


# Color



On the 200th anniversary since John Dalton published "Extraordinary facts relating to the vision of colours; With observations," the first scientifically presented, detailed observation on color vision confusion in inherited cases

Say the words "color blind" and you will cause a smirk, or at least a grin, to form on people's lips. The color blind have often been mistaken for clowns or dimwits. Now and then, however, you might hear of the expression used in a positive way. It is politically correct today to say that the law is "color blind," and that we should be too. Those who are not "color blind" are considered prejudiced.

For many years, the term "color blind" meant the inability to distinguish one color from another. It had nothing to do with emotional context or symbolic prejudgment. More recently, the term color deficiency has supplanted "color blindness." As more than 10% of the male population and 3% of the female population in the U.S. who were born with the problem will attest, it would better be termed color vision confusion.

While color vision confusion has nothing to do with intelligence or vision, it is a condition that has a significant effect on the underlying reasons why people choose certain types of work, why they may be reluctant to choose clothes, why they may be wary of some foods, and so on. From 1827 until the middle of this century, color vision confusion was called Daltonism, after the chemist John Dalton (see sidebar, page 10). By the 1870s, Daltonism was seen more and more as a hazard, as a cause for job loss. A worker who exhibited tendencies to confuse colors was assumed to be the potential cause of accidents, or downright stupid, not yet having managed to learn his colors properly.

Those who could be proven to have Daltonism were once shunned by the U.S. Army as well. Did you know that in 1881, with the approval of Congress, the Surgeon General of the United States ordered that no color blind persons should be allowed to enlist for military service? Never mind why, it was official!

A wool yarn test (Holmgren Test) was to be given to recruits. But medics who gave these tests were often color blind themselves. For them, lack of red color vision was just as well. It was better for them to be "cold blooded," unable to see the



PINK



RED

BLUE

# Confusion

BY OEDA ROSENTHAL

vivid color of fresh blood that would often freely spurt as they amputated the leg of some hapless young man who may have been a casualty because he could not distinguish blue and grey, or red and black, or the colors of the flag of his platoon. In fact, the testing process became a sham, a sneaky way to discriminate against those one wished to keep away. This test was later abandoned. When volunteers were needed for the First World War, color blind men signed up and many served with distinction. It was said that a significant number of marksmen who could pop off the pointed helmets of the Kaiser's men turned out to be color blind.

But prejudice persisted. Little wonder, then, that even our grandparents were hesitant to speak of color blindness within the family. Silence is golden.

Daltonism is not the name used for this condition anymore, not in English. In Italian, Spanish, and French, color vision confusion is still called by an even worse name—Dalton Mania. But clearly, John Dalton was neither a dimwit, nor blind, nor a maniac. He has been ranked with Newton and other geniuses. Indeed, it appears that the very condition that has been viewed with such a negative image, may well have been the catalyst for his achievements.

Take a look in any encyclopedia and you will find John Dalton listed as a chemist. But anyone who has had his visual predicament would quickly question this, because color blindness and chemistry did not mix (until the advent of computers).

The constant inability to determine colors as others see them makes work in a chemistry laboratory a hellish experience, since the color of mixtures and powders inform us visually of content, quality, and proper results, as well as temperature.

In his biography of Dalton, Isaac Asimov notes that it is not surprising that Dalton was a clumsy and slipshod experimenter in the chemistry laboratory. So why is it that this man is still listed as being a chemist? As Daniel Boorstin wrote in his book *The Discoverers*, John Dalton was the "Columbus" of quantitative chemistry. It was

Dalton's mathematical conclusions that led the study of chemistry to take a giant leap forward. Mathematics can be done without distinguishing colors.

In 1808, at the age of 42, Dalton published his "New System of Chemical Philosophy," in which he postulated that although atoms must be far too small to measure or weigh directly, it should be possible to determine relative weights of atoms of different elements. To arrive at such relative weights, we need to know how many atoms combine to form a compound.

In the ever-growing world of manufacturing that

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LIGHT BLUE



**All of these colors are perceived as green by those with color vision confusion.**

**Likewise, the color swatches on these two pages illustrate various perceptions of color. For example, the pink swatch above is seen by some as light blue.**

YELLOW

John Dalton was born in the Cumberland area of England in 1766. By fate as it were, he was in the very core of the blooming medical developments and bustling industrial activity that took place in England and Scotland at the time. Dalton had a hard time being accepted to any school because he was a Quaker. His condition, color vision confusion, did not aid his cause.

He never attended a university. His education came from Quaker schools, where he could study at his own rate, taking the time needed to make up for his confusion when color references were expected. He also taught in Quaker schools, then he taught privately. Shortly thereafter he became editor of the Manchester Library and Philosophical Society, thus assuring himself of never having to deal with color vision confusion or with chemistry again except in black and white on a printed page (but had he been alive today he would have to contend with computer-generated color printing capabilities). One of his early intellectual achievements was that he developed proof that the aurora are electrical in nature. This he did following the dramatic meteor display in 1786 and an aurora in 1787. His book "Meteorological Observations and Essays" appeared in 1793. In it he stated:

"In making observations upon phenomenon in nature, with the view to ascertain the cause, every particular circumstance should be attended to; for, though many may be found afterwards to be trivial and of little or no moment in leading us towards the discovery, yet some one or other of them generally happens to be of importance."

True as this statement is, he himself never spoke of colors in association with what he saw in meteorological displays. He did use the word rainbow, not in relation to a colorful display, but to contrast a rainbow-like arch with straight beams. He spoke of light and dark clouds, of clarity of brilliance of heavenly bodies and of weather—but colors are not mentioned at all.

The Royal Society of London offered him membership, only to be rebuffed. It was said that he felt uncomfortable among all the university graduates of elite social backgrounds that made up the society.

It may have been more true that he was annoyed that the Royal Society allowed a poor presentation on

color blindness to take place in 1777, and that Thomas Young's presentation there annoyed him, too. Young postulated that the retina contains receptors for primary colors, not absorbing humours, as Dalton suggested.

He was happy to be elected corresponding member of the French Académie des Sciences. In 1826, the Royal Academy awarded Dalton the Royal Prize. It seemed to have as little meaning for him as his membership. Dalton, ever the modest Quaker, shunned public displays of glory.

But he could not resist relishing the joy and a sense of triumph when, in 1832, the University of Oxford conferred on him an honorary doctorate. For that occasion, he had a crimson robe made by a tailor.

As he strolled proudly on the Oxford campus with the red gown blowing in the breeze, he was said to be satisfied that although, as a Quaker, he would never wear garish colors, he could allow himself to wear crimson, because he could not see the color of the garment in any other way but black.

In 1834, the University of Edinburgh also awarded him a degree. Now he had two university degrees, but he was still struggling financially.

A small sum from the estate of his brother Jonathan came his way in 1834, and a small pension was assured through the efforts of Charles Babbage and others. He was now 68.

Babbage, who today is seen as the forefather of the computer age, published an article in 1830 titled "The Decline of Science in England"—this, after three of

Britain's major scientists, including Young, died in the previous year. Dalton had complemented Babbage. A friendship followed.

Together they helped found the British Association for the Advancement of Science (BAAS) the following year. Oddly, the position Dalton chose in this new organization was that of chairman of the Chemistry section, although later he also served in other capacities. Dalton remained with the BAAS until 1837, when he suffered a stroke.

Dalton died in July of 1844 at age 77, and was accorded a state funeral. Nearly 40,000 people filed past his coffin, as shops and offices were closed for the day in his honor.

## John Dalton

1766–1844



involved chemical use, it was not enough to know what ingredients to use, but how much and what would happen. Bringing chemical reactions down to something akin to a foolproof baking recipe was a brilliant advance in chemistry. Dalton ushered in the dramatic change in the study of chemical reactions. He developed the Atomic Theory, which led others to create the atomic chart one sees in chemistry classrooms even today.

A chemist? A look at his life will show that chemistry was a bane he could not shake (see sidebar, page 12).

#### COMMUNICATING COLOR

Anyone who wants to communicate information about colors has to use the words that exist in a given language. Dalton used the same color vocabulary as anyone else would use, simply because he had no other and would not be able to explain it even if he did. It is not easy for anyone who sees the full spectrum of colors to imagine a change of color of geraniums from sky-blue to "what I call red," as mentioned by Dalton.

In my research on human factors of color vision confusion, I rarely use color names, but I have found that the subjects are very comfortable speaking in terms of colors.

They use the same terms when explaining what they see, and they equate the same colors similarly. They use color names we use, but for them they are of very different qualities. Dalton made a point of stating that of all colors, he saw blue and orange as all others do. This, from my observations, is mostly the case. But at times, the color-challenged will speak of orange as green or red.

Most who have inherited color vision confusion assume that they have found some singular method to cope with "translating" colors others speak of into their own mental visual language. Few realize others see the very same way. They all despair quietly when their "translating" system does not work for some reason—be it due to light, variation of hue, or whatever. Most often they simply skip any talk of colors, as Dalton did throughout his book on meteorological phenomena.

Dalton made no prejudgment regarding female color vision confusion. He said that he had never heard of any female who was subject to this peculiarity, but he did not claim it could not happen; and indeed, instead of speaking only of males, he referred to persons.

He also speculated on why people see differently. Here his conclusions were flawed. He ascribed the problem to humours in the eye that absorb the red and the green rays, since he was most perplexed by these colors. Since he could not see them, it stood to reason that they must be absorbed by something before the eye registers them. He went on to suggest that those humours were vitreous, or else he could have seen them by inspection.

So convinced was Dalton of his speculation that he willed his own eyes to science, and requested that they be dissected soon after his death to ascertain the facts before any changes occurred in the tissue. The eyes were dissected in July of 1844—shortly after Dalton's death—by George Wilson, with David Brewster in attendance. It was Brewster who attracted Wilson to the task. Both had personal reasons for finding the facts: both were color blind. They found no humours.

David Brewster, a graduate of the University of Edinburgh, was vocal in promoting the study of science on all levels of society. He himself had attempted to make colored eye glasses to overcome his condition, and spent much time perfecting instruments for the study of vision. He then shifted to optic theory and at last gained a reputation by inventing the kaleidoscope, which became a rousing fad in Britain.

At the time of Dalton's death and the dissection of his eyes, Brewster was distinguished editor of the *Edinburgh Journal of Medicine*. Wilson, a surgeon, went on to publish a book in 1857 on his researches in color blindness.

Dalton seemed to be fascinated by his condition. This, I have noted, is true among others. Not only do these individuals downplay their predicament due to past and present prejudice, but they seem genuinely pleased at times that they observe and note things others might not see or might ignore, and are protective of this cherished capacity as if it was a special treasure. They do not wish to part with it and would not want genetic engineering to eradicate it.

#### HUMAN FACTORS

Even today, we still do not know why the gene for color vision exists, why some have this variation of vision, or what the value of color blindness might have been in history. Very little research has been done on the human factors (the effect that this condition has on people's lives). Many will say it is of little consequence, but their sublimation goes only just so far.

Many who live with color vision confusion do not expect anyone to have a grasp of what they are seeing or going through. However, when they do come across someone who understands, they are delighted, and confess the many moments of pain due to insult that they had to endure, the frustration of the professional limitations the condition causes, and the many real-world obstacles such as computer-generated color coding. It is like the release of pent-up hurts.

Consider the fiber optics specialist who contacted me at OPTCON '91, where I did a presentation, to request that I stop at his house whenever I happen to be in the Washington, D.C. area, because he would like me to explain to his teenaged son how it was that although his father was considered a genius in the transmission of audio via fiber optics, he was a "dummy" when it came to colors. He was wary, almost terrified, to make a turn on a four lane road at night because he could not tell green lights and street lights apart and he did not stop on red lights because, he said, he did not see them. He wanted me to speak with his son person-to-person so that it would not appear to be a "put up job."

Couldn't he look it up in the library? No. No decent references on the subject have been available in libraries until now. (Never mind that Dalton introduced the subject to the scientific community 200 years ago!)

Consider the tale told by Gerald Murch of Tektronix, the man who first found that by exciting electric impulses you can get colors on computer monitors. I was invited to be a fellow panelist on a Human Factors of Color Vision

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Confusion seminar at the 1988 annual conference of the National Computer Graphics Association. The hall was packed as Murch told of the reaction of his boss when he first joyfully ran into his office to let him know of his discovery. "So what?" replied his boss. This, because the boss was color blind.

So what? Can you imagine videos, moon shots, and other computer-aided graphic information not being in color? But there is a cost as well. What about the female accountant who had to give up a job with a tax preparing chain because she could never place the processed documents in the proper bins, or even find the right program disc for her clients because the company had color-coded everything? No one even believed that she, a woman, could have been born with color vision confusion. They thought she was doing her work mindlessly.

And what about the boy who was thought to be disturbed and nearly placed on medication to alter his moods, because, although he seemed outwardly adjusted, he used strange, depressing colors in his kindergarten drawings? How many others are failed or mis-categorized for "not knowing their colors" or other associated sins?

Years earlier, I salvaged a deluged insurance company that underwrote dentists by having dentists own up to their color vision confusion. A flood of claims was due not to dental work, but to mismatched caps causing unsightly results. Emotional "pain" was the reason for the potential financial disaster of the insurance company. Since then, dental schools have introduced color vision seminars and other safeguards to alert dentists to the human factors of tooth color.

Recently, the director of research of East Carolina University Medical School was eager to have me join the faculty as an adjunct to one of the various departments, to continue my research on the human factors of color vision confusion due to illness. He thought there would be interest, especially since much talk had been generated when one of the highly regarded pathologists complained of his inability to decipher computer-generated colored slides, and a young intern was forced to drop his studies of dermatology because he had to admit he could not see what he needed to see to make a proper diagnosis.

The research director reasoned that if people born with this condition have a problem, clearly it should be of interest to find out how those who suddenly face this condition find, or can be shown, ways of coping. Some department, the Diabetes Center, perhaps, would show interest. After all, many inherited diseases, like diabetes, first exhibit themselves later in life, and their destructive visual tendencies only start after a person has already established both a linguistic and a visual vocabulary that most often includes full color references.

But as has happened before, the human factors of color miscommunication were not seen as significant enough by the medical community. Perhaps, like Dalton, I do not have the proper university degrees, although I have some.

I take comfort in that my first appearance with OSA in 1991 was on the 50th anniversary of the U.S. military grap-

pling with the problems of acquired color vision loss—due to sun reflected on water or desert sands. Edwin Land's polarized sunglasses were issued as standard gear to military personnel on all levels. They proved to be right on target. Many later credited the successes in the Second World War and their own lives to those sunglasses, particularly those who served in the North African campaign or at sea.

Here's hoping that with the reality of today's computer-triggered war machinery, refusal to consider color confusion (inherited or acquired on the battlefield, as was the case for many in the Desert Storm campaign) will not be the underlying cause for a colorful but hellish "mistake" for me to be proven right. The human factors of color confusion must be given more attention, especially in view of the fact that more and more people are acquiring, rather than inheriting, this condition.

In Dalton's day, color took on a special meaning because of exploding technological developments. Today, color has taken on special meaning for the same reason. Yet for a portion of the population it is a stumbling block, an imposition of prejudgment of intelligence and a source of insult no less than what Dalton experienced in his own life 200 years ago.

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[Most of Dalton's personal papers went up in flames when Manchester was bombed by the Germans during World War II.]

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