An Extract of Mr Isaac Newton's Letter … concerning the Number of Colors

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***An Extract of Mr*. Isaac Newton's *Letter, written to the Publisher from* Cambridge April 3. 1673. *concerning the Number of* Colors, *and the Neccessity of mixing them all for the production of* White; *as also touching the Cause why a Picture cast by Glasses into a darkned room appears so distinct notwithstanding its Irregular refraction: (Which Letter, being an Immediat answer to that from* Paris, *printed* N^{o}. 96. p. 6086. *of these* Tracts, *should also, if it had not been mis-laid, have immediately followed the same*.**

IT seems to me, that *N*. takes an improper way of examining the nature of *Colors*, whilst he proceeds upon compounding those that are already compounded; as he doth in the former part of his Letter. Perhaps he would sooner satisfie himself by resolving Light into Colors, as far as may be done by Art, and then by examining the properties of those colors apart, and afterwards by trying the effects of re-conjoining two or more or all of those; and lastly, by separating them again to examine, what changes that re-conjunction had wrought in them. This, I confess, will prove a tedious and difficult task to do it as it ought to be done; but I could not be satisfied, till I had gone through it. However, I only propound it, and leave every man to his own method.

As to the Contents of his Letter, I conceive, my former Answer to the *Quære* about the *Number* of *Colors* is sufficient, which was to this effect; That all colors cannot practically be derived out of the *Yellow* and *Blew*, and consequently that those *Hypotheses* are groundless which imply they may. If you ask, What colors cannot be derived out of *yellow* and *blew*? I answer, none of all those which I defin'd to be Original; and if he can shew by experiment, how they may, I will acknowledge my self in an error. Nor is it easier to frame an *Hypothesis* by assuming only two Original colors rather than an indefinit variety; unless it be easier to suppose, that there are but two figures, sizes and degrees of velocity or force of the Æthereal corpuscles or pulses, rather than indefinit variety; which certainly would be a harsh supposition. No man wonders at the indefinit variety of Waves of the Sea, or of sands on the shore; <6109> but, were they all but two sizes, it would be a very puzling *phænomenon*. And I should think it as unaccountable, if the several parts or corpuscles, of which a shing body consists, which must be suppos'd of various figures, sizes and motions, should impress but two sorts of motion on the adjacent Æthereal *medium*, or any other way beget but two sorts of Rays. But to examine, how Colors may be explain'd *hypothetically*, is besides my purpose. I never intended to shew, wherein consists the Nature and Diffrence of colors, but only to shew, that *de facto* they are Original and Immutable qualities of the Rays which exhibit them; and to leave it to others to explicate by Mechanical *Hypotheses* the Nature and Difference of those qualities: which I take to be no difficult matter. But I would not be understood, as if their Difference consisted in the Different Refrangibility of those rays; for, that different Refrangibility conduces to their production no otherwise, than by separating the Rays

whose qualities they are. Whence it is, that the same Rays exhibit the same Colors when separated by any other means; as by their different *Reflexibility*, a quality not yet discoursed of.

In the next particular, where *N*. would shew, that it is not necessary to mix all Colors for the production of *White*; the mixture of *Yellow, Green*and *Blew*, without *Red* and *Violet*, which he propounds for that end, will not produce *White*, but *Green*; and the brightest part of the Yellow will afford no other colour but Yellow, if the Experiment be made in a room well darkn'd, as it ought; because the Colour'd light is much weaken'd by the Reflexion, and so apt to be diluted by the mixing of any other scattering light. But yet there is an Experiment or two mention'd in my Letter in the *Transactions Numb*. 88, by which I have produced *White* out of two colorsalone, and that variously, as out of *Orange* and a *full Blew*, and out of *Red* and *pale Blew*, and out of *Yellow* and *Violet*, as also out of other pairs of Intermediat colors. The most convenient Experiment for performing this, was that of casting the colors of one Prisme upon those of another, after a due manner. But what *N*. can deduce from hence, I see not. For the two colors were compounded of all others, and so the resulting White, (to speak properly,) was compounded of them all, <6110> and only de-compounded of those two. For *instance*, the *Orange* was compounded of Red, Orange, Yellow and some Green; and the *Blew*, of Violet, full Blew, light Blew, and some Green, with all their Intemediat degrees; and consequently the Orange and Blew together made an Aggregate of all colors to constitute the White. Thus, if one mix red, orange and yellow Powders to make an Orange; and green, blew, and violet colors to make a Blew; and lastly, the two mixtures, to make a Grey; that Grey, though de-compounded of no more than two Mixtures, is yet compounded of all the six Powders, as truly as if the powders had been all mixt at once.

This is so plain, that I conceive there can be no further scruple; especially to them who know how to examine, whether a colour be simple or compounded, and of what colors it is compounded; which having explained in another place, I need not now repeat. If therefore *N*. would conclude any thing, he must shew, how White may be produced out of two *Uncompounded* colors; which when he hath done, I will further tell him, why he can conclude nothing from that. But I believe, there cannot be found an Experiment of that kind; because, as I remember, I once tryed, by gradual succession, the mixture of all pairs of Un-compounded colors; and, though some of them were paler, and nearer to White, than others, yet none could be truly call'd White. But it being some years since this tryal was made, I remember not well the circumstances, and therefore recommend it to others to be tryed again.

In the last place, had I thought, the Distinctness of the Picture, which (for *instance*) a Twelf foot Object glass casts into a darken'd room, to be so contrary to me as *N*. is pleased to affirm, I should have waved my Theory in that point before I propounded it. For, that I had thought on that difficulty, you may easily guess by an expression, somewhere in my first Letter*[1] , to this purpose; That I wonder'd, how Telescopes could be brought to so great perfection by Refractions which were so Irregular. But, to take away the difficulty, I must acquaint you *first*, That, though I put the greatest Lateral error of the rays from one another to be about $\frac{1}{50}$ of the Glasses diameter; yet their greater error from the Points on which they ought to fall, will be <6111> but $\frac{1}{100}$ of that diameter: And *then*, that the rays, whose error is so great, are but very few in comparison to those, which are refracted more Justly; for, the rays which fall upon the middle-parts of the Glass, are refracted with sufficient exactness, as also are those that fall near the *perimeter* and have a *mean* degree of Refrangibility; So that there remain only the rays, which fall near the perimeter and are *most* or *least* refrangible to cause any sensible confusion in the Picture. And these are yet so much further weaken'd by the greater space, through which they are scatter'd, that the Light which falls on the due point, is infinitely more dense than that which falls on any other point round about it. Which though it may seem a *Paradox*, yet is certainly demonstrable. Yea, although the Light, which passes through the middle parts of the Glass, were wholly intercepted, yet would the remaining light convene infinitely more dense at the due points, than at other places. And by this excess of Density, the Light, which falls *in* or invisibly *near* the just point, may, I conceive, strike the *sensorium* so vigorously, that the impress of the weak light, which errs round about it, shall, in comparison, not be strong enough to be animadverted, or to cause any more sensible confusion in the Picture than is found by Experience.

This, I conceive, is enough to shew, Why the Picture appears so distinct, notwithstanding the Irregular refraction. But, if this satisfie not, *N*. may try, if he please, how distinct the Picture will appear, when all the *Lens* is cover'd excepting a little hole next to its edge on one side only: And, if in this case he please to

measure the breadth of the colors thus made at the edge of the Suns picture, he will perhaps find it to approach nearer to my proportion than he expects.

[1] * *See* Numb. 80. p. 3079.