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ORDINARILY EMPLOYED BY RAILWAY SUR-  
GEONS FOR THE DETECTION OF SUBNOR-  
MAL COLOR-PERCEPTION (COLOR-  
BLINDNESS).

By CHARLES A. OLIVER, A. M., M. D.,

ONE OF THE ATTENDING SURGEONS TO THE WILLS' EYE HOSPITAL; ONE  
OF THE OPHTHALMIC SURGEONS TO THE PHILADELPHIA  
HOSPITAL; OPHTHALMIC SURGEON TO THE  
BALTIMORE AND OHIO RAIL-  
WAY COMPANY, ETC.

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As illustrative of the first inefficiency, as long ago as 1855, George Wilson, of Scotland, one of the first medical men and scientists to practically study the relationship existing between imperfect color-vision and railway travel, and to actually put into use the best methods of detecting the imperfection, found as the result of numerous examples and experiments, that not only may color be recognized correctly at short distances and not distinguished at longer ones where such colors are plainly discernible to the normal-sighted, but that the sensitiveness to the colors whilst being gazed at, becomes more quickly lost as they are removed from the eye of the "color-blind," than when they are removed from the unimpaired visual organ.

To these findings he gave the somewhat graphic, yet imperfect, term, "chromic myopia," or "short-sightedness to color," which he said that, as far as he was aware, "has not hitherto been generally recognized."

Established as one of the necessities to his proposed plans of testing railway employees for imperfect color-perception, it has, in most instances, been set aside by sweeping, yet ridiculous assertions of inconvenience, impracticability, chance of imperfec-

\*Paper read before the June, 1896, meeting, of the Medical Association, of the Baltimore and Ohio Railway Surgeons.

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tion of examination, untrustworthiness, etc.; assertions that will apply much more forcibly to the methods that are now so universally used; loose wool-selection at one or two meters' distance.

Here, instead of the test being made at what the present writer has designated as the distances that are requisite for future safety, they are performed at so close a range to the candidate, that the results never can be depended upon as of any practical value for the safety of life and property, when such eyes are engaged in actual service upon rapidly-moving trains that follow one another in quick succession. That any previous test should be efficient, when the visual organs are placed under such circumstances, it is requisite that it should be made where they are situated, under similar conditions and whilst they are placed in the same position as they would be when it becomes necessary that they should be the sole means of exercising prompt action in the avoidance of a threatening accident or imminent disaster.

One or two meters' distance away from the point which determines the presence or the absence of a catastrophe, is, as all practical railway men know, entirely too close for the avoidance of unfortunate results during subsequent impending danger. A laden engine, moving with the rapidity of 20 to 25 meters each second, would have been propelled into destruction long before any engineer could check its speed. In other words, the recognition of the signal must be determined at a safe point; it must be made at a sufficient distance to properly control the moving mass. To do this, the visual organ which has almost sole charge of this function, must necessarily be able to differentiate color when it is placed at a safe distance; it must have been previously tested to do it at that distance; and the testing must have been done when the eyes were placed under the same conditions and under similar circumstances as when they are employed during actual work.

In the acquired color defects, produced by the introduction of toxic agents into the system, such as tobacco, and which appear in the part of the field of vision that is used when any object is gazed at, the testing with large massings of color placed at short distances from the eyes, as in the ordinary wool-tests, becomes useless; here another worse than inefficiency come into play. As the central blind or dimmed area in the field of vision does not always include the whole surface of any of the skeins of wool, the candidates may be passed, thus allowing this most dangerous class of subjects to be placed in service where they cannot differentiate the color of signal boards and lights, or even distinguish them, as in one instance seen by the writer,

where he found a case of tobacco amblyopia actually at work upon an immense railway system, after having successfully passed the near wool-test.

At about the same time that Wilson applied his findings to color-testing amongst railway employees, Lees, of the Edinburgh, Perth and Dundee Railway, pointed out another inefficiency. He stated that it was well known that the different degrees of vividity of equal areas of red and white illumination (in fact of any color) produced alterations in impressions regarding their relative distance from one another.<sup>1</sup> Based upon this, he asserted that "a red light seen from a distance seems much further than a colorless light side by side with it, the eye assigning a less proximity to the less luminous lamp, in conformity with its experience of the different apparent brightness of lights of the same color and luminosity placed at different distances from it."<sup>2</sup>

To remedy this in railway color-testing, both the areas of reflected and transmitted color material employed, should be graded in size and intensity of tone into proportionate amounts, thus making every color used in the tests of the same distance-value.<sup>3</sup> That they are not, is too well known: that they should be, is an absolute certainty.

A third inefficiency in color-testing of this class of subjects, is where there is the want of consideration of the situation in which the testing is done.

The examinations should be conducted in places where the visual organs are to be employed and under the same circumstances in which they will be placed during actual work. The test should

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<sup>1</sup>This, which is just as true, though somewhat less noticeable by diffuse daylight, where the colors, as a rule, appear darker, is markedly seen when the color-hues are strengthened in brightness by being projected against the dark background of night.

<sup>2</sup>These are facts, that are well understood by painters and colorists, who make use of them in their dispositions of strongly and weakly reflecting color-areas, upon flat surfaces, in order to give effects of perspective and so-called warm and cold tone-contrasts.

The application of the rule of simultaneous contrasts to railway work may often be aggravated or even absolutely perverted when new color impressions produced by subjective after-color, as for example, as commented upon in the case of a serious collision, which occurred many years ago upon one of the Irish railways, in which it is stated that an engineer or stoker might, after gazing into the interior of a furnace box for a few moments time, see all color-signals of a greenish tinge.

<sup>3</sup>This rule is equally true for the gradation of the ordinary color signals used, not only in railway, but more particularly in marine service, where the danger is very great, especially in well filled and fog laden harbors.

be a practical one. By this means, the test-color selection in reality becomes the same as that which later is practically and almost constantly given to the visual organ. The loose-color selection must be removed to a safe distance from the candidate, and the test must be placed in the actual line of the railway track-age.

Any one knowing empirically, if not scientifically, that colors, especially red, green and blue, which are so much used in railway signalling, undergo such diverse modifications of hue when seen through varying degrees of solar luminosity,<sup>1</sup> can, if he be conversant with the ordinary methods of color-testing upon many of the railways, in a moment realize another source of inefficiency in the tests as usually applied.

Again, the condition of the intervening atmosphere and the dominant color of the reflecting surface near which the test is made (as for instance the green of a hillside, the grey and white of a mountain top, the blue of an ocean surface), both play important rôles in the question as to the value of the test; but as a rule, they are never considered.

The character of the illuminant itself<sup>2</sup> is of the greatest importance, and yet, how seldom until recently, in a measure in England, has it been considered. For instance, when diffuse daylight in this latitude and climate is bluish, the zirconia or metallic oxide mantel of the Welsbach light made incandescent by the admixture of air and ordinary illuminating gas, as in the commonly employed Bunsen burner, is generally known to give a greenish or nearly white tint; oils, illuminating gas and the varying shades of carbon loops made incandescent by electrical current, all emit varying degrees of yellow rays; and lastly, arcs of electricity, especially when the current is rapid and strong, even appear purplish; is it any wonder that under such varying conditions, test-colors change, not only in regard to the certain peculiarities which give them their

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<sup>1</sup> The examples: a light red becoming purplish in diminished illumination and a vivid scarlet in increased illumination, and an impure green actually partaking of its secondary admixture upon increasing the illumination and becoming greener upon lowering the illumination, are amongst the striking illustrations that concern us here.

<sup>2</sup> We are all aware that color is markedly modified by the tint of the illuminant or the incandescent material. This fact alone gives many cases of slight imperfection in color-sense the ability to partially correct their mistakes, when color is examined under a illumination which is preponderant in yellow and orange rays.

special tones of hue, but actually, as previously shown by natural illumination, to more or less change in hue itself.<sup>1</sup>

Consequently, when color is to be seen practically and daily under such conditions in railway employment by those who must depend almost wholly upon the perception of color alone for the safety of life and property, the testing should be done under similar conditions before any candidate is allowed to assume the risks that are incumbent upon such positions.

An inefficiency which many have tried to overcome, is the totally different values that are empirically placed upon the hue of the test-colors themselves. In England, Abney has done much towards this question by determining the value of the reds and the greens as ordinarily used under gas and electric light exposures upon some of the most important railways.

This inefficiency, however, can, and should be practically set aside, by assuming pigment-hues that are equivalent to the mid-way bands in the corresponding portions of the solar spectrum. These selections, which may be determined mathematically and analytically, by an International Commission, and then reproduced in pigment by a consensus of examination, by a sectional (or even a national) sub-committee of competent observers possessing normal color-vision,<sup>2</sup> can then be used for signal boards, signal lights and test-colors in the special locality given. The tests to be used by artificial light, or modified daylight, in different situations may, if thought wise, be constructed under the same general average stimuli that are to be employed in the future to illuminate the signal-color.

A marked inefficiency in all color-testing amongst railway employees, is the permittance of candidates with slight, though recognizable, imperfect color-vision, to pass the examination and afterwards to occupy positions where a part of their daily duty consists in differentiation of color.

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<sup>1</sup> For example, a definite area of red hue at a fixed point, will with varying tints of some form of dominating colored lights (especially if the substance reflecting or transmitting the red be made interchangeable in construction), affect certain peculiarities in coloration before the last phase of the color itself is annihilated: so with every other color differentiation.

<sup>2</sup> Of course, a series of International Appeal Pigment-tests could be obtained and used as checks, by the International Commission, but, as the sectional tests would most certainly represent the preponderant ratios of color in the locality in which the tests are to be employed and the signals to be used, it would seem to the writer that the plan described above, is for the present, the more practical of the two.

There should not be any degree of standard in regard to the capacity and responsibility where color differentiation forms itself as a part of the routine duty of the employes. Such positions are so few in number, when contrasted with the great supply of available applicants, and the responsibility is so grave, that no exception should be made. By this means, and by no other, will the chance of danger of admission of imperfect color seeing organs into actual service can be further reduced to a minimum.<sup>1</sup>

Again, in this connection, it must be remembered that in reality the employee is the one who is the most protected. He necessarily is the one that in an accident runs the greatest risk of forfeiting his life. Such candidates should be rejected without a particle of sentiment. They should not be accepted if they are practically unfit, even to a minor degree, for the work required of them in color-perception.<sup>2</sup>

The lack of systematic and periodic re-examination of those who have been previously accepted, is another great evil. This inefficiency in color-testing amongst railway employees, is reprehensible. It is not expecting too much that the tests employed in different seasons upon the entire personnel of the railway company, that is engaged in positions where recognition of color in any important way, affecting life and property, is at all necessary. After every case of severe injury or attack of illness that might in any way be likely to produce visual disturbance, the examination should be made. Amongst those who are known by strict, and yet silent surveillance, to use any toxic agents, such as tobacco and alcohol, the tests should be both painstakingly and frequently tried.

The increased responsibility acquired by civil service, where older subjects who are more prone to exhibit acquired color-defects than younger ones, and who are necessarily given positions that more greatly necessitate the employment of normal color organs than even before in the past, has not been considered as fully as it should be. In every such case there is sufficient reason to require careful periodic repetitions of some of the most important of the means that are employed to re-study color conditions.

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<sup>1</sup> Just as in parental countries, unremitting quarantine inspection, compulsory vaccination, etc., are the only ways to guard against danger. So here the barrier should be placed at the entrance and no one who does not possess a normal color-sense should be admitted.

<sup>2</sup> The fact that the differential diagnosis between a fixed congenital malformation and a commencing acquired color-defect in many cases, is at times, extremely difficult to determine, by an Ophthalmic Expert with his instruments of precision and his many methods of careful clinical research, renders this more pertinent.

That these general inefficiencies, so often seen in color-testing—a few amongst many of both greater and lesser importance—are still permitted, is beyond comprehension. At first sight most of them appear of minor importance to railway surgeons, the general practitioner of medicine, the railway official and the layman, yet without citing any of the well-known catastrophes, both by land and sea, that have, without question, been proven to have been dependent upon imperfect color-vision in unexamined and faultily examined employees, it must be conceded by all, that the subject, when more fully understood and better realized, becomes of vital interest. Moreover, when it is considered that between four and five in every one hundred healthy men possess degrees of congenital sub-normal color-perception that practically unfit them for employment in this peculiar direction (dangerous work that is mainly dependent upon color-vision), it seems to the writer's mind, at least, that there should not be an iota of quibble as to the advisability of the most careful and the most conscientious selection of only those candidates who possess as one of the most important parts of their physical equipment, a normal color-vision in each eye.

Green and red colors, in spite of all attempts of abandonment or change, must be used for railway signalling (and hence testing), and as these colors are the ones that are unrecognized by the great majority of the congenital cases of lowered color-perception, and are those that disappear the earliest in incipient diseases, the danger must constantly remain with us. Increased illumination of signals by electricity will not remove the cause. All that can be done is to have an uniform coloration of all colors used, both in regard to hue and tone, subject to the average varying conditions, situations and circumstances in which the signals are to be employed throughout the entire railway system of any certain geographical section; and to perform the tests under the same conditions as the candidate is to be placed when it becomes necessary for him to determine quickly and promptly the colors of the signals in actual use. The signal-colors fixed and certain, nothing further remains necessary but to make the test-colors as nearly as possible identical with them.

Knowing from experience that loose color-selection, at a distance, is the only way to accomplish the purpose properly, simply and quickly, by those who are adequately trained in its performance, some such plan as shown and described by the writer in a paper read before the 1888 meeting of the American Ophthalmological Society, can be used as the general method. By

this means, the numerous other and more complex plans can be reserved for a Chief Ophthalmic Expert of the road, and his Assistants. To them, all doubtful cases, and those where medico-legal questions may arise, can be given, so that less error in reasoning and fewer flaws in judgment can be established in any given case.

In conclusion, it must be understood that the present paper is merely an effort to supplement what the writer has time and again personally endeavored to accomplish in other ways; that is, to protect the travelling public and their property from one of the greatest of special dangers known in railway service: sub-normal color-perception (so-called "color-blindness").<sup>1</sup>

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<sup>1</sup> All that has been written here, is equally as true for the so-called traction trolleys which run at such high rates of speed, especially in the suburban districts, and so rapidly and frequently change passengers. For this class of employees, as a rule, applicants are selected for duty as both motormen and conductors, with an utter disregard, not only as to their color-vision, but, as to their other visual functions.



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