introducing unnecessary confusion into contemporary understandings of sensation and perception.[37] "You are confusing two things that all Philosophers distinguish," the anonymous philosopher wrote,

> And which effectively are as distinct as the spirit {*l'esprit*} is from the body; you confuse the sensations that the soul feels with the occasional causes of these sensations; sensations are in the soul, and are spiritual like the soul; the occasional causes of sensations are corporeal, and only differ from one another insofar that all bodies differ from one another, that is to say, by the different arrangement of the parts of matter, which we call modifications.[38]

In this brief passage, the Philosophe Gascon laid bare all the metaphysical difficulties attendant to Castel's outline of a physiology of pleasure — and indeed the very project of understanding the corporeal basis of sensation in the seventeenth and eighteenth centuries. The material motions of the body could not conceivably be the physical cause of sensation, or any other aspect of the immaterial soul.

At best, the movements of the body, of the nerves, and of the brain, could be the "occasional cause" of sensation — a causal relationship guaranteed by God, not the laws of nature.[39] Consequently, even if the motions of light and sound, of the auditory and visual nerves, resembled one another (which was far from certain), this should by no means have implied that the sensations of light and sound were in any way similar.[40] When one considered the qualitative differences between light and sound, the Philosophe Gascon concluded that it would perhaps be better to "abandon this system of vibrations" altogether, lest it lead the philosopher to "deny the distinction between the sensations of colours and of sounds."[41]

In response, Castel argued that the Philosophe Gascon had missed the point of the *clavecin oculaire*, which was designed not to translate the sensation of sound into light, but rather the sensations of music into colour.[42] The pleasure of music came "not from sound as sound, but uniquely from the movement, measure, and regularity of harmonic proportion." It was through this perception of harmony in movement, and not any qualitative equivalence between light and sound, that the soul would feel "colours in the same way as sounds."[43] This distinction, though subtle, was crucial: in insisting on the harmonic vibrations of the sensory nerves, Castel was not trying to claim that all forms of sense experience were essentially the same, but rather, that all forms of sensory pleasure were analogous and that the pleasures of one sense could be translated into another. Indeed, this was the central conceit of the ocular harpsichord, which distinguished Castel's colour music from painting: it presented the viewer with the spectacle not simply of chromatic harmony, but rather of chromatic harmony *in movement*.[44]

Even with this in mind, Castel's optico-musical philosophy did not escape the metaphysical issues that the *philosophe Gascon* had raised. From a physiological perspective, the very possibility of the optical harpsichord relied on Castel's assertion that the similarities shared by the optic and acoustic nerves could have real consequences for how the soul experienced the world.[45] Castel's contemporaries largely accepted this premise, that the soul's sensory experience of the world could be determined in terms of the body. As we shall see, where they disagreed concerned whether sensory physiology worked in the way described by Castel, whether the similarities between the sensory organs extended as far as Castel's harpsichords for the senses suggested. There was no easy way to adjudicate these questions, for the motions of the nerves lay beyond the gaze of eighteenth-century anatomists, and the music of the ocular harpsichord continued to find enthusiastic supporters — especially as the philosopher put his ideas into practice in the 1730s, 1740s, and 1750s.[46]

II. Physiological Problems

Castel returned to his optical music in 1730, when he constructed a makeshift harpsichord using "coloured slips of paper" attached to a keyboard. Despite the rudimentary nature of the instrument, its performances attracted large crowds to his workshop (so many that he eventually turned people away). These concerts also drew renewed criticism, most notably from the Comte de Buffon and Jean-Jacques Dortous de Mairan, both of whom doubted that musical principles could be successfully applied to colour.[47] In response, Castel decided to develop a more sophisticated explanation of his optical harmonics, embarking on a series of experiments designed to test the harmonic and aesthetic properties of colour, as well as the manner in which these properties appealed to sight. He presented his results in the "Nouvelles expériences d'optique et d'acoustique," a set of six articles spanning 321 pages that he published in the *Journal de Trévoux* (of which he was the primary editor) from August to December 1735.

The "Nouvelles expériences" contained a meandering series of philosophical reflections that often touched on themes only tangentially related to light and colour. From the outset, Castel revealed his ambition to move beyond the strict framework of contemporary optics by exploring the harmonic characteristics of colour through the mixing of dye and paint, rather than light. Castel never fully justified this choice, though it was representative of his broader optico-musical philosophy that tended to blur the lines between the experience of particular sensations and the physical and physiological processes that provoked them. Castel's immediate aim was to bring his theory of colours into closer alignment with contemporary music theory. The first step was to discover the fundamental scale of colours; that is, to determine which colours could be placed into the framework of the diatonic and chromatic musical scales. "If the order — *violet, indigo, blue, etc.* — is the true order," he wrote, "if it corresponds to *ut re mi etc.*, I must find in it the same number & the same distribution of tones and semi-tones."[48] Castel presented the following experimental results: the mixture of purple and indigo produced "*colombin*"; indigo and blue produced no recognizable colour; blue and green produced teal; green and yellow produced olive; yellow and orange produced apricot; orange and red produced no recognizable colour; and red and purple produced crimson. Castel then re-arranged these colours into an updated diatonic and chromatic colour scale (the tones are in bold): **blue**, celadon, **green**, olive, **yellow**, **tawny** (*fauve*), red-orange (*nacarat*), **red**, crimson, **purple**, agathe, **grey**, **blue**.[49]

ORDRE CHROMATIQUE.

Couleurs.	Bleu,	Celadon,	Verd,	Olive,
Tons....	*ut*,	*ut* ♯,	*re*,	*re* ♯,
Couleurs....	Jaune,	Fauve,	Nacarat,	
Tons........	*mi*,	*fa*,	*fa* ♯,	
Couleurs....	Rouge,	Cramoisi,	Violet,	
Tons......	*sol*,	*sol* ♯,	*la*,	
Couleurs.......	Agathe,	Gris,	Bleu.	
Tons.........	*la* ♯,	*si*,	*ut*,	

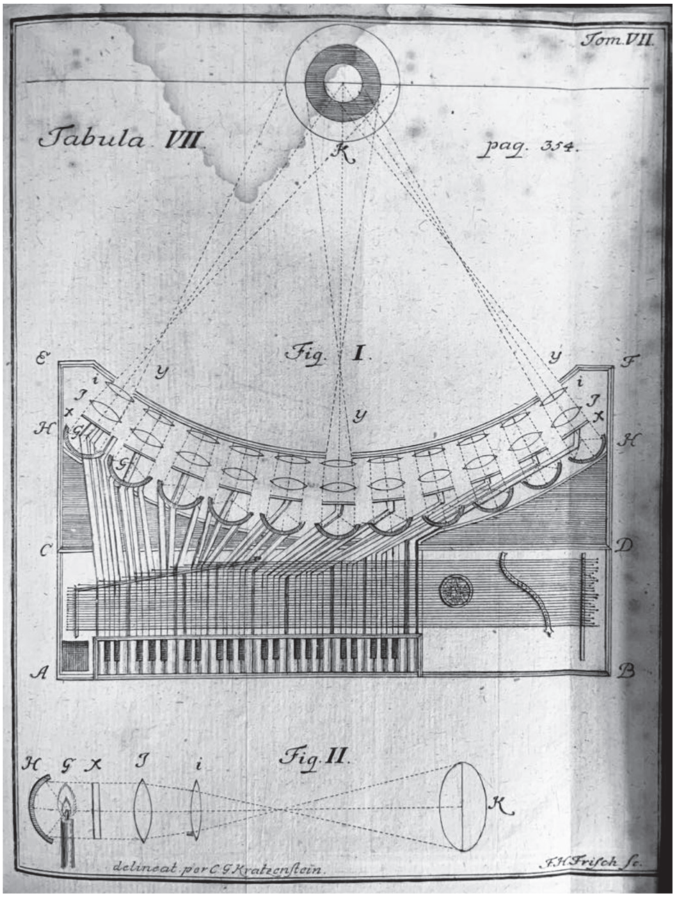
Castel's chromatic scale of colours and sound. Banières, Jean. *Examen et réfutation des élémens de la philosophie de Neuton de M. Voltaire* (Paris: 1739), 305. Huntington Library, San Marino, California, 700854.

In fact, despite investing so much energy into the ocular harpsichord, Castel was confident that the soul could appreciate the harmonic beauty of colour wherever it was perceived. He described looking up at the sky and finding blue "everywhere, or almost everywhere, a kind of fundamental bass that effectively acts as the base of most bodies, both in nature and in imitation."[50] Against this fundamental note of blue he compared red, its war-like fifth, and yellow, the weaker fourth.[51] The eye could also "know, feel, and taste harmony" outside of a purely chromatic framework, for the essence of art ultimately consisted in the combination of proportion and mobility, as manifested by the composition of a painting or a façade, the forms of a statue, or the movements of dance — the latter of which Castel described as a "true ocular harpsichord."[52] Though Castel was busy transforming his harpsichord into a physical object, it remained a metaphor illustrating that harmony was everywhere, whether in the proportions of number or the regular movements of vibration, both inside and outside of the body.

Despite the expansiveness of these claims about the universality of harmony in art and nature, Castel also took care to ground the soul's appreciation of these harmonies in the mechanism of the senses.[53] "All of the pleasures [*agrémens*] of the senses consist in the moderate shaking [*ébranlement*] of the Nerves by objects," he reaffirmed in the sixth part of the "Nouvelles expériences." More specifically, Castel argued that "the soul responds to the optic nerve in the same way as [it responds] to the auditory nerve." Simply put, "it feels the affection of one like it did the other." Castel admitted that the speed of light (perhaps a "million times faster than sound"), along with the "distinction of [visual] images,"[54] set the pleasures of sight apart from the pleasures of hearing. As with any new art, it might take time for an observer to learn to appreciate the performances of the ocular harpsichord, just as a Frenchman might be initially displeased by Italian opera.[55] For this reason, Castel declared that his colours would always be accompanied by sounds, which would act as a guide for the observer.[56] After a brief learning period, according to Castel, just about anyone would come to appreciate his chromatic music.[57]

Castel received praise for his chromatic results from some quarters. The German composer Georg Philipp Telemann visited Castel's workshop in 1737 or 1738, and was impressed by what he saw, writing that "the *Soul* receives by the diversity of *Colours* the same entertainment that it receive by the diversity of *Sounds*."[58] The German philosopher Johann Gottlob Krüger also claimed to have seen Castel's instrument, and he agreed with Telemann that, in principle at least, "our soul, in judging the agreeableness and disagreeableness of the objects which present themselves to the eyes, observes the same laws and the same rules as it does in distinguishing musical consonances from dissonances." Krüger, however, was less convinced of the extent to which the rules of music could be adapted to colour combinations: for instance, red and gold pleased the eye, whereas the corresponding interval of the second was considered dissonant.[59] Despite these reservations, Krüger proposed his own re-imagining of Castel's instrument, which disregarded Castel's colour scale and presented colours super-imposed over one another, rather than in succession.[60]

The French Cartesian Jean Banières agreed with both the general idea of the analogy between the senses and Castel's more specific analogy between colour and musical tone, though it is unclear whether he ever witnessed the optical harpsichord.[61] Banières repeated the standard mechanist position that all sensation was determined by the



Krüger's model harpsichord. Krüger, Johann Gottlob. "De Novo Musices, Quo Oculi Delectantur, Genere." *Miscellanea berolinensia, ad incrementum scientiarum ex scriptis societati regiae scientiarum exhibitis edita* 7 (1743), 345–57. The New York Public Library. Rare Book Collection. Astor, Lenox, and Tilden Foundations.

movement and shape of matter.[62] Whereas the *Philosophe Gascon* would have used this premise to insist on the absolute incommensurability between the causes of sensation and the sensation experienced by the soul, Banières made the opposite move, remarking that both light and sound made impressions of a similar sort on their respective sensory organs: "in a certain determined time, a greater or a lesser number of vibrations."[63] On this basis, Banières considered Castel's work a noble pursuit, given its clear utility for the deaf, and noted his surprise that "these Harpsichords were not more common in a century as learned, as delicate, & as curious as our own."[64]

Other philosophers were less convinced. In an early review of the "Nouvelles expériences," the Abbé Prévost dismissed Castel's "discovery" that certain colours could be harmoniously combined was as an "explanation for what had never ceased to be practiced, for what essentially constitutes Painting."[65] As for Castel's music of colours, the Abbé argued that both contemporary physiology and everyday experience demonstrated that the pleasure of the eyes was entirely distinct from the pleasure of the ears. He cited the English anatomist James Keill, who, in Prévost's words, claimed that "the shaking of the optic nerve cannot cause the soul to feel any direct and undeliberated pleasure." Moreover, even admitting the vibratory nature of light (which Prévost described as a "tonic" movement), Prévost suspected that the luminescent particles would cause great discomfort due to their swiftness.[66]

The most devastating attack on Castel's optical music came two years later, when Dortous de Mairan, the *secrétaire perpétuel* of the Académie royale des sciences, directly attacked the physics and physiology behind Castel's musical theory of colours in a discourse before his fellow academicians.[67] While Dortous de Mairan admitted that light and sound shared many similarities, he rejected outright Castel's theory that the sensations of colour and light bore any similarity. Unlike the *philosophe Gascon* and the Abbé Prévost, however, Dortous de Mairan used both psychological and physiological arguments to dispute Castel's claims. For one, the anatomy of the eyes was too different from that of the ears. According to Dortous de Mairan, the "softness, flexibility, and humidity of [the eye's] retina and choroid" were not only perfectly suited to receive the diversity of light's impressions; they also contrasted quite distinctly with the hardness and dryness of the membranes and the interior bones of the ear. The comparative inflexibility of the inner ear explained why listeners quickly found dissonance intolerable and why the proportions of musical harmony had undergone so little variation over time. In contrast, the flexibility of the optic nerves allowed for the enjoyment of a great variety of colour combinations.[68] The physiology of the human nervous system notwithstanding, the physics of light and sound also affected the sensations they produced in the soul. The sensation of "each primitive colour" was "absolute" and 'invariable," since each colour was itself "the result of a constant degree of speed and refrangibility." In contrast, the sensation of musical tones was entirely relative: "The D of the Opera could be the C of the Chapel, or vice versa."[69] Ultimately, while Dortous de Mairan accepted that the ears played a significant role in the pleasures of music, he was skeptical that this sensorial experience could be replicated for the eyes — unlike music, the pleasures of the visual arts were more intellectual in nature.[70]

Castel shrugged off the majority of these criticisms. Although he never replied publicly to Dortous de Mairan, he did briefly respond to the German natural philosopher Georg Wolfgang Krafft, who raised similar difficulties during a public session of the Imperial Academy of Sciences, held in in St. Petersburg on 29 April 1742. In summarizing this academic meeting, Castel reaffirmed that the "membranes of the eye [...], which are incontestably tense & elastic, must be shaken and trembling & consequently agitated, in the very act of vision, by very frequent and swift vibratory movements."[71] He added that his choice of colours in the colour-scale was by no means arbitrary, that the "accurate connection of Colours with sounds" had been the primary discovery of his optical research in the 1730s.[72] As for the supposed distinction between the pleasures of sight and the pleasures of hearing, a point raised by Krafft's colleague, anatomist Josias Weitbrecht, Castel dismissed the idea as "specious," Castel refuted with anecdotes of his own experience in observing colour harmonies in nature and in his own ocular instruments.[73]

Though the Abbé Prévost and Dortous de Mairan both relied on prominent anatomical authorities, and Weibrecht was an influential anatomist in his own right, it is worth noting that Castel's response to their objections was not without anatomical legitimacy. In the 1740s and 50s, many anatomists still used vibrating nerves and membranes to explain the transmissions of sensory stimuli, including the Montpellier physician Antoine Deidier, who explained in 1742 that the fibres of the retina transmitted impressions of light through their physical vibrations.[74] Ultimately, Castel's claims about the equivalency of the senses, or at least sensorial pleasure, could not be adjudicated on purely anatomical grounds. In the absence of a fully-functional optical harpsichord, his aesthetic claims were no easier to sort out. Unfortunately, Castel's attempts to build his new instrument hit a dead end. Over the 1730s, he claimed to have constructed several models, experimenting with paper, cloth, coloured lanterns, and even pyrotechnics.[75] It is likely one of these prototypes that Telemann observed in the late 1730s. But when Castel was relieved of his editorial duties at the *Jour-*

nal de Trévoux and subsequently left Paris for Bordeaux in 1746, it was with the harpsichord unbuilt and its music silent (or at least invisible).

III. Building the Harpsichord

In the late 1740s, the optical harpsichord began to take on new meanings for the French philosophical community, the majority of which had heard of — but not witnessed — the strange optical music that Castel had first promised in 1725. For many of the new sensationist philosophers, who dedicated themselves to exploring the relationship between the senses and the knowing, feeling soul, Castel's optico-musical philosophy seemed a relic of an antiquated philosophical system, a symbol of the rationalist "*esprit de système*" that had once dominated the intellectual scene. Only a blind man, "after many questions and many meditations on colours," the Abbé de Condillac wrote in 1749, could possibly "perceive in the sound of the trumpet the idea of scarlet."[76] Yet, with a bit more reflection, Condillac may have realized that his understanding of the senses was not so different from Castel's. After all, he did not deny that there was "harmony in colours," nor that there was also harmony in the "objects of touch, smell, and taste," but merely thought that the idea of creating "*airs*," or melodies, for each of these senses was fanciful.[77] Other mid-century philosophers shared this notion that sensorial pleasure was based in the perception of harmony. In his *Histoire naturelle de l'homme* (1749), the Comte de Buffon observed that the eyes naturally found regular and proportionate objects more beautiful, as also did the sense of touch and the sense of hearing.[78] In the *Encyclopédie* article on "Pleasure," we can similarly read an explanation of corporeal sources of pleasure strongly reminiscent of Castel's theories, noting that "the analogy that rules everywhere in nature" suggested that the law of consonance, which determined the pleasures of hearing, "influences all the sensations." It followed that, "[if] certain assortments of colours please the eyes, it is because they form as it were a consonance in the retina; this same law [of consonance] apparently extends to things able to act on the senses of smell and taste."[79]

In the late 1740s, Denis Diderot seized upon the *clavecin oculaire*, which he used to explore the relationship between the senses, harmony, and language. In *La lettre sur les sourds et muets* (1751), Diderot described how he took a man "deaf and mute from birth" to Castel's workshop on rue St. Jacques to show him the famous ocular harpsichord. The man, who had never known the experience of audible music, soon came to believe that the optical music of Castel's harpischord represented a visual translation of what those with hearing experienced when listening to music. He understood music to be "a particular way of communicating thought," and perceived that "[musical] instruments, vielles, violins, and trumpets were in our hands organs of speech."[80] Although Diderot was emphasizing a slightly different conception of musical aesthetics than Castel (along rhetorical rather than harmonic lines), he accepted the basic conceit of the harpsichord, which aimed to translate the audible experience of music into light and colour. In his *Encyclopédie* article on the "Clavecin oculaire," Diderot further emphasized the harmonic parallels between light and sound, and invited Castel to finish the project he had first announced almost three decades before.[81]

Castel would indeed return to the ocular harpsichord, but not before the instrument would be repurposed as an example of the sensory perfection to which the arts of cooking and distilling could aspire. From 1749 to 1755, three distinct proposals for savoury harmonies appeared in print.[82] In the first, the "Dissertation préliminaire" of Menon's *La science du maître d'hôtel cuisinier*, the academician Étienne Lauréault de Foncemagne posed the rhetorical question: "Shall one be thus blamed for suggesting that there is a harmony of flavours, like a harmony of sounds, and maybe that of colours and smells? [...] But who can find it wrong that I propose that there is a certain harmonious proportion between flavours, more or less similar to the one that the ear perceives in sounds, although of a different sort."[83] Four years later, in *La médecine de l'esprit*, the Parisian physician Antoine Le Camus similarly expressed the ambition that taste could be reduced to "a science as positive as Music or Painting." Neither Foncemagne nor Le Camus explored the physiological basis of their flavour harmonies in detail, although Le Camus did correlate the health of a person's mind more broadly with the healthy function of the body's fibres and fluids. In this way, the harmony of flavours represented the perfectibility of the human mind through the application of the appropriate medico-spiritual method.[84]

Remarkably, two years later, the chemist Polycarpe Poncelet published his own theory of flavour music, in *La chimie du goût et de l'odorat* (1755), a treatise otherwise dedicated to the practice of distillation. Le Camus thought the coincidence too good to be true, and accused the chemist of plagiarism.[85] In reality, however, while Poncelet shared Le Camus's desire to perfect the oft-maligned senses of taste and smell, his interpretation of an olfactory harpsichord relied more heavily on his re-appropriation of Castel's vibratory neurophysiology. Poncelet insisted that the physiological mechanisms of all the senses were essentially the same: "flavours consist of the vibrations of varying strengths of salts which act on the sense of taste, like sounds consist of the vibrations of varying strengths of the air which acts on the sense of hearing."[86] Poncelet went further, using the vibrations of flavours to argue that harmonic proportion could be applied to food and drink, and that "there could be a Music for the tongue and the palate, just as there is one for the ears."[87] Taste and smell were questions of proportion: the pairing of sweet and sour (lemon sprinkled with sugar for example) sounded the always pleasing perfect fifth, whereas sour and bitter (such as absinthe mixed with vinegar) produced the disagreeable fourth. These relationships were so precise, Poncelet argued, that they could be placed into "a new type of Organ, on which one could play all sorts of flavourful airs."[88] In fact, this instrument would be even more harmonious than the ocular harpsichord: while Castel's instrument simulated only part of the experience of viewing a painting, Poncelet claimed that his organ could fully encapsulate the pleasures of eating.[89]

Amidst all of this, Castel himself finally put the final touches on his harpsichord. In 1751, he managed to secure the patronage of the Comte de Maillebois, who eventually gave the philosopher some 2000 *livres* towards the construction of the instrument.[90] By the end of 1754, Castel had built a partially-complete working model, with which he performed at least two concerts in 1754 and 1755.[91] Unfortunately, while Castel claimed that these concerts were successful, the 1755 concert seems to have played the harpsichord's final note. When Castel died in 1757, Guillaume-François Berthier, the new editor of the *Journal de Trévoux*, lamented in his *éloge* for the deceased philosopher that, though the "*Clavecin pour les yeux*" had been built and rebuilt several times and at great cost, it had "neither fulfilled the goals of its Author, nor satisfied the expectations of the public." Berthier questioned whether Castel's ocular music was even possible: even if colours shared the same proportions as sounds, did it then follow that "the ocular Harpsichord could affect the organ of sight as the acoustic Harpsichord affects hearing, such that the soul feels in both cases a more or less equal sensation?"[92] Nevertheless, despite dismissing the ocular harpsichord as a failure in theory and in fact, Berthier wondered of Castel if, perhaps, "one day this magic made for the eyes could not equal in its own way the magnificence of the most beautiful concerts of music?"[93] If this ever came to pass, then the principles of this new art would surely be the same as those first expressed by Castel.

The fundamental ambiguity of Berthier's *éloge*, his oscillation between rejecting and allowing the possibility of expressing harmony through colour, is indicative of the complicated legacy of Castel's optical music. Indeed, despite Castel's failure to construct a working *clavecin oculaire*, despite the numerous critiques his ideas had received over the decades, none of the fundamental questions at the centre of his optico-musical philosophy, whether about the relationship between the senses, the materiality of pleasure, or the naturalization of harmony, had been resolved by the end the of the 1750s.[94] As we have seen, the physiological ideas that Castel had championed remained influential well into the second half of the eighteenth century. Castel's musical reading of vital function also experienced a medical Renaissance during this time, as French physicians began to explore the possibility of a musical therapeutics, one that aimed to re-calibrate the body through the application of audible harmony.[95] Eighteenth-century natural philosophers as a whole remained fascinated with music and its ability to describe both the materiality of vibration and the abstraction of proportion, and frequently turned to musical analogies and metaphors to describe the human being as a union of thought, feeling, and body.[96] Although the ocular harpsichord only played to limited audiences, its music resonated more broadly through these musical models of the body.

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Endnotes

1 Cf. Olivier Darrigol, "The Analogy between Light and Sound in the History of Optics from the Ancient Greeks to Isaac Newton," *Centaurus* 52, no. 2-3 (2010): 117-155, 206-257.

2 That is not to imply that Castel's affirmations that light and sound bore fundamental similarities, or that art and beauty could be grounded in reason, did not have their own eighteenth-century histories of debate and controversy. See in particular Donald Stephen Schier, *Louis Bertrand Castel, Anti-Newtonian Scientist* (Cedar Rapids, IA: The Torch press, 1941); Anne-Marie Chouillet-Roche, "Le Clavecin oculaire du P. Castel," *Dix-huitième siècle* 8 (1976): 141–166; Maarten Franssen, "The Ocular Harpsichord of Louis-Bertrand Castel: The Science and Aesthetics of an Eighteenth-Century 'Cause Célèbre,'" *Tractrix* 3 (1991): 15–77; Corinna Gepner, *Le Père Castel et le clavecin oculaire : carrefour de l'esthétique et des savoirs dans la première moitié du XVIIIe siècle* (Paris: Champion, 2014); Yoshiko Terao, "Le fixe et le fugitif : Tiphaigne, Diderot, Mical, Castel et leurs machines audiovisuelles" (PhD diss., L'Université Lumière Lyon 2, 2016).

3 The use of italics in quotations follows the original text throughout this article.

4 Carolyn Purnell has also recognized the continuities between Castel's optico-musical philosophy and the sentimental materialism of the mid-eighteenth century, although she focuses on the optical and aesthetic aspects of Castel's philosophy, to the detriment of his physiological arguments. Carolyn Purnell, "Instruments Endowed with Sensibility: Remaking Society Through the Body in Eighteenth-Century France" (PhD diss., University of Chicago, 2013), 90–162.

5 Louis-Bertrand Castel, "Clavecin pour les yeux, avec l'art de peindre les sons et toutes sortes de pieces de Musique, Lettre écrite de Paris le 20 févier 1725 par le R. P. Castel, Jésuite, à M. Decourt à Amiens," *Mercure de France* (November 1725): 2552–2577.

6 Isaac Newton, *Traité d'optique sur les reflexions, refractions, inflexions, et les couleurs, de la lumière*, trans. Pierre Coste (Paris: Chez Montalant, 1720; 1722).

7 On Newton's interest in music, see Penelope Gouk, *Music, Science and Natural Magic in Seventeenth-Century England* (New Haven and London: Yale University Press, 1999), 224–257; Peter Pesic, *Music and the Making of Modern Science* (Cambridge: MIT Press, 2014), 121–131.

8 Cf. Darrigol, "The Analogy between Light and Sound."

9 Louis-Bertrand Castel, "Principes physico-mathématiques du mécanisme de la nature dans la réfraction de la lumière," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (March 1720), 540–559. Schier

points out that Castel's optics differed slightly from Descartes', and suggests that the philosopher was perhaps influenced by the work of Christiaan Huygens. In the 1730s and 1740s, many natural philosophers identified Castel's optics with that of Nicolas Malebranche. Schier, *Louis Bertrand Castel, Anti-Newtonian Scientist*, 137–140. In the 1730s, Castel came to realize that his optical theories were in fundamental contradiction to Newton's, and attempted to refute the English philosopher's *experimentum crucis*. Cf. Louis-Bertrand Castel, *L'optique des couleurs, fondée sur les simples Observations, & tournée sur-tout à la pratique de la Painture, de la Teinture & des autres Arts Coloristes* (Paris: Briasson, 1740).

10 Athanasius Kircher, *Musurgia universalis; sive Ars magna consoni et dissoni, in X libros digesta*, vol. II (Rome: Francisci Corbelletti, 1650), Book IX, Part IV, P. I., 240.

11 Mark A. Waddell, *Jesuit Science and the End of Nature's Secrets* (Burlington, VT: Ashgate, 2015), 138. D'Alembert's *Encyclopédie* article on colour provides a cogent summary of the different ways philosophers understood colour in the eighteenth century. Jean le Rond d'Alembert, "Couleur," in *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.*, Vol. IV (1754), ed. Denis Diderot and Jean le Rond d'Alembert (University of Chicago, ARTFL Encyclopédie Project: Autumn 2017), eds. Robert Morrissey and Glenn Roe, http://encyclopedie.uchicago.edu/.

12 Cf. Jean-Louis Jam, "Castel et Rameau," in *Autour du Père Castel et du clavecin oculaire*, ed. Hervé Hasquin and Roland Mortier (Bruxelles: Éditions de l'Université de Bruxelles, 1995).

13 Louis-Bertrand Castel, Review of "*Traité de l'harmonie reduite à ses principes naturels*," by Jean-Philippe Rameau, *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (October 1722): 1719.

14 On French neo-classical aesthetics, see Jean Ehrard, *L'Idée de la nature en France dans la première moitié du XVIIIe siècle* (Paris: SEVPEN, 1963). On musical analogies in poetry and painting, see Joseph C. Allard, "Mechanism, Music, and Painting in 17th Century France," *The Journal of Aesthetics and Art Criticism* 40, no. 3 (1982): 269–279; Mishtooni Bose, "Humanism, English Music and the Rhetoric of Criticism," *Music & Letters* 77, no. 1 (1996): 1–21.

15 For much of the eighteenth century, natural philosophers considered the fibre to be the foundational structural and functional component of the human body, the ultimate material substrate of living tissue and the corporeal origin of motion and sensation. Roy Porter and Georges Vigarello, "Corps, santé et maladies," in *Histoire du Corps 1: De la Renaissance aux Lumières*, ed. Alain Corbin, Jean-Jacques Courtine, and Georges Vigarello (Paris: Editions du Seuil, 2005); Hisao Ishizuka, *Fiber, Medicine,*

and Culture in the British Enlightenment New York: Palgrave Macmillan, 2016).

16 Cf. H.F. Cohen, *Quantifying Music: The Science of Music at the First Stage of the Scientific Revolution, 1580–1650* (Dordrecht, Netherlands: D. Reidel, 1984).

17 Louis-Bertrand Castel, "Démonstration géométrique du clavecin pour les yeux & pour tous les sens, avec l'éclaircissement de quelques difficultés, & deux nouvelles Observations," *Mercure de France* (February 1726): 277–292.

18 Ibid., 282–283.

19 Cf. Giorgio Baglivi, *Tractatus de fibra motrice et morbosa* (Perugia: Apud Constantinum, 1700); Philippe Hecquet, *De la digestion des alimens, pour montrer qu'elle ne se fait pas par le moyen d'un Levain, mais par celui de la trituration ou du broyement* (Paris: Chez Françoise Fournier, 1710); Lorenz Heister, *L'Anatomie d'Heister, avec des essais de physique sur l'usage des parties du corps humain, & sur le méchanisme de leurs mouvements*, trans. Jean-Baptiste Sénac (Paris: Jacques Vincent, 1724). Castel demonstrated his familiarity with contemporary medical and physiological discoveries through his 1723 and 1724 reviews of Le Breton's translation of Sanctorius's *La médecine statique*, and Micheletti's *De separatione fluidorum*. Louis-Bertrand Castel, "Review of *De separatione fluidorum in corpore animali*, by Pietro Antonio Michelotti," *Journal de Trévoux* (July 1723): 1243–1258; Louis-Bertrand Castel, "Review of *La médecine statique*, by Sanctorius," *Journal de Trévoux* (March 1723): 436–442. The author is grateful to Jean-Olivier Richard for these references. Jean-Olivier Richard, "The Art of Making Rain and Fair Weather: The Life and World System of Louis-Bertrand Castel, SJ (1688–1757)" (PhD. diss., John Hopkins University, 2015).

20 Crousaz defined ideal beauty in terms of regularity, order, and proportion. He was particularly interested in music, because it most clearly illustrated how our senses and our bodies appreciated ideal beauty.

21 Jean-Pierre de Crousaz, *Traité du beau, Où l'on montre en quoi consiste ce que l'on nomme ainsi, par des Exemples tirez de la plûpart des Arts & des Sciences* (Amsterdam: Chez François l'Honoré, 1715), 298.

22 Interest in music's effects on the body, rather than on the soul (which effectively inverted the classic explanation of music's medicinal effects) took off in the eighteenth century, especially in the 1750s. Cf. François Boissier de Sauvages, *Dissertation où l'on recherche comment l'air suivant ses différentes qualités, agit sur le corps humain* (Bordeaux: Pierre Brun, 1754); Joseph-Louis Roger, *Tentamen de vi soni et musices in corpus humanum* (Avenione: Jacobum Garrigan, 1758).

23 Castel, "Démonstration géométrique," 282–283. For examples of the theory of vibrating nerves, see William Briggs, *Ophthalmo-Graphia*

(Petrum vander Aa: Lugd. Batavor, 1686); Isaac Newton, *Opticks: Or, a Treatise of the Reflexions, Refractions, Inflexions and Colours of Light* (London: Sam Smith and Benj. Walford, 1704); Etienne-François Geoffroy, "Diverses observations de physique générale: I (Observation sur la guérison de la morsure de la tarentule par la musique)," *Histoire de l'Académie Royale des Sciences* Année 1702, (1720): 16-18; Deidier, *Anatomie raisonnée du corps humain* (1742).

24 Castel, "Démonstration géométrique," 284.

25 Louis-Bertrand Castel, "Difficultez sur le Clavecin oculaire, avec leurs Réponses," *Mercure de France* (March 1726): 459.

26 Cf. Edwin Clarke, "The Doctrine of the Hollow Nerve in the Seventeenth and Eighteenth Centuries," *Medicine Science and Culture: Historical Essays in Honor of Owsei Temkin*, ed. Lloyd G. Stevenson and Robert P. Multhauf, (Baltimore: The Johns Hopkins Press, 1968); Karl M. Figlio, "Theories of Perception and the Physiology of Mind in the Late Eighteenth Century," *History of Science* 13, no. 3 (1975): 177– 212; Hubert Steinke, *Irritating Experiments: Haller's Concept and the European Controversy on Irritability and Sensibility, 1750– 90* (Amsterdam: Rodopi, 2005).

27 For a more detailed account of seventeenth- and eighteenth- century theories of perception, see Figlio, "Theories of Perception and the Physiology of Mind in the Late Eighteenth Century"; Gary Hatfield, "28. The Cognitive Faculties," in *The Cambridge History of Seventeenth-century Philosophy, Vol. 2*, ed. Daniel Garber and Michael Ayers (Cambridge: Cambridge University Press, 2000).

28 This issue manifested itself in the seventeenth century in the distinction between primary and secondary qualities. In the eighteenth century, philosophers increasingly emphasized touch as a baseline or foundational sense for the other four. On the distinction between primary and secondary qualities, see in particular J.J. Macintosh, "Primary and Secondary Qualities," *Studia Leibnitiana* 8, no. 1 (1976): 88–104. On eighteenth-century philosophers' investigation of sense experience in general, see Figlio, "Theories of Perception and the Physiology of Mind in the Late Eighteenth Century"; Jessica Riskin, *Science in the Age of Sensibility: The Sentimental Empiricists of the French Enlightenment* (Chicago: University of Chicago Press, 2002).

29 John Locke, *An Essay Concerning Humane Understanding* (London: Printed by Eliz. Holt, for Thomas Basset, 1690), IV, Ch. III. This psychological disconnect between the nerves and the sensations they produced echoed the ontological distinction between body and soul, since the material and corpuscular movements of the body, of the nerves and the fibres of the brain, could not cause effects in the soul without casting in doubt the soul's immateriality. Cf. John W. Yolton, *Thinking Matter: Materialism in Eighteenth-Century Britain* (Minneapolis: University of Minnesota

Press, 1983); John W. Yolton, *Locke and French Materialism* (Oxford; New York: Oxford University Press, 1991).

30 Andreas-Josephus Seron and Jean Astruc, *De naturali et praeternaturali judicii exercitio* (Montpellier: Viduam Honorati Pech, 1718); Antonius Malevergne du Masdoumier and Jean Astruc, *Dissertatio Medica de Sensatione* (Monspelii: Viduam Honorati Pech, 1720); Gabriel Moustelon and Jean Astruc, "Dissertatio medica de phantasia sive imaginatione (1723)," in *Disputationum Anatomicarum Selectarum. Volumen IIII: Sensus externi, interni, respiratio*, ed. Albrecht von Haller (Gottingen: Abram Vandenhoeck, 1749).

31 Emphraim Chambers, "Brain," in *Cyclopaedia, or an Universal Dictionary of the Arts and Sciences*, Vol. I, (London: J. and J. Knapton, 1728), 123.

32 Rondet, "Lettre écrite de Paris le 17 Fevrier 1726 par M. Rondet au R.P. Castel, Jesuite, en Réponse au Clavecin oculaire," *Mercure de France* (April 1726), 650–660.

33 Ibid., 652–653. Rondet's description of Briggs was slightly confused, but retained the acoustic analogy present in Briggs's work.

34 Rondet added that he took greater pleasure at the opera watching set changes than listening to music.

35 Rondet attributed all of these examples to John Thomas Woolhouse, an English oculist under whom he claimed to have worked. Ibid., 653–654.

36 Ibid., 656–657.

37 "Lettre d'un Philosophe Gascon au R.P. Castel, Jesuite, sur son Clavecin oculaire," *Mercure de France* (May 1726): 935–936.

38 Ibid., 933.

39 The *philosophe Gascon* was almost certainly drawing from Nicolas Malebranche's influential philosophy of perception. Cf. «Livre Premier: Des Sens,» Nicolas Malebranche, *De la recherche de la vérité. Où l'on traitte de la nature de l'esprit de l'homme, & de l'usage qu'il en doit faire pour éviter l'erreur dans les Sciences*, Vol. I (Paris: André Pralard, 1674).

40 Though "the objects of our senses can excite the same type of vibrations in the air," the unnamed philosopher wrote, "when these vibrations fall upon the sense organs, they are as diverse as the organs themselves." "Lettre d'un Philosophe Gascon," 939.

41 Ibid., 935–936.

42 Castel had arguably encouraged this kind of misinterpretation of his ideas by claiming explicitly that his instrument would "render *sound visible*."

43 Louis-Bertrand Castel, "Lettre du P. Castel, Jesuite, à M. de la Roque, écrite à Paris le 9. Juin 1725," *Mercure de France* (July 1726): 1542–1543. In support of this claim, Castel announced the format of his colour scale: violet, indigo, blue, green, yellow, orange, red, and burgundy.

44 Terao, "Le fixe et le fugitif," 198.

45 Strictly speaking, Castel had attempted to avoid these metaphysical issues by suggesting that the soul's perception of the body's harmonious movements was at the origin of the pleasures of harmony, rather than the movements of the body that triggered the sensation of pleasure in the soul. But this precision simply avoided, rather than resolved, the tricky question of soul-body interaction, and in particular the relationship between sensation and the nerves.

46 Before Luigi Galvani's experiments in electro-physiology in the late eighteenth century, European natural philosophers lacked the means to test their theories of nervous function. Although physiologists routinely argued against vibrating nerves on anatomical grounds, variations of the theory remained popular for most of the eighteenth century.

47 This account is from the anonymously published *Explanation of the Ocular Harpsichord, Upon Shew to the Public* (London: S. Hooper and A. Morley, 1757), 2–7.

48 Louis-Bertrand Castel, "Nouvelles Expériences d'Optique & d'Acoustique," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (August 1735): 1457.

49 Castel's initial results gave him the following chromatic colours: **blue**, celadon, **green**, olive, **yellow**, **apricot**, orange, **red**, crimson, **violet**, agathe, **indigo**, **blue**. He subsequently replaced indigo (which was too similar to blue) with grey, and apricot with fauve. Ibid., 1466–1468.

50 Louis-Bertrand Castel, "Nouvelles Expériences (II)," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (August 1735): 1662–1663.

51 Louis-Bertrand Castel, "Nouvelles Expériences (III)," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (September 1735): 1829–1838. Castel's use of the term "fundamental bass" reflected the influence of Jean-Philippe Rameau, who made the *basse fondamentale* the cornerstone of his new harmonic theory. Jean-Philippe Rameau, *Traité de l'Harmonie Reduite à ses Principes naturels* (Paris: De l'Imprimerie de Jean-Baptiste-Christophe Ballard, 1722); Jean-Philippe Rameau, *Génération harmonique, ou Traité de musique théorique et pratique* (Paris: Prault fils, 1737). Castel borrowed from Rameau's *Génération* even more heavily in Castel, *L'optique des couleurs*.

52 Louis-Bertrand Castel, "Nouvelles Expériences (VI)," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (December 1735): 2759–2764.

53 As in 1725, Castel also insisted that the harmonies of music corresponded to more than simply the vibrations of the nerves; they also coincided with the motions of life, in which he now included the material movements of tonic motion, and the more abstract movements of feeling and sentiment. Louis-Bertrand Castel, "Nouvelles Expériences (IV)," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (octobre 1735), 2026–2027.

54 Castel, "Nouvelles Expériences (VI)," 2753–2756.
55 The differences in aesthetic merit between French and Italian opera represented a notable *pomme de discorde* amongst French philosophers for much of the eighteenth century. Ibid., 2682. Cf. John Neubauer, *The Emancipation of Music From Language: Departure from Mimesis in Eighteenth-Century Aesthetics* (New Haven and London: Yale University Press, 1986); Cynthia Verba, *Music and the French Enlightenment: Reconstruction of a Dialogue, 1750–1764* (New York: Oxford University Press, 1993).
56 Castel, "Nouvelles Expériences (VI)," 2682.
57 Ibid., 2735.
58 Georg Philipp Telemann, "Description de l'Orgue ou Clavecin Oculaire," *Le Pour et Contre* XVIII, (1739): 323, 326.
59 Johann Gottlob Krüger, "De novo musices, quo oculi delectantur, genere," *Miscellanea Berolinensia, ad incrementum scientiarum ex scriptis Societati Regiae Scientiarum exhibitis edita* 7 (1743): 352–353.
60 Cf. Franssen, "The Ocular Harpsichord of Louis-Bertrand Castel," 37–38. Castel himself would propose a variation on the optical harpsichord in his *L'optique des couleurs*, in which he proposed a "Universal Cabinet of Colour and Chiaroscuro," capable of displaying the twelve possible octaves of his colour scale (144 tones), along with 506 possible variations. Castel, *L'optique des couleurs*, 315–347. Terao discusses the artisanal implications of Castel's theory of coloured cloth at length in "Le 'Ruban' du père Castel" and Terao, "Le fixe et le fugitif."
61 Jean Banières, *Traité phisique, de la lumière et des couleurs, du son, et des différens tons* (Paris: Chez la Veuve Mazieres & J.B. Garnier, 1737), xxiii–xxviii. Banières associated Castel's ideas with Malebranche's theory of light, according to which colours resulted from the variations in frequency in rays of light. Francesco Algarotti also associated Castel's optical harpsichord with Malebranche's theory of light, albeit with the contrary intention of rejecting it. Francesco Algarotti, *Il Newtonianismo per le dame ovvero dialoghi sopra la luce e i colori* (Naples: 1737), 138–139. Voltaire, at least initially, thought that Castel's ideas were partially compatible with Newtonian optics. Voltaire, *Élémens de la philosophie de Neuton, Mis à la portée de tout le monde* (Amsterdam: Jacques Desbordes, 1738), 184–185.
62 Banières, *Traité phisique, de la lumière et des couleurs, du son, et des différens tons*, xxxvii.
63 Ibid., xxiv.
64 Ibid., xxvii.
65 Antoine-François Prévost, «Musique des couleurs, Clavecin oculaire,» *Le Pour et Contre* VII, (1735): 16.
66 Ibid., 19.
67 The occasion of the presentation was to announce Dortous de Mairan's new theory of sound, which adapted Newtonian colour theory to

explain how different sounds could overlap one another without mutual interference. Cf. Jean-Jacques Dortous de Mairan, "Discours sur la propagation du son dans les différens tons qui le modifient," *Histoire et Mémoires de l'Académie Royale des Sciences Année 1737*, (1740): 8–9.

68 Ibid., 37–39. Castel would have disagreed. In the first article of the "Nouvelles expériences," he argued that the eye could only bear small variations in colour proportion. Moreover, with practice, the astute viewer would be able to recognize the true colour tones. Castel, "Nouvelles Expériences d'Optique & d'Acoustique," 1479.

69 Dortous de Mairan, "Discours sur la propagation du son dans les différens tons qui le modifient," 41.

70 Ibid., 43–35.

71 Louis-Bertrand Castel, "Sermones in solemni Academiæ Scientiarum, &c. C'est-à-dire, Discours prononcés publiquement dans l'Assemblée Solennelle de l'Académie Impériale des Sciences, le 29 d'Avril 1742. A Petersbourg," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (May 1743): 832.

72 Ibid., 834.

73 Ibid., 838.

74 Deidier, *Anatomie raisonnée du corps humain*, 287.

75 Franssen, "The Ocular Harpsichord of Louis-Bertrand Castel," 31–33. In the 1740s and 1750s, most natural philosophers associated Castel's music with his coloured cloths and ribbons. Purnell, "Instruments Endowed with Sensibility," 115.

76 Étienne Bonnot de Condillac, *Traité des systèmes* (La Haye: Chez Neaulme, 1749), 46.

77 Ibid., 49. Condillac was especially motivated to dismiss the harpsichord because his sensationist psychology was dependent on each of the senses being entirely distinct from one another. Étienne Bonnot de Condillac, *Traité des sensations*, 2 vols. (London & Paris: De Bure l'aîné, 1754).

78 Georges-Louis Leclerc de Buffon, *Histoire naturelle, générale et particulière, avec la description du Cabinet du roi*, Vol. III (Paris: Imprimerie Royale, 1749), 341–342.

79 "Plaisir," in *Encyclopédie,* Vol. XII (1765).

80 Denis Diderot, *Lettre sur les sourds et muets* (1751), 46–59.

81 Denis Diderot, "Clavecin oculaire," in *Encyclopédie,* Vol. III (1753). Diderot noted that unless some method be found to "tie the colours together and render them continuous for the eye," the experience of viewing the harpsichord would quickly distort one's vision.

82 These proposals can be tied to the emergences of the *nouvelle cuisine*, an eighteenth-century culinary trend which sought to elevate the status of cooking amongst the arts. Cf. E.C. Spary, *Eating the Enlightenment: Food and the Sciences in Paris* (Chicago: The University of Chicago Press,

2012), 195–242; Viktoria von Hoffmann, "Toward an Art and Science of Taste," in *From Gluttony to Enlightenment: The World of Taste in Early Modern Europe*, ed. von Hoffmann (Urbana, Chicago, and Springfield: University of Illinois Press, 2016).

83 Étienne Lauréault de Foncemagne, "Dissertation préliminaire sur la cuisine moderne," in *La science du maître d'hôtel cuisinier*, ed. Menon (Paris: Chez Paulus-du-Mesnil, 1749), vii–viii. Translation from von Hoffmann, *From Gluttony to Enlightenment*, 149.

84 Antoine Le Camus, *Médecine de l'esprit*, Vol. II (Paris: Ganeau, 1753), 82–83. On the development of the medical discourse of sensibility, see Anne C. Vila, *Enlightenment and Pathology: Sensibility in the Literature and Medicine of Eighteenth-Century France* (London: Johns Hopkins University Press, 1998).

85 "Extrait de la seconde lettre du Tome VI de l'année littéraire année 1756," *Critiques et éloges des Ouvrages de M. Le Camus et d'autres pièces fugitives* (Paris: Académie nationale de médecine, D 3899 [3]). Poncelet responded to Le Camus in 1774, writing that "the singular idea of [Castel's] harpsichord of colours alone inspired in me the idea of a flavoured Organ.'' He added that Castel's idea was itself "so natural, that it could occur to one hundred twenty people in succession without being shared between them." Polycarpe Poncelet, *Nouvelle chymie du goût et de l'odorat, ou l'art de composer facilement & à peu de frais les Liqueurs à boire & les Eaux de Senteurs* (Paris: Pissot, 1774), xxvi.

86 Polycarpe Poncelet, *Chimie du goût et de l'odorat* (Paris: P.G. le Mercier, 1755), xviii–xix.

87 Ibid., xix.

88 Ibid., xxv.

89 Ibid., xxiii.

90 For the purposes of comparison, the highest ranked members of the Académie royale des sciences, the *pensionnaires*, received an annual pension of 2000 livres. Roger Hahn, *The Anatomy of a Scientific Institution: The Paris Academy of Sciences, 1666-1803* (Berkeley Los Angeles London: University of California press, 1971), 79.

91 Schier, *Louis Bertrand Castel, Anti-Newtonian Scientist*, 183; Chouillet-Roche, "Le Clavecin oculaire du P. Castel," 147–149. See also Rondet, "Clavecin oculaire," *Mercure de France* (1755): 160–163; Louis-Bertrand Castel, "Lettre à la comtesse de Maillebois (16 March 1753)," in *Autour du Père Castel et du clavecin oculaire*, ed. Hervé Hasquin and Roland Mortier (Brussels: Éditions de l'Université de Bruxelles, 1995); Louis-Bertrand Castel, "Lettre du Père Castel, à M. Rondet, Mathématicien, sur sa Réponse au P.L.J. au sujet du Clavecin des couleurs," *Mercure de France* (July 1755): 144–158.

92 Guillaume-François Berthier, "Éloge historique du P. Castel," *Mémoires pour l'Histoire des Sciences & des beaux-Arts* (April 1757): 1110–1112.

93 Ibid.

94 On the ambiguous status of the harpsichord as a scientific instrument, see Thomas L. Hankins, "The Ocular Harpsichord of Louis-Bertrand Castel; Or, The Instrument That Wasn't," *Osiris* 9, no. 1 (1994): 141–156.

95 Cf. Boissier de Sauvages, *Dissertation où l'on recherche comment l'air suivant ses différentes qualités, agit sur le corps humain*; Roger, *Tentamen de vi soni et musices in corpus humanum*; Jean-Jacques Ménuret de Chambaud, "Musique (Effets de la)," in *Encyclopédie,* Vol. X (1765).

96 Cf. Francisco Labroquere and François Boissier de Sauvages, "Dissertatio medica de motuum vitalium causâ ubi, quæ pravus mechanismus usurpaverat naturæ seu animæ jura restituuntur" (Montpellier: Faculté de médecine de Montpellier, 1741); Charles Bonnet, *Essai de psychologie, ou Considérations sur les opérations de l'âme, sur l'habitude et sur l'éducation, auxquelles on a ajouté des principes philosophiques, sur la cause première et sur son effet* (London: [s.n.], 1755); Charles Bonnet, *Essai analytique sur les facultés de l'âme* (Copenhagen: Chez les Frères Cl. & Ant. Philibert, 1760); Denis Diderot, "La rêve de D'Alembert," in *Oeuvres complètes*, Vol. II, (Paris: Garnier Frères, 1875).