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ORIGINAL RESEARCH OR TREATMENT PAPER

A Method for Studying Climate-related Changes in the Condition of Decorated Wooden Panels

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ABSTRACT
Museum objects are often highly complex and composed of materials with varying properties, some of which may have changed as a result of ageing and/or conservation treatments. Research into defining sustainable environmental conditions by balancing energy cost and risk to these vulnerable objects has mainly focused on experiments in laboratories with new, single materials or on computer modelling, but only to a limited extent on actual objects. This paper presents a method to collect empirical data from a large group of decorated wooden panels in order to investigate the effects of humidity fluctuations on these objects and relate them to their material properties and construction. Wooden panels were chosen as they are regarded to be particularly sensitive to fluctuations in relative humidity. The fluctuations may cause the wood to shrink and swell and can result in open glue joints, cracks, and deformation of the panels as well as losses and cracks in the decorative layers. Empirical data are scarcely available as yet but are essential to study relationships between material properties, type of construction, damage, and as input and validation for modelling and experimental studies. The method, referred to as the Rijksmuseum Study, was performed on a group of 300 objects from the furniture and paintings collections of the Rijksmuseum.

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Introduction

Apart from making their collections accessible to the public, museums and other cultural heritage institutions have the important task of preserving their collections for future generations. Among the many risks that the objects in the collections are exposed to, the possible adverse influence of fluctuations in relative humidity is probably the most hotly debated topic (Ashley-Smith and Burmester 2013). Museums are expected to become more sustainable, and avoiding unnecessarily strict climate specifications is one of several important aspects to achieve this goal. Recent reviews state that despite the bulk of research performed, it nevertheless remains very difficult to predict how far climate specifications can be relaxed without putting the objects at risk (Atkinson 2014; Bickersteth 2014; Staniforth 2014).

In 2014, the International Institute for Conservation (IIC) and the International Council of Museums Conservation Committee (ICOM-CC) presented the IIC/ICOM-CC Declaration on Environmental Guidelines. This declaration acknowledges that the issue of museum sustainability is much broader than the discussion on environmental standards and also recommends that museums reduce their carbon footprint by considering simpler technology, renewable energy, and risk management (Bickersteth 2016).

Bickersteth (2014, 2016) and Staniforth (2014) call upon the conservation community, which is not fully unified in its opinion on appropriate environmental standards, to take a more active role in the discussion on environmental standards. Until now, most research has been experimental, performed by conservation scientists, and carried out using single, new, or artificially aged materials (Bratasz 2013). This limitation probably reduced their resemblance to the behaviour of naturally aged museum objects (Ashley-Smith 2011; Luxford and Thickett 2013).

Experimental research is valuable, but needs to be accompanied by research into the construction and materiality of museum objects and how they might have been affected by fluctuations in humidity and temperature. Evidence-based research, as Bickersteth defines it, or epidemiological research, as recently promoted by the Getty Managing Collection Environments Initiative, is unfortunately still scarce (Boersma, Dardes, and Druzik 2014; Van Duin 2014; Getty Conservation Institute 2014). This paper aims to contribute to the discussion by presenting a method that was designed for the Rijksmuseum Study, an in-depth study of the construction, material properties, and condition of a large collection of decorated oak panels in the Rijksmuseum.

A decorated panel can be defined as a multi-layered three-dimensional structure, built up from a core

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construction of wooden boards that are joined together, with decorative layers applied to one or more faces of the construction. Panel paintings as well as panels in furniture have been chosen, because together they can provide more information on wood, the core material. Decorated panels are seen as particularly vulnerable to fluctuations in climate due to the wood construction (Michalski 1996; Van Duin 2009; New 2014).

In his book *Risk Assessment for Conservation* (1999), Ashley Smith summarises the research carried out by conservation scientists on the influence of environmental conditions. Because of the lack of information on actual objects, he encourages conservators to inspect the objects in their own houses, which have probably been exposed to more extreme conditions than museum objects.

In 2011, experts came together at the Rijksmuseum to define a research agenda for the conservation of panel paintings and related objects. They emphasised the value of population research, which involves gathering data from panel paintings, as a starting point for fundamental evidence-based research, and stressed the importance of a uniform approach in the collection of data by means of a standard protocol and the use of common terminology (Kos and van Duin 2014, 194–195). The method developed for the Rijksmuseum Study provides these data and can be applied to similar and other objects.

In recent years, Brunskog, Bylund Melin and Legnér, and Holl have all investigated a substantial number of objects which were still in their original setting. By comparing the present condition to earlier condition reports and photographs, they attempted to assess possible deterioration. This information was compared to the specific environmental conditions in which the objects were kept.

Brunskog (2012) investigated the influence of cold climate to the condition and damage development of 394 painted surfaces of movable and immovable objects in 53 churches in Luleå, Northern Sweden. The surfaces were observed, photographed and present condition registered, and the process was repeated after two to three years.

The method, by Bylund Melin and Legnér (2013), applied to painted wooden pulpits in 16 churches in Sweden, combined historic data on energy consumption for heating with the present condition of the pulpits. Indoor climate indicators were cracks, open joints, woodworm, mould, paint craquelure patterns, and losses. Instruments used were the naked eye, a hand-held microscope, torch, and camera, and the condition assessment was performed by experienced conservators. A condition scale was used, with subjective quantification.

Holl (2013) investigated changes in the condition by comparing 20-year-old detailed condition reports with the present condition. Certain types of damage were identified in this survey, such as flaking and cracks in gilded surfaces, water marks, and abraded surfaces. The type of damage was described and compared to earlier condition photographs.

Design of methodology

The research projects mentioned above focused on historic houses or churches with their original furnishings. Such settings offer the opportunity to link the condition of objects to the climate in which they were kept. Contrary to these objects, none of the Rijksmuseum objects are still kept in their original settings, as they were not made for the Rijksmuseum. This applies to most museums objects, which are often older than the museum itself. Many objects have changed owners and locations many times; some no longer reside in their countries of origin. It is also probable that some objects temporarily fell out of fashion and were stored away. The climate history of museum objects is usually unknown but undoubtedly greatly varied. To investigate and model this would be a very challenging task that is outside the scope of the research presented here.

While these previous research projects have all tried to link the condition of objects to the climate in which they were kept, the Rijksmuseum Study has approached this from a different perspective. By systematically analysing the type of construction, materials, and condition of a large number of objects, the Rijksmuseum Study aims to provide input for modelling studies, experimental research, and *in situ* studies, but just as importantly to build a frame of reference for assessing the condition of similarly constructed objects. This will provide insight into the climatic susceptibility that might be expected of a certain construction. If an object is in much better or worse condition than similarly constructed objects, an explanation for this can be sought by looking into the history of this object – if known.

The results, thus, offer the possibility of comparing individual objects to patterns that are encountered in groups of similar objects. Future studies can also compare the condition of objects preserved in their original setting with similar objects in museums (Van Duin 2013; Huijbregts et al. 2015). Likewise, the research can be broadened with objects made from different materials and from other countries: for example, a comparison between Netherlandish oak panel paintings and Italian poplar panel paintings may provide further insight into their construction and possible differences in the behaviour of these wood species.

An advantage of including furniture panels is that it is usually easier to assess the original dimensions of a panel, because these mostly have cross members or cleats, similar to paintings within an engaged frame or with cross battens attached to the back. As the shrinkage of wood in the longitudinal direction is negligible compared to the shrinkage in perpendicular directions, the original size can be deduced with good precision. These cross members might cause restrain, which is one of the important parameters in the Rijksmuseum Study. The influence of restrain can be based on the type of construction and material properties, as described in handbooks on wood (e.g. Hoadley 1998, 2000; Forest Products Laboratory 1999), in research on panel paintings and marquetry furniture (Brewer 1999; Mecklenburg 2007; Bratasz 2013; Luxford, Strlič, and Thickett 2013), and in a more practical way in handbooks for joiners and cabinet-makers. Other parameters of interest are dimensions of the wooden parts of the construction, including thickness, type of joints, presence of nails, and the decorative layers.

For decorated panels, it is important to understand the materials in combination. The response of glue layers between wooden boards may, for instance, be critical, but when glue is studied as a single material this is often difficult to establish (Luxford, Strlič, and Thickett 2013). Panel paintings are usually decorated with ground, paint, and varnish layers, of varying composition, thickness, and materials. Doors of cabinets can be decorated with veneers or mouldings as well as a surface coating. The veneers and mouldings can be applied in various directions and their thickness may vary. Veneers can either be plain or applied as marquetry, which is often composed of a complex pattern of veneers of different species of wood, with varying wood grain directions. The complexity of these objects results in a great number of variables that, when expected to significantly influence the response, all must be recorded.

The Rijksmuseum Study aimed to include as many relevant objects as possible to obtain a representative overview of trends relating to their construction and condition. There is a large variation of material and constructive parameters within the Rijksmuseum collection of decorated wooden panels, and a random selection would risk neglecting important features. This makes it quite different from other large-scale surveys, like the example described by Fry et al. (2007), which used a random selection and had a very different purpose: to manage the preservation of a collection based on a combined risk analysis and condition audit.

Similar instruments were used as in the earlier described studies, such as the naked eye, magnifying glasses, torch, earlier photographs, and documentation. Historic photographs were compared to the present condition of the object in order to analyse the development of damage over time, as suggested by Michalski (1996). It was accepted that a large part of the condition assessment was ambiguous, as pointed out by Taylor and Stevenson (1999), but the long experience of the conservators increased its reliability. As the Rijksmuseum Study focused on the actual wooden construction of the panels, detailed measurements of the wooden components, X-ray photography, and dendrochronology played an important role. Different measurement techniques and scales were discussed during the development of this method. The measurements needed to be performed on a large selection of objects, using a robust measuring technique that could be applied to objects on display as well as in storage. It was decided to use commonly known measurement instruments that are available in most conservation studios: digital calliper, flexible tape measure, and metal rulers.

Performing the Rijksmuseum Study

The Rijksmuseum Study was performed by experienced conservators. Conservators are trained in visual examination, a skill that is developed through experience and knowledge of the objects. Generally, the purpose of the conservator's visual examination is multi-faceted: i.e. to identify materials and techniques used; to determine the condition and to examine and validate changes and earlier treatments; and ultimately to propose and decide on an appropriate conservation strategy. For a conservator, the object is seen as the primary source of information; this was also the case for the Rijksmuseum Study. The challenge of the Study was to make the data, systematically obtained by visual examination, accessible to other colleagues as well as to experts from other fields.

The survey was carried out in several steps, as presented schematically in Table 1. In Step 1, the initial survey, an overview of the collection, was created by performing a quick scan of the collection of cabinets and panel paintings and the relevant documentation. Furniture and paintings conservators of the Rijksmuseum were consulted to benefit from their experience and knowledge of the collection and to assess which object documentation and previous research could be included in the Study. Basic information including origin, artist and period, location, acquisition date, history of locations, and loan history was accessed in the museum registers. Further documentation included condition reports, conservation reports, records of scientific investigations, e.g. analysis of paint layers, wood identification, analysis of construction, dendrochronology, historic photographs, and infrared, ultraviolet, and X-ray photography.

In Step 2, in consultation with the conservators, a selection of objects for further investigation was made which could be assessed in four years by one researcher with assistance from conservation staff and master students. Oak was chosen as it can be easily identified by visual examination and the date and origin can be determined with dendrochronological analysis. Oak is also predominant in paintings and

Table 1. Steps of the Rijksmuseum Study.

Step	Process	Aim
1. Initial survey	A quick scan	Create an overview of the decorated panels/objects: • Panel overall • Wood material • Decorative layers • Construction • Interventions Locate archival information about the objects Create a basis for selection and identify objects which are not matching the selection criteria Identify (other) parameters of importance for the selection
2. Selection	A desk survey. Defining the selection criteria	Obtain a workable and representative selection of objects
3. Analysis of construction and materials	A desk and *in situ* survey of the selected objects	Obtain detailed information regarding construction and materials
4. Analysis of condition	A desk and *in situ* survey to analyse the condition of the selected objects	Obtain detailed information regarding changes to the objects
5. Collecting historical information	A desk survey	Gather knowledge about the history of the objects
6. Documentation of information from steps 3 to 5	Reporting	Describe construction and materials Describe material changes and patterns of change Identify changes that are typical for a certain group of object
7. Statistical analysis	Statistical analysis	Make a descriptive analysis Identify the most relevant correlations between the different parameters

high quality furniture from the Netherlands, and the Rijksmuseum has a large collection. This selection also simplifies the analysis as it excludes differences in properties due to the variation in timber species. Commonly used construction types were chosen to be able to assess how the condition might vary within a group of objects with the same type of construction and how the condition might differ between groups of objects with different types of construction. In summary, the following selection criteria were chosen: the objects had to be produced in the Netherlands, and have an oak wooden substrate and a commonly used type of construction.

For the decorated panels in furniture, 138 doors from 70 cabinets were selected, ranging from the sixteenth to the twentieth century. Doors were chosen because they can be easily inspected and due to similarities and can be defined as a decorated panel within the parameters of the Study. The number of doors per cabinet varied from one to four.

The group of panel paintings selected was restricted to paintings produced by artists born between 1601 and 1620. For this group, which consisted of 249 panels made between 1625 and 1690, technical examinations and condition reports existed, made by the paintings conservators for the Rijksmuseum online collection catalogue (to be published). Although this meant that only seventeenth-century panel paintings were included, it allowed for the comparison of the condition of a large group of objects with similar material properties and construction types.

In Step 3, the construction and materials of the selected objects were more closely examined from all sides of the object. This visual inspection was supported by existing information, such as X-ray photography, dendrochronological reports, and photographs from conservation treatments, supplemented with information about the construction as well as the technical examination reports from the paintings conservators. The following information was obtained: construction type, joinery, wood grain direction, and structural plane direction of the oak (categorised as radial, tangential, or mixed), origin and date of the oak, and, lastly, characteristics of decorative layers. Measurements of the overall geometry of the panel (height, width, and thickness, number of individual boards) were taken from the panels as well as from members such as parts of frames, boards, cleats, mouldings, battens, and the thickness of veneers and paint layers. Flexible tape measures and metal rulers were used with an accuracy of 0.5 mm and a digital calliper with an accuracy of 0.1 mm. If individual boards were tapered, the width of both ends was recorded.

The panel constructions were categorised as freely responding panels, which were not restrained, panels with cross grain members, and more complex panels. Each of these categories could be further divided in two to four construction types, as described in Table 2. Examples of freely responding panels, panels with cross grain members, and complex panels are shown in Figures 1–3.

In Step 4, the condition of the object was visually examined. The damage, defined as irreversible changes from the original state, was classified using nine condition parameters related to the movement of wood (Figure 4). The parameters included changes to the structure as well as changes to the surface layers: open glue joints between boards, cracks in wood, out-of-plane deformation, insect damage and shrinkage, minor cracks (craquelure, hairline cracks), losses or flaking parts of decorative layer, abraded or

Table 2. Description of the construction types.

Construction category	Construction type	Abbreviation	Definition
Freely responding panels	Panel in frame construction	FC	Boards, usually two or more, joined together (with glue, dowels and/or tongue-and-groove), inserted in a groove or rebate of a frame. The corners of the frame are connected with bridle joint, lap joint, mortise and tenon joint, mitre joint or butt joint. Non-restrained panel but restrained construction of the frame
	Simple panel construction	PC	Boards, usually two or more, joined together (with glue, dowels and/or tongue-and-groove). Non-restrained construction
Panels with cross grain members	Board and moulding construction	BM	Boards, usually two or more, joined together (with glue, dowels and/or tongue-and-groove). Mouldings applied on at least on side, with glue, nails and/or dowels, partly cross grain. Restrained construction
	Cleated ends	CE	Boards, usually two or more, joined together (with glue, dowels, tongue-and-groove). Cross grain cleats are joined with glue, tongue and groove, and/or nails or dowels. Restrained construction
	Panel with cross battens	PB	Boards, usually two or more, joined together (with glue, dowels, tongue-and-groove). Cross grain battens attached to the back of the wood substrate, with glue, nails and/or dowels. Restrained construction
	Panel with local reinforcement	PL	Boards, usually two or more, joined together (with glue, dowels, tongue-and-groove). Cross grain reinforcements such as wood blocks or butterfly keys attached to the back of the wood substrate, with glue, nails and/or dowels. Locally restrained construction, at the position of the reinforcement
Complex panels	Hollow construction	HC	Thin boards, usually two or more joined together (with glue, dowels, tongue-and-groove), mounted on both sides of a central frame. Rails and glue blocks inside the frame are glued and/or nailed to the boards. Restrained construction
	'Kussenkast' – Board and moulding	K	Boards, usually two or more, joined together (with glue, dowels, tongue-and-groove). The boards are usually veneered with wood veneers in graphic pattern (parquetry). Mouldings are applied on the front face of the boards and a thin board is attached to the mouldings, creating a hollow 'pillow'. The mouldings are fixed with glue, nails, and/or dowels, partly cross grain. Restrained construction
	Cradled panel	CP	Boards, usually two or more, joined together (with glue, dowels, tongue-and-groove). A grid of slats is attached to the backside of the panel, the slats in the wood grain direction are permanently fixed and battens in the cross grain direction of the boards are intended to be sliding. In many cases, cradled panels are restrained as the sliding battens are stuck
	Frame construction, thin panels	FT	Boards, usually two or more, joined together (with glue, dowels, tongue-and-groove), inserted in a groove of a frame. The boards are less than seven mm thick. Thin mouldings are glued onto the boards, partly cross grain. The construction is restrained by the inner mouldings, and the frame is restrained

lifting paint. All parameters were recorded as either present or not. Only shrinkage was quantified: out-of-plane deformation was measured by placing a metal ruler over the surface of the object on three locations perpendicular to the wood grain direction. Change was recorded as present if the displacement was more than 1 mm per 200 mm panel in width or height. Smaller out-of-plane deformations were not visible with the naked eye and therefore not classified as change. Shrinkage cracks and open joints were measured (width, length, and depth) using a ruler and calliper. The most relevant shrinkage is that perpendicular to the grain direction, due to the orthotropic behaviour of wood; from the directions perpendicular to the grain the shrinkage (and swelling) in tangential direction is most pronounced. The original size of a panel could be deduced if cross grain battens or cleats were present, as the shrinkage in the longitudinal direction of wood is negligible (Figure 5, in which the parallel to the grain directions are indicated). The overall shrinkage could then be calculated by subtracting the total width of the individual boards from the length of the cross grain batten or cleat. This was expressed as a percentage of the original size of the panel.

In furniture, the shrinkage of a freely responding panel in a frame is usually apparent next to the inner edges of the frame. When such a panel has shrunk, areas become exposed that are unvarnished or have been protected from the influence of light by the frame, become visible, and can appear either darker or lighter. The width of those areas was an indication of shrinkage (Figure 5b,c). If cracks or open joints were present, the width of these was also included in the total sum of shrinkage.

The visual examination of the surface layers was aided by torch and magnifying glass and in some cases a microscope, and the information was recorded as follows: Losses within the decorative layer were classified as none, minor, or major. Fillings and retouches, which indicate losses, were recorded as present or not. Abraded or lifting paint, as well as rebate damage on or along the edges of panel paintings, was also recorded as present or not. Contrary to the measurement of shrinkage, these parameters could not be quantified objectively; the error when using percentages would have been too high.

In Step 5, historical information about the objects was collected: age, provenance, date of acquisition, location history within the museum, loan history, historic photographs (some more than 100 years old), and records of previous conservation treatments.

In Step 6, the information gathered in Steps 3 to 5 was compiled and reported in detail using text, photographs, and drawings, and analysed to investigate the recorded changes. New photographs were taken of

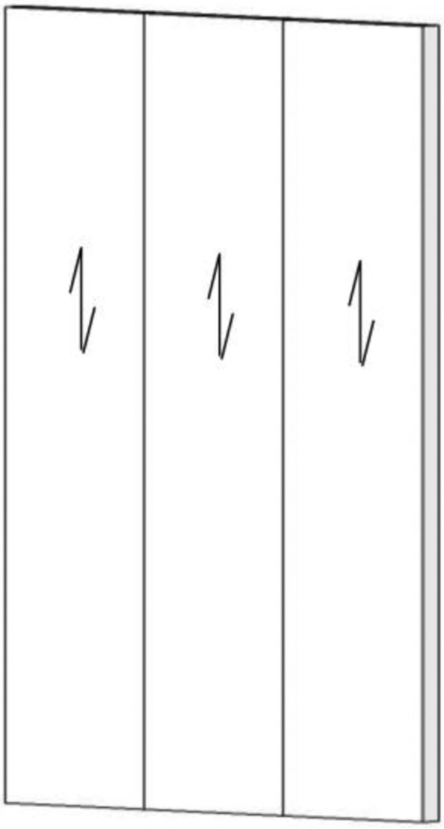

Figure 1. Example of a freely responding panel: simple panel construction. The boards, usually two or more, are joined together (with glue, butt joint, dowels, and/or tongue-and-groove). Non-restrained construction. Wood grain direction indicated by black arrows.

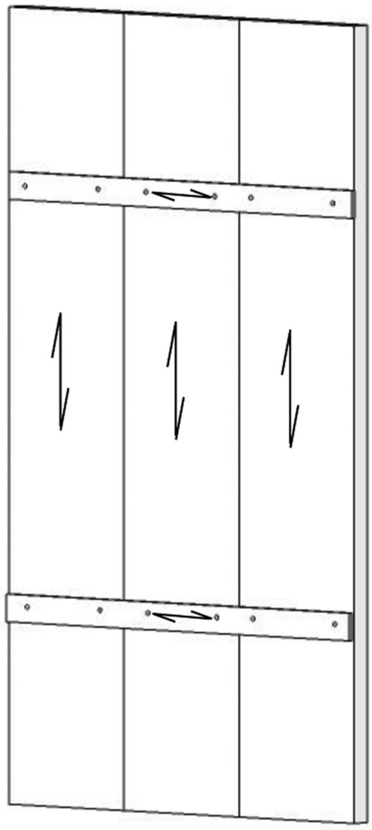

Figure 2. Example of a panel with cross grain members. The boards, usually two or more, are joined together (with glue, butt joint, dowels, and/or tongue-and-groove). Restrained construction. Wood grain direction indicated by black arrows.

details (e.g. cracks and losses) using similar angles and light conditions to the historic photographs to better visually interpret possible changes. The file for a single object contained up to 30 pages. Damage mapping, marking areas with changes such as open joints, cracks in wood, loose parts or losses, and fillings/retouches, was made using Adobe Photoshop (Figure 6). During this phase, similar objects were analysed to investigate if a particular change or parameter was general for the group of panels with the same type of construction or specific to the object in question.

Finally, in Step 7, a descriptive analysis of the construction and material parameters was made to identify the relationships most relevant to the climate-induced changes of decorated wooden panels. A statistical analysis was based on the data collected during Steps 3, 4, and 5, and all objects that were examined were included. The selected parameters were found in a high percentage of objects, where the information was well defined and where a strong relation to change or damage could be expected. These 29 parameters were further divided into four categories: type of construction, material, history, and condition, as illustrated in Figure 4. If several parameters, with a maximum of five, were not available, the object was included in the Study but not included in all parts of the statistical analysis. The most commonly missing parameters were those where the data needed to be supported by technical analysis, usually X-ray photography and dendrochronology. The descriptive analysis was performed using the frequency, mean, standard deviation, and distribution of parameters, e.g. number of boards, thickness, width, and height.

Discussion

The methodology presented in this paper was designed to facilitate a deeper analysis of climate-related changes that have occurred to decorated panels. Not only by characterising the properties of their materials but also, and perhaps more importantly, their construction. Recent articles in *Studies in Conservation* by Luxford and Thickett (2013), Staniforth (2014), and Bickersteth (2016) have pointed out that despite the existing bulk of information, research on actual objects is still limited. One of the strongest recommendations made by over 30 experts who participated in a meeting to define a research agenda for panel paintings conservation in Amsterdam, January 2011, was that more information on actual objects should be made available (Kos and van Duin 2014).

The Rijksmuseum Study differed from previous research into actual objects, because it both focused

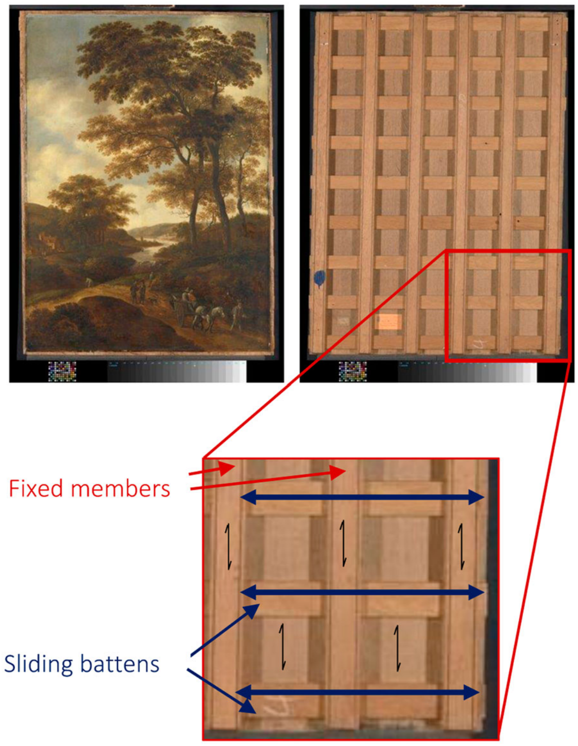

Figure 3. Example of a complex panel: Cradled panel, here illustrated by a three-board panel. Pieter Jansz. van Asch. 1640–1678. H. 1020 mm, w. 745 mm, d. 6 mm. Rijksmuseum, inv. no. SK-C-88. The boards are joined together. A grid of slats is attached to the back of the panel. The slats in the wood grain direction are permanently fixed and battens in the cross grain direction of the boards are intended to be sliding. In many cases, cradled panels are restrained when the sliding battens are stuck. Wood grain direction indicated by black arrows.

on a very large group of objects and considered the complexity of the objects. The Study was performed by experienced conservators. The methodology for the Rijksmuseum Study was developed to provide in-depth information on the construction and materiality of decorated wooden panels and possible climate-related damage, with the aim of providing a frame of reference for conservators, and supplying input and validation for experimental and modelling studies and for gathering *in situ* measurements. Together with the Rijksmuseum Study, these studies are an integral part of the Climate4Wood research project, which aims to further understand the hygrothermal mechanical properties of oak panels.

Almost 300 decorated panels were selected for examination. As part of the Study, measurements were taken, all materials and constructions were analysed, and the nature of the changes to the panel construction was recorded in order to assess when and how changes might have occurred. As a result of utilising this methodology for the Study, a greater understanding was gained about the materials and construction of each object and how this may relate to observed climate-related damage such as shrinkage, warping and cracking. By comparing this information with archival material, such as old photographs and conservation records, it was possible to observe if and how damage occurred since the records or photographs were made and, just as importantly, to understand how much of the damage that is now visible was already evident at that earlier moment in time.

This methodology and the amount of detailed information collected from a large group of objects were not only necessary within the Study but will be beneficial beyond the Study in the wider field by serving as reference data. Information gathered from a large group of objects will make it possible to compare the condition of objects with similar construction and materials. Also, panels with different constructions can be compared to each other to investigate the influence of the amount of restraint within a construction and to determine which are the most sensitive panel constructions. The behaviour of panels constructed of thick boards can be compared to that of panels made from thin boards. The occurrence of cracks within the wood can be analysed in conjunction with the failure of glue joints. Damage development, albeit only after the time of acquisition by the museum, can be assessed. The substantial reference data can also form a basis for comparison with similar objects in other collections, for instance objects which are part of collections of historic houses and for which the (climate) history can be better assessed. It would be beneficial to extend the Study beyond cabinet doors and seventeenth-century panel paintings and beyond Netherlandish objects with an oak substrate. For instance, one avenue of future research may include carrying out a similar study on Southern European panels made of poplar.

There were several challenges experienced throughout the Study. Most notably, it was time-consuming to gather and record all data. Fortunately, much relevant information was already available, such as X-ray photographs, dendrochronological analysis, high-resolution photographs, as well as historic conservation and photographic records and technical information prepared for the online paintings catalogue. Challenges included the statistical analysis of the large number of variables but also the usually unknown history of the objects, including their climate history and how this might have affected their condition. The objects in the Study came from many different locations, often untraceable, and most changed hands and environmental conditions many times in the past. To investigate and model this would have been a very challenging task that was outside the scope of this research. It was not known where the objects originally stood, nor how often they were moved to other locations. In addition, reliable historic climate data of Rijksmuseum galleries and stores were unavailable. Therefore, the indoor environment variable had to be

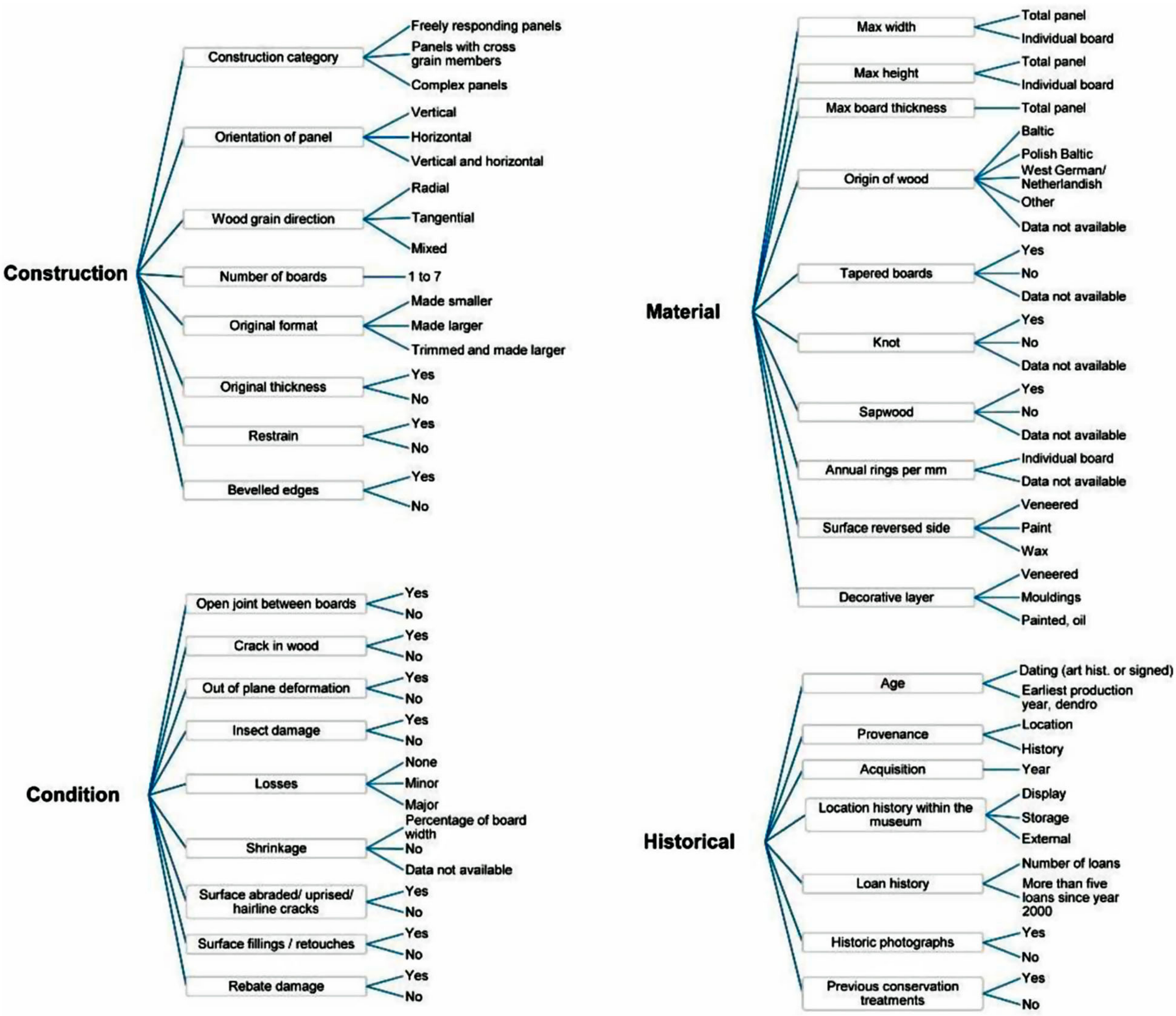

Figure 4. Structuring the parameters into four groups: Construction, material, history, and condition.

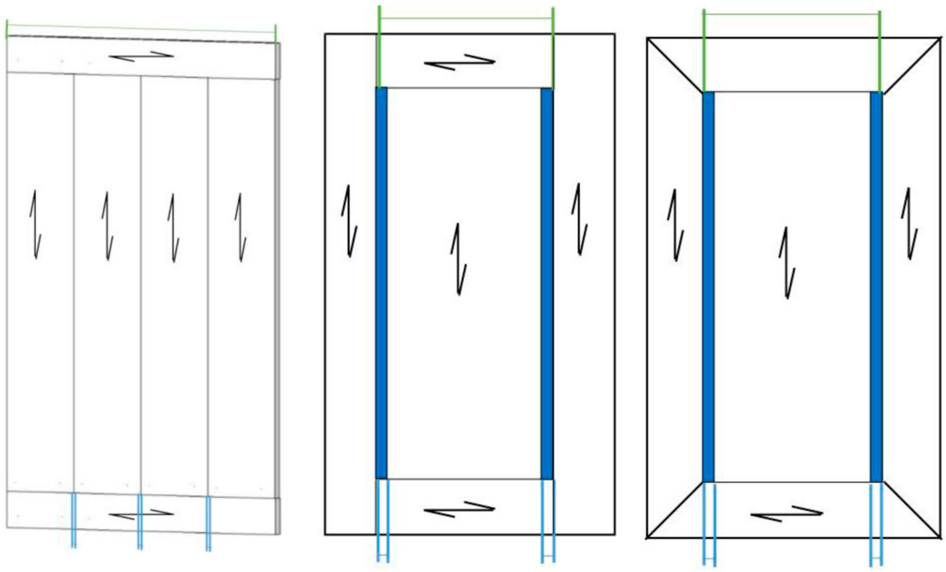

Figure 5. Shrinkage measurement procedure. (a) Construction with cleated ends: the sum of the width of the individual boards (blue lines) is compared to the length of the cross grain member. (b, c) When the panels are inserted into a frame, shrinkage can be identified along the edges of the frame, because previously covered areas have a different colour. These areas are here illustrated as blue lines. The width of these areas is an indication for the amount of shrinkage of the panel.

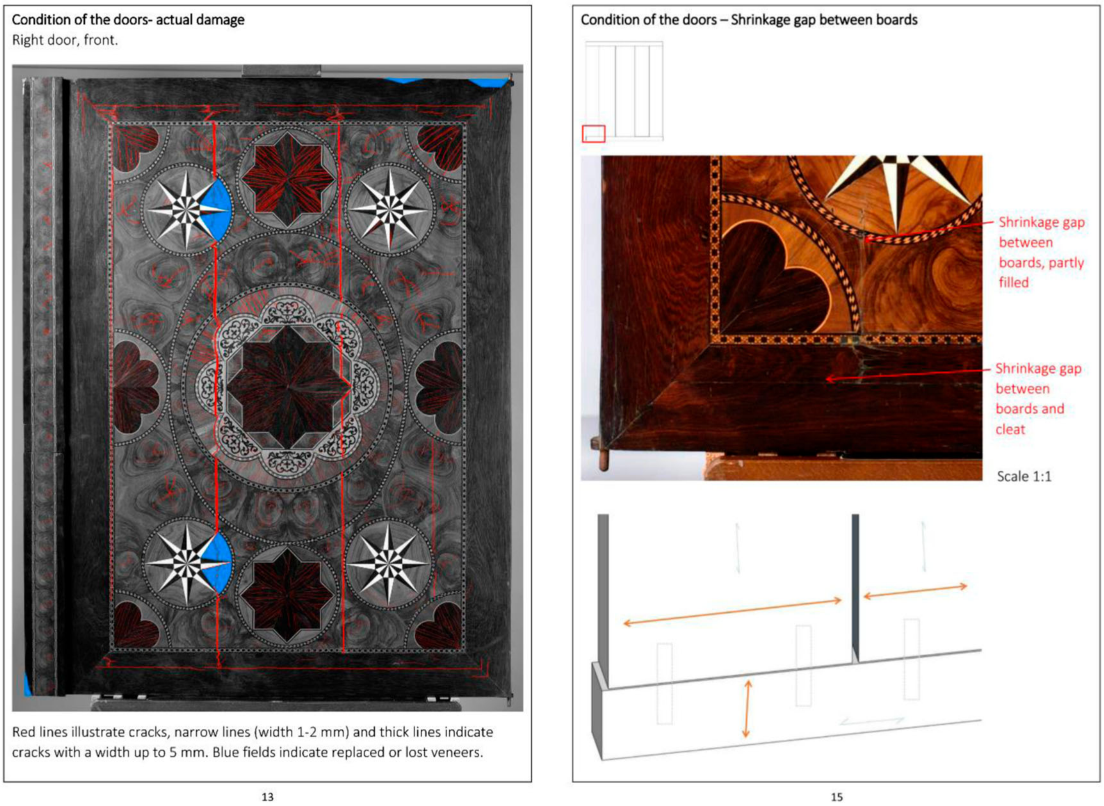

Figure 6. Example of the documentation of a cabinet. Rijksmuseum, inv. no. BK-NM-6073.

excluded from this study. Despite the relatively small amount of information regarding the historical climate conditions of these objects, it is still possible to interpret the results of this project, as this situation is experienced by most museums throughout the world.

Conclusion

The methodology developed in this project proved effective in bringing together different types of information. The structured procedure enables a thorough generation of potential relevant information that can be broadly used in- and outside this project. We strongly recommend that more museums follow this example so that more in-depth object-based information becomes available, to allow well-informed decision-making, with an active engagement of conservators, about creating a more sustainable museum environment.

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