

differ not inconsiderably from those which belong to the musical scale and he is obliged, after all, to place blue and indigo together, taking their "mean rates" as corresponding with G. I do not know how far Newton's measurements are correct; but I find that Professor Zannotti, of Naples, gives for the diameters of the rings from red to red the cube-roots of the numbers 1, $\frac{8}{3}$, $\frac{27}{8}$, $\frac{64}{27}$, $\frac{125}{64}$, $\frac{216}{125}$. The intervals between these, taken successively, are $\frac{8}{27}$, $\frac{16}{81}$, $\frac{10}{27}$, $\frac{8}{81}$, $\frac{10}{27}$, $\frac{8}{81}$; that is—major-tone, semi-tone, minor-tone, major-tone, minor-tone, $\frac{1}{2}$ -tone, major-tone. Calling the major-tone M , the minor tone m , and the semi-tone x , for the sake of brevity. I will give the five different forms of which the musical scale is capable—expressed by the succession of intervals—and show that the above series of intervals is one of them:—

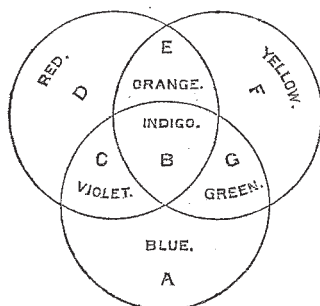
	D,	E,	F,	G,	A,	B,	C,	D
(1)	m	x	M	m	M	x	M	or Sintono.
(2)	M	x	m	M	m	x	M	or Newton's scale of colours.
(3)	M	x	M	m	M	x	m	
(4)	m	x	M	M	m	x	M	
(5)	M	x	m	M	M	x	m	

Varieties depending upon the permutation of the quantities M , m , and x . The 1st contains the imperfect fifth, DA ; the 2nd two such fifths, EB and FC ; the 3rd GD ; the 4th A_2E_3 ; and the 5th the imperfect fifth, C_2G_3 —all of course with their corresponding augmented fourths.

Thus, Newton's scale of colour is one of a series of five scales of sound, all requiring modification by a *comma* of one, or at the most two-fifths; but all are found of perfect major and minor tones and major semitones. If the correlation between colour and sound exists, I think it will be found here. If this be admitted, the colours and notes corresponding are as follows:—

D, E, F, G, A, B, C, D

Red, Orange, Yellow, Green, Blue, Indigo, Violet, Red;
or better according to the figure—



Thus the series of colours corresponds with the Gregorian Scale of the *first mode* and not with the modern scale of C . I may remark, by the way, that the ancient Greek *plain chant* is said sometimes to have a notation in which the notes are distinguished by different colours. It would be interesting to know whether such a notation has any scientific foundation.

In conclusion, I would say, that Newton's rings give a far more clear division of the colours that we get in the spectrum and the distinction between blue and indigo is too well defined to warrant them to be treated as Mr. Barrett has done. No doubt the neighbourhood of indigo is a difficult one and to make the correlation with sound complete, this colour itself ought to be divided into two; indigo-blue and indigo-violet corresponding to the notes B_0 and B_1 , both of which are required to obtain the fourths and fifths all perfect. Allow me to inquire if there be any marked line in the red, dividing it into two reds separated by the interval $\frac{8}{27}$? I ask this question because the Sintono Scale (1) requires two D's differing by this interval, to complete its intervals of fourths and fifths. Also, would the correction of the fifths, &c., in the other four scales given above, by the introduction of one or two new notes, be such that these notes can be made to correspond to marked divisions in the spectrum or to like divisions in the series of colours determined by Newton's method?

W. S. OKELY

THE supposed analogy between the spectrum and the musical scale is not strictly accurate, because in the former the colours blend into one another imperceptibly, while the notes of the latter are separated by distinct intervals.

Yet it is precisely on this blending of the colours that the pleasing effect of the spectrum depends. If we place red, orange, yellow, &c., in their order, in immediate juxtaposition, as distinctly defined bands, we obtain precisely that arrangement which is admittedly distasteful.

The chromatic scale, as its name implies, approaches more nearly to the spectrum than does the diatonic; but the spectrum would be still better represented by the sliding tones produced by running the finger up the sounding string of a violin.

But leaving this objection, which may be thought too critical, I would remark, that the analogy which Mr. Barrett points to is rather one of melody than of harmony.

In the case of a musical concord, the two notes fall simultaneously on the ear and are perceived as one compound sound, the effect of which is very different from that produced by sounding the notes in succession, however rapid; yet this last is what rather seems to correspond to the sensation produced by two colours placed in juxtaposition, the eye passing rapidly from the one to the other. To obtain the optical analogue of a musical concord, the colours ought to be received simultaneously on the retina—in other words, should be blended. Could not this be accomplished by producing two distinct spectra by means of two prisms and causing the so-called harmonious colours in either to overlap one another on the screen? Blending thus, for example, those rays of the two spectra whose vibrations are to one another in the ratio of 100 to 75, their resultant (a purple of some sort, I suppose) would give us the true analogue of the fifth in music.

Similar experiments, I am aware, have been made by causing patches of colours to rotate upon a disc so rapidly that they are in effect blended upon the retina; but some modification of the method above suggested would seem to have the immense advantage of enabling the experimenter to combine colours whose wave-lengths would be in any desired ratio.

I should be curious to know whether the result of such an experiment would be that the compound tint produced by the two rays would be more or less agreeable, the more or less nearly its component parts were in the exact musical ratio; also whether, when the two colours were slightly "out of tune," we should have the phenomena of "interference" presenting themselves analogous to the "beats" in music.

A curious speculation here suggests itself. It is well known that what are called complementary colours—red and green, for instance—produce, if combined in due proportions, white.

Proceeding by the above method, then, should we find that the particular tints of red and green necessary to produce white, are those whose ratio is exactly that of the musical fourth? If so, white is as much entitled to a place in our catalogue of colours as purple or any other harmonised compound.

If white is not the optical representative of the musical fourth, where shall we look for its analogue in the latter science? Can any of your readers suggest a method of producing a *white sound*? "White," we know, is the resultant of the blending of the whole rays of the spectrum—i. e., of the same part of the retina simultaneously receiving rays whose wave-lengths pass imperceptibly through every conceivable shade of difference.

If it were possible for a violinist to slide his finger up the string of his instrument in such a way that, instead of producing a sound varying in pitch, every part of the string passed over should continue to sound simultaneously with every other part; or, if we can suppose some millions of violinists each sounding a note inappreciably higher than his neighbour, but comprehending among them every conceivable shade of pitch within the octave, we might possibly obtain the purest and most æthereal of tones, a "White Sound!"

Edinburgh, Jan. 24

FRANCIS DEAS

Government Aid to Science

WILL you allow me, with the utmost respect, to remind your able correspondent, that *every individual* in the state pays taxes for ignorance and inefficiency; while so interwoven are the interests of man with man—so often does inquiry after the most abstract principles lead to valuable practical results, that it is impossible to predict in which department of Science discoveries may be made that shall materially lighten these unsatisfactory imposts. Hence the field of research should be open to all and

every facility afforded. If this be not the duty of the State it is difficult to explain its *raison d'être*.

The question from the economical point of view is—Shall we pay heavy rates for prisons and workhouses, or shall we try to lighten them by the spread of education? It is well to remember that the law of supply and demand will not avail here, for they who most want it are the least likely to ask for instruction. Perhaps, Mr. Wallace's chief objection is to the unsatisfactory way the money raised by rating, is expended. And here is room for large reforms, if not retrenchment. His proposal regarding the British Museum seems admirable. It is painful to see what excellent opportunities for teaching those who really require it, are lost in that magnificent collection, for want of a little, a *very little*, more expense and trouble.

These remarks are made from the very lowest stand-point, the principle of self-interest—a principle, I believe, your correspondent would heartily despise; for the man of science is essentially liberal, essentially averse to huckstering calculations of profit and loss, essentially unqualified for scrambling after loaves and fishes.

E. G. A.

Kant's View of Space

I AM quite willing to leave the readers of NATURE and the students of Kant to decide on the propriety, in English philosophical discourse, of calling Space and Time "forms of Thought," the more so as Sir W. Hamilton—a great stickler for philosophic precision—uses the term in that sense and would have been surprised to hear that he had misrepresented Kant in so doing. My opponents persist in limiting the term Thought to the restricted meaning given to it in Kant's terminology, which, in English, is restricting it to Conception or Judgment: on this ground they might deny that Imagination or Recollection could be properly spoken of as Thought. Throughout I have accepted Thought as equivalent to mental activity in general and the "forms of Thought" as the conditions of such activity. The "forms of Thought" are the forms which the thinking principle (Kant's *pure Reason*) brings with it, antecedent to all experience. The thinking principle acts through three distinct faculties: Sensibility (Intuition), Understanding (Conception), and Reason (Ratiocination): to suppose Thought absent from Intuition, is to reduce Intuition to mere sensuous impression. Therefore, whatever is a form of Intuition must be a form of Thought.

The following passage from Mr. Mahaffy's valuable translation of Kuno Fischer's work on Kant, may here be useful: "Sensibility and understanding are cognitive faculties differing not in degree but in kind, and form the *two original faculties of the human mind*" The general problem of a Critick of the Reason "is subdivided into two particular objects, as human Reason is into two particular faculties of knowledge. The first object is the investigation of the sensibility; the second, that of the understanding. The first question is, How is rational knowledge possible through sensibility? The second question, How is the same knowledge possible through the understanding?" (pp. 4, 5.)

Those who maintain that it is improper to speak of Space and Time as forms of Thought, must either maintain that Kant held Sensibility *not* to be a faculty of the Mind (thinking principle); or that the term Thought is *not*, in English discourse, a correct expression for the activity of the thinking principle. I believe that the student will agree with me in saying that, although Kant restricted the term Thought to what we call Conception or Judgment, he understood by the activity of the mental faculties (Pure Reason) what we understand by Thought.

It is not, however, to continue this discussion that I again trespass on your space; but to reply to the personal part of Mr. Sylvester's letter. He charges me with misquoting myself and with misquoting him. I said that, in my exposition, Space and Time were uniformly spoken of as forms of Intuition and I say so still. Mr. Sylvester has taken the trouble of reading that exposition without taking the trouble of understanding it; he declares that he "has marked the word intuition as occurring once and forms of sensibility several times; but forms of intuition never." His *carefulness* may be estimated by the fact that the word intuition occurs *four* times on the two pages: his *comprehension* by the fact that it is perfectly indifferent whether Sensibility or Intuition be the term employed, since sensibility is the faculty and Intuition the action of that faculty. Mr. Sylvester, not understanding this, says "If form of sensibility is as good to use as form of intuition, form of understanding ought to be as good as form of thought; but Mr. Lewes owns that the former is indefensible, whilst he avers that the latter is

correct." Considering that this passage occurs in a letter which charges me with unfair misquotation, it is curious. So far from owning that the former is "indefensible," it is what I declare to be true; and, with regard to the latter, though I do think a form of Understanding is a form of Thought, my statement was altogether *away* from it, namely, that Space and Time as forms of Sensibility, would be incorrectly spoken of as forms of the Understanding.

With regard to the alleged misquotation of his own words, which he characterises as unfair and as "too much like fighting with poisoned weapons," it was a charge which both astonished and pained me. There are few things for which I have a bitterer contempt than taking such unfair advantages of an adversary. I beg to apologise to Professor Sylvester for any misrepresentation which, unintentionally, I may have been guilty of. But, in accepting his denial of the construction I placed upon his language, I must still say that, after re-reading his letter, I am at a loss to see what other construction it admits of, that has any bearing on the dispute, and that he has not expressed his meaning with sufficient clearness. Intuition and Thought are there compared with Force and Energy as terms "not convertible"; Force is detached from Energy as potential from actual and Intuition without Thought, is made to hold an analogous position. Here is the passage; let the reader judge:—

"Can Mr. Lewes point to any passage in Kant where Space and Time are designated *forms of Thought*? I shall indeed be surprised if he can do so—as much surprised as if Mr. Todhunter or Mr. Routh in their Mechanical Treatises were to treat *energy* and *force* as convertible terms. To such a misuse of the word energy it would be little to the point to urge that *force without energy is a mere potential tendency*. It is just as little to the point, in the matter at issue, for Mr. Lewes to inform the readers of NATURE that *intuition without thought is mere sensuous impression*."

Is it to use "poisoned weapons" to interpret this as assuming that Intuition and Thought differ as potential and actual? I repeat that, since Mr. Sylvester disclaims the interpretation, my only course is to apologise for it; but, after his own misinterpretations of me, he will not, I hope, persist in attributing mine to a desire to take an unfair advantage. If I make no reply to the other points roused in the various letters it is in order not to prolong the discussion.

GEORGE HENRY LEWES

I DO not know whether Mr. Sylvester and Dr. Ingleby will be satisfied with Mr. Lewes' letter in yours of the 27th. I am not and I think, in defending his former mistake, Mr. Lewes has fallen into additional errors.

It is undoubtedly fair to translate an author into your own language before criticising him, provided you found no criticism on the language that you have put into his mouth. But this I think Mr. Lewes has done. He accuses Kant of inconsistency in speaking of pure *à priori* cognitions, when, on his own system, pure thought only supplies one element to these cognitions, the other being derived from sense or intuition. Now (not to insist here that Kant constantly uses the term cognition in a wider sense than that which Mr. Lewes insists on fastening upon him), this criticism is evidently invalidated by the simple remark that Kant admits pure intuitions, as well as pure concepts and explains the nature of mathematics, as a system of *à priori* cognitions, by the fact that its object-matter consists of nothing but pure intuitions.

Mr. Lewes now informs us that Kant's Intuition and Thought "differ as species and genus." According to Kant they differ in kind; and Leibnitz was as wrong in making sensibility a species of thought as Locke was in making Thought a species of sensibility. Space and Time, Mr. Lewes adds, are forms of "mental activity" and, therefore, are properly termed "forms of Thought," in the meaning of the latter term which is usually current in this country. If they were forms of mental activity they would be forms of Thought, according to Kant, likewise; for the criterion by which Kant distinguishes between Intuition and Thought (under which term he includes both the understanding proper and the reason proper) is that, in the former, the mind is passive (receptive) while, in the latter, it is spontaneously active; and it is precisely on this ground—the passive reception of them by the mind—that he refers Space and Time to Sensibility rather than Thought. This is repeatedly brought out in the Transcendental Deduction of the Categories. See in particular Sections 11 (Meiklejohn, p. 80) and 18 (Meiklejohn, p. 90).