MUSEUM LIGHTING: ITS PAST AND FUTURE DEVELOPMENT

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ABSTRACT

Light damage to materials has been known for centuries but a serious study of the permanence of colours began earnestly in the 19th century. Throughout the 20th century, researchers sought to quantify the rate of fading and offer techniques conservators could use to slow deterioration rates. This evolved into controlling light exposure to match the needs of both the objects and the viewer. The information has grown and the expertise to use it made more difficult to master. Of all the environmental parameters that effect museum artifacts, light exposure is arguably the most complex and the only one that is essential to the observer. Recent work has suggested that to manage this combined decay/experience parameter a communal approach is needed. That is to say an approach involving the technical contributions of the entire conservation field working collectively. We suggest that such a communal approach is not only logical but allows the conservation field to address more sophisticated topics of perception and visual performance as well as new technologies in illumination.

BACK TO THE PAST

The deleterious effects of the natural environment, and particularly of daylight, were well known in ancient times. Vitruvius tells the story of the notary Faberius who had the walls of his house painted with cinnabar. They started darkening within 30 days and required repainting. Still, it wasn't until the 17th –18th century that natural philosophers began serious study of light and colour, a period that included Isaac Newton's 1670's studies on optics [1], Pierre Bouguer's first attempts to measure light intensity in 1729 [2] and Grotthus, who in 1817, in an amazing insight, noted that light absorbed by a molecule can produce a chemical change.

Artists and colour manufacturers soon began paying attention. According to Padfield and Landi, the first systematic tests of lightfastness were carried out by Dufay about 1733 but the results of his experiments apparently have not survived [3]. Sir Joshua Reynolds was known to have crudely tested his materials in 1772 [4]. George Field, the British colour manufacturer and author, conducted his own pigment fading tests, beginning as early as 1804. His ten notebooks being ultimately passed on to Henry Charles Newton, one of the original partners of Winsor and Newton, founded in 1832 [5].

All through the early and mid-19th century we consistently find light and air pollution damage to artist materials linked together as threats to be considered seriously. Even Michael Faraday weighed in on these issues during a period when he was the most sought after scientific consultant in England [6] [7].

Setting the tone for our modern concepts of light damage to artist materials were the landmark efforts of A. H. Church, *The Chemistry of Paints and Painting*, and Dr. W. J. Russell and Captain W. de W. Abney's monumental study on the *Action of Light on Watercolours*. Church not only included remarks on the fading characteristics of many pigments then commonly used but he also reports on what others had been doing on the topic – in fact a review of current and past research. His book even includes the remarks of John Ruskin, a man who never seemed to lack an opinion on most matters of aesthetics and preservation, including lighting [4]. But it was Russell and Abney who were left to compile the first truly modern scientific study of light damage [8]. In their highly readable report we encounter strong evidence of light exposure as the cause of fading. They report also on the wavelength specificity of colour change including the potency of different light sources. They use spectrophotometric descriptions of change, the reciprocity law is stated in its modern form, and the effects of light filtration are reported. Their work even extends to the benefits of oxygen-free enclosures. This is perhaps more amazing because they acknowledged lacking a scientific theory of how colour is actually produced and science was still decades away from a quantum theory of atomic structure.

By 1894, with the encouragement of Captain Abney, filtered glass skylights were added to protect the Raphael cartoons in the South Kensington Museum, London. The public seems to have accepted it but a few critics didn't appear to have much sympathy with this new preservation trend. Brommelle tells us that Lord Crawford's reaction in 1923 was less than encouraging:

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"One question which ought to be settled was how far there was any justification in using the results of scientific investigations to preserve the colours of museum specimens…Many years ago the Raphael cartoons at the South Kensington Museum had been placed in a fine gallery which was glazed with a nasty lemon-colored glass, which gave one the feeling when entering the room of going into a tomb."[9]

Crawford doubted the virtue of preservation for future generations, at least at the current technological level, and didn't want to "…sacrifice too much to posterity".

The first widely read recommendations for museum light intensity appeared in the July 1930 issue of *Burlington Magazine*. Feller presents thirteen sets of recommendations for low, medium and high illumination levels, published throughout the 1930s and 1950s in various journals and books. These thirteen sets, when averaged, come out to 57, 142 and 258 lux, respectively [10]. Except for the highest level of illumination, for materials virtually non-reactive to light, these quantities round off nicely to Thomson's first recommendations (50/150 lux) that appeared in *Studies in Conservation* [11] and were later refined in his book, *The Museum Environment* (50/200 lux) [12]. A partial list of the early authors on these topics through the 1970's is Launer, McLaren, Hanlan, Harrison, Padfield, Robert L. Feller, and Ruth Johnston-Feller. During this period the effects of UV radiation on fugitive and permanent colours were determined and industrial fading standards became widely used in exposure studies in the paint industry and were later adopted in conservation research. Also the vulnerability of large numbers of artists' materials appeared along with more theoretical mechanistic studies [3, 13, 14]. Padfield and Landi stand out in this group since their work continues to be a framework component for many contemporary risk models.

For the next two decades, Garry Thomson and Robert L. Feller became the two most influential voices on the subject of light damage and control, one on either side of the Atlantic Ocean. Feller because of his laboratory's focus on building up the foundations of preventive conservation science using a well-defined research base in the paint and textile industries [15], and Thomson because, up until the first edition of *The Museum Environment* in 1978, no one had written a book on preventive conservation in museums that was comprehensive, yet clear enough for scientists and conservators to use with nearly equal ease.

Museum lighting should not be treated totally *in vitro,* separate from the trends in preventive conservation as a whole. As early as 1844 a handbook by David Boswell Reid on building environmental techniques had been published [16, 17]. It was clear from transcripts during the National Gallery controversies of the early 1850's that Reid's work was known to Sir Charles Eastlake [6, 18] yet Reid's work was apparently never taken seriously enough to be used to improve what was by today's standards an insufferable Gallery environment.

What really produced major ripples on the otherwise placid museum world were the threats of destruction in two world wars, which culminated in the removal of paintings from the National Gallery in London to slate quarries in Manod during the Second World War [19]. Observations of the preservative effect of these stable conditions on canvas and panel paintings suggested to F.I.G. Rawlins (scientific adviser to the National Gallery) that the equal constancy provided by air conditioning would benefit the paintings returned to the National Gallery. Rawlins was also an early worker on colour measurement. In 1955, Rawlins, Robert Organ and R. Sneyers distributed a questionnaire to 64 institutions on indoor climate. Compiled into one comprehensive report, remodeled and extended at ICCROM by Plenderleith and Philippot, it helped create an appetite for more information [20]. After the IIC London Conference on Museum Climatology, the genii could no longer be returned to the bottle and a thirst for more information was sated when Thomson skillfully stepped in and added lighting – which had been weakly represented in the ICCROM report.

Similarly, drawing on a diversity of research from other fields, and filling in where artists' materials presented valuable new research opportunities, Robert Feller and his staff, frequently in partnership with his equally capable wife, Ruth Johnston-Feller, became a fountainhead of applied work that included a large contribution on light damage and its control. Both Feller and Thomson had two properties that guaranteed their celebrity. They wrote early, and they wrote uncompromisingly on scientific issues with simplicity and clarity.

A common over-simplification is that the product of this period in museum lighting research was the "lux laws" supplemented with prohibitions on ultraviolet and infrared radiation. The lighting guidelines were static and immutable. In reality both Thomson and Feller realized that light damage needed to be managed and could not be completely avoided. But it took a few new voices to introduce concepts of risk management.

From the 1980's onward, an ever larger emphasis began to be placed on examining all elements of museum lighting [21, 22, 23], rendering it practicable in operation [24, 25], and considering other environmental factors [26]. Risk assessment and management thinking showed that rules can be stretched, or violated, for a rational need as long as proper monitoring and documentation is maintained to insure that long-term exposures were controlled. Michalski has recently discussed balancing "situation-specific resolutions" involving object sensitivity, object visibility, lamps, fixtures, rooms, buildings, viewers' reactions to each of these and to the whole, budgets, and finally the influence of everything on the particular museum's goals [27]. At present only the Canadian Conservation Institute, has actually appeared to implement it in their lighting recommendations in the form of higher light levels for enhancing the experience of the museum visitor under a few specific circumstances [28]. Those circumstances are artifacts with low contrast details, dark surfaces, where complex visual searches may be required within a limited time and finally, older viewers. In each of these cases, up to three times the basic light intensity (50 lux) may be employed - ideally compensated by proportional "dark periods". A situation where, for example, older viewers are viewing dark coloured textiles, will according to these recommendations allow 3 x 3 x 50 lux = 450 lux. To limit the overall light exposure, compensation in exposure time must be applied – again depending on the objects belonging to one of three sensitivity classes. Together with these "dynamic" lighting guidelines CCI recommends lowering – where practical and possible – the UV content of the radiation to max. 10 microwatts per lumen.

At present, we know the vulnerability of materials to light and the spectral energy distribution from light sources. We have instruments to measure light and dosimeters to integrate light exposure. The one major weakness is that our vulnerability classes have often been defined using freshly prepared materials that are more reactive in most cases than identical, aged materials. But since this tends to over-estimate vulnerability it leads to a conservative specification for light levels on objects containing these materials.

Into the future

Michalski has also considered where we need to go in the future and has concluded that:

"The information has grown to the point where it has both revealed the arbitrariness of the simple rules, and outstripped the ability of a conscientious professional to do something reliably better in the time they usually have available".

He calls for collecting and combining this lighting information with newer, cleverer heuristics, into a place and form where it can serve the needs of a "communal risk assessment model" on the Internet [29]. This "communalism" does have its own risks. As a place to warehouse, update and add information that can be accessed by conservators using advanced risk management tools, one can hardly disagree. The data's integrity should be expected to pass built-in quality assurance tests or conform to protocols also described at the same location. Such an environment might also provide a moderated "wikipedia" forum for expanding topics of concern. A few of the topics we would like to see discussed are:

1. Improved understanding and use of colour rendering metrics
2. Response to new lighting technologies that evolve from national or international energy conservation policy
3. Acquisition of a larger number of damage spectra. Emphasis on acquiring sensitivity data on aged and new objects - including anoxic protection.
4. Consensus protocols for human assessments including issues of aesthetics and visual performance.

1. The appearance of an object depends on the spectral power distribution of the light source, the reflection and refraction by the surfaces to be illuminated, and the response of the human visual system [30]. Full adaptation is assumed when making judgments and all intervening fluid media do not contribute. We add to this, that the associated geometries of all three be equally described. The current method for establishing a colour-rendering index for light sources (CRI) by the International Commission on Illumination (CIE 13.3) does not permit the user to "match" a light source to the reflectance properties of surfaces in order to optimize the index value/ viewer experience. The index only relates to the properties of the light source in rendering 8 test colours – compared to a reference illuminant of the same colour temperature. Nor does the index permit direct comparison between dissimilar lighting sources. There are strong arguments why one or the other feature might be useful in museum lighting. Rather than assume that solid-state 3 or 4-band sources such as LEDs (Light Emitting Diodes) are

inherently defective or conversely, a panacea, the metric should be offered that answers the question: “Which color palettes can be illuminated that would provide an acceptable quality of light for this source’s spectral power distribution?” The obverse would be “What palettes represent a consensus for unacceptability in colour rendering?”

A manufacturer tends to broadcast the CRI of its light sources when it suits its marketing plan, and even dissuades inquiries about it when it doesn’t. For incandescent lamps this is hardly an issue since they will be compared to a model of an incandescent source of the same color temperature insuring a good score in the colour rendering index. There is no reason to assume manufacturers will change their tactics in the future. Thus we hope for an updated method from the CIE or another party that permits the use of the current CIE 8-colour set, the expanded set (12 or 14 colours), or a true user-supplied set of colours along with different reference comparison.

2. With national energy policies progressively taking firmer and firmer positions on energy conservation, combined with stronger rules on hazardous waste disposal, both the traditional incandescent and fluorescent light sources face significant competition in the future from new light sources – probably with questionable colour rendering properties. We have to prepare for a future with compulsory use of efficient, non-polluting light sources - where the presentation part of museum lighting *must* receive the same attention as the preservation part.

3. We have an ever-growing realization that damage spectra are important and more of them should be measured. Discontinuous spectral sources like LEDs, compared to continuous blackbody illuminants, *at equal luminosity*, will nearly always have spectral energy peaks that exceed the equivalent blackbody or near correlated colour temperature sources (even high CRI fluorescent lamps). If such peaks coincide with damaging wavelengths for a colorant, it will fade faster [31]. We would like this information built into risk models before it is discovered empirically on museum walls. The usefulness of any risk-determining process is limited by the uncertainties of the input information. What conservators repeatedly request of conservation scientists are high quality data. Many of them are content to make important and decisive decisions if that trust is present. Tools that substantially reduce the uncertainties in fading or other colour change mechanisms caused by lighting, directly on objects in a manner that is “virtually” non-destructive, informs the probability that fading rate is accurate for that object extrapolated to the walls, and improves the accuracy applied to similar objects [32]. Such tools need to be more commonly found in institutions and their results also shared. A user’s group could be established and just as important that the information be shared, inter-laboratory comparisons in the form of round-robin evaluations carried out.

4. Assessing the human response to lighting in a way that is comparable between institutions, researchers, and lighting designers is critical if these techniques will ever serve any “communal” value. Thomson offered the most fundamental rules when he wrote:

- “Adapt your eyes to the illuminant under test
- Look at a set of representative objects under it and accurately memorize their colours,
- Adapt to the reference illuminant,
- Look at the same objects under the second illuminant and compare the colours to the colour in our memory.” [12]

Apart from the physical difficulties in trying to do this, and there are many, what questions should we ask when we “compare”? Or what colour performance test should we apply?

A large and important topic in museum lighting is “visual performance”. This topic is not a new fashion to museum lighting. It is central to the whole reason we exhibit artifacts in the first place and has been embedded in at least one set of guidelines for the last decade [28]. Preservation and presentation is co-equal. Conservation insures the continuance of “generational equity” but not without sharing that equally, in so far as it is possible, between all generations - and doing it well. An object poorly seen is partially wasted, as also the CIE recognized [33]. So a concern for “visual satisfaction” should include sharper concerns for all types of visual quality. This applies to colour differentiation, contrast sensitivity, and viewing of small details, for everyone – young and old - who visits museums. These should stand beside the minimization of disabling glare, visual confusion caused by clutter, and large contrasts in the visual field around the artwork. The variety of simple assessment tools that measure these performances is large and performance measuring techniques designed for pathologies could easily be a part of some lighting selection processes [34].

However, lest we get wrapped up in issues and decide that the “sky is falling” with new fears that are more illusory than real, we should concede that the human visual system has evolved to accommodate and adapt to a very large range of lighting conditions and the necessity to encumber lighting guidelines with extra requirements need reasonable vetting, for which a communal model may be well suited.

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