Answer to Huygens' critique of Newton's new theory of light and colours, dated 10 June 1673

Author: Isaac Newton

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LB. 6. 152.

(Pr. Trans: 96.)

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Mr Newton's Letter upon his receipt of Monsieur Hugens's Book de Motu Pendulorum, together with some considerations upon it; as also an Answer to the same M. Hugens's Letter of June 10. 1673; in which Answer he further explains his New Theory of Light and Colors, and particularly that of Whiteness, etc.

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Sir

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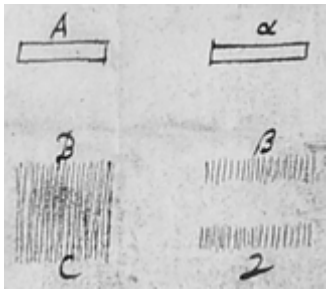
Concerning the bussiness of colours; in my saying that when M. Hugens hath shown how White may be produced out of two uncompounded colours, I will tell him why he can conclude nothing from that; my meaning was, that such a White, (were there any such,) would have different properties from the White, which I had respect to, when I described my Theory, that is, from the white of the Sun's immediate light, of the ordinary objects of our senses, & of all white Phænomena that have hitherto faln under my observation. And those different properties would evince it to be of a different constitution: Insomuch that such a production of white would be so <47v> far from contradicting, that it would rather illustrate & confirm my Theory; because by the difference of that from other whites it would appear that other whites are not compounded of onely two colours like that. And therefore if Monsieur N. would prove any thing, it is requisite that he do not onely produce out of two primitive [2]colours a white which to the naked eye shall appear like other whites, but also shall agree with them in all other properties.

But to let you understand wherein such a white would differ from other whites & why from thence it would follow that other whites are otherwise compounded, I shall lay down this position

That a compounded colour can be resolved into no more simple colours
then those of which it is compounded.

This seems to be self evident, & I have also tryed it severall ways, & particularly by this which follows: Let α represent an oblong piece of white paper about $\frac{1}{2}$ or $\frac{1}{4}$ of an inch broad & illuminated in a dark room with a mixture of two colours cast upon it from two Prisms, suppose a deep blew & scarlet, which must severally be as uncompounded as they can conveniently be made. Then at a convenient distance, suppose of six or eight yards, view it through a clear triangular glass or crystall Prism held parallel to the paper & you shall see the two colours parted from one another in the fashion of two images of the paper as they are represented at β & γ where suppose β the scarlet & γ the blew, without green or any other colour between them.



Now from the afforesaid Position I deduce these two conclusions: 1 That if there were found out a way to compound white of two simple colours onely, that white would be again resolvable into no more then two. Secondly That if other whites (as that of the suns light &c) be resolvable into more then two simple colours (as I find by experiment that they are) then they must be compounded of more then two.

To make this plainer, suppose that A represents a white body illuminated by a direct beam of the sun transmitted through a small hole into a dark room, & α such another body illuminated by a mixture of two simple colours which if possible [3]may make it also appear of a white colour exactly like A. Then at a convenient distance view these two whites through a Prism & A will be changed into a series of all colours, Red, Yellow, Green, Blew, Purple with their intermediate degrees succeeding in order from B to C. But α, according to the afforesaid experiment, will onely yeild those two colours of which it was compounded, & those not conterminate like the colours at BC but separate from one another, as at β & γ, by means of the different refrangibility of the rays to which they belong. And thus by comparing these two whites, they would appear to be of a different constitution & A to consist of more colours then α. So that what Monsieur N. contends for, would rather advance my Theory by the access of a new kind of white then conclude against it. But I see no hopes of compounding such a white.

As for Monsieur N. his expression that I maintain my doctrine with some concern I confess it was a little ungratefull to me to meet with objections which had been answered before, without having the least reason given me why those answers were insufficient. The answers which I speak of are in the Transactions from pag 5093 to pag 5102. And particularly in pag 5095, to show that there are other simple colours besides blew & yellow, I instance in a simple or homogeneal green such as cannot be made by mixing blew & yellow or any other colours. And there also I show why, supposing that all colours might be produced out of two, yet it would not follow that those two are the onely originall colours. The reasons I desire you would compare with what hath <47ar> been now said of white. And so the necessity of all colours to produce white might have appeared by the experiment pag 5097 where I say that if any colour at the Lens be intercepted the whiteness (which is compounded of them all) will be changed into (the result of) the other colours.

However, since there seems to have happened some misunderstanding between us, I shall indeavour to explain my self a little further in these things according to the following method.

Definitions.

1. I call that Light homogeneal, similar or uniform whose rays are equally refrangible.

2. And that heterogeneal whose rays are unequally refrangible.

Note. There are but three affections of light in which I have observed its rays to differ. viz: Refrangibility, Reflexibility & Colour, & those rays which agree in refrangibility agree also in the other two & therefore may well be defined homogeneal: especially since men usually call those things homogeneal which are so in all qualities that come under their knowledg, though in other qualities that their knowledg extends not to there may possibly be some heterogeneity.

3. Those colours I call simple, or homogeneal, which are exhibited by homogeneal light.

4**{.}** And those compound or heterogeneal which are exhibited by heterogeneal light.

5**{.}** Different colours I call not, onely the more eminent species, red, yellow, green, blew, purple, but all other the minutest gradations: much after the same manner that not onely the more eminent degrees in musick but all the least gradations are esteemed different sounds.

Propositions.

1. The Sun's light consists of rays differing by indefinite degrees of refrangibility.

2. Rays which differ in refrangibility, when parted from one another do proportionally differ in the colours which they exhibit. These two Propositions are matter of fact.

3. There are as many simple or homogeneal colours as degrees of refrangibility. For to every degree of refrangibility belongs a different colour by Proposition 2. And that colour is simple by Definition 1, & 3.

4. Whiteness in all respects like that of the Sun's immediate light & of all the usuall objects of our senses cannot be compounded of two simple colours alone. For such a composition must be made by rays that have onely two degrees of refrangibility by Definition 1, & 3.; & therefore it cannot be like that of the suns light by Proposition 1; Nor for the same reason like that of ordinary white objects.

[4]5. Whiteness in all respects like that of the Sun's immediate light cannot be compounded of simple colours, without an indefinite variety of them. For to such a composition there are requisite rays indued with all the indefinite degrees of refrangibility by Proposition 1. And those infer as many simple colours, by Definition 1 & 3. & Proposition 2 & 3**{.}**

To make these a little plainer, I have added also the Propositions that follow.

6. The rays of light do not act on one another in passing through the same Medium. This appeares by several passages in the Transactions pag. 5097, 5098, 5100, & 5101, & is capable of further proof.

7. The rays of light suffer not any change of their qualities from refraction**{.}**

8. Nor afterwards from the adjacent quiet Medium. These two Propositions are manifest de facto in homogeneal light, whose colour & refrangibility is not at all <47av> changeable either by refraction or by the contermination of a quiet Medium. And as for heterogeneal light, it is but an aggregate of severall sorts of homogeneal light no one sort of which suffers any more alteration then if it were alone becaus the rays act not on one another by Proposition 6. And therefore the aggregate can suffer none. These two Propositions also might be further proved apart by Experiments, too long to be here described.

9. There can no homogeneal colours be educed out of light by refraction which were not commixt in it before: Because by Proposition 7, & 8, Refraction changeth not the qualities of the rays, but onely separates those which have divers qualities, by means of their different Refrangibility**{.}**

10. The sun's light is an aggregate of an indefinite variety of homogeneal colours; by Proposition 1, 3, & 9. And hence it is, that I call homogeneal colours also primitive or original. And thus much concerning colours.

Monsieur N. has thought fit to insinuate that the aberration of rays (by their different refrangibility) is not so considerable a disadvantage in glasses as I seemed to be willing to make men beleive when I propounded concave mirrors as the onely hopes of perfecting Telescopes. But if he please to take his pen & compute the errors of a Glass & Speculum that [5]collect rays at equall distances, he will find how much he is mistaken, & that I have not been extravagant, as he imagins, in preferring reflexions. And as for what he says of the difficulty of the praxis I know it is very difficult, & by those ways which he attempted it I beleive it unpracticable. But there is a way insinuated in the Transactions pag. 3080 by which it is not improbable but

that as much may be done in large Telescopes, as I have thereby done in short ones, but yet not without more then ordinary diligence & curiosity.

Your humble Servant

I. Newton

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Cambridg. June 23. 73.

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H Relation

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[1] *The contents of this note are only visible in the diplomatic transcript because they were deleted on the original manuscript*

[2] N 6 **{**8. 6.**}{**p. 6.**}{**n. 6.**}**

[3] N 7

[4] *The contents of this note are only visible in the diplomatic transcript because they were deleted on the original manuscript*

[5] N 6 P 2 6092