SDAR* Journal of Sustainable Design & Applied Research

Volume 4 | Issue 1 Article 5

2016-11-16

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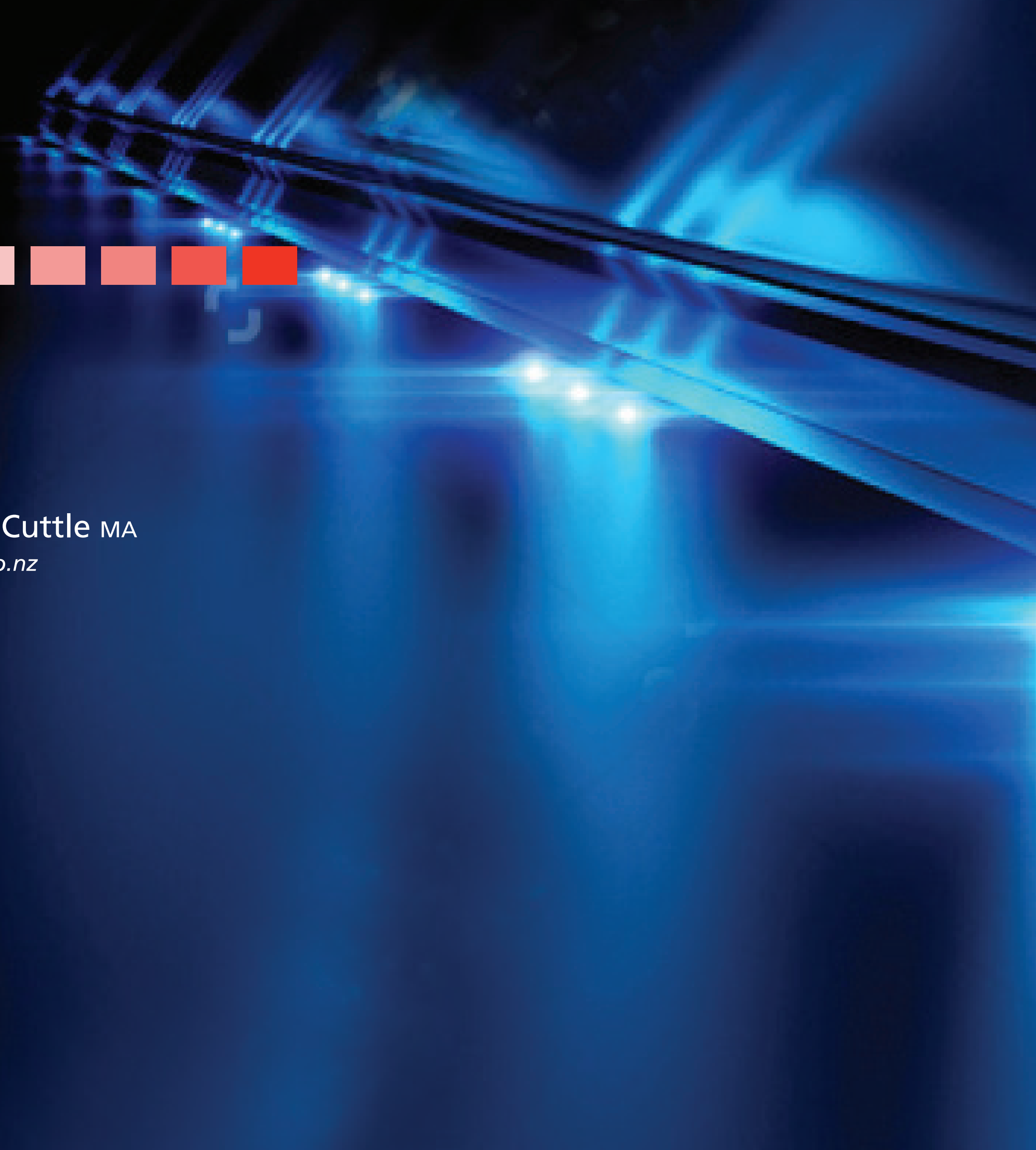
Recommended Citation

Cuttle, Christopher (2016) "A Reassessment of General Lighting Practice Based on the MRSE Concept," *SDAR* Journal of Sustainable Design & Applied Research*: Vol. 4: Iss. 1, Article 5.
doi:https://doi.org/10.21427/D7RP4F
Available at: https://arrow.tudublin.ie/sdar/vol4/iss1/5

A Reassessment of general lighting practice based on the MRSE concept



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Abstract

A case is made for reassessment of the purpose of general lighting practice, involving a change from lighting standards specifying illuminance for high levels of visual performance, to providing for predictable assessments of surrounding brightness. Mean room surface exitance (MRSE) is proposed as a suitable metric for this purpose. This metric actually serves a dual role, in that apart from providing practitioners with the means to design for chosen levels of surrounding brightness, it would enable regulators to specify for perceived adequacy of illumination, PAI. The adoption of PAI specified in terms of MRSE as the prime criterion for specifying indoor illumination levels in lighting standards would invoke fundamental changes in general lighting practice. These are discussed, together with limitations of the MRSE concept and the need for both further research and feedback from industry professionals.

1. The need for change

The first professional lighting institution was founded in 1906 in New York under the slightly quaint title of The Illuminating Engineering Society, and this set the pattern for national and regional lighting institutions around the world. The general aim was to provide a sound, scientific basis for the development and application of electric lighting, and by any reasonable standards, those institutions have achieved notable success. From the outset, they faced the formidable task of making light a quantifiable commodity. To this day, light is the only one of the fundamental quantities defined by the General Council for Weights and Measures that is not specified purely in physical terms, but is actually defined in terms of human response. It was a major achievement when, in 1924, the International Commission on Illumination defined the lumen, relating human assessment of light to radiant power distribution, and this era has been described by the author as the first stage of the lighting profession[1].

The early approach to specifying provision of lighting was based on providing for peoples' need for visibility, and the scientific community responded by introducing the concept of visual performance, which became the basis of general lighting practice. It was shown by research that speed and accuracy in detecting the detail of a visual task depends upon the angular size and luminance contrast of the critical detail, together with the illuminance incident on the task. In this way, by classifying the visual task difficulty associated with a broad range of human activities, lighting standards could be developed that specified minimum illuminance levels to perform specific visual tasks with speed and accuracy. At the same time, procedures for application were developed to enable compliance with the standards to be provided for with efficient use of resources. This scheme had every appearance of being a beautifully conceived application of scientific knowledge and engineering skill for the benefit of society at large, and while it may be seen as the second stage of the lighting profession[1], its achievement has proved difficult.

Since the end of the first stage, so much has been learned not only about human response to light, but about the role of human nature in lighting. It was in 1945 that the work of HC Weston[2] at the National Physical Laboratories in the UK provided a research-based platform for developing lighting standards based on visual performance. However, this date happened to coincide with the onset of the proliferation of the fluorescent lamp, which caused lighting to no longer be thought of as a commodity to be applied stringently to provide for peoples' needs, but as a means for generating feelings of wellbeing and stimulation. As if this was not enough, it soon became apparent that if something is found to be difficult to see, there are more effective ways of overcoming that than washing the visual task with light. Figure 1 shows an example of an office space lit by a combination of electric lighting and daylight, where the lighting distribution shows no pattern of relationship to visual tasks, but instead is directed towards providing for the appearance of a comfortable and pleasant environment. As in this instance, all around us we can see examples of the visual content of activities having been redesigned (screen-based reading tasks) or eliminated (bar-code readers), these innovations obviating the need for selective

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DOI: https://doi.org/10.21427/D7RP4F

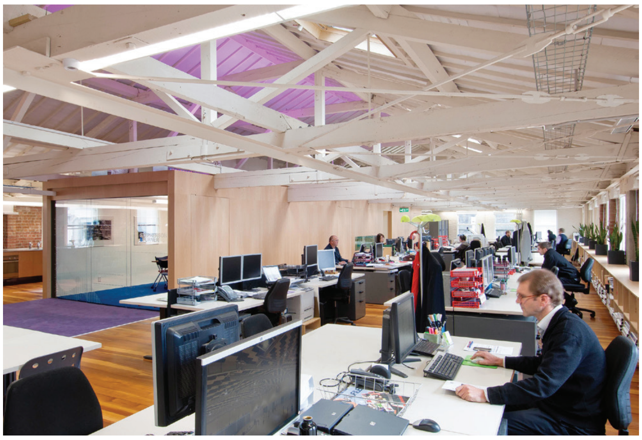

Figure 1. An open-plan office space, with separate enclosed meeting rooms, lit by a combination of electric lighting and daylight. The lighting distribution is unrelated to either visual tasks or the horizontal working plane, but is instead arranged to provide for a comfortable and pleasant working environment.

task lighting. It should be seen as remarkable that despite all these changes in how people interact visually with their surroundings that the level of illuminance on the horizontal working plane (HWP) persists as the metric that lighting practitioners employ for specifying illumination adequacy for all manner of human activities, irrespective of whether or not there is an identifiable visual task.

This situation has not passed without challenge. It was once again New York that, during the 1960's, took the lead with the formation of the Independent Association of Lighting Designers, IALD. This was to some extent in response to legal restrictions on the activities of the IES (it was registered as an educational institution), but also it was a reaction against the notion that the purpose of providing lighting was to be assessed in terms of satisfying prescribed illuminance values. This has led to a divided profession. On one hand, those who associate with illumination engineering institutions, such as IES and CIE, and on the other, those who associate with lighting design institutions, such as IALD and PLD. This has occurred despite several attempts to integrate engineering and artistic design objectives, of which perhaps the most notable was the 'designed appearance method' due to JM Waldram[3], which sought to apply an illumination engineering approach for providing a designer-orientated distribution of lighting. While Waldram's work gained significant accolades and would seem to have influenced some lighting designers, it failed to make any impact upon the course of general lighting practice. Instead, illuminance measured on the horizontal working plane persists as the universal metric for specifying illumination adequacy.

2. A proposal for change

From the foregoing, the profession may be seen as continuing to specify lighting in terms of second stage objectives, while lighting practice has moved on to different design objectives. Third stage objectives, based on human response to light exposure, are yet to be addressed by general lighting practice.

The author's involvement with lighting practice, and his observation of the characteristics of lighting that are recognised as representing good current practice, have led him to propose ***mean room surface exitance*** (MRSE) as a better lighting metric for general lighting practice, in that MRSE would seem likely to provide a reliable indicator of ***surrounding brightness***[4], where this term relates to an overall assessment of how brightly-lit, or dimly-lit, a space appears to be. In doing so, he has explained, "*This proposal is based on reason rather than research, and it is hoped that someone somewhere will feel motivated to investigate the validity of the concept for this purpose*[1]*"*. Since then there has been both discussion and research concerning the MRSE concept, and it is time to evaluate the situation; but first, a brief review of MRSE is in order.

2.1 The MRSE metric

Mean room surface exitance may be applied in any enclosed space where inter-reflection between the surrounding surfaces generates a diffused light field, and crucially, it may be applied in two distinctly different ways. For lighting practitioners, MRSE may be used as a reliable means for indicating how peoples' perceptions of surrounding brightness are likely to vary in response to lighting, regardless of the distribution of illumination, or of surface reflectances. For regulators, it would enable reliable specification of minimum illumination levels to satisfy the criterion of ***perceived adequacy of illumination***, PAI, which indicates whether or not surrounding brightness at a specific location is perceived to be adequate for the human activity associated with that location.

A procedure for predicting assessments of surrounding brightness would be directed towards characteristics of lighting distribution that are distinctly different from those employed in the familiar approach to assessment of lighting performance. It would be concerned with the density of luminous flux emanating from surrounding surfaces, rather than of flux incident upon them. This rules out illuminance as an appropriate metric, but it should not be assumed that attention is necessarily directed towards luminance. The visual effect to be characterised is an overall impression of the level of surrounding brightness, which does not depend (as luminance does) upon a particular viewing location or direction of view. Instead the form of measurement that is proposed is exitance, being the density of luminous flux (lm/m^2) exiting, or emerging from, a surface. This line of reasoning leads to mean room surface exitance, MRSE, being the proposed metric for predicting the assessment of an adequately lit space.

In this way, MRSE indicates both the average flux density emerging from surrounding room surfaces, and the average level of the diffused field of inter-reflected flux within the volume of a space. Understanding the manner in which the diffused light field is generated and sustained is crucial to recognising the workings of the MRSE metric.

Within a room, MRSE is the average exitance of all room surfaces:

$$MRSE = \frac{\Sigma A_S M_S}{\Sigma A_S} = \frac{\Sigma A_S E_S \rho_S}{\Sigma A_S} \qquad (1)$$

Where A_S = area of surface S (m^2)
M_S = exitance of surface S (lm/m^2)
E_S = illuminance of surface S (lx)
ρ_S = reflectance of surface S

Because an accurate calculation of MRSE involves determining the illuminance of every significant surface within the room, this is best handled by a computer program. However, the author has also proposed an alternative procedure[1] that has the attraction of not only being readily applied, but of making the workings of the procedure apparent, although it does incorporate an assumption that makes it less accurate:

$$MRSE = \frac{FRF}{A\alpha} = \frac{\sum A_S E_{(d)S} \rho_S}{\sum A_S(1-\rho_S)} \qquad (2)$$

Where FRF = First reflected flux (lm)

$E_{(d)S}$ = Direct illuminance of surface S (lx)

$A\alpha$ = Room absorption (m^2)

Until the luminous flux emitted by the luminaires has undergone a reflection, it has no visible effect. The first reflected flux (FRF) is the source for the multiple inter-reflection process that generates the diffused light field within the volume of the space. For an enclosure of uniform surface reflectance, the average flux density within that field may be determined by application of Sumpner's principle[5], which states that as the total luminaire flux must equal the rate of flux absorption by the room surfaces, the average surface illuminance is given by dividing FRF by the room absorption, Aα, as indicated in formula (2). This provides a calculation procedure that can be carried out on the back of an envelope, and furthermore, the interrelationship between the characteristics of the room and the provision of light can be quite readily visualised. However, the assumption that, after the first reflection, all surfaces have reflectance values equal to the area-weighted average room surface reflectance value, inevitably introduces error. The extent of this error is discussed in Section 3, but as error is avoided by use of formula (1), it should be applied in all applications where accuracy is important.

2.2 Surrounding brightness

It may be noted that some researchers (such as Rea *et al*, 2015) have made use of the terms 'spatial brightness' and 'scene brightness' to refer to brightness as presented to the eye. These terms have been defined in various ways by the different researchers, usually in terms of luminance distributions. The term 'surrounding brightness' is used throughout this paper to identify it as a distinct concept. Instead of being based on the notion of a scene presented to a viewer who is at a specific viewpoint and looking in a specified direction, it refers to an assessment of the overall brightness of an enclosed space, without regard to the viewer's location or viewing direction. It is specified in terms of MRSE, and it is a response to an ambient condition, unaffected by body or head movement, and may be assessed on a multi-point scale of 'very dim' to 'very bright', as set out in the following subsection.

Assessment of the adequacy of illumination may be seen as a step beyond brightness assessment. It is a judgement of whether or not the illumination is adequate for a specific purpose, and so it is a binary assessment for which the activity associated with the space is an influential factor. For example, a surrounding brightness level assessed as adequate for a doctor's waiting room might be judged dim, or even gloomy, in the surgery. It is proposed that the appropriate criterion for standards to regulate general lighting practice is the perceived adequacy of illumination, PAI, for which the corresponding level of surrounding brightness would depend upon the activity associated with the space. It should be noted that whereas brightness assessments can be obtained quite economically through use of laboratory viewing cabinets, data that enables comparisons of similar spaces but with different recognitions of associated activity calls for an altogether higher level of research commitment. Even so, this should be seen as a crucial research objective, without which, lighting standards are little more than iterations of commonly accepted practice.

Based upon these considerations, MRSE is proposed as a metric to serve both types of assessment. It is proposed to fulfil the need for a metric that corresponds to typical human assessments of surrounding brightness, that is to say, how brightly-lit, or dimly-lit, a space appears to be. Also, it is proposed for specifying the perceived adequacy of illumination, PAI, for which assessment depends upon recognition that the space is associated with a specific human activity. While the extent to which MRSE fulfils these purposes has yet to be established, it is reasonable to assert that for any metric to do so, it would need to be some sort of measure that corresponds to the density of luminous flux from the surrounding surfaces that provide the stimulus for vision. On that basis, MRSE should prove to be a more appropriate metric than horizontal working plane illuminance.

2.3 MRSE research

Various researchers have reported studies of human assessments of brightness, but too often the brightness levels are recorded in forms that are incompatible with the MRSE metric. Among the exceptions are a study by McKennan[6], which is discussed in Section 3, and another by Rea, Mou and Bullough[7]. This latter study, which involved gathering responses from subjects exposed to controlled lighting conditions in a viewing cabinet, found better correlations between brightness assessments and illuminance at the eye on a vertical plane, than with horizontal illuminance.

The author's plea for "someone somewhere"[1] to take up the challenge of investigating the MRSE concept led to research on this topic commencing at the Dublin Institute of Technology in 2011. James Duff has reported two experimental investigations involving human subjects, the first conducted in a laboratory viewing booth[8] and the second in a small office[9]. In both situations, subjects assessed 27 lighting conditions, comprising three levels each of surrounding surface reflectances, luminaire flux distribution, and MRSE. Responses were recorded on the following scale:

7. Very bright
6. Bright
5. Slightly bright
4. Neither bright nor dim
3. Slightly dim
2. Dim
1. Very dim

The key findings of the first study[8] in a viewing booth were:

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DOI: https://doi.org/10.21427/D7RP4F

- A simple linear relationship was found to exist between MRSE and spatial brightness.
- A broadly unpredictable relationship was found to exist between horizontal working plane illuminance and spatial brightness.

(As has been explained, the author prefers to use the term 'surrounding brightness' rather than 'spatial brightness' as the latter term has been defined in different ways by other researchers. However, the conditions of Duff's experiments coincide well with the author's definition of surrounding brightness which makes them directly comparable.)

The second study[9], in a full-scale office where the activity was readily recognisable, confirmed the above findings, and also included assessments of PAI. Again, a simple linear relationship to spatial brightness was found, and an additional finding was recorded:

- Levels of spatial brightness reported were strongly correlated with levels of PAI reported.

While conducting these investigations, Duff had to cope with various practical issues that were outside the range of conventional procedures. The measurement of MRSE involves gaining a response to the entire sphere of diffusely reflected light while ignoring direct flux from the luminaires. The difficulties he had to overcome led him to devise a novel procedure involving high dynamic range imaging, and he achieved this making use of available hardware and software[10]. He also examined calculation procedures for predicting MRSE, and investigated the extent of error incurred by formula (2), comparing MRSE values calculated by both formulae (1) and (2) for two different luminaire distributions, a downlighter and an uplighter, located at the centre of a room for which the five different reflectance combinations shown in Table 1 were specified[11].

Reflectance reflectance	Ceiling reflectance	Wall reflectance	Floor combination
1	0.5	0.5	0.5
2	0.6	0.5	0.4
3	0.7	0.5	0.3
4	0.8	0.5	0.2
5	0.9	0.5	0.1

Table 1. Reflectance combinations for Duff's comparison[11] of formulae (1) and (2), the results of which are shown in Figure 1. In every case the average room surface reflectance is 0.5, and the five combinations represent increasing levels of surface reflectance diversity.

The result of this comparison is shown in Figure 2. It can be seen that formula (2) tends to slightly underestimate MRSE due to downlighting, and, to a rather greater extent, to overestimate for uplighting. Luminaires that provide a balance of upward and downward flux will incur errors between these levels, with the extent of error increasing as the diversity of reflectances increases.

For practical applications, the underestimation incurred by using formula (2) will often be acceptable, as predictive calculations cannot be exact as they are liable to be upset, at least to the extent

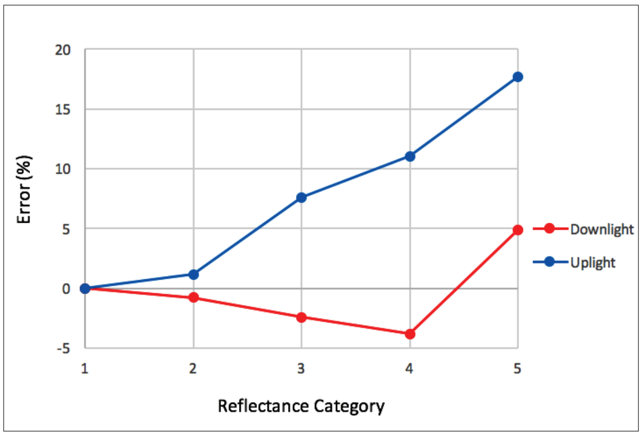

Figure 2. Levels of error incurred using formula (2) rather than formula (1) in Duff's comparison[11] for downlight and uplight luminaires illuminating a room with the five reflectance combinations shown in Table 1.

indicated, by factors such as changes of furniture, to which MRSE would be more susceptible than horizontal illuminance. The higher level of error involved for uplighting is discussed in Section 3, but it may be noted that for luminaires that emit combinations of upward and downward flux, the actual error can be expected to fall between these extremes. While initial estimates of this sort can be instructive, for finalising installation specifications, Duff's calculation procedure[10] based on formula (1) should be applied.

3. Implications of proposed change

The approach to lighting practice described in this paper involves changes in how lighting may be measured and calculated, and how it might be specified in standards. Underlying these practical changes is a fundamental difference of understanding as to what is the purpose of lighting. Instead of illuminating visual tasks to provide for visual performance, the prime purpose is understood to be to influence the appearance of overall brightness, or dimness, of the spaces that people occupy and use. Regulators would be able to specify lighting standards that would ensure that the people using a space would be likely to assess it to be adequately lit. Such standards would merely restrict lighting practitioners from providing lighting likely to be assessed inadequate, and so should not restrict how they choose to distribute light within the space, nor whether they opt to design for efficiency or for an illumination hierarchy. More generally, practitioners would be able to apply the MRSE concept to generate predicted assessments of surrounding brightness, and where standards do not apply, these could range from very dim to very bright, while they exercise full control over the distribution of lighting within the space. The shift from providing for visibility to providing for surrounding brightness is a fundamentally different understanding of the purpose of lighting, and its adoption for general lighting practice would cause practitioners to revaluate their current understanding of how their work influences human response.

3.1 MRSE and surrounding brightness

The author has tentatively proposed[1] a range of subjective assessments related to a logarithmic scale of MRSE, shown in Table 2. This was based on experience of practical measurements and student projects conducted over several years, but which fell short of the standards for publishable research. Duff's experimental studies of the relationship between MRSE and human response represent the only research to date to meet that criterion, but the restricted scope of Duff's experiments needs to be taken into account. It should be noted, for example, that Duff's experimental situations exposed subjects to a range of three MRSE levels; 25, 50 and 100 lm/m^2; and this covers only a small part of the scale indicated in Table 2. On the seven-point response scale shown in subsection 2.3, the subjects' responses generally fell between 2 (dim) and 4 (neither dim nor bright), and although these assessments appear to accord reasonably well with the author's descriptors, research studies covering a range of MRSE sufficient to generate responses covering the entire range of responses, from very dim to very bright, are needed to provide acceptable confirmation of the relationship.

Mean room surface exitance (MRSE, lm/m^2)	Perceived brightness or dimness of ambient illumination
10	Lowest level for reasonable colour discrimination
30	Dim appearance
100	Lowest level for 'acceptably bright' appearance
300	Bright appearance
1000	Distinctly bright appearance

Table 2. Tentatively proposed range of subjective assessments of lighting appearance related to mean room surface exitance[1].

The data generated by Duff for his comparison[11] of formulae for MRSE prediction provides insight into some practical differences from conventional practice that would be encountered in devising lighting installations to comply with MRSE standards based on surrounding brightness. Figure 3 shows a replotting of the data on which Figure 2 is based. In every case, the luminaire, whether a downlighter or uplighter, emits 5000 lumens, but the differences in MRSE levels produced could be expected to surprise experienced practitioners. It is the conventional understanding that while uplighting may produce attractive lighting effects, it is less efficient than downlighting and so should be reserved for applications where the purpose is to create decorative effects, and not used where efficiency is an important concern. This notion of 'efficiency' can be seen to be a direct consequence of the long-term effect of lighting practice being required to comply with horizontal working plane illuminance specifications, where the 'efficient' way to achieve compliance is inevitably to direct the luminaire flux onto that plane. Providing for surrounding brightness calls for a different way of thinking about what 'efficiency' means in lighting practice.

Formula (2) shows the crucial role of first reflected flux FRF for generating MRSE. As the diversity of Duff's five reflectance combinations increase, they follow the practice of conventional décor with higher levels of ceiling reflectance, and lower levels of floor reflectance values. The underlying principle is that when the purpose is to provide for surrounding brightness, 'efficient' application of luminous flux calls for the initial luminaire flux to be directed onto the room surfaces that have the highest reflectance. In this way, the pathway to efficient practice is not to unthinkingly direct light

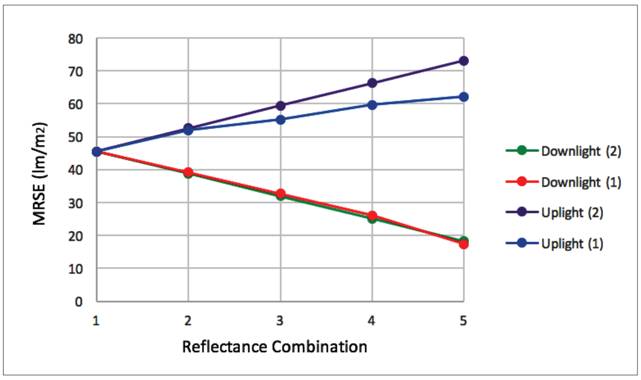

Figure 3. Plot of MRSE levels based on Duff's comparison[11] of downlight and uplight luminaires calculated by exact formula (1) and approximate formula (2). The room characteristics are as described previously, and in every case the luminaire emits the same level of luminous flux.

onto a specified measurement plane, but it is for the practitioner to start the process of devising an appropriate distribution of luminaire flux by evaluating the distribution of room surface reflectances. For conventionally decorated rooms, uplighting will be the optically efficient option, but if the ceiling is dark and the walls are light, then attention should switch to wallwashing. There is no such thing as a universally efficient luminaire.

3.2 Illumination hierarchy

Even so, the pursuit of efficiency in conventionally decorated rooms would inevitably lead to successions of uplit rooms, all with softly diffused illumination reflected from matt white ceilings. While there are some spaces for which this type of lighting might be entirely appropriate, such as corridors, stairways and lift (or elevator) cars, there are far more spaces in which some surfaces or objects can be identified as deserving, or requiring, ***visual emphasis***. Lighting practice that is directed towards compliance with current standards aims to achieve illuminance uniformity, but if standards were to be specified in terms of MRSE, then practitioners would have freedom to determine distributions of luminaire flux. Some might find this freedom confusing and opt for 'design by rote' solutions, but the very fact that practitioners would be able to comply with lighting standards while having the freedom to determine the distribution of direct flux, would open up opportunities in general lighting practice. It would enable practitioners, whether they consider themselves to be engineers or designers, to give consideration to the specifics of each space within a lighting proposal, and to develop an ***illumination hierarchy*** specific to each space, specified in terms of ***target/ambient illuminance ratio***, TAIR[12,13].

The author has proposed a scale relating TAIR to visual emphasis, shown in Table 3, and again, this is a proposal based on practical experience and student projects. It is yet to be subjected to rigorous research examination, but it should not be supposed that a relationship of this sort can ever be defined precisely. Its purpose would be to guide practitioners towards creating an ordered priority of visual emphasis related to the specifics of each individual installation. In this way, a practitioner would be able to make a statement by devising an illumination hierarchy that draws attention to selected objects and surfaces, whilst not being required to comply with a lighting standard. For this to become general practice, it would need the MRSE metric

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DOI: https://doi.org/10.21427/D7RP4F

to become accepted by regulators, and TAIR to become accepted by practitioners. It may be expected that if such acceptance is achieved, these concepts would be taken up readily by lighting design software producers, who would see opportunities to extend the scope of their products into the lighting design process.

Visual emphasis	Target/ambient Illuminance ratio, TAIR
Noticeable	1.5:1
Distinct	3:1
Strong	10:1
Emphatic	40:1

Table 3. Approximate guide to visual emphasis related to TAIR, being the ratio of target illuminance (the sum of direct illuminance and MRSE) to MRSE. (Adapted from Cuttle[12]).

For many practitioners, such acceptance would involve a reassessment of the purpose of lighting and procedures for its provision in general practice. The first level of understanding is that the flux from the luminaires travels through space without visible effect until it undergoes its first reflection, and this FRF becomes the source for both the MRSE (the diffused field of inter-reflected flux within the space), and the distribution of TAIR (which defines the illumination hierarchy). The next level of understanding concerns the two stages of optical control involved in achieving an illumination hierarchy. The luminaires that house the light sources provide the first stage of optical control by directing the distribution of initial flux, which is the source of FRF. The second stage of optical control is due to reflection from, and between, the objects and surfaces that comprise the lit space, and which become the second stage luminaire whose function is to present light to the users of the space. The author has published[13] a spreadsheet that facilitates application of the concepts described in this paper.

3.3 The need for research

The change of understanding that would follow from this reassessment of lighting would bring about changes in our perceptions of the limitations of our knowledge, and would generate a new set of priorities for researchers.

Past studies of brightness have involved various terms to describe its appearance. It would be beneficial for researchers to adopt the seven-point brightness assessments scale used by Duff, and so enable comparisons between their findings. This scale avoids some confusions that have occurred in the past by involving just two descriptors – bright and dim. Some researchers have switched from dim to dark at the bottom end of the scale, but dark is the absence of light, and apart from astronomers seeking to retain their scotopic adaptation, the elimination of light has no place in lighting design. Emotive terms, such as gloomy and brilliant, should be avoided as they are context related, and as far as possible, researchers should avoid any form of implication that bright is good, or that dim is bad. For example, attractive displays of brightly lit objects in museums or retail premises (particularly for jewellery displays) may depend upon the displayed objects being presented in settings that are dimly lit. Equally, evaluative terms such as acceptable, satisfactory or preferred, should be avoided.

There would be plenty to occupy researchers in this new environment. In an earlier paper[1] the author reviewed a study by McKennan[6] in which he recorded overall brightness assessments as people moved between 16 differently lit spaces, and when they reached the end, they turned around and repeated their assessments going in the opposite direction. There was clear evidence that the assessment of each space was affected, significantly but not strongly, by the experience of the previous space. This suggests that MRSE specifications might need to take account of previous experience to give reliable indications of surrounding brightness.

This discussion, and also the above study, have been restricted to enclosed spaces with electric lighting. There is no obvious reason why daylit spaces should not be treated similarly, but that needs to be verified. However, unenclosed spaces, as encountered outdoors, do not generate diffusely inter-reflected light fields, and so the MRSE concept would not be applicable. Even so, it should be expected that a metric that relates lighting to visual response would assess reflected light rather than incident light, and a move towards MRSE specifications for enclosed spaces should lead to research into suitable metrics for unenclosed spaces.

Other discussion points raised by the author[1,12,13] have included the effect of direct light at the eye, whether from luminaires or windows. It cannot be correct to add this stimulus when examining how light at the eye relates to assessment of surrounding brightness, but equally, it cannot be correct simply to ignore it, as MRSE does. It may be speculated that its effect would be to reduce surrounding brightness, particularly if it is strong enough to be a significant source of disability glare. Also, the concept of visual emphasis, which is a vital aspect of the illumination hierarchy concept, currently lacks any recognisable research basis. So while it is proposed that adoption of the concepts described in this paper would comprise a distinct step towards the third stage of the lighting profession, it should be expected that this step will open up new issues to be resolved, rather than solving the issues of lighting applications.

4. Conclusions

While the MRSE approach indicates opportunities that have the potential to take general lighting practice a distinct step forward, it cannot be claimed that existing knowledge of the MRSE concept is sufficient for it to be adopted for lighting standards to govern general lighting practice. Research to date does indicate that it is better suited for this purpose than horizontal illuminance, and so to that extent it should represent an improvement on current practice, but perhaps that is only because horizontal illuminance is so unsuited for the purpose. The fact is that more research is needed, but for that to occur, there needs to be an increased awareness of the potentials offered by a reassessment of the purpose of general lighting practice.

Acknowledgements

The author thanks Dr Kevin Kelly for his advice and comments on this paper, and James Duff for the use of his material. He also thanks the three anonymous reviewers for their comments, which provided helpful contributions to the final review of the paper. Figure 1 was photographed by Paul McCredie, in the architectural practice of Stephenson and Turner, Wellington, New Zealand.

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