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Article: Playing with Time: Budgeting Light-Induced Damage to Manage Light Risk Associated with the M+ Opening Exhibition

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Playing with Time: Budgeting Light-Induced Damage to Manage Light Risk Associated with the M+ Opening Exhibition

INTRODUCTION

Overall Context: M+

Based in Hong Kong, M+ is a new museum dedicated to collecting, exhibiting, and interpreting visual culture of the 20th and 21st centuries. Designed by Herzog & de Meuron, it aims at becoming one of the largest museums of modern and contemporary visual culture, with a broad ambition to be one of the world's leading cultural institutions. The museum has a total of 17,000 square meters of exhibition space.

Currently, the M+ collection consists of roughly 7700 objects and 47,000 items from archives and the library's special collection and covers a wide geographic range with a large emphasis on Hong Kong artists. Since the inception of the project, the collection has been acquired at a fast pace. With newly constructed facilities and a fast-growing museum team, the organization is coping with constant rejigging of teams' roles and responsibilities while constantly evolving and developing into a functional museum toward business as usual.

In line with organizational objectives, it is imperative for M+ to form a general strategy on preventive conservation. In particular, an emphasis has been placed on light exposure limits and rotation of collection items on exhibition, as these issues factor into budgeting and have an impact on exhibition narrative. In addition, institutional commitment for rotation has been managed from early on to ensure the program is sustainable in consideration of the growing but yet still relatively small team and of budget allocation, as well as future commitment to rotation.

Basic Information on Light-Induced Deterioration

When UVs are excluded, color change is the main light-induced deterioration: it is irreversible, cumulative, and follows the "reciprocity principle": for instance, 6 months under 50 lux induces the same change as 3 months under 100 lux.

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Light sensitivity is assessed and described using Blue Wool Standard (BWS) cards: any material changing color as quickly as BWS1, 2 or 3 is considered highly sensitive to light. Materials at BWS7 or above have low to no light sensitivity.

The light dose that induces a Just Noticeable Difference (JND) in color has been studied using accelerated light aging tests under mild conditions. Results obtained for BWS below 3 are indicated in figure 1.

It is usually and internationally accepted as best practice to exhibit highly sensitive items only for 3 months at maximum 50 lux, every 2 years, with no UV or daylight used.

M+ Opening Exhibitions and Rotation Needs

Around 1500 collection items, representing approximately 20% of the M+ collection, were selected for the opening exhibitions. Roughly 9% of the total exhibition includes

	Light Dose to a JND* (in lux-hours—no UV)
BWE 1	~100,000
BWE 2	~600,000
BWE 3	~2,400,000
*JND in color for flat, opaque, mid-size materials compared side by side under daylight at minimum 500 lux.	

Fig. 1. Light dose to reach a JND (in lux-hours) by BWS for highly light sensitive materials.

surrogates of the collection and will not be included in the present study.

M+ has planned seven opening exhibitions (with durations varying between 12 and 16 months) to showcase the collection and to foster audienceship within the community, as well as across Asia and the world. More than 60% of the items selected for exhibit are likely highly sensitive to light. These are mostly works on paper, including photography and different contemporary printing techniques, often pristine and with unknown behavior to light. It comprises prestigious art works such as Marcel Duchamp's *Rrose Sélavy (Box in a Valise)* (1935–1941/1963–1966), *Press Conference*, oversized gouache on paper by Zou Tiehai, as well as a large collection of photographs including silver prints, artist-designed posters, architectural drawings, and various kinds of mass-produced items. It should be noted that other 3D and installation art items can also be highly sensitive to light depending on the materials used.

Considering the item selection and the exhibition durations, and without taking into account any other mitigation means, more than 1800 rotations were required to comply with the already-mentioned international exhibition recommendations associated with best practice. Implementation of such a massive rotation program was not achievable, especially at an early stage of the institution's existence. In addition, the budget restrictions induced by the COVID-19 pandemic were forcing the institution to consider reducing costs related to its operations, including the one associated with the rotation program.

This presentation describes an alternative approach to mitigate the light risk associated with the M+ opening exhibition series that draws on differentiating an unwanted change from the resulting damage, which is the loss of the item's value.

USING A VALUE-BASED APPROACH FOR THE LIGHT RISK MITIGATION DECISION

Damage resulting from light exposure depends on various parameters:

- The item's light sensitivity plays a key role, as it determines the induced color change.
- The extent of damage is also related to the item's museum value, which depends on its cultural significance, its importance within the collection, and expected use by the institution. More damage would result from fading Duchamp's *Box in a Valise* than one of the mass-produced posters from the collection.
- Finally, the role color plays in the museum value is the last parameter to consider. A similar color change would have a greater impact on *Press Conference* with all depicted flags than on a black-and-white print.

Value at Risk to Light of a Collection Item

Value at risk to light of an item is the portion of its museum value that is negatively affected by its light-induced color change. It depends on the role the color information is playing in conveying the item's museum value, and as a general rule, *the higher the value at risk to light, the tighter the control*.

Figure 2 unfolds the overall approach on how to assess value at risk to light of a collection item to help mitigate its light risk and manage its change adequately. To assess the value at risk to light of a collection item, one needs to understand the relation between the exposure to light of an item and the resulting loss of its museum value. This is done by first estimating the induced color change and then the consequent loss of value.

To quantify the light risk, the total loss of value at risk to light is evaluated by estimating the color change below which all color information would be lost. This threshold is expressed in JNDs and depends on the role of the color information in the museum value. For illustration purposes, this article will use an example with a threshold of 10 JNDs.

The next step is to set an expected lifetime for the item in the collection. This depends on the item's museum value, and as a general rule, *the higher the value, the longer the lifetime*. Suppose that the example in this exercise has an expected lifetime of 500 years.

The maximum acceptable color change (in JNDs) over the item's lifetime (in centuries) can be budgeted resulting in deducing a Preservation Target (PT), the period of managed use during which 1 JND is allowed. It corresponds in this example to 10 JNDs for the next 500 years and is equivalent to 1 JND for every 50 years.

The light dose allocated to the PT is quantified by assessing the item's material light sensitivity. In the example provided, for an item with light sensitivity equivalent to BWS1, the allocated light dose to PT corresponds to 100,000 lux-hours for the next 50 years.

The final step is to manage light risk associated with the use of the item by applying the reciprocity principle. This allows one to safely optimize the visibility of the item while maximizing the duration of its physical exhibition. Exhibit recommendations express the resulting balance.

Setting Levels of Light Control According to Value at Risk to Light

By applying this light control approach to the subset of the collection identified as highly sensitive to light, M+ is able to build broad categories of relative value at risk to light and to set levels of light control accordingly, following the general rule that the higher the value at risk, the tighter the control.

As indicated in figure 3, three levels were used to assess an item's museum value: High, Medium, and Lower. Each value level is associated with a lifetime for the item in the collection—the higher the value, the longer the lifetime. The role

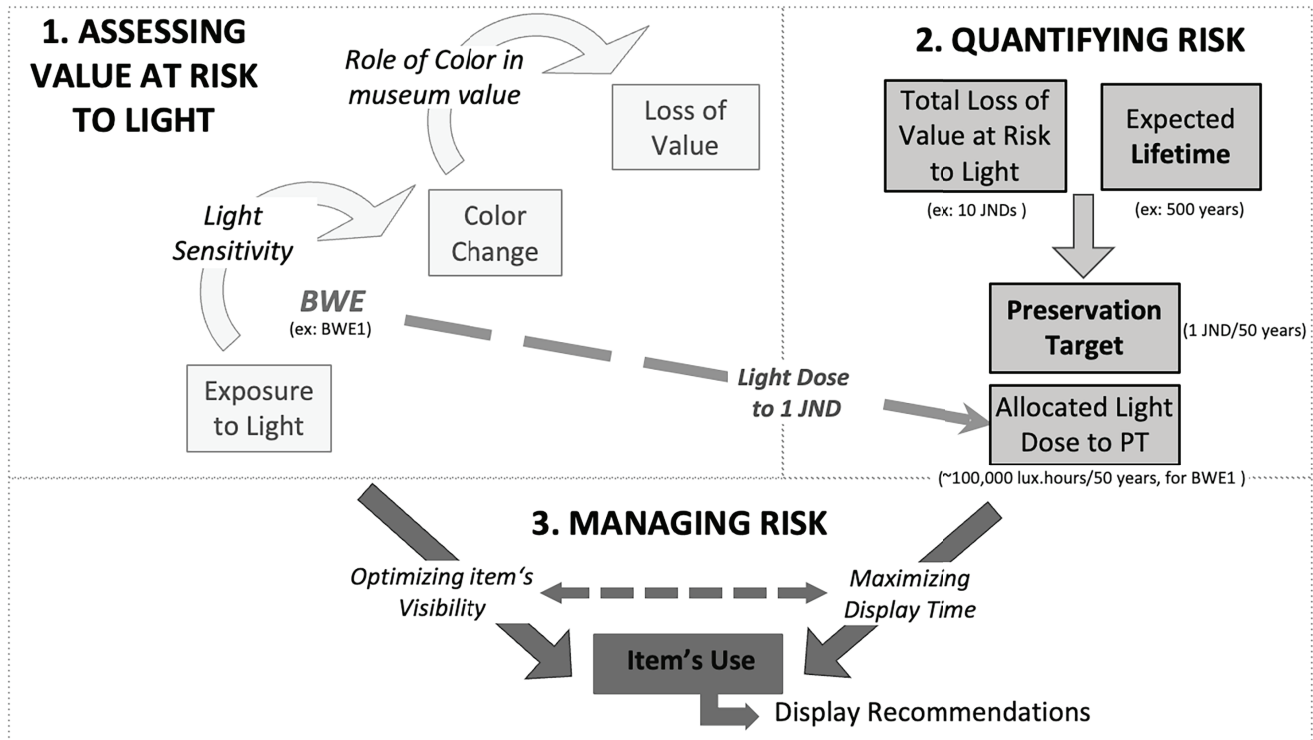


Fig. 2. Schematic showing use of value at risk to light of a collection item to help in managing its light risk.

		Museum Value		
		High	Medium	Lower
Role of Color Information	Important	A	B	C
	Average	B	C	D
	Smaller	C	D	D

Fig. 3. Category of relative value at risk to light by museum value and role of color information.

of color information is estimated by evaluating the impact of color change on the item's museum value. Three levels were used: Important, Average, and Smaller. Each level is associated with a threshold of maximum color change (in JNDs). Four categories of relative value at risk to light are obtained: A, B, C, and D. Category A includes items with the highest value at risk and D with the lowest.

Each category of relative value at risk is associated with a PT: the higher the value at risk, the longer the PT. PTs reflect the commitment of the institution regarding the care and the use of

its collection: setting them is one of the most sensitive decisions regarding collection care. It is institution specific and should involve the entire institution and be endorsed at its highest level.

Figure 4 presents the PTs as currently set at M+ at its early stage of existence to fit its collection of contemporary visual culture.

Press Conference, with its high museum value and the important role of the color information, is a good representation of category A. An artist-designed poster would well represent items from category B, whereas an example for

Category of Relative Value at Risk to Light	Time to Reach 1 JND
A	20 years
B	10 years
C	5 years
D	2.5 years

Fig. 4. Value-based M+ PTs (in years) by category of relative value at risk to light.

M+ Preservation Target	Category of Relative Value at Risk to Light	BWE 1 (100,000 lux-hours)	BWE 2 (600,000 lux-hours)	BWE 3 (2,400,000 lux-hours)
20 years	A	Individually Assessed ~3.5% at 50 lux max (or 10 days/year) Loan highly restricted	Individually Assessed ~20% at 50 lux max (or 10 weeks/year) Loan restricted	Short Exposure ~80% at 50 lux max (or 9 months/year)
10 years	B	Individually Assessed ~7% at 50 lux max (or 3.5 weeks/year) Loan restricted	Short Exposure ~40% at 50 lux max (or 4.5 months/year)	Mid-Exposure No time restriction at 75 lux max
5 years	C	Individually Assessed ~14% at 50 lux max (or 7 weeks/year) Loan restricted	Short Exposure ~80% at 50 lux max (or 9 months/year)	Mid-Exposure No time restriction at 150 lux max
2.5 years	D	Short Exposure ~28% at 50 lux max (or 5 months/year)	Mid-Exposure No time restriction at 75 lux max	Mid-Exposure No time restriction at 200 lux max

Note: Max % of its PT, an item can be on display assuming ~ 150,000 lux-hours annual light dose; no UV / no daylight.

Fig. 5. M+ Exhibition recommendations for highly sensitive materials.

category C would be an installation containing black-and-white photographs as essential elements.

Furthermore, the M+ exhibition recommendations are formulated by cross-referencing the PT table—as just seen—with figure 1 that indicates the light dose to reach a JND for each BWS. They are presented in figure 5. To allow for easier viewing, note that this figure only includes the recommendations for highly sensitive collection items.

Overall Value-Based Decision Framework

Figure 6 summarizes the decision framework used at M+ to prioritize the mitigation of the light risk for items highly sensitive to light and to formulate its exhibition recommendations.

First, the category of relative value at risk to light of an item needs to be assessed using the table presented in figure 3. Once this is done, it is possible to quantify the light risk, and to deduce the item’s PT according to values shown

1. ASSESSING VALUE AT RISK TO LIGHT

Table 2: Category of relative value at risk to light

		Museum Value		
		High	Medium	Lower
Impact of Color Change	Important	A	B	C
	Average	B	C	D
	Smaller	C	D	D

2. BUDGETING CHANGE & QUANTIFYING RISK

Table 3: M+ Value-Based Preservation Targets

Category of relative value at risk to light	Time to Reach 1 JND
A	20 years
B	10 years
C	5 years
D	2.5 years

3. MANAGING LIGHT RISK

Table 4: M+ Display Recommendations
(Max % of its PT, an item can be on display assuming ~150,000 lux-hours annual light dose; No UV / No daylight)

M+ Preservation Target	Category of relative value at risk to light	BWE1 (~100,000 lux-hours)	BWE2 (~600,000 lux-hours)	BWE3 (~2,400,000 lux-hours)
20 years	A	Individually Assessed ~3.5% at 50 lux max (or 10 days/year) Loan highly restricted	Individually Assessed ~20% at 50 lux max (or 10 weeks/year) Loan restricted	Short Exposure ~80% at 50 lux max (or 9 months/year)
10 years	B	Individually Assessed ~7% at 50 lux max (or 3.5 weeks/year) Loan restricted	Short Exposure ~40% at 50 lux max (or 4.5 months/year)	Mid exposure No time restriction at 75 lux max
5 years	C	Individually Assessed ~14% at 50 lux max (or 7 weeks/year) Loan restricted	Short Exposure ~80% at 50 lux max (or 9 months/year)	Mid exposure No time restriction at 150 lux max
2.5 years	D	Short Exposure ~28% at 50 lux max (or 5 months/year)	Mid exposure No time restriction at 75 lux max	Mid exposure No time restriction at 200 lux max

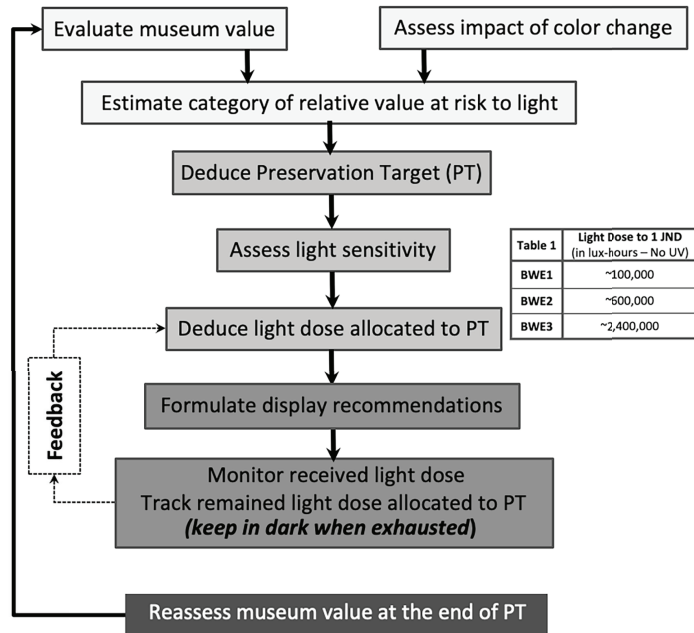


Fig. 6. Value-based decision framework to mitigate light risk as used at M+. Adapted from Beltran et al. 2021.

in figure 4, which have been approved by M+ executives. Light sensitivity can then be assessed. Once the item's BWS Equivalence (BWE) is estimated, the light dose allocated to the PT is deduced using the data already presented in figure 1. Light risk can then be managed over the item's PT according to the various contexts involving its exposure to light.

The reciprocity principle is applied on the light dose allocated to the PT, and the exhibition recommendations can be formulated as already mentioned (see figure 5).

Monitoring the light dose received is required, and the remaining light dose allocated to the PT is tracked and updated after each exposure to light. Once the light dose allocated to PT is exhausted, the item should be kept in the dark until the end of the set duration. At that end of it, the item's museum value is reevaluated along with its associated category of relative value at risk, and a new PT is then set.

Adjustments to Circumstances Associated with the M+ Opening

Some adjustments needed to be made to the overall decision framework to deal with the uncertainties and time pressure associated with the specific circumstances of the M+ opening.

They are highlighted in green in figure 7.

As museum value is still a working concept, making assumptions to approximate it was necessary: it was

estimated by assessing the importance of the item in the exhibition curatorial narrative. Three levels were considered. The role of color information was estimated in a systematic manner and using two levels only: Important, for all colored items and/or with low contrast, or Average, for black-and-white items with high contrast. The category of relative value at risk to light was then defined following table 2bis of figure 7, and the corresponding PT, deduced using data from figure 4 as already explained. Note that category D of relative value at risk to light as defined in figure 3 was not used for the opening exhibition to stay on the safe side.

Finally, to estimate the light dose allocated to PT, the light sensitivity of the selected items considered likely sensitive to light needed to be roughly estimated: as the conservation team was not in a capacity to assess item-by-item due to the limited access to the collection, it was decided that light sensitivity of any colored item likely would be equivalent to BWS1.5 and to BWS3 for black-and-white items on robust support. Corresponding data are shown in table 1bis of figure 7, and the resulting exhibition recommendations used for the M+ opening exhibition are presented in table 4bis of figure 7.

The implementation of a few actions, highlighted in purple in figure 7, are already anticipated to take place after the opening exhibition:

1. ASSESSING VALUE AT RISK TO LIGHT

Table 2bis: Categories of relative Value at risk for M+ Opening Display

		Importance in curatorial narrative		
		Anchor	Medium	Lower
Role of Color Info	Important	A	A	B
	Average	B	B	C

2. BUDGETING CHANGE & QUANTIFYING RISK

Table 3: M+ Value-Based Preservation Targets

Category of Relative Value at Risk to Light	Time to Reach 1 JND
A	20 years
B	10 years
C	5 years
D	2.5 years

3. MANAGING LIGHT RISK

Table 4bis: Display Recommendations for M+ Opening Display

Relative Value at risk to light	BWE1.5	BWE3
	A	~350,000 lux.hours ~12% at 50 lux max (or 6 wks/year)
B	~23% at 50 lux max (or 12 wks/year)	No time restriction at 75 lux max
C	~47% at 50 lux max (or 5.5 mths/year)	No time restriction at 150 lux max

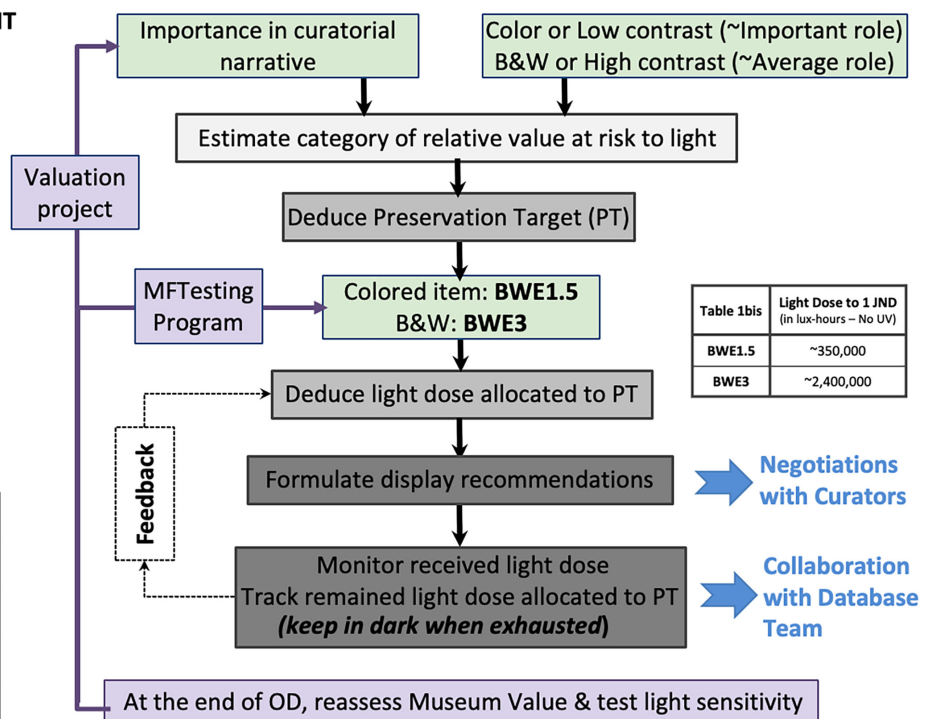


Table 1bis: Light Dose to 1 JND (in lux.hours - No UV)

BWE1.5	~350,000
BWE3	~2,400,000

Fig. 7. Adjustments to overall light risk mitigation decision framework to accommodate M+ opening circumstances.

- A proper method to assess the item’s museum value should be further researched, likely in a cross-departmental valuation project for the collection.
- A testing program using a microfader is expected to refine rough estimations of an item’s light sensitivity.

It is important to emphasize that the success of the proposed method to adequately mitigate light risk relies on two pivotal elements that ensure the continuity required for the rigorous monitoring of the remaining light dose allocated to the PT:

- The categories of relative value at risk to light and associated PTs as indicated in table 3 in figures 6 and 7 should be used consistently, before and after the opening exhibition.
- The light dose received during the opening exhibition needs to be adequately monitored to properly update the light dose allocated to the PT.

IMPLEMENTATION OF THE APPROACH TO THE M+ OPENING EXHIBITION

The implementation of the presented approach for the M+ opening exhibition required two collaborative processes. This article will now briefly show how rotations were discussed and negotiated with curators, and will also introduce the workflow used by the M+ databases manager to help ensure necessary tracking of the remaining light dose allocated to the PT.

Negotiating Rotations with M+ Curators

In the year leading to the beginning of the opening exhibitions’ install, the M+ conservation team launched a series of workshops with the curators. The decision-making process related to rotation developed during these workshops is presented in figure 8.

First, curators were briefed on the value-based approach and the PT. The rotations based on curatorial priorities for narratives were then carefully reviewed and corrected whenever needed. Once everyone understood the approach, it became apparent that some further refinement was needed considering how much, in some cases, curatorial priorities

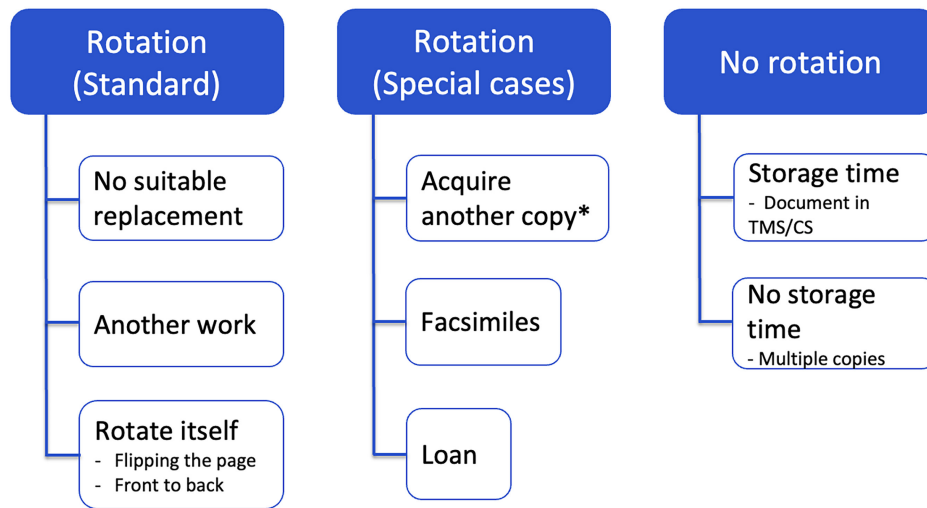
for narrative differed from what could be the item’s museum value. Relative value at risk to light was then updated accordingly using categories A, B, and C already mentioned. For each individual collection item, the annual light dose allocated by its PT was then calculated by Conservation along with the expected light dose received during the opening exhibition: any items with storage rest time of more than 3 years were selected for rotation. After reassessing museum values and PTs, the conservation and curatorial teams reconvened to discuss and agree on rotations before submitting the exhibition list to M+ management for approval.

The ways to rotate or not rotate is a constant negotiation. Curators carefully consider the impact of changing artworks that may be critical to their narrative or create an imbalance to the portfolio of artists they wish to represent, or the rarity of one artist’s work in the collection that makes it difficult to replace. M+ conservation and curatorial teams discussed the impact of extending exhibition time beyond the recommendations and explored whether there are other factors to consider, such as future loans or special exhibitions. The result of rotation decisions often falls into one of the scenarios presented in figure 9. It should be noted that although acquiring another copy for rotation has never been attempted in M+ history, it is now an option considered for further discussion within the organization.

The number of expected rotations for M+’s opening exhibition, following recognized best practices, was estimated to be 1835 rotations for about 800 highly light-sensitive items. This posed multiple challenges to an institution with a small collection and a growing team. Relaxing the international recommendations by including some adjustments related to the item’s material sensitivity allowed M+ to reduce the number of rotations significantly. Nevertheless, this latter approach does not factor in the curator’s assessment of the item’s value at risk to light, a core element for setting the PT, and results in the absence of any benchmarking behind the amount of storage time required and budgeting light exposure for the future. In contrast, the presented value-based approach allowed conservators and curators to negotiate the rotation of about 380 collection items while also taking into account the storage time post opening exhibition consequent to the decision made.

<p>1 Conservation to present lighting approach</p>	<p>2 Discuss rotation candidates (value at risk & material sensitivity)</p>	<p>3 Curators to confirm rotation list</p>	<p>4 Collection and exhibition team in M+ to assess rotation (i.e., manpower, schedule)</p>	<p>5 Endorsement by M+ management</p>
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Fig. 8. Steps of the decision process on rotation implemented during M+ opening exhibition preparation.



*In the future, can be flagged at acquisition after initial value assessment.

Fig. 9. Main scenarios used for decision on rotation.

Negotiation with curators is often educational and multi-disciplinary. It allows all parties involved to approach decision making from a holistic viewpoint, factoring in other considerations such as future loans, special exhibitions, limitations of the existing collection, and/or other intentions such as presenting female artists in narratives. The proposed rotation program will be reviewed by M+ management so that they can place adequate resources behind the effort. The decision to exhibit objects for a longer time than recommended and left unrotated needs to be justified and documented. For each item, associated storage time is logged into the collection management database until the museum implements a Microfade testing program, currently planned for 2022.

Recording and Tracking the Light Dose Allocated to the PT

Together with the collections database team, conservators are currently developing two different tools that will allow implementing the “light budgeting” approach in the museum’s everyday decision making. These tools will be incorporated into M+’s collection management system, Museum System (TMS) and Conservation Studio (TMS-integrated software).

The first tool is the “light dose recording sheet,” which allows recording of light dose received by a collection item during consecutive exhibitions (fig. 10).

The measurements will be taken during exhibition using a simple, multipurpose environmental monitoring device able to measure visible light. The light dose recording sheet allows recording multiple measurements during one exhibition. The light dose is calculated by multiplying the average visible light measured on the item and the time of exposure during consecutive exhibiting.

The second tool, presented in figure 11, is the “light exposure decision-making tool,” which allows for calculating recommended exhibition time and the maximum lux level for exhibition purposes. It consists of four different sections. The first section of the tool—estimated value at risk to light and associated PT—is where data required for all further calculations will be input: museum value, impact of color change, light sensitivity, and the year of the assignment of the PT. The second section shows exhibition recommendations calculated from data entered previously. Using the data recorded in the light dose recording sheet, the third section shows the light dose used so far and the annual light dose per given amount of time left until the end of the PT (1 year, 5 years, or 10 years—the timeframe will be gradually adjusted to museum operational needs). The fourth section is the “exposure calculator for exhibition planning,” which allows for informed decision making related to the time of exposure (and consequently rotations plan) for future exhibitions and advice on the required time in storage after the exhibition.

Once the design and implementation of the first tool (the light dose recording sheet) is finalized, it will be tested during the opening exhibition. The implementation of the second tool (the light exposure decision-making tool) within the rigid structure of the M+ database proved to be challenging, needing more time and labor. This tool requires interdepartmental collaboration and as such needs to be accessible to all the stakeholders involved in the decision making (curatorial, registration, and conservation). The M+ database team will be working on its development and implementation later this year.

LIGHT DOSE RECORDING SHEET

EXHIBITION TITLE		EXHIBITION PERIOD		TIME OF EXPOSURE (h/week)
drop down box		FROM	YYYY-MM-DD TO YYYY-MM-DD	
Light Source		Measurement remarks		
drop down box		Free text		

MEASUREMENTS +

DATE	HOUR	Examiner	Visible Light: Lux	UV: μ W/Lumen
YYYY-MM-DD	HH:MM	Name Surname	LLL	LLL

DATE	HOUR	Examiner	Visible Light: Lux	UV: μ W/Lumen
YYYY-MM-DD	HH:MM	Name Surname	LLL	LLL

DATE	HOUR	Examiner	Visible Light: Lux	UV: μ W/Lumen
YYYY-MM-DD	HH:MM	Name Surname	LLL	LLL

Visible Light AVERAGE: Lux	AVERAGE UV: μ W/Lumen	LIGHT DOSE RECEIVED
LLL	LLL	LLL

Fig. 10. M+ light dose recording sheet.

LIGHT EXPOSURE DECISION-MAKING TOOL

ESTIMATED VALUE AT RISK & ASSOCIATED PRESERVATION TARGET

Museum Value	Impact of color change	Light sensitivity/ Blue Wool Equivalency	Year of assignment of Preservation Target	General Category of Light Risk	End of Preservation Target (PT)
Remarks					
Free text					

DISPLAY RECOMMENDATIONS

Recommended Display time & availability for loans	Max lux level recommended	Other recommendations	Remarks
			Free text

EXPOSURE HISTORY

Light dose from PT used so far (lux.hours)	Years left until end of PT	Light dose left until the end of PT (lux.hours)	Annual light dose per year left until the end of PT (lux.hours)

EXPOSURE CALCULATOR FOR DISPLAY PLANNING *

Expected lux level	Planned duration of the display (in weeks)	Exposure hours per week	Expected light dose received during display (lux.hours)	Difference between recommendations & expected light dose received during display	Consequent required time in storage after display

* This section does not contain permanent data. Information entered should not be saved.

Fig. 11. M+ light exposure decision-making tool.

CONCLUSION

Managing the light-induced change of an item over its PT allows some operational flexibility that permits reconsidering the rotation program planned for the M+ opening exhibition. For each item at risk to light, the decision was made while also considering the duration the item would need to stay in storage after exhibiting. The discussion resulted in reducing the number of required rotations to an operational manageable level during the opening exhibitions of M+ while still ensuring the preservation of the selected collection items for the set anticipated collection lifetime. Note that the method proposed assumes strict compliance to the exhibition limitations set by the item's PT and its material sensitivity to effectively mitigate light risk. A Microfade testing program is planned to refine initial estimations of light sensitivity for collection materials. Accountability for the decision made on the item's exhibition is also required. This relies on the management's involvement and its associated support and on the commitment of all stakeholders to stick to the decision made as documented and recorded in the collection database.

The M+ conservation team has seen how setting the PT according to the category of relative value at risk to light fits well with the specific needs of M+, its collection of contemporary visual culture, and expected uses. This effort should also be seen as the first step toward the implementation of a value-based collection care approach. Cross-departmental efforts to assess the value of collection items continue to develop. Once a method to estimate an item's museum value is set, the assessment of value at risk will probably be expanded beyond light risk and to various subsets of the M+ collection or processes. It is expected that a value-based approach to collection care helps increase the institution's sustainability as it permits to prioritize resources allocation on mitigating what is at greater risk.

This project is far from being finished and will require many other adjustments that will be shared in the future.

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