OPEN ACCESS ISSN 2544-0357

icai

International Journal of Young Conservators and Restorers of Works of Art

2
2018

Ana Braamcamp de Figueiredo, MA
ana.braamcamp.de.figueiredo@gmail.com

Maria Aguiar, PhD
mcaguiar@porto.ucp.pt

The lining of canvas paintings with seams

ABSTRACT

Large painting supports were often created by seeing together several pieces of canvas. The lining problems caused by the adhesion of a new support to canvases with seams have been solved by conservators in different ways.

A survey has been undertaken to evaluate the efficiency of five systems by making models and submitting them to tension until fracture with a dynamometer Hounsfield H10K-S® at stable environmental conditions (20 ºC, 65% RH). For lining, we used BEVA 371® as adhesive and four types of reinforcement fabric: linen, sized linen, polyester (Trevira C.S. ISPRA®) and sized polyester.

We concluded that lining canvases with seams improves their mechanical resistance; that it is preferable to apply an interleaf to offset the seam relief; that the polyester textile used presents an inferior performance; and that the use of Reemay as mid-material improves the mechanical behaviour of linen textile.

KEYWORDS: *conservation and restoration, canvas painting, lining, seams, stretching, uniaxial tension tests, fracture, stress.*

INTRODUCTION

Large scale paintings on canvas often contain seams as the painting format is larger than available loom widths (Fig. 1). Once these large-scale canvases require repair, seams have often posed problems that have, in the past, been resolved by lining.[1] Before lining, restorers looked to reduce the seam relief on the back of a painting to avoid marks in the pictorial surface[2]:

- Elimination of the excess textile and thinning the seam with a scalpel;
- Elimination of the seam.

These days, conservators try to respect the painting in all its components and so these old solutions are avoided. When lining is need, seams are kept intact. Different systems can be used to display the lining canvas around the seam to avoid relief transfer. These systems are based on empirical knowledge as there is no work published about the lining of paintings with seams. Also note that, in reports, small or even none mention is made to the specific care concerning seams during treatment procedures.[3] This paper aims to bring to discussion the problem of canvas paintings with seams, even if the tests presented here do not reflect reality due to their academic limitations.

Lining a painting with seams requires careful procedures, so that the transfer of the seam relief to the pictorial surface do not happen.[4] However, even if the lining has been made perfectly, there are no guarantees that, in the future, transfer of the seam relief will not occur. The tension forces applied during stretching and with environmental changes might push the seam relief to the pictorial surface over time[5]. This phenomenon happens due to the misalignment and alignment of forces[6] (Fig. 2): being the major stretching force applied to the lining fabric, the lining support will react to form in-plane and can push the seam to the front if the forces applied are sufficiently high compared to the resistance of the original canvas.

Most reports do not describe how seams are treated. This lack of information was one of the biggest difficulties and limitations of this work. Therefore, the five lining systems to be tested (Fig. 3) were selected with verbal information given by some Portuguese conservators that use these systems in practice.[7] Models have been submitted to uniaxial tension tests until fracture. So, before describing the results, it is important to be aware of the mechanics and forces involved in stretching paintings.

FIGURE 1
Alignment of forces that can origin the transfer of the seam relief to the pictorial surface
source: Ana Braamcamp de Figueiredo

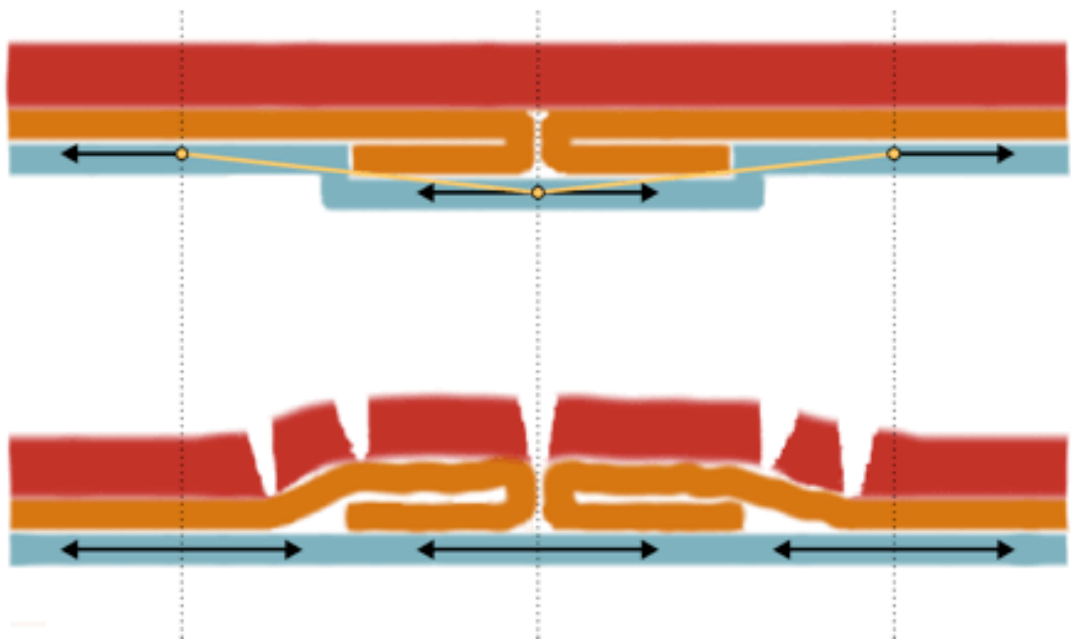
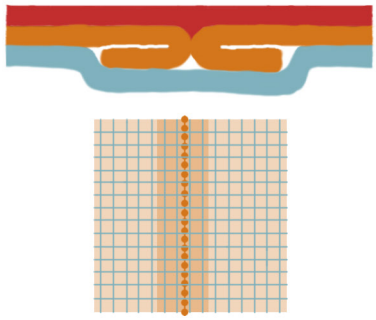
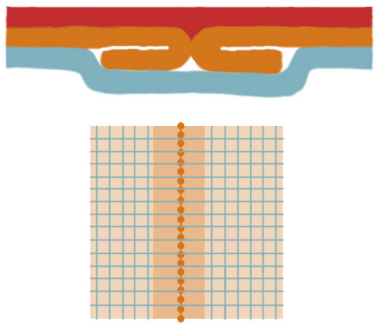


FIGURE 2
Five lining systems selected to be tested under tension until fracture; (red) ground and paint layers; (orange) painting support; (blue) lining fabric; (green) interleaf
source: Ana Braamcamp de Figueiredo



System 1: one piece of fabric
Description: entire lining fabric adheres to the painting support by going around the seam relief; so-called 'normal lining'.



System 2: one piece of fabric with removal of yarns
Description: entire lining fabric with removal of some yarns in the area and in the direction of the seam, in a way that over the seam relief there are only perpendicular yarns to the seam.
Objective: decrease thickness of the lining fabric in the seam area and decrease the forces applied in this area.

System 3: two pieces of fabric
Description: one piece of fabric ends in one of the seam sides; the other piece of fabric adheres to the other part of the painting support and overlaps the seam and a little part of the other piece of lining fabric.
Objective: reduce the applied force in the seam and make lining easier.

System 4: three pieces of fabric (bridge)
Description: two pieces of fabric cover the painting support as far as the seam borders; a third piece adheres to the seam to create continuity of the lining (bridge).
Objective: offset seam relief and make lining easier.

System 5: interleaf
Description: an interleaf is fixed to the painting support (without overlapping the seam) to offset the seam relief; an entire piece of fabric is then fixed as if it was a normal lining.
Objective: offset the seam relief and make lining easier.

STRETCHING CANVAS PAINTINGS

Conservators have been concerned about the long-term effects of applied forces on stretching a painting. Several studies revealed the great importance of stress[8] to painting conservation. However, it is important to notice that stress values must be low of approximately 2 N/cm.[9]

Berger and Russell analysed the behaviour of a canvas with a ground layer in a fixed stretcher when subjected to relative humidity (RH) variations. The canvas was stretched with a stress of 1 N/cm; after the increase of RH from 20% to 60%, the stress rose to 2 N/cm; when RH was increased to 100%, the canvas showed a greater increase of stress, with a final value of 8 N/cm.[10]

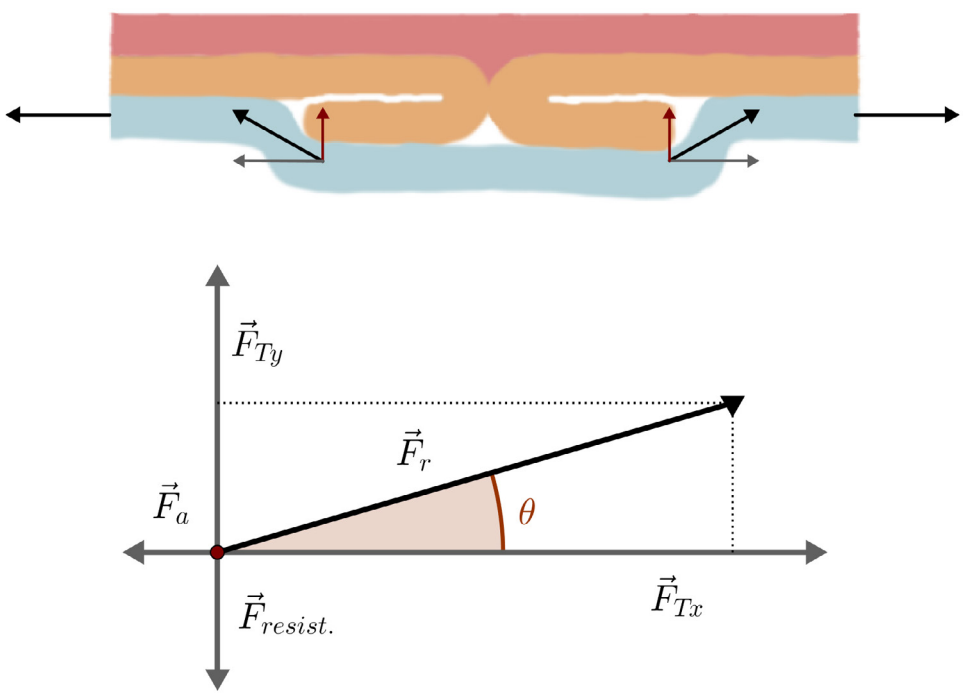
Roche analysed cracking development with the use of fixed stretchers (variable stress with RH variations) and elastic stretchers (constant stress), having decided on the greater advantages of elastic stretchers (constant stress[11]). However, it is important not to apply excessive stress to paintings.[12]

In the past, after stretching, paintings should sound like a drum. However, the evolution of methods and criteria for conservation took to the use of less stress for stretching painting. Idelson studied the stress applied in paintings by Italian conservators and obtained values between 0.68 N/cm and 6.8 N/cm, with an average value of 1.8 N/cm. The lower stress values were associated with modern art conservation and the highest values to traditional lining techniques. Idelson also evaluated the painting's resistance to perpendicular deformation according to the stress applied in the canvas stretching. He concluded that the resistance to this type of deformation does not significantly change after 2.0-2.5 N/cm applied to the stretching.[13]

STRETCHING LINING PAINTINGS WITH SEAMS

It can be useful to analyse theoretically (in a very simple way) what happens when a lined painting with seams is submitted to increasing tension[14]. The lining fabric, which contours the seam relief at the reverse of the original canvas, is subjected to the following forces (Fig. 4):

FIGURE 3
Forces that act on a canvas painting with seam lined with a fabric around the seam when submitted to traction
source: Ana Braamcamp de Figueiredo



- The tension force [$\mathbf{F}_T$] can be divided in two orthogonal components [$\mathbf{F}_{Tx}$] and [$\mathbf{F}_{Ty}$]. The existence of [$\mathbf{F}_{Ty}$] is due to the alignment of the applied forces in-plane.
- [$\mathbf{F}_a$] represents the frictional force caused between the adhesive and the lining material.
- [$\mathbf{F}_{resist}$]represents the resistance from the original canvas to the alignment of the lining fabric.
- The net force [$\mathbf{F}_r$]is formed by the sum of forces [$\mathbf{F}_{Tx}$], [$\mathbf{F}_{Ty}$], [$\mathbf{F}_{Ta}$] and [$\mathbf{F}_{resist}$].
- The angle θ is variable according to the slope of the lining fabric.

As the tension force [$\mathbf{F}_T$] increases, the stretching of paintings with seams lined can be split into three moments:

1. [$\mathbf{F}_{Ty}$] = [$\mathbf{F}_{resist}$]. [$\mathbf{F}_{Ty}$] is not higher than [$\mathbf{F}_{resist}$] and so the two forces cancel each other out. The transfer of the seam relief to the pictorial surface does not occur. The increase of [$\mathbf{F}_{Ty}$] will induce the same increase of [Fresist] until the limit of the original canvas resistance to deformation is reached.
2. [$\mathbf{F}_{Ty}$] > [$\mathbf{F}_{resist}$]. [$\mathbf{F}_{Ty}$] exceed the deformation resistance of the original canvas and transfer of the seam relief to the pictorial surface occurs.
3. [$\mathbf{F}_{Ty}$] = 0 and [$\mathbf{F}_{resist}$] = 0. The tension forces are now in-plane and the lining fabric stretched. At this moment, the seam fracture might have take place, depending on its elasticity and resistance to tension.

It is clear that if the y component of the net force is zero, the seam relief on the back of the painting will not be transferred to the pictorial surface. Also note that the angle θ is related to the slope of the lining fabric when it contours the seam on the back of the painting. Thus, a seam with higher relief leads to a higher angle of degree, which causes an increase of the y force components and, therefore, a greater tendency for the transfer of its relief to the pictorial surface. Some conservators' proposals for the lining of paintings with seams seek to delete y components of the net force. For example, the use of an interleaf to compensate the seam relief or the use of a bridge over the seam.

MATERIALS AND METHODS

Models were prepared to be tested under uniaxial tension until fracture. Original canvases (throughout this paper called paintings) were lined with the five different lining systems using the same adhesive and four different lining canvases. Paintings had a seam at their middle, with the exception of a group that worked as behaviour control.

To prepare paintings, linen[15] was cut in 20 x 20 cm pieces. At their middle, an overhand stitch seam was made in the warp direction with cotton thread at 4-mm intervals. The canvases were then sized with animal gelatin[16] (5%) on both sides. Two ground layers of calcium carbonate and rabbit skin glue[17] (1:13) were applied in one size. The ground layer had no oil binding medium because it was not possible to submit samples to accelerated ageing and therefore, the ground layer would still be very flexible and present a different mechanical behaviour to real cases.[18] For the same reason, a paint layer was not applied over the ground layer. On the other hand, the mechanical characteristics of paints are influenced by the binder type and also by the pigment used[19]. To simplify this study, the paint layer effects were disregarded.

For lining, four types of tabby weave textiles were selected:

- Linen, the same as for paintings.
- Linen sized with animal gelatin (5%) on both sides.
- Polyester.[20]
- Polyester sized on both sides with *BEVA 371*[21] in White Spirit (1:4).

Linen was selected due to conservation tradition that uses this type of fiber for lining. In some cases a higher rigidity is needed, so sized linen was also tested. Polyester is increasingly used in modern conservation, as it is associated with desirable properties like better mechanical resistance and excellent stability to RH changes.[22] For samples lined with an interleaf (system 5), a polyester non-woven tissue (Reemay) was used.

For this research, only one adhesive was selected, BEVA 371, so that the different results could be compared. The adhesive diluted in WS (2:1) was applied in several coats, one on the back of the paintings[23] and two on one side of the lining fabric. Samples with *Reemay* received one coat on the lining fabric and four coats (two on each side) on *Reemay*. After drying, paintings and lining fabric were put together

in a low-pressure table with the ground layer side down, and adhesion of the lining fabrics was done by melting at 70ºC for 20 minutes at 45 mBa pressure.

Each sample was cut into five strips of 3 cm wide (and 20 cm high). The results presented here are the average of these five tension tests until fracture. Samples were stored in a room with stable environmental conditions at 20 ºC and 65% RH for a minimum of 24 hours. These values were chosen because rooms for painting exhibitions usually have these environmental conditions. They are estimated to be approximately the right values for human comfort and for preventing biological growth in organic materials.[24]

The equipment used was a dynamometer Hounsfield H10X-S with a 2.5 kN load cell, 150 mm gauge length, 10 mm/min velocity and 5 N pre-load. Tests were filmed at three different angles (front, side, back) to understand and document phenomena that occurred at painting and lining level and deformation on the seam level. Through side videos, it has been possible to evaluate the seam transfer to the painting surface (seam distortion).

RESULTS

Data analysis was made with the average value of fracture of the following elements: ground layer, seam and lining fabric. Evaluation of seam distortion was also made (Fig. 5).

Ground layer fracture

This was the first element to break allowing an average extension of 0.30 mm. The ground layer of non-lining paintings (R) broke at 38.13 N. Every lined painting bears higher values; the lowest is 39.68 N (SP.3) and the highest is 91.08 N (SL.1).

Seam distortion

Seam distortion occurred at a moment close to ground fracture in every sample with a seam. The highest distortion degree was in SP.2 (0.69 mm) and the lowest in SL.4 (0.25 mm). It has been observed a decrease of these values from system 1 to system 5.

	Code			
Painting with seam non-lined	R			
System	**Polyester**	**Sized Polyester**	**Linen**	**Sized Linen**
Without seam	P.0	SP.0	L.0	SL.0
1 (entire fabric)	P.1	SP.1	L.1	SL.1
2 (yarns removal)	P.2	SP.2	L.2	SL.2
3 (2 pieces of fabric)	P.3	SP.3	L.3	SL.3
4 (3 pieces of fabric - bridge)	P.4	SP.4	L.4	SL.4
5 (Reemay - mid-material)	P.4	SP.4	L.5	SL.5

TABLE 1: *Code for samples to be tested*

source: Ana Braamcamp de Figueiredo

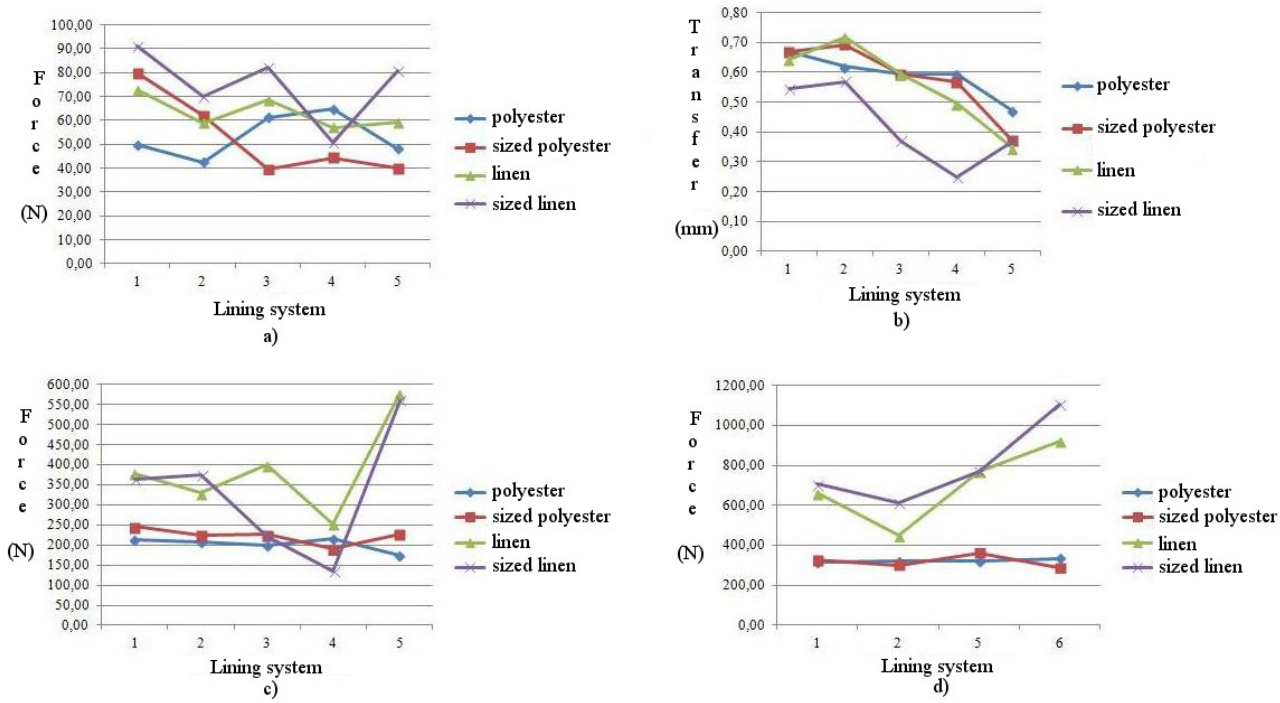


FIGURE 4: *Results analysis*
a) Rupture force of the ground layer according to the system used
b) Transfer degree of the seam relief according to the system used
c) Rupture force of the seam according to the system used
d) Rupture of the lining fabric according to the system used
source: Ana Braamcamp de Figueiredo

Seam fracture

Seam fracture occurred when samples presented an extension of 2.50 mm. In the non-lined sample (R), this moment appears at 84.74 N, while in lined samples this value increases to an average of 285.82 N: the lowest is 135.97 N (SL.4) and the highest is 577.60 N (L.5).

Lining fabrics

Systems with two or three pieces of fabric (systems 3 and 4) were excluded from this topic, as fracture occurred at adhesive level. Linen presents a higher resistance than polyester and a lower extension capacity. Sizing polyester with *BEVA 371* does not significantly change its resistance (321.42 N for polyester and 324.21 N when sized) and its extensibility is 37.56 mm for polyester and 34.22 mm when sized. Linen when sized does modify its resistance (698.80 N for linen and 798.15 N when sized) but not its extensibility (5.43 mm for linen and 5.49 mm when sized).

Result comparison by lining systems

Normal lining (1) presented lower resistance values when lined with non-sized polyester (P.1), both at ground and seam level – 49.84 N and 212.24 N. The higher values for ground resistance were obtained with sized linen (SL.1) – 91.08 N. However, L.1 and SP.1 presented very close values. For seam resistance, the highest value obtained was 378.18 N, corresponding to L.1 but very close to SL.1.

In system with yarns removal (2), P.2 obtained the lowest values both at ground and seam level – 42.64 N and 207.28 N. The highest values were reached by SL.2 – 70.22 N for ground and 375.46 N for seam.

In system with two pieces of fabric (3), fracture occurred at adhesive level by detachment of the two pieces of lining fabric at the same time than the seam rupture (L.3 and SL.3), with the exception of SP.3. Regarding numbers: ground broke at a minimum of 39.68 N (SP.3) and a maximum of 82.36 N (SL.3); seam at a minimum of 198.88 N (P.3) and a maximum of 398.96 N (L.3).

Adhesive fracture also occurred in system with three pieces of fabric - bridge (4). The lowest force for ground was 44.48 N (SP.4) and the highest 65.00 N (P.4), but L.4 and SL.4 had similar values. Regarding seam fracture, this occurred at lower forces in SL.4 (135.97 N) and higher forces in L.4 (251.70 N).

System with an interleaf (5) obtained values of ground fracture between 39.84 N (SP.5) and 80.80 N (SL.5). As regards seam fracture, there is a significant difference between polyester (P.5, SP.5) and linen tests (L.5, SL.5): the first group found lower values (173.12 N for P.5) and the second group found the highest values (577.60 N for L.5).

Samples lined without seams

There were two types of reaction: fracture of the painting first (P.0. SP.0) or fracture of the lining fabric first (L.0. SL.0). The painting fracture occurred at an average extension of 7.85 mm, with a minimum force of 665.90 N (P.0) and a maximum force of 772.40 N (L.0). The maximum force tolerated by the samples before fracture lay between 287.84 N (SP.0) and 1104.32 (SL.0).

DISCUSSION

It is important to remember fracture force values concerning paintings with seams that were not lined (R), since they work as reference to evaluate the several systems by comparison: ground layer fracture at 38.13 N (equivalent to a stress of 12.71 N/cm) and the seam fracture at 84.74 N (28.25 N/cm). Let us also remember that stress used for stretching paintings does not need to be over 2.5 N/cm[25]. Thus, considering values obtained in these tests, stretching a painting with recommended stress would not be enough to fracture the ground layer[26]. Also notice that lining of paintings with seams (for all the above systems) increases the overall resistance.

Regarding the different lining systems, and for comparison motives, normal lining (system 1) was chosen to be the reference system because it is the one closest to a normal lining.

Comparing systems that present a continuous lining fabric (systems 1, 2 and 5), there is a decrease in the ground resistance to break from normal lining (1) to lining with yarns removal (2) or with an interleaf (5). The same does not apply to the seam resistance: from normal lining (1) to lining with yarns removal (2), there is a general decrease; while from normal lining (1) to lining with an interleaf (5), there is a decrease of resistance when polyester is used but an increase when linen is used. However, when it comes to lining a painting with seams, it is very important to look at the transfer degree of the seam relief to the pictorial surface (seam distortion); and in this aspect, there is no variation from normal lining (1) to the system with yarns removal (2) but major advantages for lining with an interleaf (5).

Due to their similar behaviour under tension, systems with two pieces of fabric (3) and with a bridge (4) will be analysed together and compared with normal lining (1). In terms of improvement of the ground resistance, only P.3 and P.4 obtained positive results. The other models have decreased the overall resistance when compared with system 1. However, systems with two or three pieces of fabric (3 and 4) presented improvements of the seam distortion, even if they cannot overcome lining with an interleaf (5). When polyester is used, lining with three pieces of fabric - bridge (4) presents advantages over lining with two pieces of fabric (3), and when linen is used, the opposite applies.

According to Hedley, conservators should use for lining a stiffer material than the painting because this is the only way that it will work as a support for the painting, reducing stress applied on painting materials.[27]

As noted, linen presents a lower extension ability and a higher tension resistance than polyester, being a stiffer material. This property of linen is improved when fabric is sized with gelatin. Thus, linen represents a better mechanical support material for lining paintings than the polyester used. These facts are confirmed by the results obtained in tests with samples without seams:

- Paintings suffered fracture when they presented an average extension of 7.85 mm and supported an average force of 719.88 N (239.96 N/cm).
- When polyester was used for lining, the painting was the first to fracture, and so the painting was supporting the majority of the forces involved.
- When linen was used for lining, linen fracture first with higher forces than polyester: 919.20 N (306.4 N/cm) and 1104.32 N (368.11 N/cm) for sized linen. The lining textile was supporting the major forces, fulfilling its role in increasing the overall mechanical resistance.

CONCLUSIONS

With this research, it has been possible to evaluate the mechanical behaviour of paintings with seams lined with four types of fabrics at constant temperature and RH.

Whatever the system used, lining improves the mechanical resistance of samples, promoting conservation. It is also noticeable that the option of using a type of fabric has an effect on the overall mechanical behaviour. However, some observations need to be made.

- In the lining of paintings with seams, one of the real problems is the transfer of the seam relief to the pictorial surface; this is why it was important to find an alternative to normal lining (1). Lining with a bridge (4) or with an interleaf (5) revealed the best results.
- Removal of yarns in the area and direction of the seam does not improve the overall behaviour. Actually, this procedure reduces the resistance of linen. Thus, there is no improvements that justify the use of this system for the lining of paintings with seams.
- The use of Reemay as interleaf does not change the mechanical behaviour of polyester. On the contrary, it does change the mechanical properties of linen, which are improved. It must also be observed that this system was the best concerning the non-transfer of the seam relief to the pictorial surface.
- Samples lined with sized linen presented the best performance (with the exception of SL.4) for increasing the overall mechanical resistance. It was also stated, by empirical observation, that the adhesion of this type of support to the painting was more easily removed, facilitating future interventions.

In this research, it has been concluded that, in terms of the relation between seam distortion and improvement of the mechanical resistance of the painting, the use of Reemay as interleaf to compensate the seam relief with a sized linen lining (SL.5) or not sized (L.5) offers the best results. However, if a polyester textile (Trevira C. S. ISPRA) needs to be used, system 4 (with three pieces of fabric overlapping) also showed good results. It is important to note that these systems are the ones that present a more practical solution when paintings to be treated have several seams in different directions.

Another important conclusion from these tests, which must be highlight, concerns the polyester textile Trevira C. S. ISPRA. This fabric revealed inferior results due to its extensibility and inferior resistance. However, the adhesion of the polyester textile to the painting has been made without pre-stretching the fabric. Thus, it would be interesting to evaluate its performance with the polyester textile stretched before lining.

Although systems with the use of Reemay (5) or forming a bridge (4) with materials such as linen or sized linen, have shown better results for lining canvas paintings with seams, these results are not definitive because they represent merely a small sample group of tests. It is not known the behaviour of these systems towards stress and relaxation cycles, temperature and RH variations or even after ageing. These factors are of major importance for canvas paintings conservation so further tests need to be carried out. It must also be emphasise that these conclusions are the result of the use of excessive forces that are not applied in reality for stretching a painting. Therefore general conclusions cannot be made and these tests can just give us guidelines for what it is most likely to happen.

ENDNOTES

[1] Museum, 'The Care of Paintings: Fabric Supports', Museum, vol. 13, nº 3, 1960, p. 144.

[2] E. N. López, 'Estudio Técnico y Problemática de las Costuras en la Pintura sobre Lienzo', Master's Thesis, Universidad Politécnica de Valencia, 2008, p. 30.

[3] We must refer to the good example of the technical report for the painting "La Justice de Trajan" - Giocanti, H. and Raynaut, A. 'Rapport d'intervention. Object: Traitement de Conservation du support de l'oeuvre suivante: La Justice de Trajan de Nicolas Pinson', Ateliers Lazulum, Marseille, 2007, http://lazulum.free.fr/doc/pinson.pdf (accessed 3 May 2014).

[4] Gac, A. le, 'Critérios de intervenção e escolha de tratamentos: a pintura monumental "Milagre"', *Boletim ADCR*, nº6, 1997, p. 9.

[5] H. Giocanti and A. Raynaut, '*Rapport d'Intervention. Objet: Traitement de Conservation du Support de l'oeuvre suivante: "La Justice de Trajan" de Nicolas Pinson"*', Ateliers Lazulum, Marseille, 2007, p. 30 http://lazulum.free.fr/doc/pinson.pdf (accessed 3 May 2014).

[6] A. Roche, *Comportement Mécanique des Peintures sur Toile. Dégradation et Prévention*, CNRS Éditions, Paris, 2003, pp. 142-145.

[7] Some information concerning these five systems has been provided verbally, for example, the methodology followed by the Conservation Center of Art School from Catholic University of PortoFrom the research carried out, it was rare to find technical reports or documents concerning interventions in paintings with seams that explain the way seams were treated before, during and after lining.

[8] In this article, stress values will be written in N/cm for easier comparison. 1 N/cm = 100 N/m = 100 g/cm. The use of force per width instead of force per area by different conservators is due to the difficulty of measuring the thickness, and so the cross-area, of paintings. To make studies more suitable for practical use and for general understanding of paintings' behaviour, the painting thickness is ignored. However, the conventional measure of stress is expressed in MPa (1 N/cm² = 1 MPa). P. G. Chiriboga Arroyo, *Finite Element Modeling of Vibrations in Canvas Paintings,* PhD Thesis, Escuela Politécnica Nacional Quito in Ecuador, 2013, p. 14, http://repository.tudelft.nl/view/ir/uuid%3Aa30b358e-d0de-4a81-92f3-e9f255443043/ (accessed 26 November 2014).

[9] G. A. Berger, 'A Structural Solution for the Preservation of Canvas Paintings', *Studies in Conservation*, no. 3, 1984, p. 139, http://www.jstor.org/stable/1506016 (accessed 6 December 2013).

[10] G. Capriotti and A. I. Idelson, *Tensionamento dei Dipinti su Tela. La Ricerca del Valore di Tensionamento*, Nardini Editore/Provincia di Viterbo, Firenze, 2004, p. 28.

[11] If stress is constant, there is theoretically no material fatigue. A. I. Idelson, 'About the Choice of Tension for Canvas Paintings', *CeROArt*, 2009, http://ceroart.revues.org/1269 (accessed 30 March 2014).

[12] Roche calculated the percentage of fissures formed after RH variations: fixed stretcher presented 22.24% (1.5 N/cm) and 17.32% (2 N/cm); elastic stretcher presented 0.20% (1.5 N/cm) and 0.92% (3 N/cm). The use of 3 N/cm stress is already too high. G. Capriotti and A. I. Idelson, Tensionamento dei Dipinti su Tela. *La ricerca del valore di tensionamento*, Nardini Editore/Provincia di Viterbo, Firenze, 2004, pp. 45-46.

[13] Idelson, A. I., 'About the Choice of Tension for Canvas Paintings', *CeROArt*, 2009, http://ceroart.revues.org/1269 (accessed 30 March 2014).

[14] This analysis is the result of a discussion with Professor André Paulo Catarino from the Textile Engineering Department of Universidade do Minho (Portugal).

[15] Belgium linen without knots, tabby weave, 16 x 16 yarns/cm², 135 g/m², provided by Agar-Agar, http://agargar.net/ (accessed 8 September 2016).

[16] Supplier AgarAgar, http://agaragar.net (accessed 8 September 2016).

[17] Ibidem

[18] Also note that, by the use of just one binding medium, it is easier to understand some results (as did Mecklenburg or Roche in his studies). See Mecklenburg, M. F., 'Some aspects of the mechanical behavior of fabric supported paintings', unpublished report to the Smithsonian Institution, research supported under the National Museum Act, 1982 and Roche, A. *Comportement mécanique des peintures sur toile. Dégradation et prévention*, CNRS Éditions, Paris, 2003.

[19] M. F. Mecklenburg, 'Some Aspects of the Mechanical Behavior of Fabric Supported Paintings', unpublished report to the Smithsonian Institution, research supported under the National Museum Act, 1982, pp. 11-15.

[20] 100% polyester, 16 x 16 yarns/cm²: Trevira C.S. ISPRA, 130 g/m², manufactured by C.T.S., http://www.ctseurope.com/.

[21] Supplier AgarAgar, http://agaragar.net (accessed 8 September 2016).

[22] A. Tímar-Balázzy and D. Eastop, 'Chemical Principles of Textile Conservation', Butterworth Heinemann, Oxford, 2007, pp. 60-61.
C. Young and S. Jardine, 'Fabrics for the Twenty First Century: as Artist Canvas and for the Structural Reinforcement of Easel Paintings on Canvas', Studies in Conservation, nº4, vol 47, 2012, pp. 237-253.
[23] This unusual procedure was made because some ground layer was transferred to the back of the paintings and the correct adhesion of the lining fabric needed to be guaranteed.
[24] A. Calvo, 'Técnicas de conservação de pintura', Civilização Editora, Porto, 2006, p.71.
[25] Idelson, A. I., 'About the Choice of Tension for Canvas Paintings', *CeROArt*, 2009, http://ceroart.revues.org/1269 (accessed 30 March 2014).
[26] These tests have been made with new materials, without ageing, which have better mechanical properties than old materials.
[27] Hedley, G., 'The Stiffness of Lining Fabric: Theoretical and Practical Considerations', *6th Triennial Meeting*, ICOM Committee for Conservation, Ottawa, 1981, pp. 6-7.

REFERENCES

Bergeaud, C., Hulot, J. F., Roche, A., *La Dégradation des Peintures sur Toile. Méthode d'examen des altérations'*, École Nationale du Patrimoine, Paris, 1997.

Berger, G. A., 'A Structural Solution for the Preservation of Canvas Paintings', *Studies in Conservation*, no. 3, 1984, http://www.jstor.org/stable/1506016 (accessed 6 December 2013).

Calvo, A., *Técnicas de conservação de pintura*, Civilização Editora, Porto, 2006

Calvo, A., *Conservación y Restauración de Pintura sobre Lienzo*, Ediciones del Serbal, Barcelona, 2002.

Capriotti, G. and Idelson, A. I., *Tensionamento dei Dipinti su Tela. La ricerca del valore di tensionamento*, Nardini Editore/Provincia di Viterbo, Firenze, 2004.

Chiriboga Arroyo, P. G., *Finite Element Modeling of Vibrations in Canvas Paintings* PhD Thesis, Escuela Politécnica Nacional Quito in Ecuador, 2013, http://repository.tudelft.nl/view/ir/uuid%3Aa30b358e-d0de-4a81-92f3-e9f255443043/ (accessed 26 November 2014).

Giocanti, H. and Raynaut, A., *Rapport d'Intervention. Objet: Traitement de Conservation du Support de l'oeuvre suivante:* La Justice de Trajan *de Nicolas Pinson*, Ateliers Lazulum, Marseille, 2007, http://lazulum.free.fr/doc/pinson.pdf (accessed 3 May 2014).

Grimm, M. W. and Paar, R. *The Directory of Hand Stitches Used in Textile Conservation*, American Institute for Conservation of Historic and Artistic Works, Washington D. C., 1995.

Hedley, G., *The Stiffness of Lining Fabric: Theoretical and Practical Considerations*, 6th Triennial Meeting, ICOM Committee for Conservation, Ottawa, 1981.

Idelson, A. I., *About the Choice of Tension for Canvas Paintings*, CeROArt, 2009, http://ceroart.revues.org/1269 (accessed 30 March 2014).

Le Gac, A., *Critérios de Intervenção e Escolha de Tratamentos: A Pintura Monumental* Milagre, Boletim ADCR, no. 6, 1997.

López, E. N., *Estudio Técnico y Problemática de las Costuras en la Pintura sobre Lienzo*, Master's Thesis, Universidad Politécnica de Valencia, 2008.

Maltieira, R., 'A Tela na Pintura Portuguesa. Estudo de um conjunto de pinturas do Museu Nacional Soares dos Reis'. In A. Calvo and E. Vieira (ed.) *Matrizes da Investigação em Conservação e Restauro I*, Universidade Católica Editora, Porto, 2014, pp. 157-177.

Mecklenburg, M. F., *Some Aspects of the Mechanical Behavior of Fabric supported Paintings*, unpublished report to the Smithsonian Institution, research supported under the National Museum Act, 1982.

Museum, *The Care of Paintings: Fabric Supports*, Museum, vol. 13, no. 3, 1960.

Roche, A., *Comportement Mécanique des Peintures sur Toile. Dégradation et prévention*, CNRS Éditions, Paris, 2003.

Tímar-Balázzy, A. and Eastop, D., *Chemical Principles of Textile Conservation*, Butterworth Heinemann, Oxford, 2007.

Villarquide Jevenois, A., *A Pintura sobre Tela. Historiografia, Técnicas y Materiales*, Ediciones do Castro, Coruña, 1999.

Young, C. and Katlan, A. W., 'History of Fabrics Supports', in J. H. Stoner and R. Rushfield, (ed.), *Conservation of Easel Paintings*, Routledge, New York, 2012.

Young, C. and Jardine, S., 'Fabrics for the Twenty First Century: as Artist Canvas and for the Structural Reinforcement of Easel Paintings on Canvas', *Studies in Conservation*, nº4, vol 47, 2012, pp. 237-253.

Ana Braamcamp de Figueiredo
Since 2016, is Master in Painting Conservation by Portuguese Catholic University of Porto (Portugal). Bachelor degree in Conservation since 2012, by the same University.