IN-BETWEEN PLEATS

Pleats, pleating and 'pliable logic'

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Royal College of Art

February 2020

A thesis submitted in partial fulfilment of the requirements of the Royal College of Art for the degree of Doctor of Philosophy

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ABSTRACT

In-Between Pleats is a research project constituted by a series of case studies, historical research, a short intensive pleating apprenticeship, and live performances. The research objective emerged through the exploratory making of pleats. It is to create new thinking about pleats by examining the dynamics of handmade and digital technology, and the potential of those pleats on the body and movement, interrogating three research questions: 'What is a pleat?', 'What is in a pleat?', 'What do pleats do?'.

Pleating is a type of fabric manipulation and so this research refers to 'textile thinking' for analytical thinking. The research starts with an understanding of pleating history and techniques. A selection of materials, including cotton, silk, and synthetic fibres, are tested, recognising that the quality of pleats and pleating is directly affected by the specific fibre and forming structure. It is these differences that offer a range of perspectives to this study. These explorations, led by textile thinking, help to anchor my practice among other practitioners, and position this study in the research context.

The experiments to reproduce Mariano Fortuny and Issey Miyake pleats establish a fundamental understanding of pleating techniques, which form the first layer of analysis for this study, and lead to a methodology for the next layer of research. I propose a new methodology: 'pliable logic', derived from my making and thinking, evolving from Pennina Barnett's 'soft logic', Sarat Maharaj's 'think-speak-write', and Gilles Deleuze's concept of 'plica ex plica', to interrogate and revisit the research questions.

A new pleating method – fabric mould – is originated from my research into materials and techniques; new types of pleats emerge from the application of 3D printing technology. Using these newly produced pleats in live performances, a space to rethink the relationship between garments, textiles, body and movement, offered new perspectives of what pleats and pleating are. Pliable logic provides innovation for both the creation and interpretation of pleats and pleating, through an oscillation between making and theory.

The research proposes a new taxonomy of pleats based on my making experiences. A speculative proposition of what future pleats will look like and be made of, builds a perspective that reinvigorates the way in which pleats and pleating are perceived.

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word count: 35253

AUTHOR'S DECLARATION

During the period of registered study in which this thesis was prepared the author has not been registered for any other academic award or qualification. The material included in this thesis has not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

Signature:

Date:

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01

INTRODUCTION:

Like many others, I am attracted to the geometric repetition of pleats, and the way they move with the body.

SPACE

LUXURY

TIME

PRAY

LIFE

PRAY

LABOUR

FABRIC

COLOUR

Fig. 1.1 Tsai-Chun Huang
Plica ex plica (2016)
laser printed paper, 42cm×29.7cm

Project Background

It has been evidenced that geometric consistency can affect mental wellbeing (Larson, 2007, p.526). Geometric repetition is also highly valued for its aesthetic possibilities in the field of design (Knauer, 2008, p.VIII; Melcher and Cavanagh, 2013, p.388; Soegaard, 2017[1]).

Fashion adopts geometric shapes in many ways, for example the 2D visual patterns of print designs and the 3 dimensional forms of body silhouettes. Pleats, which provide both 2D visual effects and 3D forms at the same time, are the focus of this study. Arguably the iconic design of early 20th Century pleated garments is the Delphos dress (see Fig. 1.2) by Mariano Fortuny y Madrazo (1871-1949). He revived the aesthetics of Greek style (Brandstetter, 2015, p.107). His design sits between the bustle fashions of the Victorian age and the modernist design of Jeanne Lanvin or Madeleine Vionnet (Desveaux, 1998, p.10). The Delphos dress liberated women's bodies from a corseted aesthetic, and has come to be seen as representing the early 20th Century avant-garde (Deschodt and Poli, 2000, p.171).

What is more intriguing to me is that fashion theorists and textile researchers believe that a full knowledge of the method used to create the well-known Fortuny pleats still remains unknown (Kearney, 1990, p.86; Deschodt and Poli, 2000, p.172). Experts have endeavoured to demystify the secret by referring to diagrams of the pleating machine Fortuny patented in 1909 (see Fig. 2.1), as well as examining existing original Delphos dresses collected by museums. This mystery is, in part, a reason to explore more about the formation of pleats.

Pleats and pleating have been commonly understood as a type of fabric manipulation that adds extra texture to textiles, or as a process for creating layering effects with fabrics. However, in the textile literature, pleats and pleating are usually absent. From a textile production perspective pleating is not considered a fundamental technique, like weaving or knitting (Thompson, 2014, p.472). Even though embroidery and stitching are not structurally required to establish a piece of textile, they are still commonly viewed as sources of textile thinking due to their character of threading.

A partial exception to this general rule can be found in the concept of 'soft logic' as proposed by Pennina Barnett in her article, 'Folds, fragments,

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Fig. 1.2 Mariano Fortuny Delphos (ca1919-1920) Silk taffeta, glass beads, 165cm
Image: Palais Galliera, musée de la Mode de la Ville de Paris

1. https://www.interaction-design.org/literature/article/repetition-pattern-and-rhythm, accessed 8th Jan, 2019.

surfaces: towards a poetics of cloth[2]'. Barnett conceives of the fold as metaphor for inclusive non-binary thinking. Nevertheless, her main focus on softness is applied to textiles in general, rather than specifically to the fold, pleats, or pleating.

In determining their 'category', pleats and pleating cannot be anchored to either fashion tailoring or textile manufacturing technique. In publications and exhibitions, researchers organise pleats and pleating with other fashion and textile skills. In *Manufacturing Processes for Textile and Fashion Design Professionals* (2014), Rob Thompson presents Elaine Ng Yan Ling[3]'s case study of combining a 3D printed and pleated structure in a section on moulding, in a sub-chapter on additive manufacturing. In *Haute Couture Ateliers: The Artisans of Fashion*, Hélène Farnault gives pleating an individual chapter, as she gives to embroidery, lace, textile design, feathers, and leather. In *Manus × Machina: Fashion in an Age of Technology*[4], an exhibition at The Metropolitan Museum of Art, curator, Andrew Bolton, separates the exhibition into two galleries; one examines traditional tailoring and dressmaking techniques which include paper patterns and toils, the other examines various couture skills, including pleating.

These content arrangements show how textile engineers and fashion historians perceive pleats and pleating. They situate pleating production as a post processing procedure which does not fundamentally affect the formulation of textiles in the same way that weaving and knitting do. In fashion, pleating is usually viewed as a couture craft, as ornamentation on garments, but at the same time sharing a similarity with tucks, which serve a practical function in garment construction.

For these reasons, pleats and pleating have not been considered as fundamental to the formation of textiles and have therefore not been encompassed as part of the contemporary concepts explored in textile thinking. I believe that pleats and pleating have their own distinct methodology and conceptual potential.

This study investigates the multiple meanings of pleats, and the various techniques of pleating, through a proposed methodology: 'pliable logic'; a concept that emerged from reflecting on 'textile thinking', and my maker's experience of learning to pleat, making a fashion collection with pleats, and

2. First publish as an article in the catalogue of exhibition *Textures of Memory: the poetics of cloth* (1999), and then reprinted in the *Textile Reader* (2012) edited by Jessica Hemmings.

3. Ling is a designer at The Fabrick Lab set up by 360 Fashion in China.

4. *Manus × Machina Fashion in an Age of Technology*, The Metropolitan Museum of Art, New York, 5th May- 5th Sep 2016.

pleating workshops with participants. This methodology will be discussed in detail in *Chapter 5: Pliable logic*. The workshops act as a laboratory for the exchange of ideas. Observing others making pleats helps me to understand my own making procedure. These research methods provide a space for me to rethink my research questions.

Research Questions and Aims

Over the course of the research journey, I have expanded my understanding of pleating through theoretical discussion and have adopted various methods to interrogate both the physical properties and possible meanings of these manipulated sections of fabric. I have searched for new types and expressions of pleats in workshops, in live performance, and explored the same pleating patterns with the most basic domestic tools, through to contemporary machine technologies.

This study is focused around three research questions: 'What is a pleat?', 'What is in a pleat?', and 'What do pleats do?'. Answering these questions will lead to new forms of pleats and pleating methods.

My research aims are as follows:

- Use my expertise of making pleats and leading workshops to interrogate the meanings of pleats. The hands-on procedure provides an embodied experience of the production of pleats. This embodied experience is a form of knowledge that can answer the research questions.
- Develop a taxonomy that recognises the formation and mechanism of pleats through mapping out the history and pleating practitioners.
- Develop a new thermal pleating technique by adopting maker's knowledge and through this, propose ways of working with digital technology to produce 3D printed pleats.
- Generate a methodology, termed 'pliable logic', that encompasses theoretical and practical phases, for use in textile research practice.
- Explore the potential of the new forms of pleats developed by this research beyond their material form.

Clarification of Terms: Language | Technique & Fabric | Pattern

Before starting this research project, there are three key elements that need to be clarified to avoid possible confusion. The first element is to distinguish 'fold' and 'pleat'; the second is the pleating method and fabric; the third element is the pleating pattern I use throughout this research project.

- 'Fold' and 'Pleat'

The Cambridge Dictionary defines the pleat as a noun that refers to 'a narrow fold in a piece of cloth made by pressing or sewing two parts of the cloth together'[5]. The dictionary includes the concept of fold as part of the pleat, and this distinguishes 'fold' from 'pleat', implying that pleat is one type of fold. The Cambridge Dictionary defines the fold as a noun that is 'a line or mark where material was or is folded'[6]. It does not refer to layering of the surface as it does for 'pleat', which again makes the fold distinct from the pleat. Furthermore, 'fold' as a verb is defined as an action to bend material. What is worth noting is that paper and cloth are the materials that are especially associated with these actions in the dictionary definitions.

Alongside folds and pleats, drapery is a similar formation worth clarifying. Gen Doy examines drapery in various contexts, including philosophy and art. Doy observes that drapery is 'carefully arranged or invented to look more than just cloth' as it has 'undergone various transformations due to labour, whether classed as art, craft or manual labour' (Doy, 2002, p.10). She describes a female model in a photograph by E. Benard (or Bernard)[7](see Fig. 1.3).

> Her dress is used as drapery, rather than clothing, as she is posed taking it off in such a way that the hang of the dress results in artistic folds which start to bunch out on the floor.
>
> ibid., p.13

Extrapolating from Doy's analysis, drapery can be understood as another type of fold. The word 'hang' and 'hanging' frequently appear in Doy's text. Therefore, I would argue that drapery is a free flow form that contains folds,

5. https://dictionary.cambridge.org/dictionary/english/pleat, accessed 15th Mar 2017.
6. https://dictionary.cambridge.org/dictionary/english/fold, accessed 15th Mar 2017.
7. Doy includes two spellings because both Benard and Bernard appear in the Bibliothèque documentation (Doy, 2002, p.235).

which are effected by gravity. It is clear that the ‘pleat’ is different from ‘drapery’ and the ‘fold’.

For the purpose of this project, pleats are defined as: A 3 dimensional structure, or effect, formed through a process of manipulation, that establishes a fold, or series of folds, or appearance of folds, in material, fabric, or garment[8].

8. An in-depth discussion of the etymology of the word ‘pleat’ can be found in *Chapter 4: Field Mapping.*

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Fig. 1.3 E. Benard (Bernard)
Photograph of Cabanel’s Studio (ca1887)
Image: Bibliothèque Nationale de France

- Pleating method and fabric

Pleating is a type of fabric manipulation, which advances with material and technological development. Technological evolution is a key concern of this research, given that one aim of this project is to create new forms of pleats and pleating. Technological developments in manufacturing processes also affect the way in which we understand the meaning of textiles (Igoe, 2018, p.1797). Pleats and pleating are formed through the pattern structure and repetitive action, influencing the ways in which we understand the materiality.

Textile researchers, Sharon Baurley (in her thesis PhD Fashion and Textiles, RCA), and Matilda McQuaid (in the catalogue *Structure and Surface: Contemporary Japanese Textiles (1999))*, classify pleats into three types according to the manufacturing process. The first category is 'manual processing', in which the fabric is pressed by hand using an iron. The second category is the 'continuous machine method', which is the most common type in current industry. The last is the 'hand pleating method', which involves sandwiching cut fabric between kraft paper (Baurley, 1997a, p.42; McQuaid, 1998, p.25). These categories are all achieved through heat application, and the organisation is based on whether the pleat is produced by hand or machine, excluding other types of pleats. I would like to offer an alternative classification based on the mechanism of construction and the way in which the pleat itself is formed. I categorise pleats into four groups: 'stitched[9]', 'thermal', 'structural[10]' and 'digital' pleats (see Fig. 1.4). These categories help to demonstrate and think about how artisans move between hand and machines. This research has focussed on 2 of these categories: 'thermal', and 'digital' pleats.

Thermal pleats can be traced back to ancient Egyptian and Greek clothing. In ancient Greece, prior to the use of flat irons, thumbnails were used to score the crease and stabilise the pleats. This technique can still be seen in some parts the Greek countryside, where peasant women pleat their national dress bonnets (Deschodt and Poli, 2000, p.104)[11]. The ancient Greeks (approx. 500–450 BC) would hand pleat the fabric, soak it in a thin starch solution, tie together to stabilise the pleats, and then leave it in the sun to dry.

9. The category of 'stitched pleats' can be easily understood by the fabric manipulation, smocking or pintucks , which required threading to stablise the pleats, making the pleats static rather than mobile.

10. The category of 'structural pleats', is a unique form of making that involves woven or knitted yarns. When the fabric comes out of the loom, or off the needles, the fabric will contract into place because of the tension applied to the yarn or the structure formed. These 'structural pleats' are distinct from the other forms of making as they concern a single line of yarn in their fabrication. I have not used this method in my research.

11. Deschodt and Poli mistakenly cite the book as *Historie du costume dans l'antiquité antique.* Léon Huezey did not publish this book. The accurate reference is *Historie du costume antique d'après des etudes sur le modèle viviant*.

Although a more complete definition and evolution which demonstrate various pleats in their tangible form, and an etymology, will be discussed in *Chapter 2: Pleating Practice (i) Experiments*, and *Chapter 4: Field Mapping*, I would like to preface that discussion by stating that this project concentrates on the thermal method, which I learnt from my time as a studio technician in Ciment Pleating Ltd in 2016. In hand pleating, thermal processed pleats are executed by sandwiching fabric between two kraft paper moulds and then stablising with steam. This method best suits polyester[12], as this synthetic fabric contains heat-set mouldability.

12. I have tested viscose and nylon with the fabric mould method, however these two types of fabric did not hold the pleats well.

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Fig. 1.4 Taxonomy of pleats

- <u>The pleating pattern</u>

Cubic Pattern

The majority of projects in this study use a specific pleating pattern, which I developed in 2009[13] and have called Cubic Pattern (see Fig. 1.5). The Cubic Pattern is a 4-way stretch (see Fig. 1.6) tessellation[14] pattern, which can be viewed as a less condensed variation of the classic origami pattern 'Water Bomb'[15] (see Fig. 1.8).

The Cubic Pattern looks like a chess board with one cube standing up and the next one sitting down, showing a less condensed gathering of cubes compared to the Water Bomb pattern. It therefore takes less material to form the same size of area and this means the Cubic Pattern is looser in density and stretches very easily. As a result, the contraction is not as tight as the Water Bomb.

As can be seen in still video images (Fig. 1.7), the Cubic Pattern is formed by twisting a flat plane 90 degrees and pulling up the height of its edge length. The Cubic Pattern can stretch easily back to a flat surface, providing high elasticity. The Cubic Pattern creates volume and its high elasticity changes the silhouette during movement.

This research has focussed on experimenting with techniques and applications of a single pleating pattern, rather than to develop a variety of patterns. I have followed my Cubic Pattern through a range of technical experiments and product developments. However, many other pleating structures are referenced across the project.

Water Bomb pattern

The Water Bomb pattern contracts the space between squares. When fully folded, all the squares meet each other to establish a flat surface. The reverse side shows the contraction points, which gives rise to Ciment Pleating naming this design 'star pleats' (see Fig. 1.9). They choose to focus on the mechanism of the folding rather than on the appearance of the fold, helping us to separate out structure and appearance.

Each of these pattern variations affects the flexibility of the structure. The

13. Andrea Russo, an Italian paper-folding artist, published this pattern in 2011 and the pleating studio, Global Pleating in Alexandria, Egypt, also holds this pattern under the name 'Dice'.

14. The term tessellation originates from the Latin 'tessella', meaning 'small square' [https://www.britannica.com/art/tessera-mosaic, accessed 4th Oct, 2015]. These squares were the mosaic pieces used to decorate architectural spaces. Islamic cultures developed this technique into an art form in the design of mosques, where representational imagery was forbidden.

15. It was pointed out to me that my Cubic Pattern was a less condensed variation of the classic Water Bomb design, by the manager, Matt Weinert, at Ciment Pleating, when I was working there as a studio technician.

Water Bomb pattern is very stretchable and can easily form curves with manipulation. Tine de Ruysser adopts this pattern with electro-conductive paint on cotton fabric for her research project (PhD Jewellery Design, RCA). She calculates a way to join the front and reverse sides of the structure to build an origami shoulder cape (Fig.1.10) (De Ruysser, 2009, pp.147-154).

Issey Miyake's Water Bomb

In 2014, Miyake Design Studio released a variation of the Water Bomb pattern for his Steam Stretch Series[16] (Fig. 1.12). It is not immediately apparent that there is a difference between the classic design and Miyake's variation, but Miyake has divided the extraction points (see Fig. 1.11), creating another square at the intersection of each cube. An analysis of the pattern differences can be seen in Figs. 1.8 and 1.11.

Due to the inserted square at the intersection of each cube, Issey Miyake's variation of the Water Bomb pattern cannot form a continuous flat surface, which means the squares on the top plane do not meet each other. However, this variation still provides a high flexibility to form a wide scope of curvature.

Cube pleat

During the pattern survey, I discovered a similar folding structure in Sharon Baurley's research on the 3D formation of textiles, which she names Cube Pleat (Baurley, 1997 p.44).

The appearance of Sharon Baurley's Cube Pleat is similar to my Cubic Pattern, with one cube standing up and the next one sitting down. However, areas between the cubes (indicated on Fig. 1.13 by a dotted cross) are tucked inside the joining edge. This structure means that the pattern is static and non-stretchable. It does not serve an elasticity function. Baurley's pattern experiment stopped at the stage of pleating a piece of polyester with stainless steel yarns. It was not for any garment application[17].

16. A detailed analysis follows in *Chapter 2: Pleating Practice (I) Experiments*

17. Sharon Baurley visited Inoue Pleats during her PhD research in 1995/6. Her research commenced by examining trompe l'oeil effects on fabric, and gradually moved to the creation of real 3D effects through embossing, moulding, and pleating (Braddock, 1998, p.75). In her thesis, Baurley documented her collaboration with Inoue Pleats, which began with her contributing a new pleating pattern, Cube Pleat, to Inoue's library. Subsequently, they worked together to pleat a 100% polyester fabric Cube Pleat pattern, spattered with stainless steel (Baurley, 1997a, p.46).

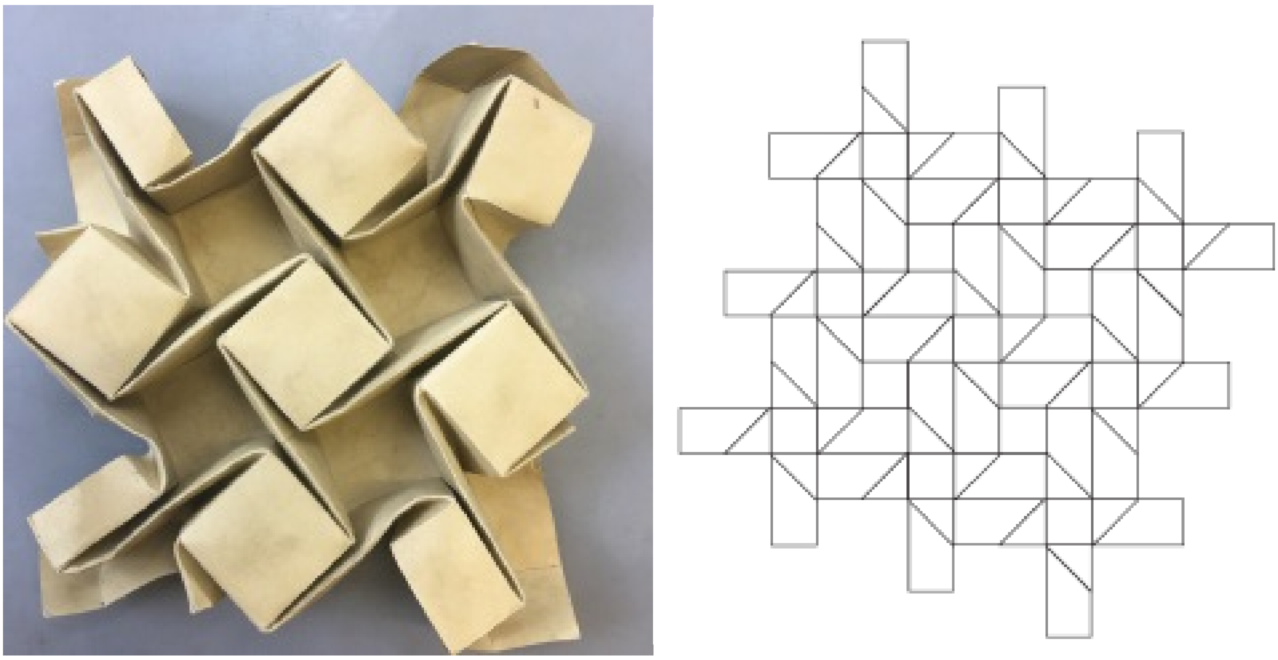
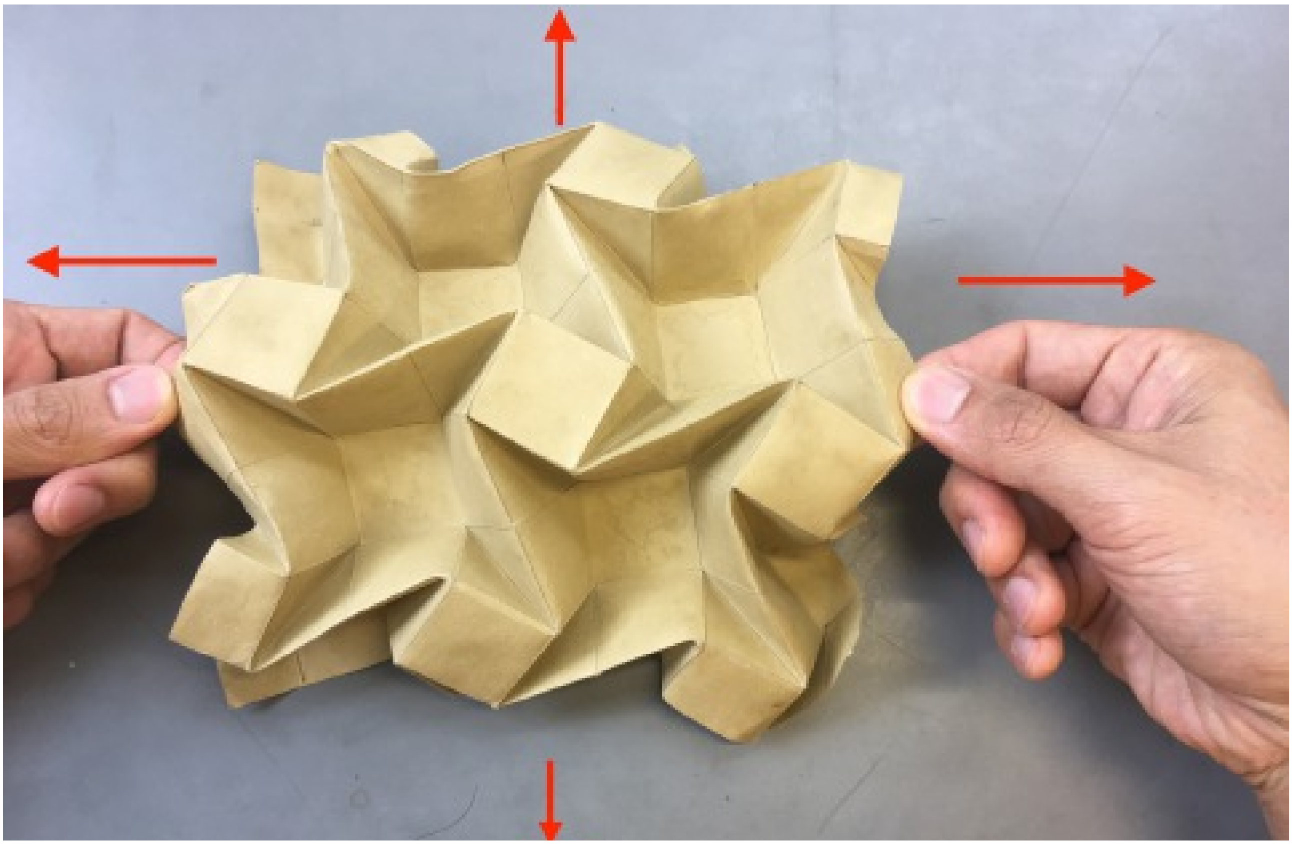


Fig. 1.5 Cubic Pattern structure and its digital pattern folding template



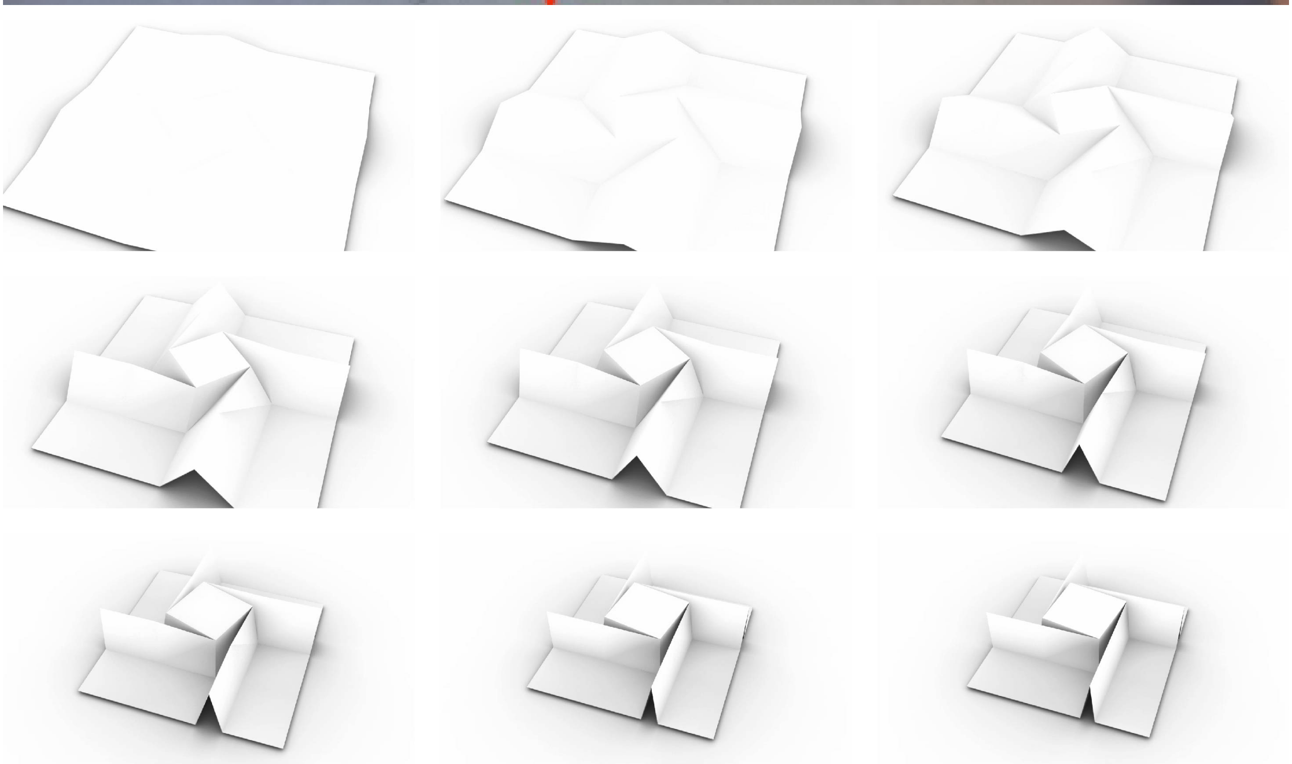


Fig. 1.6 Cubic Pattern 4-way stretch analysis
Fig. 1.7 Cubic Pattern formation. Video stills: Cubic Pattern (2011), video by Chung Huang (00’09”)

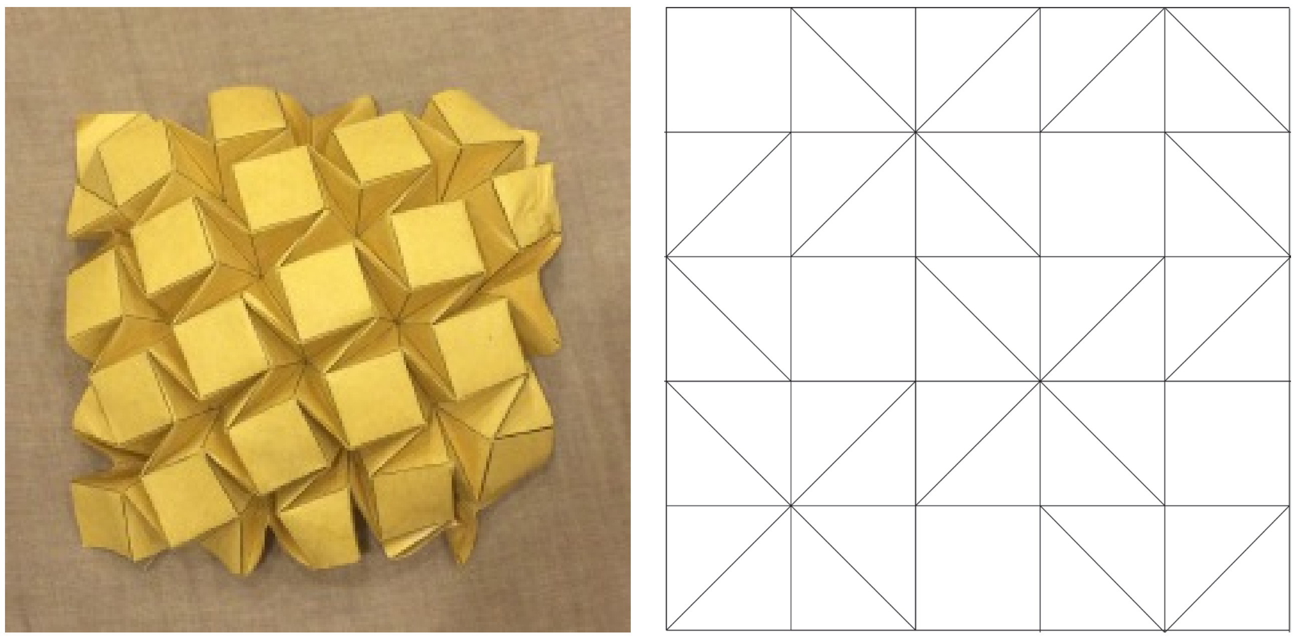


Fig. 1.8 Water Bomb structure and its digital pattern folding template.

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Fig. 1.9 Star pleats, the reverse side of the Water Bomb pleat. Image: Ciment Pleating.

Fig. 1.10 Tine De Ruysser
Wearable Metal Origami Shoulder Cape (2009)
Cotton, electrodag, copper
Image: Tine De Ruysser

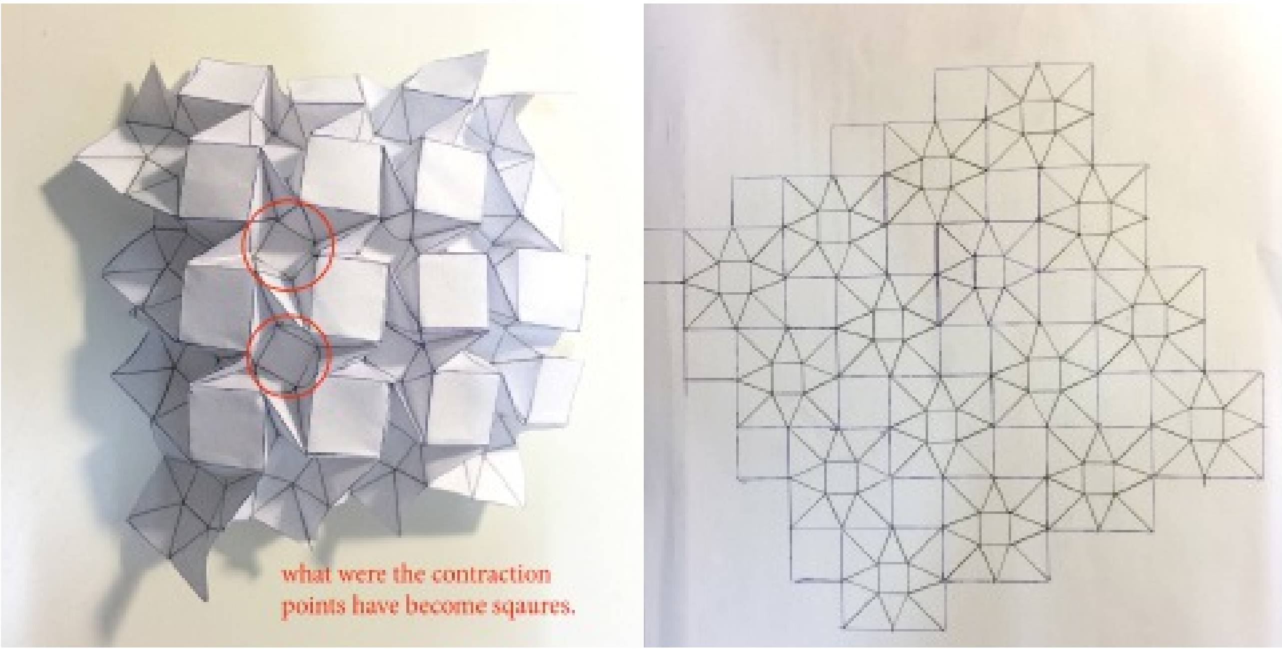

Fig. 1.11 Issey Miyake's water bomb structure and its digital pattern folding template

Fig. 1.12 Issey Miyake
2015 Spring/Summer collection (2015)
Steam stretch yarn, polyester

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Fig. 1.13 Cube Pleat structure and its pattern folding template. Image: Sharon Baurley

Redacted Image

Fig. 1.14 Sharon Baurley and Inoue Pleats
Cube Pleat (1997)
Polyester, stainless yarn, dimension
Image: Sharon Baurley

Content Overview

This research borrows the fold as a metaphor that determines its structure, similar to one unit of a pleat (see Fig. 1.15). The research thus embodies what it also describes, revealing knowledge within itself, the spaces in-between[18], that might be hidden from sight, or on the reverse side.

After outlining the research questions, positioning this research, and identifying key pleating techniques and patterns here in **Chapter 1: Introduction**, I examine two iconic designers, Mariano Fortuny and Issey Miyake, who ustilise pleats as their main design method, in **Chapter 2: Pleating Practice (i) Experiments**. Although they both adopt pleats as their main approach to fashion design, Fortuny pleats before the garment construction, while Miyake pleats after it. This production difference between them, demonstrates a contrast that is worth exploring, in terms of the final silhouette and the effect of the pleats. A series of practical experiments try to demystify the secrets of Fortuny pleats and to understand how Miyake establishes an entire aesthetic based on pleats. From the comparison of their pleats alongside the practical experiments, I present my reflections, in order to contextualise my making in a wider history of pleating culture and to draw out some primary answers to my research questions.

Chapter 3: What is a pleat? What is in a pleat? What do pleats do?, explores three phases of pleats and pleating, which are learning, workshopping and making. These practical exercises help me to understand my research questions through my physical actions. Knowledge transference is not a one-way flow. The communications between workshop participants and me, establish a 2-way ideas exchange, which leads me to territory I have never considered. Through an examination of these practices from the perspective of the three research questions, I determine that pleats and pleating should have their own textile thinking, according to their physical creation and structure, which other forms of textile do not contain.

The history and different branches of textile thinking, and pleating in digital technology, form the basis of **Chapter 4: Field Mapping**. This chapter begins

18. The title of this research thesis *In-Between Pleats*, emerges from the process of making. Folding the fabric, I became interested in what was tucked away, folded out of sight. It is also a reference to the annual fashion exhibition of the Metropolitan Museum of Art in 2017, Rei Kawakubo/Comme des Garcons – *Art of the In-Between*.

with an investigation into the origin of the word 'pleat', using the method Victoria Mitchell employs in her textile thinking theory. I expand this approach to include an examination of the Chinese character for 'pleats'. The enquiry goes on to consider textile practitioners' creative concepts and analyses in relation to pleats. As a maker, I also use my own experiences to reflect on my understanding of pleats. This background research is necessary in order to determine what precedents exist and what there remains to be redeveloped.

Chapter 5: Pliable Logic, proposes a new methodology for the interrogation of pleating practices. After investigating thermal pleating techniques, I felt an urgency to establish a research methodology specifically for pleats and pleating, as they contain the properties of layering and repetitive folding action, that current textile thinking does not include. 'Pliable logic' builds upon Pennina Barnett's 'soft logic' (expanded to a wider notion of 'softness'), together with Sarat Maharaj's 'think-speak-write' (identified as a type of recursive sequence), and Gilles Deleuze's concept of '*plica ex plica*'[19]. The subsequent projects presented, follow this pliable logic as a way to work towards the research objective of creating new types of pleats, and examining the applications of pleats on the human body.

Folding back, **Chapter 6: Pleating Practice (ii) New Technology**, describes 2 projects that were created using pliable logic as a strategy. In these projects, 'Fabric Moulds', and '3D Pleating', I use my maker's knowledge of textiles and experiences of fabric manipulation, to demonstrate a deeper relationship between craft knowledge and technology. I use live performance to test out the function of pleats in order to observe them in motion. I explore a range of solutions to redevelop current hand-pleating techniques, both with basic equipment that suits the domestic realm, and the latest[20] 3D printing technology. The making process and reflective thoughts in this chapter are divided into 2 columns to reveal a 'back and forth' route, as suggested by pliable logic. I believe that the methods described in this chapter may provide various technical perspectives that answer my research questions: 'What is a pleat?', 'What is in a pleat?', 'What do pleats do?'.

19. From the Latin, meaning 'fold from fold'.

20. The 3D printer used was the SLS, the Selected Laser Sintering by Sinterit.

Chapter 7: What is a pleat? What is in a pleat? What do pleats do? (Revisited), synthesises the research findings and uses them, once again, to address the research questions. I reflect on how my textile knowledge and manipulation of fabric, guide me through the pleating techniques, redeveloping projects to demonstrate the push/pull relationship between maker's autonomy and new technologies. The understanding of the formation of the pleats and the performance of the pleats lead to the answer of research questions. This study concludes that 'shuttling', 'luxury', and 'mobility' become focal points in addressing the research questions.

The last chapter, **Chapter 8: Conclusion**, identifies the key contributions, which are the taxonomy of pleats, and 'pliable logic' as a methodology for textile research practice, and the originality of fabric moulds and new forms of pleats made by this study. The study projects what future pleats will look like and be made of based on the ideas 'shuttling', and 'mobility'. Moreover, this chapter considers pleats and pleating as a space for thinking, asking what further questions are revealed.

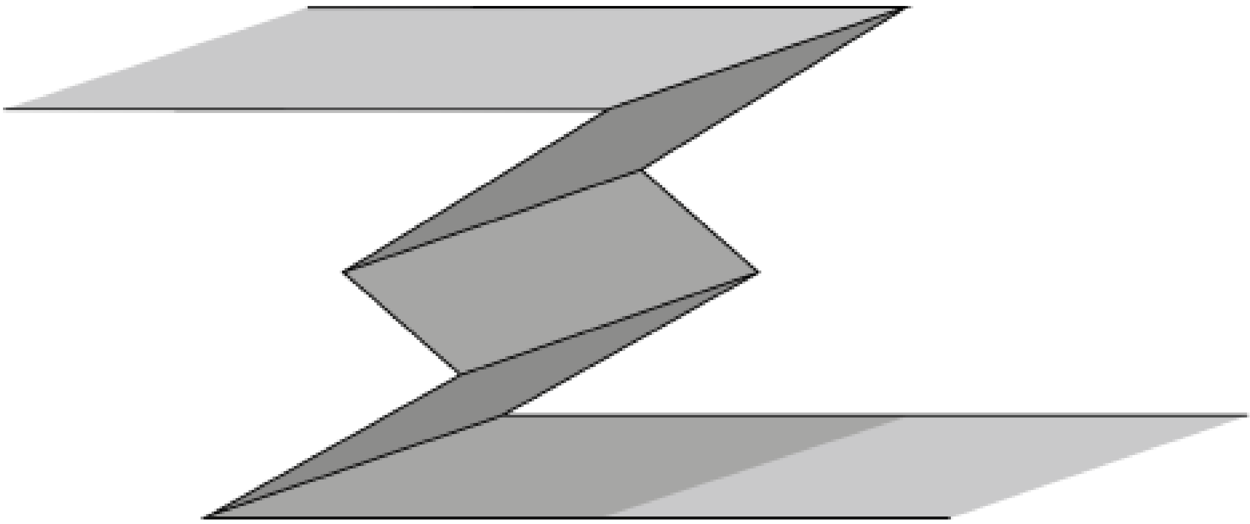


Fig. 1.15 One unit of a folding structure

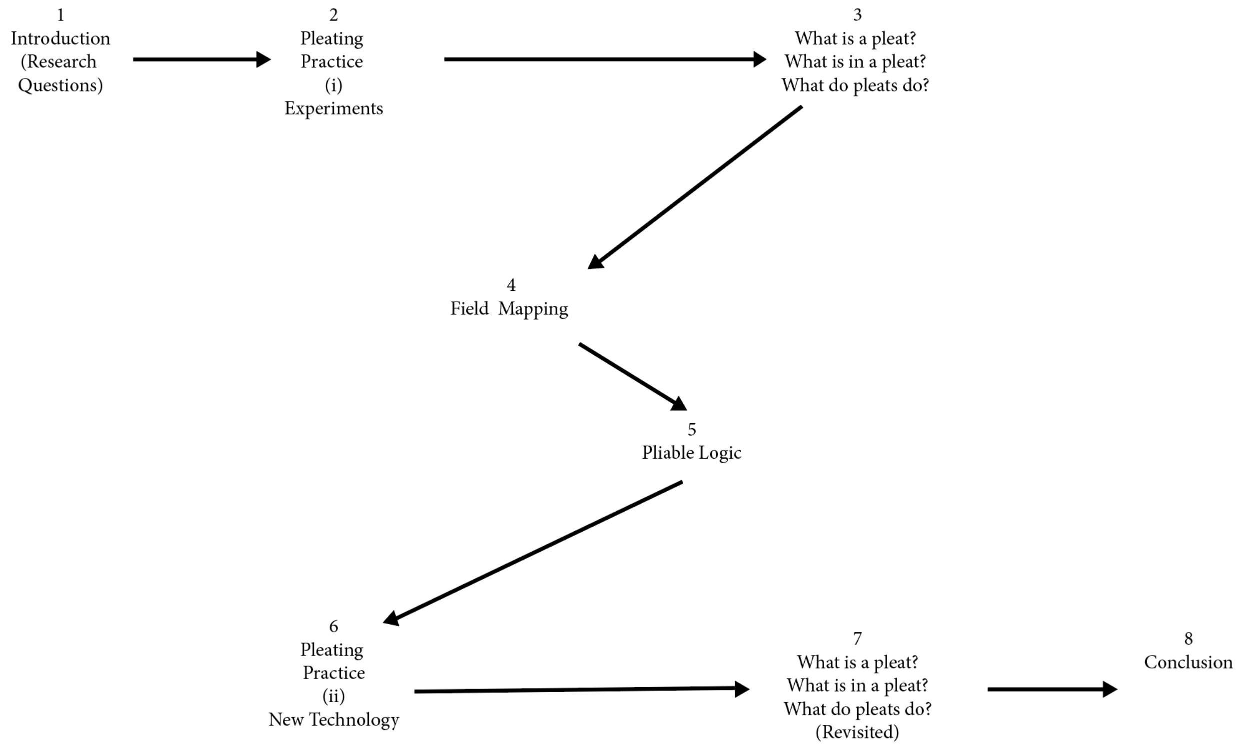


Fig. 1.16 In-Between Pleats chapter sequence

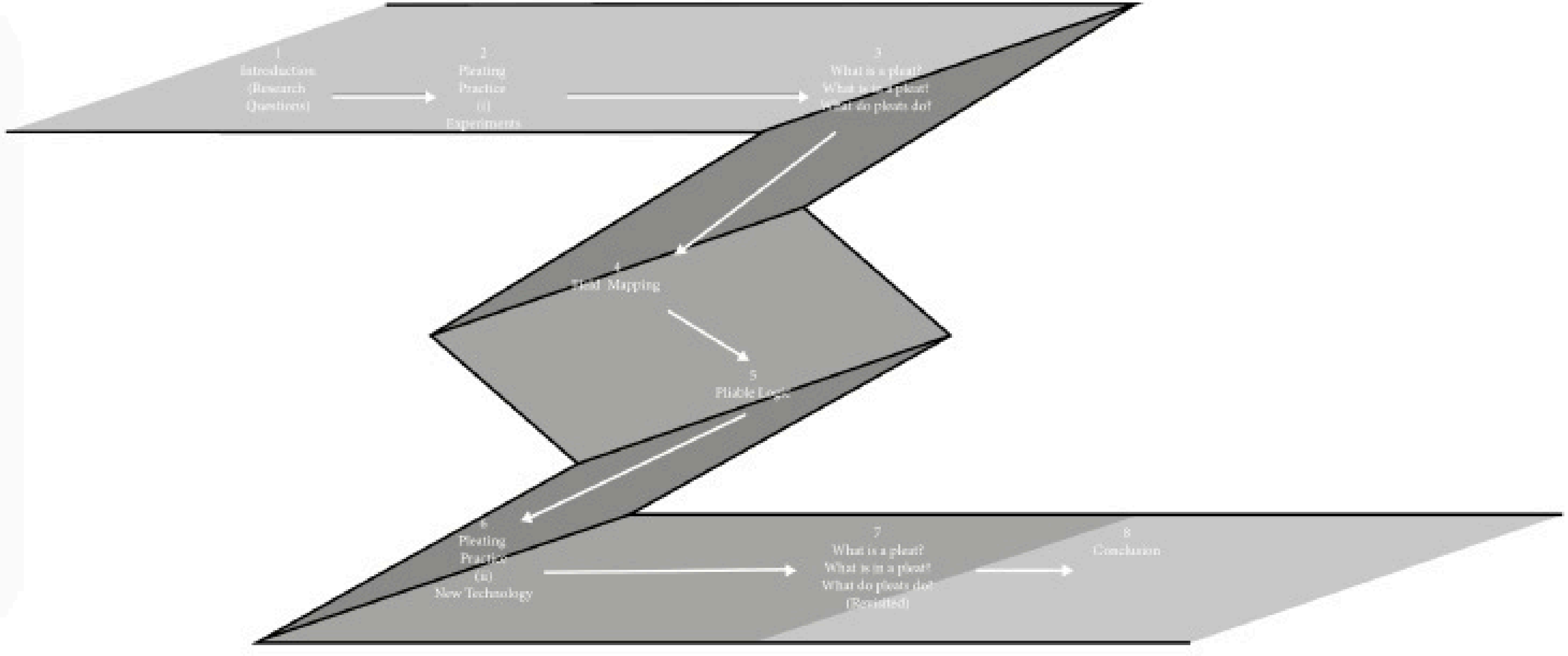


Fig. 1.17 In-Between Pleats research structure

02

PLEATING PRACTICE (i) EXPERIMENTS:

It is worth exploring the work of two of the key figures in pleating design, Mario Fortuny and Issey Miayke.

In order to get an understanding of the research questions, 'What is a pleat?' 'What is in a pleat?' 'What do pleats do?' it is worth exploring the work of two of the key figures in pleating design, Mario Fortuny and Issey Miayke. Through archival, historical and practical research, a better understanding of their methods can help to gauge the limitations and possibilities of their design practice.

Mariano Fortuny Experiments

The process of producing the Delphos gowns remains largely unknown. There are however, some extant diagrams of the machines Fortuny used, because he applied for a patent in 1909 (see Fig. 2.1). Fashion historians and textile researchers have spent considerable effort trying and demystifying Fortuny's secret, using the pleating machine diagram as their starting point. The diagram shows several hooks on the two ends, with ceramic tubes in the middle (Deschodt and Poli, 2000, p.172).

Anne-Marie Deschodt and Doretta Davanzo Poli believe that Fortuny revived a Venetian Renaissance pleating technique used to pleat church vestments (ibid., p.104) (see Fig. 2.2). They argue that after the fabric was prepared with starch or egg white glue, Fortuny and his staff used their thumbnails to form the pleats, and then twisted the creased fabric, squeezing it with their hands. The fabric was then hooked onto the machine he invented. The hollow ceramic tubes were heated up with steam, to dry and fix the pleats[21]. It took about 2 hours to pleat a 'Delphos' dress, but the removal of the glue, in order to make the fabric supple and wearable once the pleats are in place, could take up to another 8 hours.

I was very sceptical about Deschodt and Poli's belief that Fortuny used thumbnails to pleat and twist the fabric before heat stabilising with his machine. Thumbnail creasing long lines on fabric will not result in pleats sitting neatly next to each other in a straight formation, no matter how precise the technician, especially not hundreds of equidistant pleats across an entire garment. In terms of the patent diagram, the ceramic tubes only touch the pleated fabric at a few points. How could these limited points of heat contact stabilise the whole piece of fabric? Furthermore, why would there be weights at the side to pull straight the fabric between ceramic tubes?

21. In the 'Notes' of *Fortuny,* Deschodt and Poli cite Clara Pavato's opinion that the machine was not commercially successful.

Redacted Image

Fig. 2.1 Mariano Fortuny pleating machine diagram. Patent no. 414,119 (1909) Image: Archives INPI, France. Annotation: Tsai-Chun Huang

Redacted Image

Fig. 2.2 Benedictine convent of Engelberg, Switzerland
Undergarment (Alb) (ca1300-1310)
Linen, silk, 181cm
Image: Museum Schnütgen

Usually pressure is applied when the fabric is contracted into the pleat shape, changing the form of the textile, rather than after the form has been changed. From my reading of the machine diagram, the weights imply that the fabric needed to be straightened. Why would the fabric need to be straightened, if it was thumbnail creased? Perhaps the fabric was curled as a result of a different pleating method. I decided to study the real Delphos dress in person.

<u>Archival viewing</u>

In November 2015 I had the opportunity for an archival viewing (see Fig. 2.3) of 3 Delphos dresses in the collection of The Museum at FIT (Fashion Institute of Technology, New York).

The Delphos dresses are 100% silk, a natural fibre that presents the pleats but does not permanently hold them. The dresses I was shown at The Museum at FIT were all tagged as 1920s[22]. These dresses are curled in boxes when the museum stores them (see Fig. 2.4). Ariele Elia, Industry Coordinator, told me that this is how the garments were originally sold to customers. Unless it comes to an important exhibition, the garments are kept in this form. The Museum at FIT allow one to be uncoiled for research purposes.

This coiled form is not usual for garment storage but it is consistent where hanging the garment in a more conventional fashion could compromise the precision of pleats. Gravity would slowly pull out the pleating structure. A contemporary example of this is the care instructions that come with Issey Miyake's pleated garments. In the instruction pamphlet[23], Miyake Design Studio suggests that it is better to '…roll the garments along the lines of the pleats into a cylindrical bar shape when storing'[24].

Labels attached to the Delphos dresses suggest that customers who wanted to have their dresses washed should return them to the factory on the island of La Giudecca (Carrara, 2010, p.352) for repleating (Kearney, 1992, p.87).

Fashion theorists suggest that glass beads along the seams and the hem (see Fig. 2.5), add balancing weight to stabilise the shape of the dress (Fukai, 2002, p.381; Carrara, 2010. p.352). However, these beads are relatively light compared to 7 metres[25] of silk fabric, so I am doubtful of this assumption and

22. The violet one was given the specific year, 1928.

23. The fact that there is an instruction pamphlet, which includes detailed information for the cleaning and storage of the clothes, shows by itself that the care requirements are beyond what is normally expected.

24. This information can be found on their website as well. https://support.isseymiyake.com/hc/en-us/articles/115010891347-Please-tell-me-how-to-store-PLEATS-products-, accessed 12th Nov, 2018.

25. This length is calculated as follows: The depth of each pleat on the Delphos dress is between 3-5mm (the total width is 6-10mm), and each dress has a front and a back panel which contains around 430-450 pleats. The calculation adopts the median 8mm x 440 pleats x 2 panels = 702cm.

believe those beads are included for aesthetic reasons.

Fortuny released several variations of the Delphos dress, including long sleeves, short sleeves, and sleeveless. The museum opened a sleeveless apricot Delphos dress for me (see Fig. 2.6).

Fortuny studio's staff hand stitched all seams (hem, neckline, side seem) (see Fig. 2.7) to keep the flexibility, visual effect of the pleats, and so that it could be taken apart for re-pleating[26].

The Delphos dress is formed of 3 pieces: The front panel by a single piece; 2 back panels meet at a central zip (see Fig. 2.8). Each front panel contains between 430-450 pleats (Deschodt and Poli, 2000, p.171; Smelik, 2014, p.39), and the width of the dress is around 40cm when laid flat. Each pleat is approximately 3-5mm wide, continuous and in line with each other.

<u>Ciment Pleating</u>
I was very curious about how Fortuny produced his Delphos gowns, so I visited F. Ciment Pleating Ltd in London[27] and asked their technician, Gary Mitchell, for an answer.

When I explained the purpose of my visit, Mitchell was completely unflustered. He grabbed a piece of light polyester and began twisting the two ends of the fabric in counter directions. Soon the fabric became a stiff rope. He then used strong steam from an industrial iron to fix the fabric (see Fig. 2.9).

After unravelling the fabric, he repeated the actions of twisting and ironing an additional two times, increasing the number of creases.

He opened the fabric and told me: "These are Fortuny pleats" (see Fig. 2.10). After seeing the outcome, I was very sceptical because from the documentation[28] I had seen, the Delphos dress showed a group of perfectly aligned continuous pleats, similar in size, rather than a wrinkled fabric with random creases. My doubt about the result encouraged me to explore further.

26. *Fashion and Fabric*, Design Museum Denmark, Copenhagen, 2014-2019, museum label.

27. I first visited F Ciment Pleating in 2015 and in the same year could make a comparison with Tom's Sons International Pleating in New York. Both studios work across hand and machine pleating. Gérard Lognon in Paris works in a similar way and is a provider for several couture houses, including Chanel and Dior.

28. At this stage I had not yet viewed the original garments at The Museum at FIT and was working from documentation photographs.

Fig. 2.3 Museum at FIT archival viewing
Kyle Farmer and Ariele Elia
New York, USA (2015)

Fig. 2.4 Museum at FIT archival viewing
Mariano Fortuny Delphos dress (ca1920s)
Coiled for storage
Pleated silk, glass beads, 30cm×30cm
New York, USA (2015)

Fig. 2.5 Museum at FIT archival viewing
Mariano Fortuny Delphos dress (ca 1920s)
Coiled for storage
Pleated silk, glass beads, 30cm×30cm
New York, USA (2015)

Fig. 2.6 Museum at FIT archival viewing
Mariano Fortuny Delphos dress (1928)
Unravelling Delphos dress
Pleated silk, glass beads, 145cm×30cm
New York, USA (2015)

Fig. 2.7 Museum at FIT archival viewing
Mariano Fortuny Delphos dress (1928)
Hand stitched hem
Pleated silk, glass beads, detail
New York, USA (2015)

Fig. 2.8 Museum at FIT archival viewing
Mariano Fortuny Delphos dress (1928)
inside
Pleated silk, glass beads, detail
New York, USA (2015)

Fig. 2.9 Fortuny pleats experiment: Gary Mitchell's attempts. Twisting fabric for ironing.

Fig. 2.10 Fortuny pleats experiment: Gary Mitchell's attempts. Unravelling fabric after ironing. Pleats in detail.

Fan cardboard

After describing the ceramic tubes heating method, Deschodt and Poli write in around 1925 Fortuny changed to two cardboard moulds to pleat his garments (ibid., p.127).

This two-cardboard mould technique seems similar to the current pleating technique using kraft paper. According to Andrew Bolton, this method was developed by eventaillistes (fan makers), Martin and Édouard Petit in France in the 1760s (Bolton, 2016, p.93). Bolton uses the *Encyclopédie* by Denis Diderot and Jean le Rond l'Alembert as the organisational principle for the exhibition, *Manus × Machina: Fashion in An Age of Technology* , illustrating different *métier* (professions) defined by the encyclopaedia, such as *dentellerie* (lacework), *brodeur* (embroidery), and *maroquierie* (leatherwork). Although pleats are mentioned under *taileur* (tailoring) in the *Encyclopédie*, as parts of a garment, no pleating techniques are referenced. The most relevant technical section in the *Encyclopédie* is *eventalliste* (see Fig. 2.11), which is the technique of making a folding fan, and this section becomes the frame used by Bolton in the exhibition to introduce pleating. According to Hélène Farnault, the oldest paper moulds in the oldest pleating studio in Paris are over 150 years old (Farnault, 2014, p.171) adding credence to the idea that the methods used to create folding fans were precursors to the kraft paper pleating method.

Bolton's taxonomy of couture techniques presents a clear structure for the exhibition, delivering an overview of different types of skills. His classification encouraged me to think about the categorisation of pleats in my own research. My taxonomy, 'stitched pleats', 'thermal pleats', 'structural pleats', and 'digital pleats', demonstrates the different ways in which pleats are formed, helping to answer the question 'What is a pleat?'

I visited the archive of French fan maker, Duvelleroy, Paris, in August 2018, which is presented in part, in the shop. Fan making tools, paper moulds, weights and irons, both historical and contemporary, are available for consultation (see Figs. 2.12, 2.13, 2.14).

Duvelleroy fans are made from several different materials, including paper, cotton leaf, feathers, and silk. On enquiring how the natural fibre materials were fixed into shape (generally, pleats do not hold with natural fibres) I was told that the fan makers apply starch to stiffen the fabric before they sandwich it in the pleated moulds. The moulds are then sent to steam for 30 minutes. They are ready to open once they fully cool down.

During this research process I have been trying to understand what pleating is through examining different techniques. The visit to the Duvelleroy archive, encouraged me to think of pleating as an 'effect' rather than a technique. There are many ways to achieve a pleated result. Fan makers can use natural fibres such as silk with the addition of starch. This is possible because of the small scale of the item they are creating, and the fact that it will not be washed or affected by body temperature.

While Bolton suggests that it was the eventalliste that first created pleats through paper moulding, Ciment pleating in London has practiced a paper moulding technique for decades that is similar to those of the eventalliste. The paper mould technique used in Ciment Pleating, is that fabric is sandwiched in between two layers of kraft paper that have been pre-creased with the desired pleating pattern[29]. The fabric is contracted by the paper mould and tied with strings to apply pressure. It is then sent to a steam cupboard for 30 minutes[30]. After it has completely cooled down the paper mould can be opened and the pleated fabric removed.

Even though, the two-cardboard mould method that Deschodt and Poli describe seems similar to kraft paper moulding, I do not believe Fortuny used this approach to pleat his tiny pleats. At Ciment Pleating the technician told me that to maintain geometric precision, pleats under 10mm have to be maunfactured by machine. The thickness of the two layers of kraft paper together with the fabric, mean that a narrow pleat will not have enough space to crease properly. My own experiments in this regard have shown that it would be very difficult to create tiny pleats by hand. It is extremely

29. They keep approximately 3,000 paper patterns (Fig. 3.10) in their studios and they are the main suppliers of delicate pleats for haute couture and high fashion in the UK, which can be seen in the video on their website and was confirmed in conversation with Ciment Pleating technicians. At the same time, Ciment Pleating also offers a machine pleating service.

30. The time varies depending on material thickness. Different studios prefer different timings.

hard to maintain parallel lines across two identical cardboard moulds, with hand drawing and hand folding (see Fig. 2.15). The paper mould twists out of shape. When I experimented with 10mm pleats, the paper moulds bent during the pleating process (Fig. 2.16), making it very difficult to form a consistent shape. Considerable weight had to be applied to prevent the mould from flipping up. (Extra numbers of sticks were needed to stabilised the contracted pleats (see Fig. 2.17).)

There are many issues, including the twisting moulds, uneven pleats and mispleats, that are difficult to overcome when using the two-cardboard method (see Fig. 2.18-2.21). The pleating does not resemble the dress in the Fortuny archive at FIT museum. The pleats in my experiment were very straight and stiff, and did not contract tightly to each other; by contrast, the pleats on the Delphos dress were supple, a little bit wavy and tightly compressed. It is reasonable to deduce that this method was not used by Fortuny to produce Delphos dress.

Redacted Image

Fig. 2.11 *Encyclopédie* eventailliste section

Fig. 2.12 Duvelleroy shop visit
Fan moulds
Paper
Paris, France (2018)

Fig. 2.13 Duvelleroy shop visit
Pleated fan fabric
Polyester
Paris, France (2018)

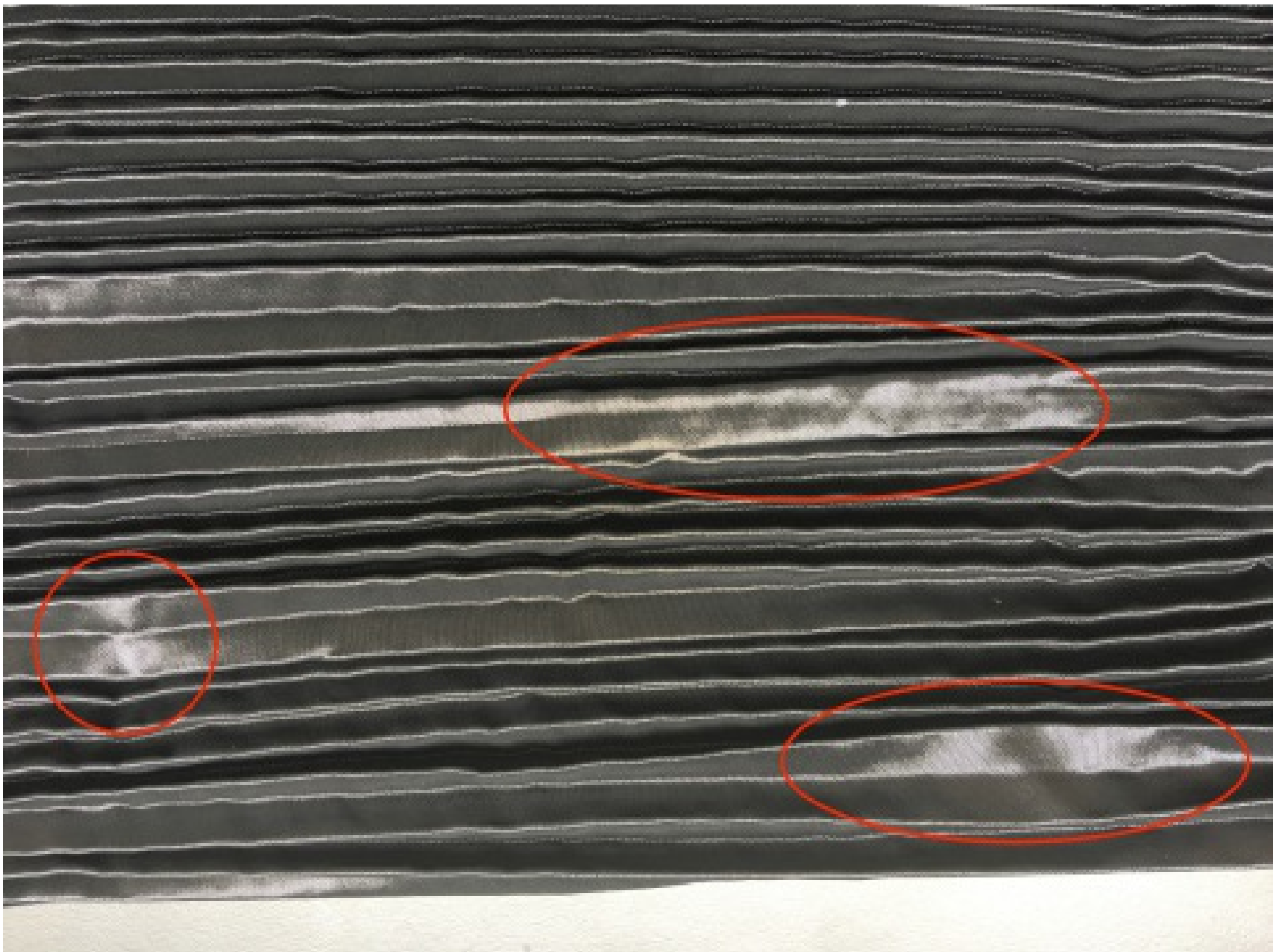
Redacted Image

Fig. 2.14 Fan pleating manual process
Image: diptyqueparis-memento.com
The original print hangs in the Duvelleroy shop

Fig. 2.15 Fortuny pleats experiment: Kraft paper mould. The moulds stay flat when expanded.
Fig. 2.16 Fortuny pleats experiment: Kraft paper mould. The moulds easily warp after contraction.

Fig. 2.17 Fortuny pleats experiment: Kraft paper mould. It usually takes 2 sticks to stablise the pleated moulds, but this time it requires 5 extra sticks to stablise the moulds.

Fig. 2.18 Fortuny pleats experiment: Kraft paper mould. Moulds are damaged after one pleating procedure.
Fig. 2.19 Fortuny pleats experiment: Kraft paper mould. Tiny pleats are easy to mispleat.



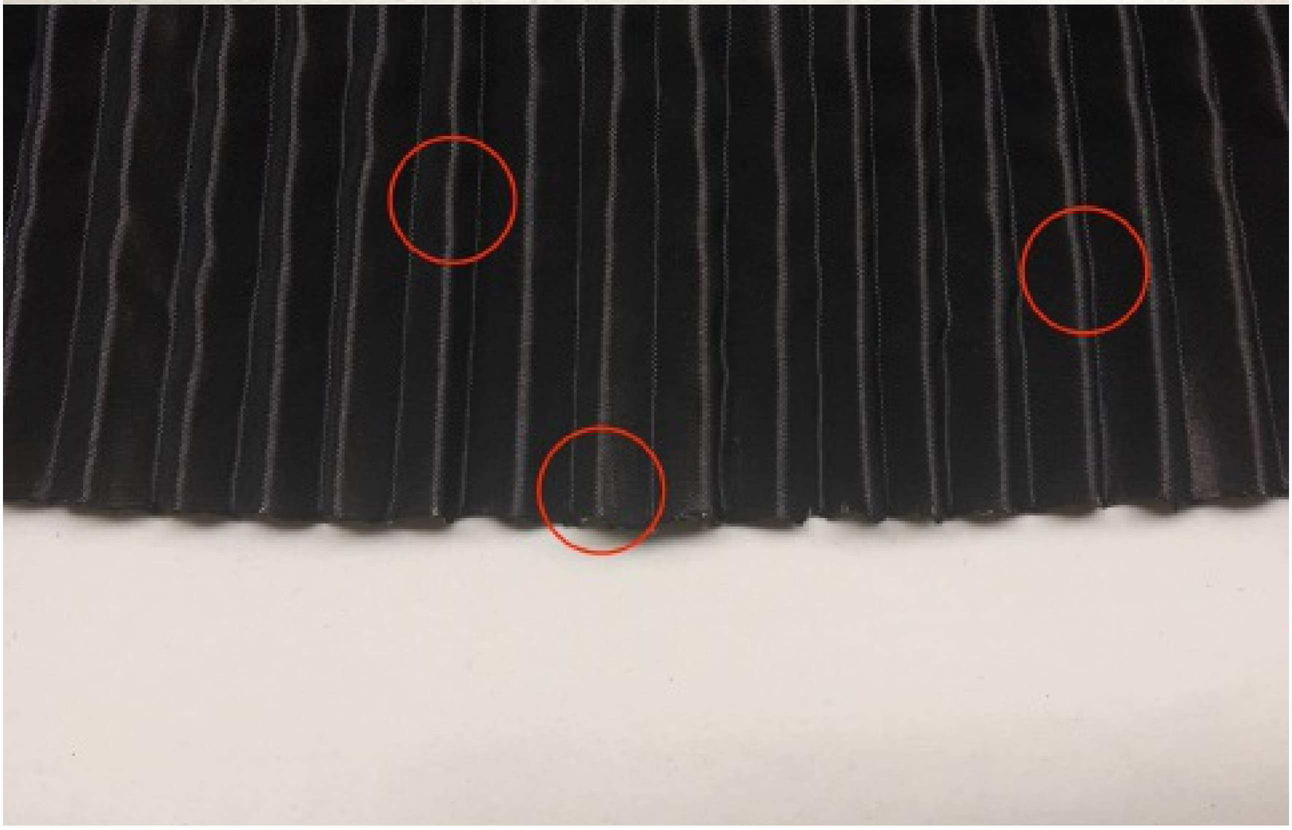


Fig. 2.20 Fortuny pleats experiment: Kraft paper mould. The crease lines vanish on the outcome due to mispleat and the difficulty to press the moulds.
Fig. 2.21 Fortuny pleats experiment: Kraft paper mould. The folds are not sharp.

Mary McFadden

In the 1970s', American couturier, Mary McFadden used the thermal plastic property of polyester to create what she and others have called a 'Fortunyesque' dress (Milbank, 1985, p.106). She began design experiments with silk in 1974 but soon realised pure silk would not hold pleats. In 1975 she then sourced a piece of polyester charmeuse, which she then had machine pleated. She named this fabric 'Marii' and created collections of women's gowns using it, alongside other fabrics and trimmings (McFadden, 2004, p.24). Marii is a polyester fabric used to create a new style of pleated dress, reminiscent of Fortuny's silk Delphos (see Fig. 2.22).

McFadden's work looks Fortunyesque, certainly at a distance, and the design follows Fortuny's aesthetics. Nevertheless, when viewed in detail, McFadden's pleats are closer to the irregular creases of the sample Gary Mitchell demonstrated at Ciment Pleating, than the straight continuous accordion pleats of Fortuny's original (see Fig. 2.23).

Shibori

Kathleen Kearney has yet another theory on how the pleats were made. Kearney endeavours to replicate the method Fortuny might have adopted, and suggests that he used a pole-wrapping technique[31]. She comes to this conclusion because the pleats on the dress show an irregularity[32] (Kearney, 1992, p.89), meaning a manual process was involved.

Pole-wrapping involves wrapping a piece of fabric around a pillar and then coiling string around the fabric at a desired width. The fabric and string are then pushed to the end of the pillar to form pleats. The pole, fabric, and string are then dry steamed. When the pole is removed the pleated fabric and string are in a coil. Kearney argues that it is at this moment that Fortuny used his patented machine (ibid., p.87) (see Fig. 2.1). She suggests that the ceramic tube steamer would straighten the fabric to prepare it for garment production.

I experimented with a pole-wrapping technique with workshop participants at the Xue Xue Institute in Taipei (see Fig. 2.24).

31. Her research showed that Fortuny was a Japanese culture enthusiast and he keenly studied traditional Japanese craft, especially fabric manipulation. In 1900, a pole-wrapped shibori product from Japan won a bronze medal at the Paris World Fair. Kearney suggests that Fortuny might have attended this event and have seen this skill, as he was a regular traveller to Paris.

32. The pleats on the Delphos dress are not 'machine perfect'. There are small variations in width.

Once the fabric was completely tied to the pole with a string, winding at 5mm intervals, participants began to push and squeeze the fabric to one end. They then painted the fabric. This class was advertised as a shibori workshop. The painted fabric is left to dry before opening and then traditionally ironed flat, as the focus is on the colour pattern not on the structure. However, I decided to add in a further step and steamed the pole with the fabric, in an attempt to thermally fix the pleats that had been created through the threading technique[33].

After 30 minutes steaming, the poles were left under the sun to dry completely (see Fig. 2.25). Participants then unwound the strings to release the pleated fabric. The result was very similar to Fortuny's pleating effect, certainly much more so than the crease-like pleats that Gary Mitchell had demonstrated (see Fig. 2.10).

My investigations indicate that Kearney's theory is the one that most closely results in Fortuny pleats. Following the example set by many historians and textile researchers, including Anne-Marie Deschodt, Doretta Davanzo Poli, Mary McFadden, Andrew Bolton, Gary Mitchell, Akiko Fukai and Gillion Carrara, I have sought to understand more about how Fortuny achieved his pleats (see Figs. 2.26, 2.27, 2.28, 2.29, 2.30). This exploration has shown me that there are other methods for the creation of pleats beyond the conventional stitching and kraft paper techniques. These additional methods include hand creasing with starch application, and shibori pole wrapping. Even though the kraft paper technique and shibori tying seem very different, as the former needs 2 moulds and the latter just requires a pole and a string, they both require pressure while steaming, and the force is transferred into shapes which are fixed via the heat.

All of these approaches produce the similar result of layering 2D fabric into 3D forms. If the aim of this research is to produce a new type of pleat, perhaps the focus should shift from method to effect. Pleats and pleating may not need to be defined by the method of their creation. As long as the result looks like pleats, then can it be called pleats, and can the process by which is was created be called pleating?

33. This is an example of how my knowledge of pleating techniques has added to other craft processes. Traditional shibori can work with painting the contracted fabric, cold dying, and hot dying depending on the how the dye is fixed. The hot water dying is analogous to pleating insomuch as they are both thermal processes. However, in shibori it is not usual for the structure of the contracted fabric to be fixed, as the contraction is simply part of the process required to create the colour pattern. I describe this further in the following chapter.

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Fig. 2.22 Mary McFadden
Pleated Gown (ca 1976)
Polyester, 140cm
Image: vintagevirtuosa

Fig. 2.23 Mary McFadden
Pleated Gown (ca 1976)
Polyester, detail
Image: vintagevirtuosa

Fig. 2.24 Fortuny pleats experiment: shibori workshop. Tying fabric on poles with string.
Fig. 2.25 Fortuny pleats experiment: shibori workshop. Drying fabric under the sun after steaming.

Fig. 2.26 Fortuny pleats experiment: shibori workshop. Unravelling the fabric.

Fig. 2.27 Museum at FIT archival viewing
Mariano Fortuny Delphos dress (ca1928)
Unravelling the dress
Pleated silk, glass beads
New York, USA (2015)

Fig. 2.28 Fortuny pleats experiment:
Gary Mitchell's attempts
Potters Bar, UK (2015)

Fig. 2.29 Fortuny pleats experiment
Kraft paper mould trial
London, UK(2017)

Fig. 2.30 Fortuny pleats experiment
Shibori trial worksop (2018)
Unravelling the fabric
Taipei, Taiwan(2018)

Issey Miyake Experiments

The preeminent, and most commercially successful of mass-produced machine pleats in the last quarter century, has been those of Issey Miyake (Kawamura, 2004, p.125). Miyake has taken what has been considered a 'cheap material' – polyester – and transformed it into high-end fashion garments through the application of heat and pressure (Smelik, 2014, p.45). Before examining something of Miyake's process, it is important to understand the cultural context from which his work emerged, and some of the textile processing companies that were working with pleating in Japan.

The Japanese have a useful notion for the consideration of pleats: 'keijijo-kioku', or 'memory of shape' (Baurley, 1997a, p.16). Creases in both kimono and shibori demonstrate the concept. Traditionally, kimono are folded in a box for storage; the folded lines are naturally embedded in the garment (see Fig. 2.31). Before the western concept of tailoring arrived in Japan, the Japanese were accustomed to the creases and folding lines on kimono and would not try to get rid of them. It is a western concept to use irons to eliminate creases and wrinkles on garments (Baurley, 1997b, p.35). Similarly, shibori is the technique to dye folded, tied, wrapped, or stitched fabric and, after the dyeing process, the blank white portion left by the folding, tying, wrapping or stitching, represents the impression of the tied shape. It can be said that the 'blank' is the trace of the memory of shape. The concept of keijijo-kioku identifies the crease as having cultural significance in Japan.

The crease in the Japanese garment has been revered and exploited. The crease left in the kimono by the 'accident' of storage, through the concept of keijijo-kioku, is elaborated into an art form, first through shibori and then through expanded pleating techniques.

<u>Machine pleating</u>

It is from this context that Miyake's work emerges. In 1988 Issey Miyake spotted a pleated scarf and was struck by the idea that this could lead to a new form of silhouette (Cawaii Factory[34], 2012, p.58; Koike, 2016, p.146). It was from this chance encounter that Miyake began to develop the range of

34. Cawaii Factory was jointly founded by Tamaki Harada and Mari Nakamura in 1999. All the articles they publish in the book *Pleats Please* are shown as authored by Cawaii Factory.

garments that would later become Pleats Please. He informed Makiko Minagawa[35] that he wanted to create whole folded and pleated garments, which were easy to look after and reasonably priced so as to be accessible to the public (Sato, 1999, p.24). Minagawa understood that in order to respond meaningfully to Miyake's instruction, she needed to expand her textile experiments to unconventional materials (Cawaii Factory, 2012, p.61).

Minagawa knew that polyester had the properties that meant it could be successfully thermally pleated, but as up until that point Miyake's design team had used mainly natural fibres, she needed to conduct further experiments to understand the fabric better (Miyake, 2012, p.60).

She began by sourcing conventional apparel textiles. Soon she encountered 3 problems. The first was thickness. After a garment was made, the layers of fabric became too thick to be sent through pleating machines (Kitamura, 2012, p.25). The second problem was the weight. Due to the contraction of pleats, the pre-pleated piece should be three or more times larger than the final product (see Figs. 2.32, 2.33). It would not be a problem to use general apparel textiles to pleat a scarf in terms of weight, but when it came to a whole garment with 3 times, or more, of the amount generally used, the dress became too heavy (Cawaii Factory, 2012, p.60). The last problem was cost. It was easy to comprehend that when the fabric was three or more times than was usually needed, the price of the product soared, corresponding to the amount of fabric used (ibid., p.59).

Minagawa knew she had to extend her research and experimented with apparel material used to line or interline garments. In the fashion industry at the time, people tended to categorise fabric according to its functions and it was considered inappropriate to use fabric without following its functionality. During the sample testing for a collaboration with William Forsythe, she encountered a warp knit fabric, Tricot, produced by Toray Co., Ltd. (ibid., p.65). She had found the fabric she was looking for. She had some test garments made and sent them to Polytex Industry Co., Ltd., for pleating.

My own research journey echoes some of these issues. When I hand pleated

35. Makiko Minagawa has been the chief textile designer in Miyake Design Studio since 1971 when Issey Miyake founded the label.

a whole garment the thickness[36] was not a problem. However, I also encountered the difficulty of total garment weight, and fabric cost[37]. For my trial, I used kraft paper to sandwich the fabric, controlling the pleating procedure myself, and enabling me to handle 2 or 3 layers at the same time. Whereas Minagawa worked with knitted fabric, I chose woven textiles, which hold the pleats better. My Cubic Pattern is very three-dimensional and I like to show the structure. To tackle the weight and price, I deliberately picked polyester organza or taffeta. These two types of fabric are very light, so even if I use 3 metres to make a shirt, it will not be too heavy, and will not pull the pleats flat. Polyester organza and taffeta are also low price.

Miyake studio has experimented with Polytex for a long time and exploited several pleating machines.

Automatic pleating machines appeared at the end of the 19th Century. The machines were manually operated at first, and later were powered by electricity (Karl Rabofsky GmbH, 1998, p.592). The basic structure was similar to hand roller fluters (Fig. 2.40) that predate the machines by two decades.

The first pleating machines were produced by Karl Rabofsky GmbH in 1896[38]. This company is still active today and produces automatic pleating machines (see Fig. 2.34). On site visits to Ciment Pleating, London, and Sinta, New Taipei City, staff at both of these two studios indicated that Karl Rabofsky machines have been considered the 'bench mark' for pleating machine quality. They were also expensive.

Paradoxically it was the high price of the German manufactured machines that created a competitive market in Taiwan.

Sinta is the only factory in Taiwan that provides both hand and machine pleating services (see Fig. 2.35). It is a family-run business, and the current manager Leo Liu is the second generation. He told me that in the 1970s, garment factories in Taiwan had high demand for production machines. At that time, Taiwan was a major manufacturer for the garment industry.

36. Machines conventionally only accept one layer of fabric at a time but it is possible to hand pleat several layers together. Eventually Polytex adjusted their machines so that they could machine pleat more than one layer of fabric simultaneously, allowing Miyake to pleat whole garments together.

37. I was commissioned to design the costumes for *Little Girl Inside Me*, an MA graduation production at CSM. The budget was extremely tight. I found myself trying to source best value fabrics in order to buy the quantities I needed to create the pleating effect I was after. For a further analysis of the creation of the costumes for this dance production, see *Chapter 6: Pleating Practice (ii): New Technology*.

38. Karl Rabofsky GmbH is a German company founded in 1896 by Karl Rabofsky. The company was dedicated to manufacture of manually operated pleating machines for the fashion and textile industry at first, and later expanded its business to produce pleating machines specifically to pleat material for air and water filtration.

Despite dealing in bulk quantities, these factories did not have the budget to import expensive German pleating machines. Hsin Tai Cloth Folding Co. Ltd., purchased one machine from Germany, took it apart to study the structure and created their own version to supply the industry. Taiwan then began to export these machines internationally.

Even though pleating machines offer efficient ways to produce large quantities of pleats in a short period of time, it was not until 1941 when the synthetic fibre, polyester, was invented, that people could enjoy permanent pleats, thanks to the thermal plastic property of the new fabric (Bolton, 2016, p.93). Polyester completely changed the durability of pleats. Pleats formed with polyester do not need to be repleated after use or washing. They tolerate humidity well. This drastically decreases the cost of producing pleats, making them more accessible to the general public.

Inoue Pleats Co. Ltd., founded in 1936, was the first company in Japan to produce pleats on a commercial scale. Inoue Pleats focuses on thermal moulding methods to alter the fabric form. They provide both machine pleating and hand pleating services[39]. Their hand pleating techniques include the shape forming properties of shibori (see Fig. 2.36).

39. Over the years, Inoue Pleats has become the largest pleated fabric provider in Japan. It created fabric for Issey Miyake until their collaboration was suspended when Miyake Design Studio required sole use of Inoue pleated fabrics, to which the company did not agree (Baurley, 1997a, p.44).

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Fig. 2.31 Folded kimono (ca 1900-1949) Exhibition: *Japanese Folds* (2015) Image: Museum of Applied Arts & Science

Redacted Image

Redacted Image

Fig. 2.32 A garment is sent to pleat. Image: miyakeissey.org, MIYAKE ISSEY EXHIBITION: The Work of Miyake Issey
Fig. 2.33 Size difference before and after pleating. Image: francetvinfo.fr, Japonismes. Objets inspirés Exhibition.

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Fig. 2.34 Automatic pleating machine: PLEATWORKER by Karl Rabofsky. Image: Karl Rabofsky GmbH

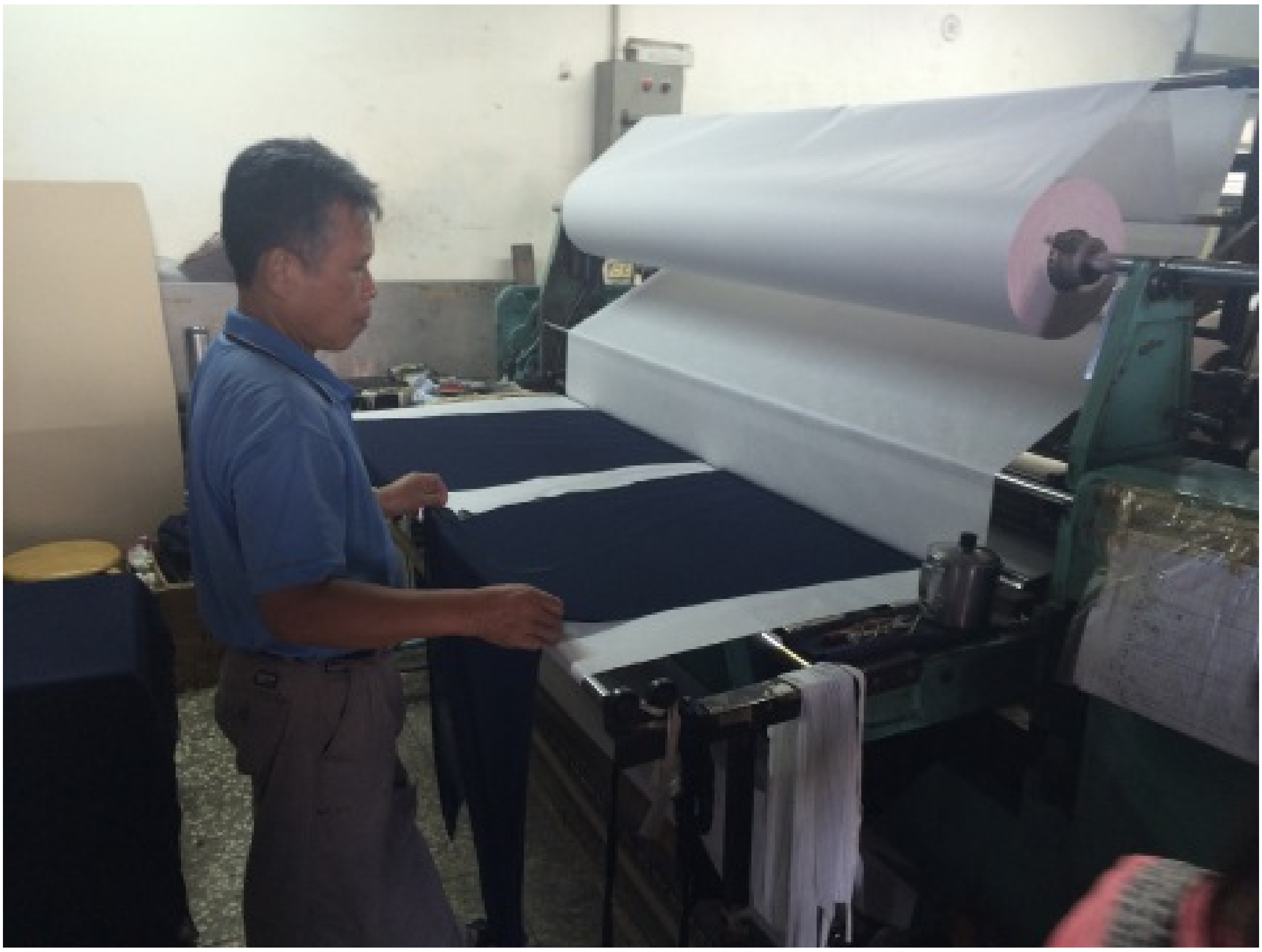

Fig. 2.35 Automatic pleating machine in Sinta, Taipei, Taiwan.

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Fig. 2.36 Inoue Pleats Co. Ltd.
Crystal Σ (1997)
polyester, 149.9cm
Image: The Museum of Modern Art

Heat Press pleating

In the documentary film *Issey Miyake Moves* (1993), Miyake Design Studio demonstrate the use of various machines to create the garments for Pleats Please. One of the machines is heat press. Studio technicians can be seen randomly folding, twisting and tying fabric, generating interesting pleating patterns. These manipulated textiles are then sent to the steamer or heat press to imprint the shape (see Fig. 2.37). The process in these experiments is between hand and machine. Unlike the early hand tools in which the pleat is formed through a hand operated machine, here the pleat itself is created by hand but fixed by the machine.

In my own experiments with students, as the facilitator of textile workshops, I have asked participants to develop 3 dimensional structured pleats. In one such instance at the Xue Xue Institute, Taiwan in 2016, a participant created a flat structure that was too large for the steamer. I was stuck in thinking how to fix the form. Recalling Miyake's method I experimented with a heat press machine that was originally used for colour sublimation.

The result was unexpectedly good. The heat press has a higher temperature than the steamer[40] and so the edges are sharper than steamed ones (see Fig. 2.38). The drawback is that heat press machines generate unwanted creases in the fabric. They clamp the mould and the fabric so tight and flat that there is no room for excess fabric to stay neutral.

Using heat press to change the form of fabric has a history in the labour-saving devices used in domestic chores in the mid-19th Century. At that time semi-automated tools and irons were introduced to the market.

In the Victorian Era (1837-1901), women's fashion was extravagant, bustle style, with a large amount of pleated trimming and hem. The trimming could be detached for laundry, then re-pleated and sewn back (see Figs. 2.41, 2.42).

In her history of domestic labour-saving devices, Autumn Stanley states that the invention of pleating machines was the most significant in terms of the

40. Steam is created and evaporates at 100 degrees Celsius, so achieving higher temperatures is a challenge. Professional steamers have a pressure mechanism to raise the temperature, but generally these are still limited to temperatures of 104 degrees Celsius.

time saving they afforded to manual workers (Stanley, 1995, p.311)[41]. These pleating machines began from a simple hand-rocker style, which only allowed a short length of trimming to be pleated at one time (Fig. 2.39). This design was revised to a more sophisticated roller style in which the pleated fabric could be as long as necessary. These roller machines can be seen as a prototype of modern industrial pleaters (Fig. 2.40).

I demonstrated the 'Geneva Hand Fluter' branded hand-rocker tool during a workshop at ACG, Guangzhou. Both the plate and the handle were heated up in a small oven for 20 minutes (see Fig. 2.43). Placing damp natural fibre fabric on top of the plate, the handle was then slowly rocked on top of the fabric (see Fig. 2.44). The water evaporates and the pleats are thermally formed (see Fig. 2.45).

These 19th Century hand tools, created for domestic use, are inspiring, insomuch as they offer the possibility for pleating effects without the necessity of large-scale industrial machinery. What sorts of production methods are available to me? What sorts of adjustments can be made to these processes to find new forms of pleat?

<u>Steam Stretch Technology and 4-way stretch</u>

Current pleating machines in the industry are designed to create 2-way stretch pleats (see Fig. 2.46). Due to the linear direction of fabric, the machines are designed with rollers that take in the material at one end, fold it, fix it with heat, and export it to the other side (see Fig. 2.47).

Sunray pleats (which are currently still formed by hand in the UK and France) are pleated by new machine manufacturers in Taiwan and China, using the same principle (see Fig. 2.48). Even though sunray pleats curve out of the machine (the width at the top of the pleat is narrower than at the bottom, creating the sunray effect) they are still formed on a linear trajectory.

Before Miyake Design Studio released Steam Stretch in 2012, if textiles required 4-way elasticity, factories would send the fabric into the pleating machine a second time at a 90° angle to obtain 4-way contractions. A good example is the Petit Pli, a baby grow that grows up with babies.

41. These machines were often, and unusually for the time, invented by women. From 1859 to 1883, at least 12 women acquired U.S. patents for these devices.

By sending the fabric into pleating machines twice (first along the fabric grain and a second time against the fabric grain), Petit Pli baby clothes create a 4-way expansion to fit children's growth in both vertical and horizontal directions (see Fig. 2.49). However, this technique is only possible for flat and simple patterns. Complex origami patterns, like the Water Bomb or other tessellation patterns (see Figs. 1.5, 1.8, 1.11) could only be hand pleated due to the linear character of the fabric and the machine working principals[42] but now can be achieved by steam stretch technology.

In March 2012, Miyake Design Studio Creative Director, Yoshiyuki Miyamae, presented steam stretch technology in a catwalk show (see Fig. 2.50). This new technology weaves steam-stretch yarns into fabric according to pleated patterns, so that the fabric shrinks when it encounters steam.

Miyame's technical solution incorporates elements of both structural pleats (which I have previously defined as being created through tension on the yarn) (see *Chapter 1: Introduction*, note 8) and thermal pleats (the pleating structure is reconfigured by steam). This is a breakthrough in the use of machines to create 4-way pattern pleats.

The steam stretch garments have floating yarns on the crease lines. It is these crease lines that the floating yarns pull together, transforming the fabric from 2D surface to 3D form (see Fig. 2.51). This process makes obvious what is in fact always the case in a pleating structure: that crease lines are the critical point of transformation. The planes in the pleated structure remain identical before and after pleating. The process of pleating is to answer the question: how should this crease line be reconfigured? Whether it is simply folded and stitched, thermally processed, or structurally weaved, all techniques necessitate the folding of lines to form the pleats.

There is some 'cultural circularity' in this examination of Fortuny's and Miyake's pleats. Fortuny, an iconic pleating designer in the West, is inspired by a Japanese handicraft skill – shibori – to create a classical Greek 'ideal'. Miyake redevelops western production procedures and pleating mechanisms to create new machine technologies for pleating production. There is a relationship here between the East and the West, a relationship I also feel that

42. This conclusion comes from my experiments and the conversation with Sinta manager, Leo Liu, on 4th August, 2016.

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Fig. 2.37 Heat press experiment. Video still: Issey Miyake Move (1992) Video by Sestuko Miura (53’30”)



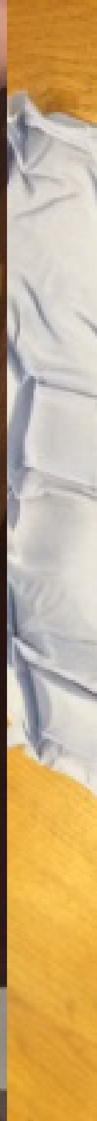


Fig. 2.38 Miyake pleats experiment: pleating workshop. Heat press moulds with fabric

Fig. 2.39 Hand pleating machine: rocker model. Geneva Hand Fluter (1868) cast iron, 9cmx15cmx 14cm
Fig. 2.40 Hand pleating machine: roller model. H Sommer fluter (1877) cast iron, 18cmx32cmx 23cm

Fig. 2.41 Geneva Hand Fluter Trade card (ca 1867), 9.5cm×6.5cm
Fig. 2.42 American Machine Trade card (ca 1877), 9.5cm× 6.5cm

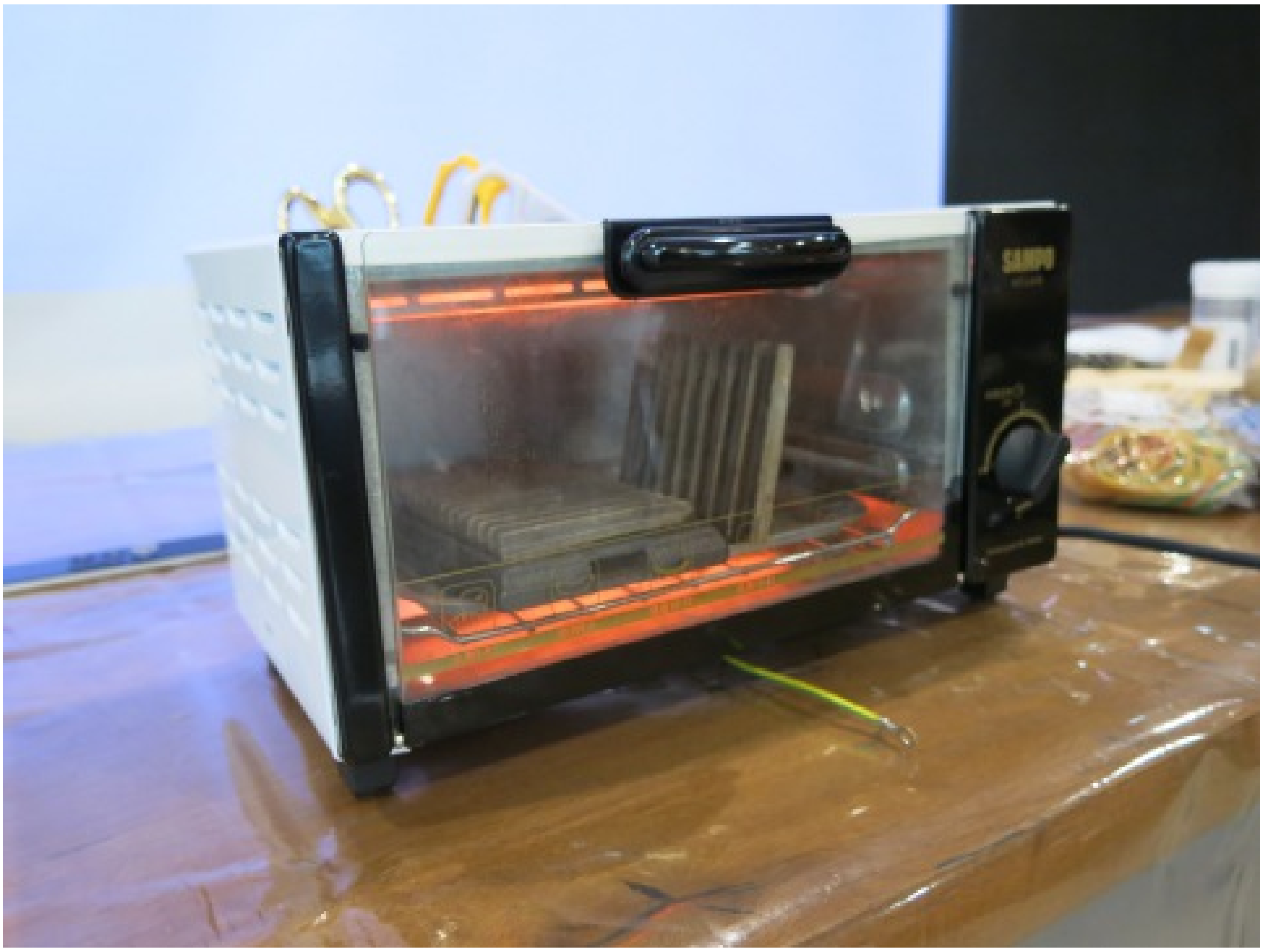

Fig. 2.43 Geneva Hand Fluter demonstration: heating up by a domestic oven.

Fig. 2.44 Geneva Hand Fluter demonstration: fluting a piece of silk

Fig. 2.45 Geneva Hand Fluter demonstration: pleating effect

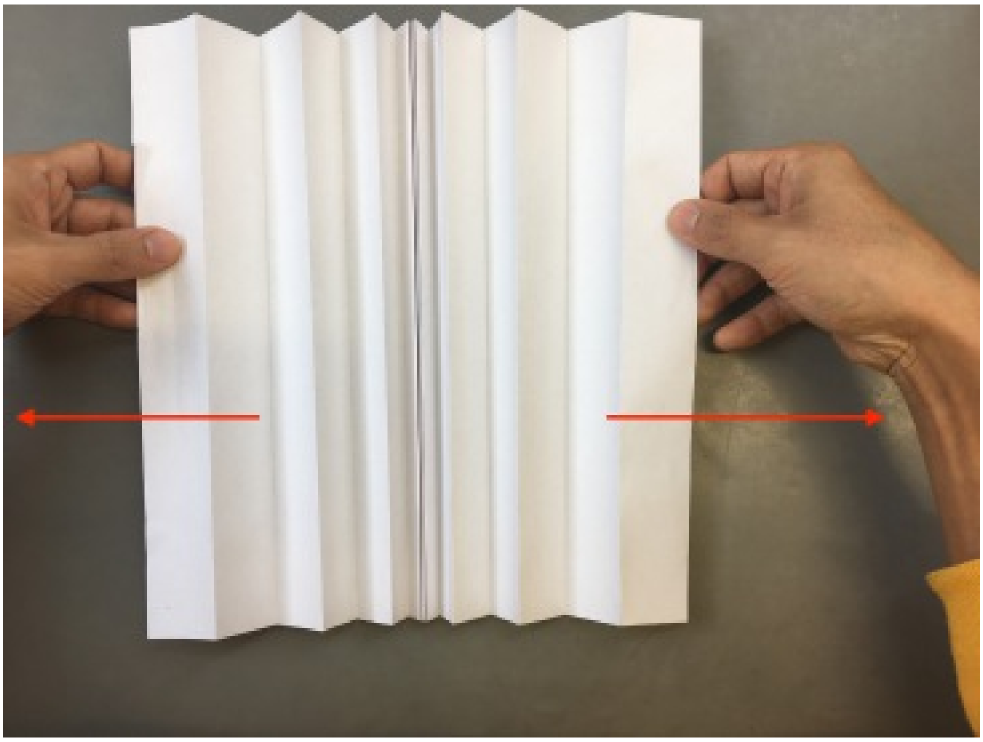

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Fig. 2.46 2-way stretch
Fig. 2.47 Pleating machine working diagram. The upper blades fold fabric while lower blades send fabric into a heated cylinder. Image: *Pleating: Fundamentals for Fashion Design*

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Fig. 2.48 Sunray pleating in progress. Video still: Sun-ray pleating machine (2017), video by Hsinher Pleating Machine Co., Ltd. (00’51”) Annotation: Tsai-Chun Huang

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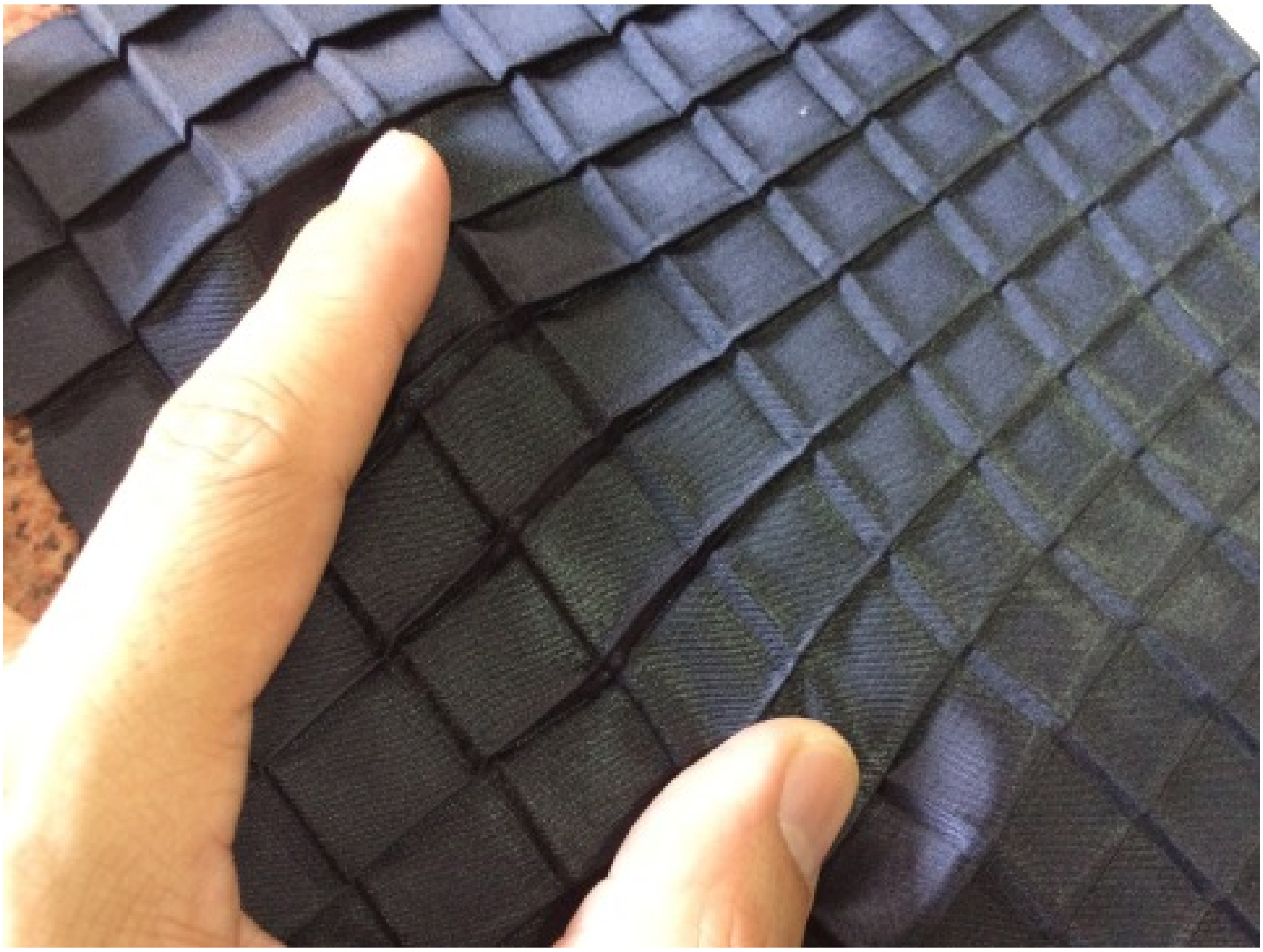

Fig. 2.49 Petit Pli baby grow designed by Ryan Mario Yasin. Double pleating for 4-direction stretch. Video still: Petit Pli– Clothes that grow with your child. (2018), video by Ryan Mario Yasin (01’18”) Annotation: Tsai-Chun Huang

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Fig. 2.50 Steam stretch catwalk show. Video still: Issey Miyake Autumn Winter 2012 (2012), video by Issey Miyake USA (11’03”)

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Fig. 2.51 The floating steam stretch yarns. Video still: Steam Stretch (2014), video by Issey Miyake (02'30") Annotation: Tsai-Chun Huang

03

WHAT IS A PLEAT?
WHAT IS IN A PLEAT?
WHAT DO PLEATS DO?

Making
Workshopping
Learning

I am somehow embodying as a researcher who has come from Taiwan to London.
Through the process of replicating the pleating practices of Mario Fortuny and Issey Miyake, facilitating 'discovery' workshops, reading historical and interpretive analyses, and producing pleats for my own collections, I have come to understand that my research methods are learning, workshopping and making. As a maker, I understand the pleats through the process of producing them, in addition to visual observation and theoretical research[43] (Bolt, 2007, p.27). Hands-on practices provide me with bodily understanding and physical insights that can help to answer my research questions.

Learning as a studio technician in Ciment Pleating helps me to answer the question, 'What do pleats do?'. Workshopping with participants develops conversations that can help to answer the question, 'What is in a pleat?'. Making the *Cubic Pleating* collection helps me to answer the question, 'What is a pleat?'. These methods, detailed in this chapter, are followed by my reflections and begin to build my own research methodology.

Learning (to pleat): What do pleats do?

Ciment Pleating is the foremost pleating workshop in London. In February 2015 I visited as a client, to have a technician's help in pleating a piece of polyester fabric using a Cubic Pattern kraft paper mould that I had made (see Fig. 3.1). Even though I later successfully reproduced pleats in my own studio space with the steam from industrial irons based on my visit, my skill to sandwich the fabric and knowledge of material were limited to pleat the pattern that I had brought with me.

Therefore, I decided to work as a studio technician at Ciment Pleating to increase my knowledge[44]. It was an intensive experience, which broadened my understanding of pleating and made me rethink what pleats do. Although, I was not in charge of complex patterns, observing other technicians in Ciment Pleating, I came to understand that different pleating patterns demand different methods of processing. Tips included, for example, the method to keep chiffon flat between moulds[45], and the way to align fabric with the paper pattern to create a perfectly matched edge[46].

43. Barbara Bolt describes how David Hockney's understanding of the technical expertise demonstrated in an exhibition of self-portraits by Jean-Auguste-Dominique Ingres (National Gallery, London, 1999) is determined by Hockney's own experience as a painter and the bodily knowledge that he has accumulated over time. Bolt believes this kind of understanding cannot emerge from theorists.

44. I worked as a studio technician in Ciment Pleating on a part-time basis from March 2016 to June 2016.

45. You blow with your mouth to get rid of any trapped bubbles or lumps in the fabric ahead of contracting the fabric in the moulds.

46. You have to anticipate where the crease lines will end up on finished fabric and place the fabric in the mould accordingly.

During my time as a studio technician, I learnt both hand pleating and machine pleating methods. Machine pleating is not a difficult task. The fabric is sent in and fixed by the heat roller (see Fig. 3.2). Hand pleating is very different from machine pleating. Before the pleating procedure, the studio needs to produce paper moulds, which can be reused for repeated processing if they are well kept. Producing paper moulds is very time consuming and each mould will only produce one type of pleat in a certain size. That is to say, different sizes of each pleat pattern require separate moulds (see Fig. 3.3). This is why hand pleating studios store thousands of paper moulds.

As a studio technician, the first task I was given was to produce large accordion pleats for curtains used in coaches (see Fig. 3.4). Through a repeated working pattern from Monday to Friday (a pattern which resonates to the form of the accordion pleats themselves!) the pleating actions are slowly embodied. The gestures become a reflexive action. When contracting sandwiched fabric in the paper moulds, I was told to fold the moulds towards my body (see Fig. 3.5). Gradually, the slats and the weights on the paper moulds are pushed away from me and the moulds are contracted. This working order has been passed down from Ciment Pleating technicians as their bodily knowledge. The action of pulling the contracted pleated pattern towards my body secures one end of the paper mould by my side, stabilising the fabric sandwiched in between.

The repetitive gestures in the process of pleating are necessary to achieve equality and balance across the pleated fabric. At the same time these gestures establish a kind of ceremonial ritual for pleaters. This phenomenon echoes Yuki Nishimura's observation of the similarity of the Chinese characters for 'fold' and 'pray' (see *Chapter 4: Field Mapping*, p.124). Through the repetition of the pleating gestures, I experienced folding as praying.

Steaming is the most important stage during the hand pleating process. The contracted paper moulds, with the fabric in between, are tied with strings or belts and then sent to the steamer for 30 minutes (see Fig. 3.6). The steam permeates the moulds to reach the fabric and melts the yarn at the fold lines.

Synthetic textiles, especially polyester, give the sharpest lines, as they are petroleum material and respond to the heat of the steam. After the steaming, the moulds are cooled completely before being opened. This is essential because the yarns harden as the temperature drops. The pleating process can be viewed as a reconfiguration of the yarn.

When pleating the curtains for the coaches, I found that there were occasions when the edges did not perfectly align, or there were 'mispleats'. The Ciment Pleating technicians taught me to use an industrial iron to erase the incorrect creases and reform them in the right positions. Steam is, by its nature, 100° C, so using a higher temperature iron, it is possible to reconfigure the yarn, to step backwards as it were, and to start the process anew.

Understanding this process changed my perception of pleating that this technique is simply a form of thermal modification: a thermal moulding process. I came to the conclusion that if I have good control of this concept, I can substitute the technique with other procedures and mechanisms to produce pleats. It is not necessary to adhere to the kraft paper moulding technique, professional steamers, and cast-iron weights. The key principle is one of thermal modification. The elements to achieve this are variable and can shift according to need. I can produce pleats in my own way.

For example, a client brought a piece of polyester mesh into Ciment Pleating. The fabric was tied with a lot of glass marbles (see Fig. 3.7). They asked us to put these materials into the steamer. This was the only piece I encountered that did not use kraft paper moulds to reconfigure the textile during my time as a studio technician. This work raises another question. If the fabric does not overlap on itself, can it be called a pleat? This helped me to clarify the difference between pleating and moulding. Pleating has to include over-layering planes, while moulding transfers one form to another.

<u>Pleats change fabric texture</u>

Machine pleating only offers 2-way stretch patterns such as accordion pleats or flat pleats, which limits the pleated effect. Machines used to create sunray pleats follow a quarter circle working path, but still in a linear direction.

Apart from the sunray pleating mechanism, pleating machines create pleats in straight lines on the fabric at 90° to the grain. Even if a section of fabric to be pleated is comprised of 2 or more pieces, potentially of different styles, the process will remain consistent and the joining seam will not drastically modify the visual effect of the pleats. However, if technicians feed a piece of fabric into the pleating machine on the diagonal angle of 45° against the grain, the hang of the subsequent garment will show more movement, in a wave shape (see Fig. 3.8). When a piece of fabric is pleated at 45° against the grain, the pleats break the resistance of the grain, creating more elasticity to the fabric (in the same way that Madeleine Vionnet's bias cut technique allows garments to stretch and therefore be more fitted to the body). Laying a pleat on the diagonal is applied to products such as scarves, which require high flexibility to achieve a better wrapping result (see Fig. 3.9).

Although pleating machines transform the 2-dimensional plane of the fabric into a 3-dimensional structure, the resulting pleats have a shallow depth when lying flat in the contracted form. This is because machine pleating uses a heated clamping mechanism to set the pattern. Machine pleats expand the surface potential of the fabric, rather than building a visually 3-dimensional form (see Fig. 6.37).

<u>Hand pleating allows for a greater variety of pattern.</u>
Hand pleating offers freedom to pleat a greater variety of patterns. Ciment Pleating stores approximately 3,000 patterns (see Fig. 3.10). These designs allow me to further interrogate how folding structures are formed, and how the pleats affect the textiles to which they are applied. Most of the paper patterns are 4-way stretch, which cannot be accomplished by machine pleating.

Paper mould patterns carry the properties of tessellation origami, often presenting complex designs. When adopting paper moulds to pleat, it is essential to pay attention to the alignment of the mould with the fabric grain. If the grain follows the pattern's direction, the valley and mountain folds will sit along that grain and the pleated fabric is more likely to be long lasting, retain its pleated form and possess sleek edges[47]. If the pattern sits off the direction of the grain, the fabric will maintain a higher resistance to the steam and risks losing the pleated effect, making it difficult to maintain the form (see Fig. 3.11).

Materials react differently to being pleated.
For plain fabrics and those with regular visual patterns (which form the majority in the market) the pleating process adds to the visual effect. However, pleating patterns are mainly formed of the repetition of a single unit that is tessellated across space. Therefore, when the folding pattern and the printing pattern meet, two regular repeats collide, one is visual, the other is structural. The collision is also a regular pattern (see Fig. 3.12).

Designers have taken advantage of the expanding and contracting properties of pleats to form different visual effects. For example, colouring the portion of the pleat which is hidden when the pleats are contracted, allows for a flash of colour when the pattern expands (see Fig. 3.13).

My own experiments with colour in relation to the Cubic Pattern demonstrate that the application of colour can create an optical shift in the perception of the form of the pleats, as 3-dimensional forms. (See Appendix 1-1 *Cubicolour*) The optical understanding of space, width and depth perception, play differently on the eye depending on where the colour is applied.

Another example is the use of reflective fabric which plays with light, casting it back in different directions. The pleats multiply and complicate the reflections made possible in reflective fabric, fragmenting the surface to reflect the light (see Fig. 3.14).

47. In a 4-way stretch pattern, even when the pattern sits on the direction of the grain, some folds will sit at 90 degrees to the grain, and others on the diagonal. However, the 'sharpening effect' of having the main folds along the line of the grain has a cohesive result across the whole piece of pleated fabric.

Fig. 3.1 Ciment Pleating 1st visit
Cubic pattern kraft paper mould enquiry
Potters Bar, UK (2015)

Fig. 3.2 Ciment Pleating 2nd visit
Machine pleats
Potters Bar, UK (2015)

Fig. 3.3 These are accordion pleat moulds at Ciment pleating. Different sizes of the same pattern require separate moulds.

Fig. 3.4 The 2-inch accordion pleat curtains I made, in a box ready for shipping.

Fig. 3.5 My first task in Ciment pleating was to pleat 2-inch accordion pleats as curtains for coaches.

Fig. 3.6 Ciment Pleating 2nd visit
Professional steamer
Potters Bar, UK (2015)

Fig. 3.7 Moulding with glass marbles at Ciment Pleating

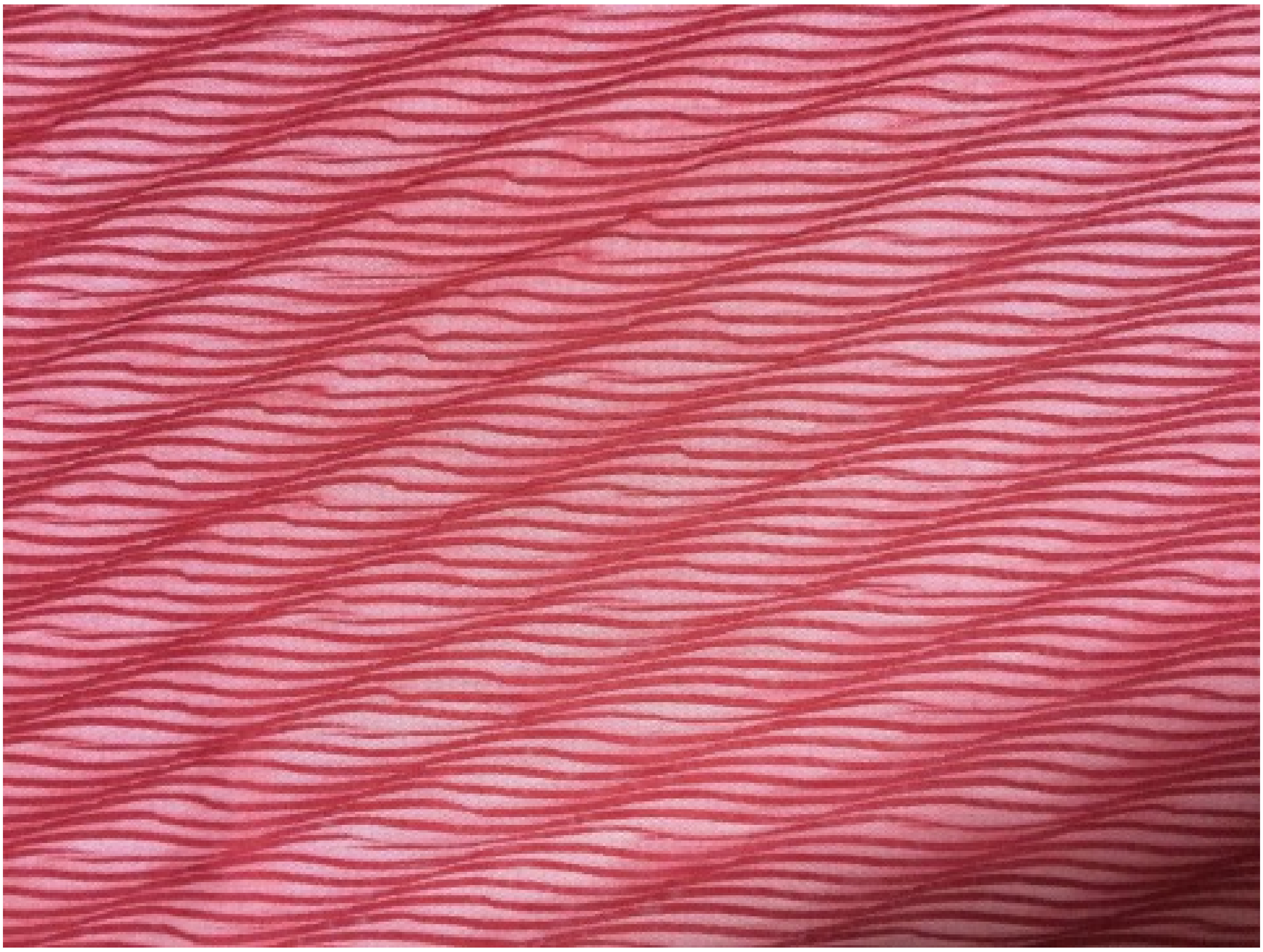

Fig. 3.8 Fabric is offset 30 degree when sent into the pleating machine for an oblique effect.

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Fig. 3.9 Pleating against grain direction for a higher elasticity. Image: Happyface313.com

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Fig. 3.10 Each cylinder is one set of moulds. Image: Ciment Pleating

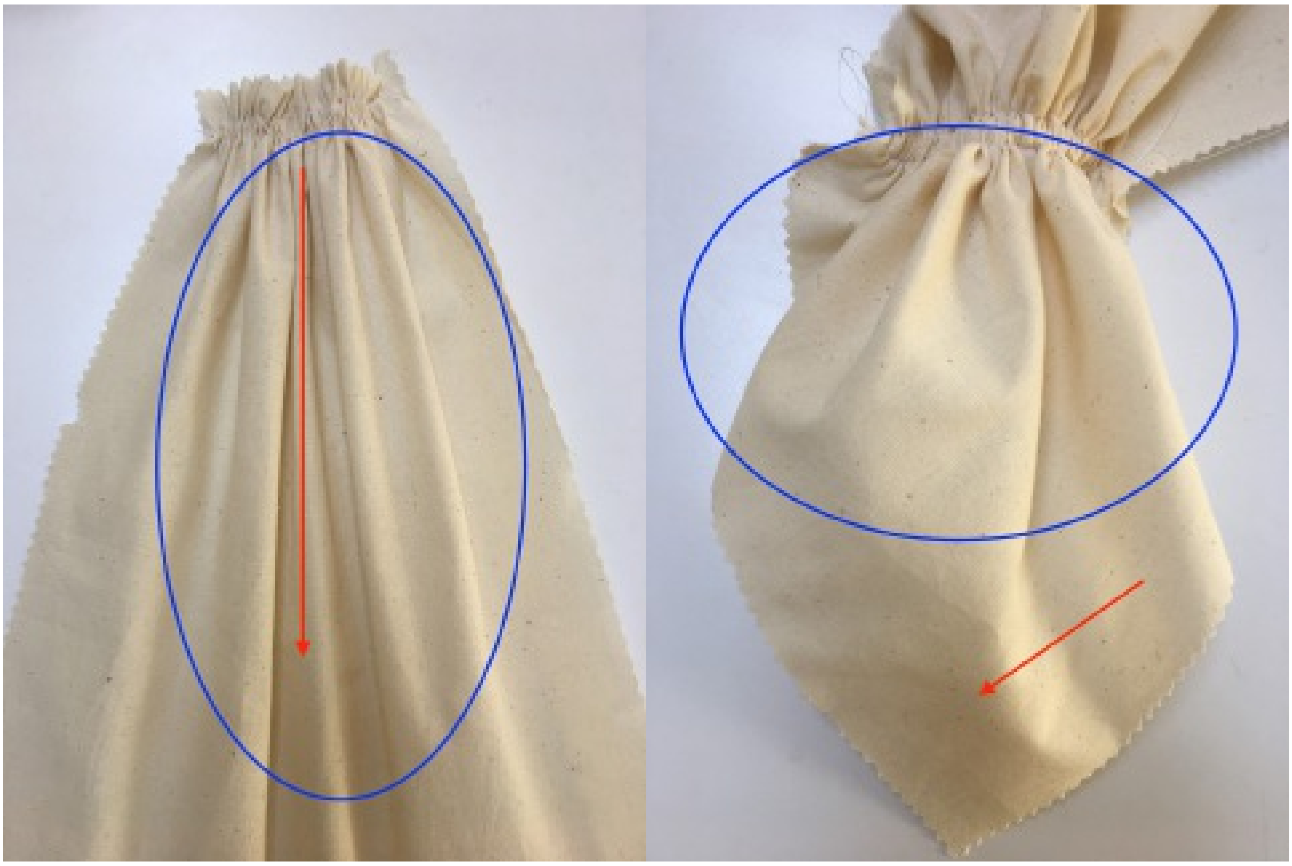

Fig. 3.11 Pleating against fabric grain creates rounder edge

Fig. 3.12 Anonymous clients
Pleated sample (2016)
Reflective polyester, size varies

Fig. 3.13 Mary Katrantzou
2017 Autumn/Winter sample (2016)
cotton, polyester, 120cm×70cm

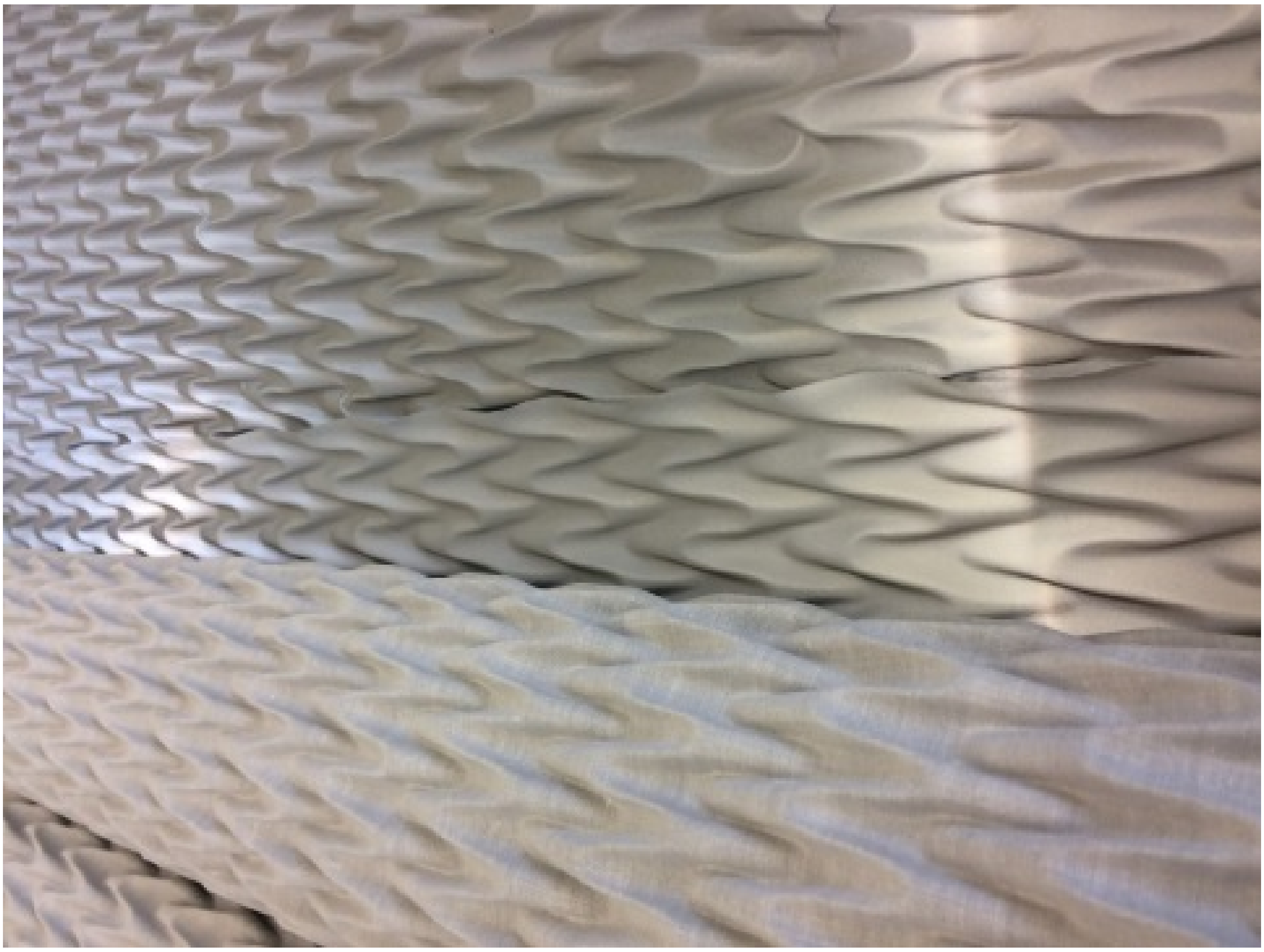

Fig. 3.14 Victoria Beckham
2017 Autumn/Winter sample (2016)
Reflective polyester, 20cm×70cm

Workshopping (with participants): What is in a pleat?

In my role as facilitator of a number of pleating workshops, I have conversed and learnt together with participants. This discourse has been an inspiration to create new pleating methods and new ways of thinking about what pleats can come to represent. The discourse is embedded in the pleats.

Since October 2015, I have held a number of pleating workshops: 1 in The Czech Republic, 4 in the US, 4 in the UK, 14 in Taiwan, and 14 in China[48]. Positive responses and recommendations led to further invitations to facilitate sessions. Workshopping has become an essential part of my investigation into pleating methods. Collective research through experiments with workshop participants has encouraged me to focus on what is possible without industrial machinery, with limited time, and undeveloped skill sets. It has also allowed me to test out approaches and explore methods. It is this opportunity that has encouraged me to invent my own portable steamer to conduct workshops in different countries (see Fig. 3.15).

Workshops generally follow the format: brief introduction to the history of pleating, focus on key designers, folding exercise to create sample paper mould, creation of pleating sample, garment fabrication, pleating of garment using my paper moulds. Without needing to visit a dedicated pleating studio, workshop participants get a sense of the whole pleating process from beginning to end.

Across the workshops participants had a wide range of design experiences and capabilities, from complete beginners to members of faculty. When it came to pleating techniques, participants were more or less uniformly 'new learners'. The advantage of this was that they were unencumbered by the conventional 'rules' of pleating and could offer new perspectives for the creation and use of pleated fabrics. For example, a participant of the workshop at Prague Quadrennial 2019 disregarded my instructions for the size of fabric to be pleated and as a result ended up with a partially pleated section, where the pleating design emerged from the flat plane of the fabric. She also chose to cut and sew sections of pleated material together, forming a 3D structure (see Fig. 3.16).

48. In The Czech Republic, the workshop took place during Prague Quadrennial. In the US, these workshops took pace at Design for Stage and Film at Tisch School of Arts NYU, Fashion Design at Parsons School of Design, and for members of faculty at Fashion Institute of Technology. In the UK workshops took place at 'Across RCA' and 'Work in Progress Show', Royal College of Art, and also at 'Shaping Your Area' in Roman Road Yard Market organised by St Margaret's House. In Taiwan workshops took place at Xue Xue Institute, Shih-Chien University, 'In Circle', Songshan Cultural Creative Park, Municipal Hongrenguomin Junior High School. In China, ACG Chongqing, ACG Changdu, ACG Guangzhou, ACG Shenzhen, ACG Shanghai, ACG Zhengzhou, ACG Dalian, ACG Hangzhou, Southwest University, Shanghai Design College of China Academy of Fine Arts, Sichuan Normal University, International School of Nanshan Shenzhen, Sanda University, China Construction Bank Dalian Branch, Zhengzhou No.1 High School.

The workshops usually ended with a group critique while participants were wearing their own design. Together we explored the differences between each garment, in relation to some of the examples we had discussed at the beginning of the workshop, for example, Miyake's Pleats Please (see Fig. 3.17).

For the workshops in Taiwan, we also visited Sinta. Participants therefore not only learnt hand-pleating methods but also acquired a basic understanding of machine pleats. During the tour from Leo Liu CEO, participants asked questions. These questions opened lines of research that were new and useful.

The participant question: 'How is it that a single machine can produce different types of pleats?' allowed me to better understand the possibilities and restrictions of machine pleating. Leo Liu demonstrated the machine mechanism that can vary the rigidity of the contraction. By altering the amount of clamps and the force they apply, the system can create tight and loose pleating patterns on the same section of fabric. It was here that I understood how the classic Issey Miyake Homme Plissé trousers (that I was wearing that day) were made.

The participant question: 'What is the history of the pleating industry in Taiwan?' gave rise to an answer which allowed me to understand how Western technologies were redeveloped in Asia as part of the manufacturing boom of the late 20th Century. (This has already been described. See *Chapter 2: Pleating Practice (i) Experiments*, p.59)

<u>Thoughts exchange in pleats</u>

Preparing to present in front of a group of people encouraged me to reorganise my thoughts. This is how my classification of pleats – stitched, thermal, structural, and digital[49] – emerged. Participants responded to these categories as a way to differentiate and understand a variety of pleating methods. The process of preparing for the workshops was also a practical opportunity for me to combine historical, theoretical, and practical approaches, and I could see where these areas interacted and overlapped. In one sense this is obvious – preparing a workshop has the effect of demanding that a facilitator

49. These categories are introduced in *Chapter 1: Introduction*.

condenses their knowledge in a clear and deliverable way – on the other, the process of making the workshops had the effect of situating the research in an informal 'laboratory' where ideas were presented, challenged and tested.

During a workshop at Xue Xue Institute, Taiwan, a participant asked me to explain the difference between mokume shibori (see Fig. 3.18), a technique which threads the fabric with a needle to create the tying design, and smocking, when I was demonstrating with a 16 row Read Pleaters smocking machine (see Fig. 3.19). Both techniques require threading to contract fabric[50]. This question encouraged me to examine the similarities and contrasts between shibori and pleating, and I realised that shibori is actually a kind of natural fibre pleating which is nevertheless ironed flat after dying, as the focus is on the colour pattern rather than the structure created during its processing. Shibori can be understood as a kind of pleating which replaces steam with a hot dye solution (a different thermal moulding process). At a later workshop I explored shibori as a type of fabric pleating method with participants[51].

At a workshop for Design for Stage and Film at Tisch School of Arts NYU I was exploring different types of machine pleating technologies with participants. I demonstrated a Geneva hand-rocker pleater in the class and showed Fortuny's patent diagrams to open up a discussion. A MFA student asked me if I had thought about producing my own pleating machine. This question gave rise to my investigation into the mechanism of pleating machines. I began to consider what the next innovation for pleating machines could be and wondered if it would be possible to create a 4-way stretch pleating machine, which would reduce hand-labour[52]. More than that, it focused my analysis of the essential qualities of pleats.

50. As will be discussed in *Chapter 4: Field Mapping*, Caroline Bartlett's *Full Circle* is another example of 'stitched pleats'.

51. This 'discovery' became part of my research into understanding Fortuny's pleating technique and was described (with sample image) in *Chapter 2: Pleating Practice (i) Experiments*.

52. In conversation with Leo Liu, the manager of Sinta in Taiwan, he explained that it would not be possible to create a 4-way stretch pleated pattern with the current pleating machines because they operate on a linear rolling principle. However, as discussed in *Chapter 2: Pleating Practice (i) Experiments*, Miyake's Steam Stretch technology, is an example of how a machine-made fabric becomes a 4 way stretch through the application of steam. In this example it is not the machine 'doing' the pleating but rather the careful weaving of yarns that then respond to the heat.

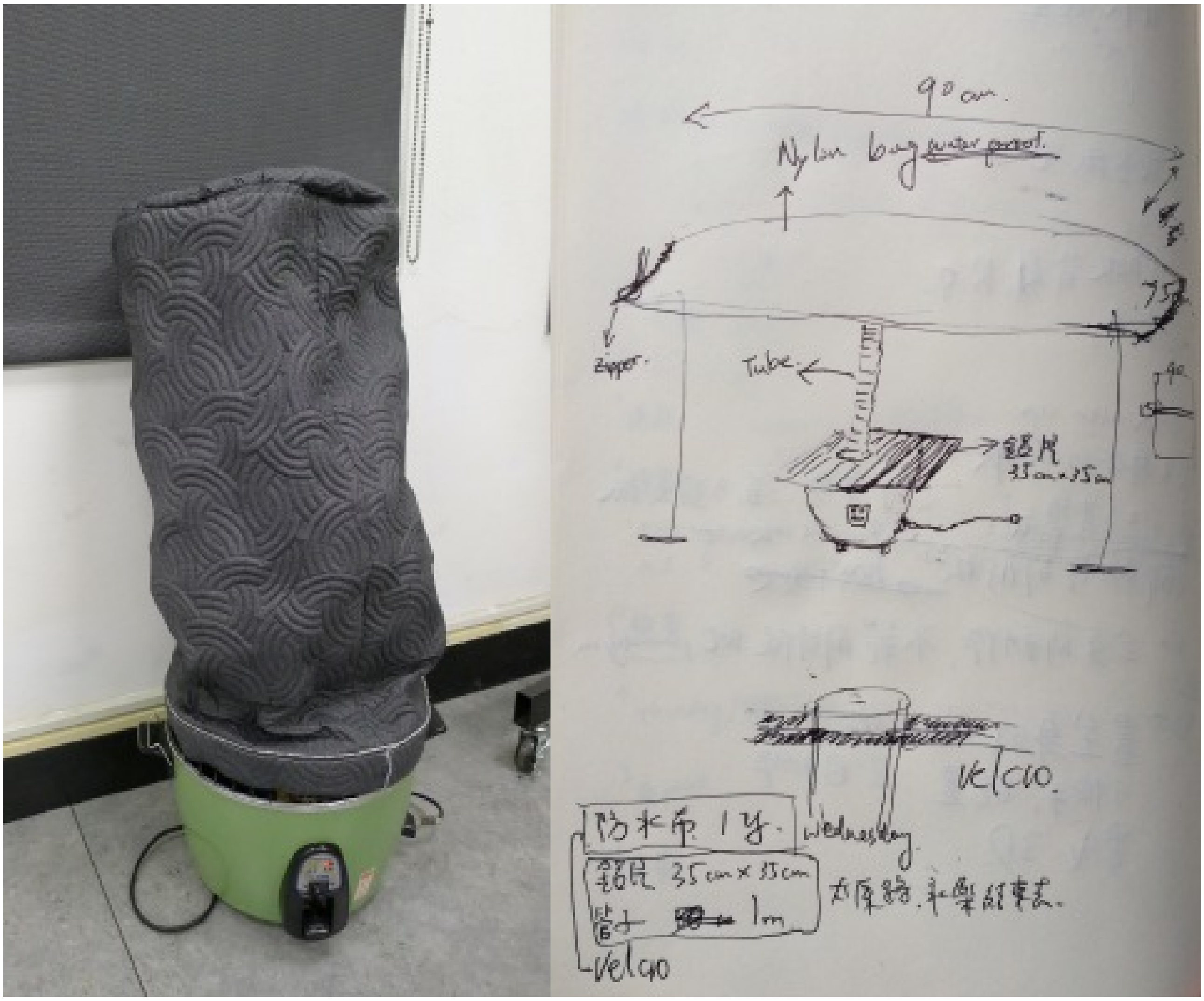

Fig. 3.15 Tsai-Chun Hunag
Selfmade Portable steamer and the design sketch
Padded fabric, 30cm×100cm (2016)

Fig. 3.16 Pleating Workshop
Participant's design, Prague Quadrennial
Prague, Czech Republic (2019)

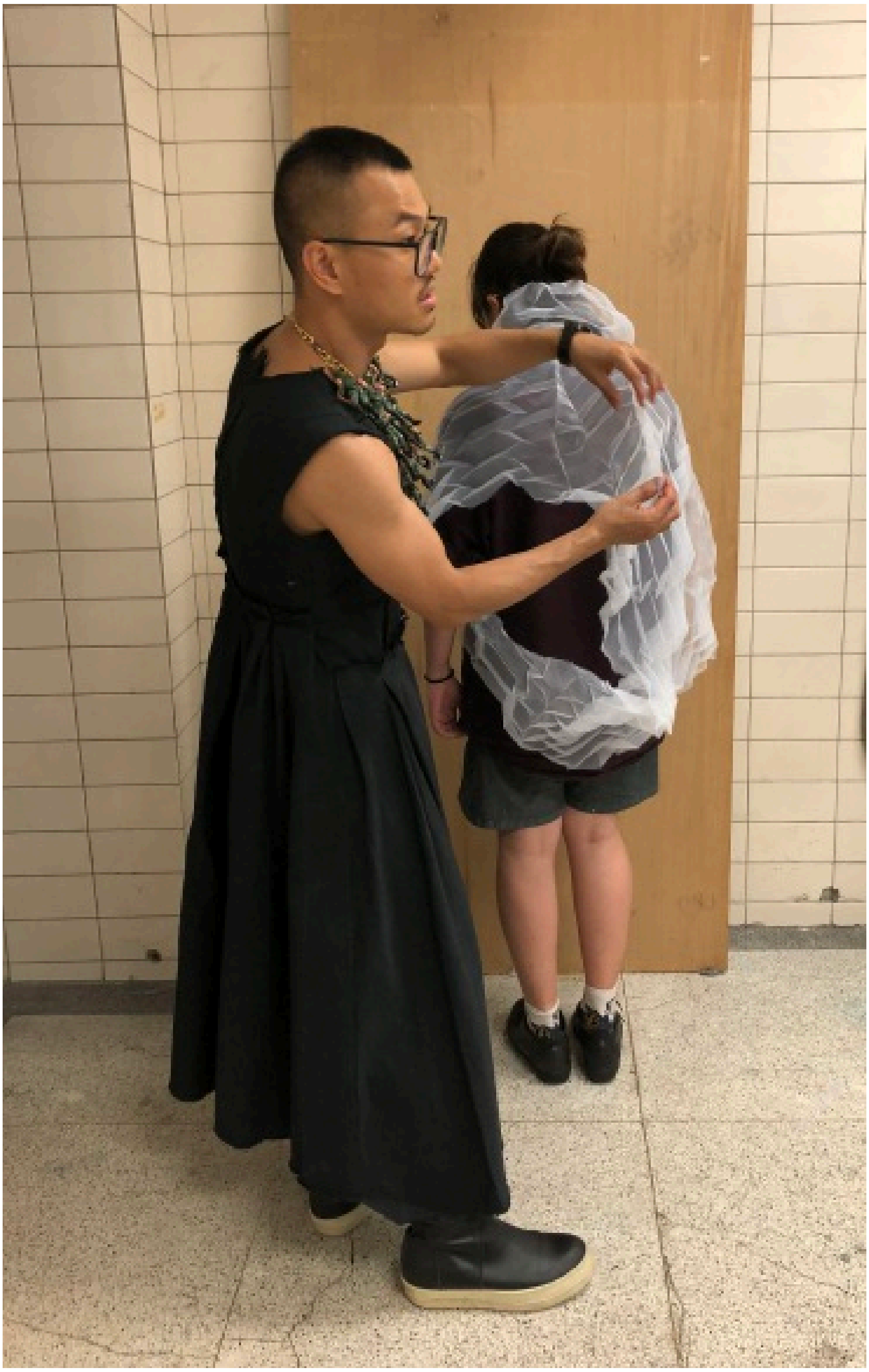

Fig. 3.17 Pleating Workshop
Result critique, Shih-Chien University
Taipei, Taiwan (2018)

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Fig. 3.18 Mokume Shibori. Image: townhillstudio.co.uk

Fig. 3.19 Read Pleaters smocking machine, 16-row model (ca 1982)

Making: What is a pleat?

The evolution of pleating is not just about technological advancement, it is about how the application of knowledge can bring together, alter and create new forms. In this sense pleating is a process of thinking and making.

Inversion process

In the book, *Pleats Please* (2012), edited by Miyake himself, he describes the history of establishing the brand Pleats Please including technological development, design philosophy, and branding. Miyake discloses various difficulties the company faced in developing technological solutions for pleating garments. However, to my reading, the substantial breakthrough is not technological but rather how Issey Miyake adopted a Japanese way of thinking about the body and clothes, and then transformed pleated garments as a result.

His 'inversion process' is a major innovation. Instead of the standard process for making a pleated garment in which fabric is first pleated, and then cut and sewn (see Fig. 3.20), Miyake's design team creates the garment, folds it, and then sends it to be pleated as the final step (see Figs. 3.21, 3.22, 3.23, 3.24, 3.25). Such a novel idea emerged from traditional Japanese culture in which garments are considered as flat as the fabric they are made from. For Miyake, pleating a garment is the same as pleating a piece of fabric. This inversion process changed the order of production and has a radical effect on the final look.

I decided to examine Miyake's 'inversion process' with the skill I learned from Ciment Pleating. The garments need to be thin and flat without any Western cut and sew technique of tucks. I made a simple rectangular top out of black polyester fabric (see Fig. 3.26). All the 'finishing' – hemming, waist band, button holes – need to be made before pleating. The whole garment is then placed in between paper moulds for pleating. After steaming with an industrial iron for 20 minutes, they were left to cool, and then opened (see Fig. 3.27). The garment was ready for wearing without any further intervention[53] (see Fig. 3.28).

53. In the case of the top, it could simply be worn. For a skirt design, a fastening button would be needed to be sewn in after pleating.

Cubic Pleating collection

Inspired by the discovery of this process, later in 2015, I revised the paper mould pleating technique to make a collection shown as part of the *Elsewhere* (2015) exhibition[54]. I kept using my Cubic Pattern and named this collection, *Cubic Pleating* (see Fig. 3.29, 3.30, 3.31). This experience helped me to become proficient in pleating and offered me space to rethink the composition of pleats, including production methods and material requirements.

The collection contains 3 garments and each garment was pleated in a range of different materials: silk organza, polyester, silk crepe, faux leather. The collection was an opportunity to test different fabrics and to see how they responded to the pleating process.

A pleat is an experimental journey of thinking

During the course of my research I have tried to keep abreast of the latest technology. Faced with the resources of these cutting-edge industries, it is easy to feel left behind. It is true that technological development is important, and at the same time, meaning is brought to garment design through the application of thoughtful processing, not just technical innovation. Miyake's inversion process is a good example of this. I believe fashion is influenced by technology but led by thinking. The tiny accordion pleats that Miyake adopts have been practiced for thousands of years. They are not his invention. Japanese garment tradition maintains creases and treats the garment as a flat piece of cloth. Miyake brings these processes together, redeveloping pleating machines to pleat the whole garment at once. He uses technologies to bring fashion aesthetics forward and another layer of meaning to pleated clothes.

Prior to the production of the *Cubic Pleating* collection I had always made a 'perfect plan' before I began making anything. I thought that I should be able to determine the pleating outcome and be able to anticipate the final size, shape and stability simply with a 'mathematical formula'. However, pleating is an experimental journey the outcome of which is unclear until it is completed. Different fabrics need different folding processes. Fabrics react in various ways to different pleating patterns (regardless of whether

54. This exhibition was curated by the Eastern Study Group founded by Far Eastern students from Royal College of Art, Fashion and Textile Research.

the manufacturer guarantees that the fabric composition is 100% polyester). Fabrics require various temperatures and durations to pleat effectively. These variables all affect the final results, and it is only through making that the outcome can be determined. This necessitates a process of 'play' in which maker and fabric have to 'get to know each other' before deciding the whole style of the garment.

The garment design emerges from the making process. Rather than drawing the designs first, I only came up with one or two basic silhouettes and instead let the making experience lead me to new looks. For example, I would pleat a piece of fabric first and experiment with it, placing it in different positions on a mannequin. I would also place it on human models so that I could explore the interaction of the fabric with body movements. The garment would then be formed out of these experiments. After the first garment was made, I would design the second garment from concepts that emerged during the first making, and so on. This gave me lots of space to review every step of the pleating process. I can use the natural 'gaps' between different stages of making to rethink the precedents and to advance the pleating technique with new methods.

One of the results of this process on the fabrication of my own collection, was to form garments with the minimum of elements. One top in the collection was a simple rectangle of fabric with body holes. The geometry of the pleats leads the creation of the silhouette. The interaction of the body and the pleats changes the shape of the garments and creates new looks. This is a making-led design process at work.

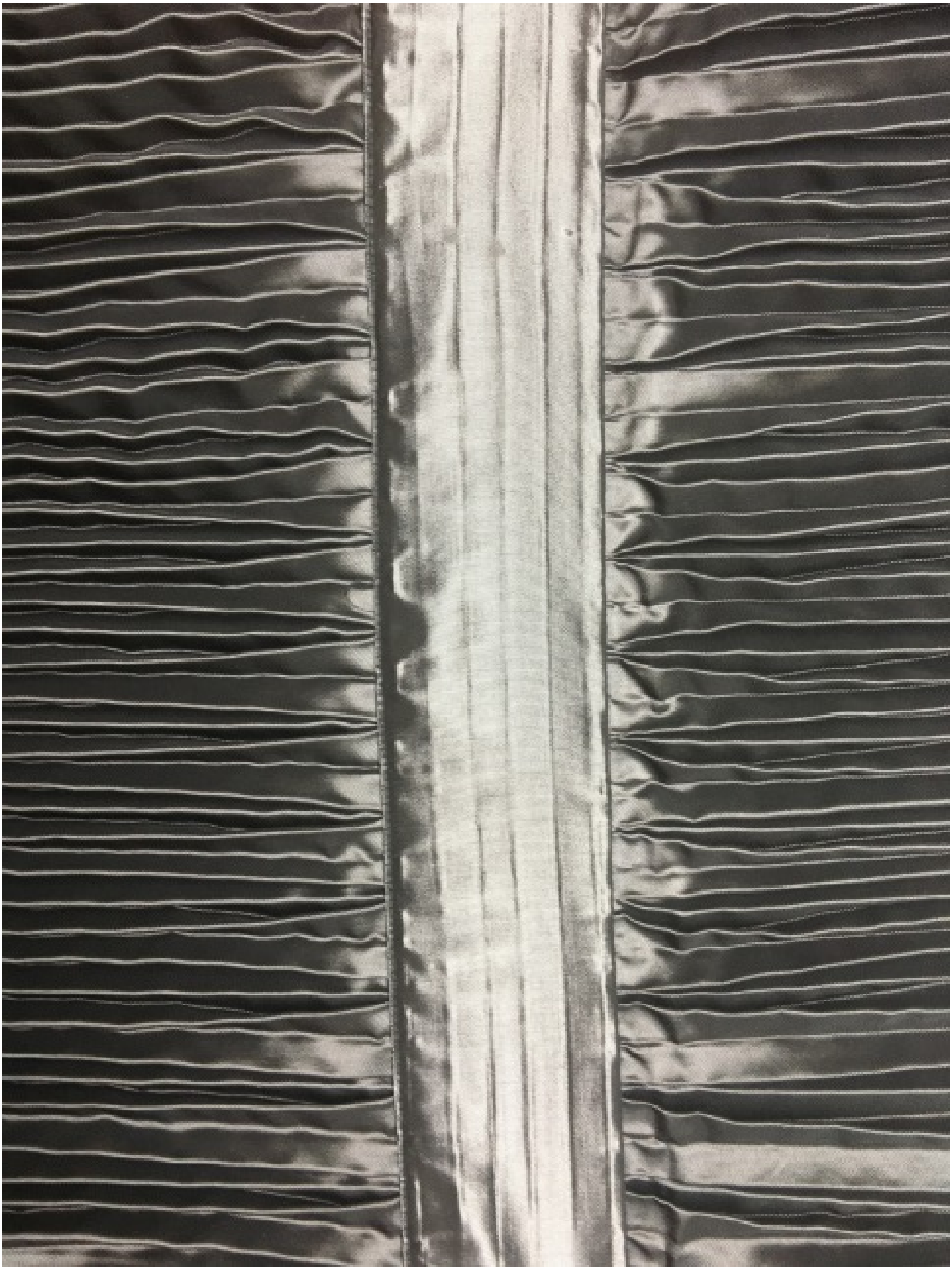

Fig. 3.20 The seams flatten the pleats in standard pleated garments.

Fig. 3.21 The seams follow the pleats in the inversion process.

Fig. 3.22 A circle cut bonded with black bias tapes.
Fig. 3.23 A circle cut after inversion process.

Fig. 3.24 Fabric joining seam.
Fig. 3.25 Joining seam after inversion process.

Fig. 3.26 *Inversion Top* before inversion process.

Fig. 3.28 Tsai-Chun Huang
Inversion Process Top (2015)
polyester, 35cm×60cm

Fig. 3.29 Tsai-Chun Huang
Cubic Pleating– coat (2015)
wool, faux leather, 50cm×100cm

Fig. 3.30 Tsai-Chun Huang
Cubic Pleating– square shirt (2015)
silk, polyester, 70cm×70cm

Fig. 3.31 Tsai-Chun Huang
Cubic Pleating–jacket (2015)
silk, polyester, 50cm×60cm

Fig. 3.27 Taking *Inversion Top* out from the kraft paper moulds. Video still: Opening paper moulds (2015), video by Tsai-Chun Huang (00’53”)

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04

FIELD MAPPING:

This research project investigates pleats and pleating both conceptually and technically.

This study seeks to understand the potential of pleats to generate new thinking, and at the same time to understand what pleats could be physically in a manufacturing environment which is changing rapidly with technological developments.

This chapter is divided into two. The first section gives some context for the conceptual lineage of 'textile thinking' and the textile practitioners who have made with these concepts in mind. The second section considers how textile makers, especially those related to pleating, have used digital technology in their processes.

Section 1 | Conceptual Context: Textile Thinking

Textile manipulation has implications for meaning. Janis Jefferies states that:

> Through manipulation of textile signs – cloth, related materials, processes, histories, and technologies – people produce knowledge.
>
> (Jefferies, 2016, p.3)

New York Times art critic, Holland Cotter, elaborates this view, emphasising that the knowledge textiles produce could be related to an understanding of human experience.

> The major art critics are acknowledging what artists have always known, that textile materiality with all its gravity, responsiveness and connections to life and loss holds tremendous capacity to speak to issues of our human condition.
>
> (Cotter, 2014, p.4)

Jefferies contributes to the concept of textile thinking by identifying a relationship between textiles and language[55]. She states that 'textile' and 'text'

55. In *Text and Textiles: Weaving Across the Borderlines* (Jefferies, 1995, pp. 164-173), Jefferies aligns weaving and writing, and sees both of these terms as interchangeable metaphors for the creation of text and textile. We weave text and write textile.

are not only etymologically connected, reflecting a close relationship and complexity of meaning in association with making, but also share pliability and capacity to form structural relations between components. Roland Barthes writes that 'text is a tissue' (Barthes, 1977, p.159), which is a 'tissue of quotations from the innumerable centres of culture' (Barthes, 1977, p.146). Jefferies elaborates this tissue into 'an SMS message, embroidered by hand and machine as an updated form of communication' (Jefferies, 2016, p.4). However, textiles are clearly not as the same as the textual language (Dhamija, 2004, p.303) and between these two etymologically connected terms there is a gap. The desire to make sense of the gap between things (the fabric) and words (the language) is evident when theorists use textile metaphors[56]. Victoria Mitchell states that textiles are inherently associated with terms such as 'interweaving' and 'thread', which are signifying agents within current critical-cultural practice. This is because textile's pliability shows interconnection and fraying between contrasting disciplines (Mitchell, 2000, p.13), which makes textile not inseparable from other disciplines.

Since pleating is a type of fabric manipulation, it is worth investigating how fashion dictionaries define 'pleat'.

In the 'Fashion A-Z' from the website Business of Fashion, Camilla Morton defines 'pleat' as layers of fabric that have been pressed into place. Her definition implies that 'pleat' contains two essential elements which are the action of folding and the fabric as material[57]. Morton creates another index for 'plissé', which is derived from the French for fold. She classifies plissé as a type of crinkled, wrinkled texture of fabric that is different from pleats. In the *Encyclopædia Britannica*, 'pleating' is referred to as putting a creased design into fabric[58].

I have come to the understanding that 'fold' refers to the mark, the line, and the action of folding. 'Pleat' refers to the layering of materials through the action of folding.

Mitchell traces the etymological roots of 'textile' to its Latin origin. I would like to investigate the etymology of 'pleat' to better understand the embedded

56. Examples include Claire Pajaczkowska suggesting 9 types of textile techniques as tools to form metaphor; Susanne Küchler connects art and mathematics through knotting; Tim Ingold considers how writing practices are themselves types of weaving, citing, for example, the way in which ancient Greeks and Romans incise letters on hard surfaces, or the way in which contemporary authors create intersecting narratives.

57. She also explains different types of pleats, and that they can be 'inserted' as well as 'inverted'. https://www.businessoffashion.com/education/fashion-az/pleats, accessed 13th, Mar, 2017.

58. The encyclopædia looks further into various types of pleats and the manufacturing process of pleating via machines and by hand. https://www.britannica.com/topic/clothing-and-footwear-industry, accessed 13th, May, 2017.

meaning of the word.

It may be easier to start from the French, which has a closer relationship with Latin than English. Both ‘fold’ and ‘pleat’ can be translated from ‘pli’ as a noun, or ‘plie’ as a verb. From the French we can go back to the Latin. ‘Plic-’ as a prefix means ‘fold’ from ‘plico’ (to fold, bend, or roll up). In *The Fold: Leibniz and the Baroque,* Gilles Deleuze references the Latin phrase, ‘*plica ex plica*’, a process whereby a fold always ensues from another fold. Claire Pajaczkowska, in *Making Known: The Textiles Toolbox* includes ‘pli’ as the Latin root which indicates the notion of fold in a section on ‘Plaiting’. She points out that ‘pli’ in Latin refers to multiple layers or layering. In modern English, several words contain ‘pli’, such as complicate, multiplicity, explicit and implicate. In these examples ‘pli’ refers to an intricate status, layering of facts or the unfolding of truth. ‘Pli’, the Latin root for ‘fold’ and for ‘pleat’ can be said to imply a concept of explicitly unfolding layers of meaning. Additionally, ‘fold’ appears in the ‘Drapery’ section, which Pajaczkowska considers is best explored in movement. She indicates that ‘folding’ is one of the three essential structures along with ‘cut’ and ‘silhouette’ to turn cloth into clothing. In her terms, the fold (what I could name the ‘accidental fold’ of drapery) plays a role in reconfiguring the proximity and distance between garments and the body, selves, individuals and groups. It is through movement that the fold is continually shifting the distance between the physical space, via its opening and closing action. She even elaborates this space into a mental space as a philosophical ground for textile thinking, which I will introduce later.

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Fig. 4.1 The Chinese word for ‘pleat’: 1300BC-220BC-63AD Image: Dictionary of Origin of Chinese Characters.

Chinese is known for expressing meaning through its pictorial characters. It is worth investigating the evolution of the Chinese character for ‘pleat’. This character follows one of the six main principles of Chinese character construction: ideogram compound. This group of characters is formed of pictograms of objects presented literally and metaphorically, which together establish a meaning.

From the image evolution of the character, it can be seen that the original[59] word for ‘pleat’ is a drawing of clothes on the left with two feathers basking

59. The earliest Chinese pictographs can be traced back to 1800BC-1500BC.

under the sun on the right (see Fig. 4.1). Later, in Qin Dynasty (221BC-206BC), the character was simplified from pictorial images to strokes that are called Small Seal Script. Even though the images were reduced to a few strokes, it is still possible to recognise that there is a dress on the left with feathers and sun on the right. According to the *Dictionary of Origin of Chinese Characters*[60], the left side refers to garments, and the feathers represent birds flying back and forth, implying the pleats on the garment are formed back and forth.

Japanese paper folding artist, Yuko Nishimura, said, “to fold is to pray”[61]. She uses her paper folding experiences to understand the meaning of the characters from Chinese. She asserts that it may not be an accident that the Chinese for folding (折) and praying (祈) share the same right half character, and that the left half of ‘folding’ refers to ‘hands’ and the left half of ‘praying’ refers to ‘heart’ (see Fig. 4.2). From her perspective, perhaps the ancestors viewed hand folding as an embodiment of mind praying.

Alongside the exploration of the potential for language to hold meaning beyond merely designating or describing textiles, through researching etymology, ‘textile thinking’ has sought to incorporate wider cultural ideas into an analysis of textiles.

Pajaczkowska employs psychoanalysis to explore textile thinking. She explains how different textile praxis, such as felting, spinning, stitching or knitting, articulate embodied knowledge with abstract thinking and knowing. The articulation can be realised through a ‘platform’, which she names ‘textile ego’, derived from Didier Anzieu’s ‘skin ego’. Ego is a junction of bodily experience from biology and the embodied knowledge of culture and society, according to Freud and post-Freudian psychoanalysis. In Pajaczkowska’s theory, this is the intersection where biological instincts and human subjectivity meet. Through retrospective thinking and techniques of self-reflexivity, designers, artists and craftspeople can reappraise their experiences and understand what they have done as embodied knowledge. This forms the basis of the psychoanalysis of textile thinking. Through this reflexive process, practitioners establish their ideas, speculating new

Fig. 4.2 Chinese characters for ‘fold’ and ‘pray’ from Yuko Nishimura’s interview video *Folded Light, Folded Shadow*.

60. http://qiyuan.chaziwang.com/etymology-6102.html, accessed 15th Mar, 2017.

61. KAItv, 2014. *Folded Light, Folded Shadow* by NISHIMURA Yuko, [video online] Available at https://www.youtube.com/watch?v=8np2P7S0n5E, accessed 14th Mar, 2016.

materialities and possibilities, pushing the boundary of textile thinking. Caroline Bartlett uses her memory to create a series of pleated artefacts. During an interview with June Hill, Bartlett explains it is the way in which humans record their memory that interests her. She describes how John Berger's writing on life's experiences, folding backwards and forwards, inspired her to create the works, *Pulse* and *Full Circle* (see Fig. 4.3, 4.4). Life journeys are a major driver for her creativity.

Full Circle uses a type of stitched pleats (in my category of pleats[62]). In another interview with Daniel Crowder on TextileArtist.org[63], Bartlett talks about why she chose pleating as a recent technique (despite the fact that she started her career with printing and embroidery). She remembers the moment she saw a smocked piece *Untitled* (soft honeycombed square textile smocked with buttons) by Polly Binns (see Fig. 4.5), and how she was inspired to transcend the flat surface. Bartlett also points out that she was highly influenced by Yoshiko Wada's shibori technique from the book *Memory on Cloth: Shibori Now* (2002). She then adopted pleating because its properties fold backwards and forwards, to conceal and reveal like memory, sometimes floating on the surface and sometimes sinking to the bottom of consciousness. This is the junction where Pajaczkowska's textile ego emerges and the moment artists snatch creativity.

I deduce that it would be useful to explore further the action and materiality of pleating, in order to define pleating as textile thinking and consider it as a distinct branch.

This research study focuses on thermal pleats. This is a type of post processing, different from woven or knitted pleats, which are structurally formed. The thermally formed additive manufacturing process has different properties to weaving, knitting or stitching, which are the foundations used to form a piece of fabric. Textile artists and craftspeople who established textile thinking based on these fabric production methods, have concentrated more on the relationships between yarns, threads and fibres. Pleating, as an additive post-production process, offers other dimensions, such as the action of folding and layering of surface, and these particular properties of pleats

62. These categories are 'stitched', 'thermal', 'structural' and 'digital' pleats and are outlined in *Chapter 1: Introduction*.

63. The full interview is available at https://www.textileartist.org/caroline-bartlett-embroidering-truth, accessed 21st Apr 2018.

and pleating may be able to formulate their own textile thinking.
In order to articulate pleating as textile thinking, I made an introductory paper model (see Fig. 1.1). The experiment attempts to condense meanings into the Deleuzian form of '*plica ex plica*'. These meanings are distilled from the literature of pleats and pleating in history, my learning, workshopping, and making experiences. The paper model can be seen as 'textile ego' that intersects my bodily knowledge as a craftsman and my understanding of textile thinking.

Plica ex plica

The paper model is a process of abstract thinking, which reveals concepts folded into the pleats. It begins to answer the question, 'What is in a pleat?'. Layers and layers of pleats offer layers and layers of meaning. In the paper model of '*plica ex plica*' (see Fig. 1.1), the outer pleat shows space and colour. The next pleat shows luxury and fabric. The third pleat shows time and labour. The fourth pleat is prayer. The inner most pleat, is life itself.

When I looked into the history I became aware that pleating represented luxury, as it required an excessive amount of fabric. Pleats use double or even triple the amount of fabric 'necessary' in a garment. In times of material scarcity, pleats represented a heightened social status and the wealth of the wearer. Pleated garments were expensive because of both the quantity of fabric and the amount of labour required to make them.

During my work as a studio technician at Ciment Pleating, I repeatedly pleated accordion pleats from 8am to 5pm Monday to Friday. By pleating more and more fabric, I gradually understood that it is my time and labour that is in the pleat. Each pleat not only contains an excessive amount of fabric, but also the time and labour I have devoted to make the pleats.

A further reference that expands the answer to the question 'What is in a pleat?' can be found in the scripts of plays of the Yuan Dynasty (1271 AD-1368 AD) (see Fig. 4.6). The 'fold' (折) as a unit, represented each separate narrative element, similar to the 'act' in Western theatre. For Yuan Dynasty playwrights, every 'fold[64]' contained a story, and a life.

64. Although there is a separation between the word of 'fold' and 'pleat' in current Chinese, in Ancient Chinese the words would have been used interchangeably and are pronounced identically.

This reflective thinking gave me the opportunity to closely examine the qualities of both the act of pleating and the pleats themselves, to pull out possibilities and to incorporate pleating as part of textile thinking. By undertaking this reflective process, I have come to realise that my research does contain textile thinking.

The embedded meaning in these pleats indicates that pleating could itself be a way of 'textile thinking', similar to the way in which textile theorists and practitioners have seen an interdependence between specific linguistic terms, the act of making, and materiality.

In *Selvedges* (2000), Jefferies describes how textile practitioners use their practice to rethink what textiles are. She begins by outlining her education in Poland where the notion of 'loom thinking' originated in 1913 (Jefferies, 2000, p.22), and then introduces textile practitioners of the late 60's and early 70's. She also presents a wide-ranging discussion that includes feminism and post-colonialism, which is triggered by textile arts, to give examples of how materiality evokes critical debates. It is apparent that Jefferies has confidence in textiles and materiality, as a way of both making and thinking, and she encourages textile practitioners to establish an independent aesthetic as an equal partner to other visual cultures.

It is also worth noting that Catherine Dormor establishes her own textile-space for 'production, analysis and reception of textile-based artworks and theoretical perspectives' (Dormor, 2012, p.26). She states that this space not only offers place for theoretical thinking and making, it also provides a platform for the potential dialogue between theory and practice to happen. It is this dialogue that has the potential to generate new meaning.

My research journey shows that there is a logic embedded in the form of pleats, and in the action of pleating. This logic is different from textile thinking, which is derived from weaving, knitting, embroidering and stitching, because pleats and pleating have their own production reasoning, which includes folding and layering. I propose that pleating requires its own

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Fig. 4.3 Caroline Bartlett
Full Circle (2016)
Printed, stitched linen, porcelain,
each 101cm×117cm
Image: textileartist.org

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Fig. 4.4 Caroline Bartlett
Full Circle, detail (2016)
Image: textileartists.org

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Fig. 4.5 Polly Binns
Untitled (1982)
Cotton duck, thread, porcelain, 54cm×54cm
Image: MutualArt Services, Inc.

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Fig. 4.6 The play script of *Outlaws of Marsh* by Chin-Chih Kang (ca 1300AD). The circled words 'Fold' are akin to the English 'Act'. Image: artfoxlive.com. Annotation Tsai-Chun Huang.

form of critical thinking that is specific to its own particularities.

Section 2 | Digital Context: New Technologies

What has emerged from my enquiry into the history of pleats, is that it is actually a history of technological development and material invention. As mentioned in *Chapter 1: Introduction*, Andrew Bolton believes pleating is such a significant profession for couture making (Bolton, 2016, p.13) that he includes a section on pleating in the annual fashion exhibition *Manus × Machina: Fashion in An Age of Technology*. As Louise Valentine indicates, 'the most striking attribute arising from this contemporary arena is the rise of new hybrid and digital forms of, and concepts for craft practice' (Valentine, 2010, p.77), that is to say, new technologies, that are changing the way we create and understand fashion.

In the past, computer-aided design (CAD) and computer-aided manufacture (CAM) were industrial level processes. The cost was high and the equipment was too large for small studios or domestic spaces. Technological advancements, and the shrinking of both machinery size and cost, have made the means of production directly accessible to individual designers and artists (Dormer, 1997, p.173). We are encouraged to adopt these technologies to digitally produce prototypes. Digital production methods have also opened creative possibilities and changed conventional production thinking (Philpott, 2010, p.10; Shillito, 2013, p.24).

Digital technologies are affecting the ancient practice of pleating as well. A new way of producing patterns and pleats is emerging, employing methods that diverge from those conventionally used. 'Digital pleats' can therefore be considered as a separate category from stitched, thermal, and structural pleats.

The creation of kraft paper moulds is the most time-consuming part of the hand-pleating process. In pleating studios, technicians hand draw or score pleating patterns on kraft paper (see Fig. 4.7) and then hand fold these sheets to sandwich fabric for steaming[65]. The staff at Sinta, the pleating company in Taipei, spent 3 months before they opened, scoring and folding paper patterns[66] (see Fig. 4.8). Artists and researchers are trying to find ways to reduce this labour consuming work.

65. Hand drawing and folding processes can be seen in the video released by Ciment Pleating: '*How to make a sunray pleat pattern*', https://www.youtube.com/watch?v=zPONu55_vg4, accessed 2nd November 2018.

66. Personal conversation with Leo Liu, Sinta Manager, 20th August 2016.

From 2005 to 2009, Tine De Ruysser conducted her research on metalised origami and she used several technologies to formulate her pleating patterns. She used common computer 3D graphic software, including Rhino and Adobe Illustrator, to draw the pleating patterns (Ruysser, 2009, p.79) (see Fig. 4.9). She encountered some software specially designed for origami, but they did not meet her needs[67].

De Ruysser indicates that the digital file was of vital importance for her various experiments[68]. Even though the final metalised process of her piece was achieved by an electro conductive procedure, when De Ruysser later developed related products, she again used Rhino to draw flat patterns to test out the sample forms.

Similarly, between 2005 and 2011, Rachel Philpott started her structural textiles research (PhD Textile Design, RCA), which depended on computer graphic software. Philpott used Adobe Illustrator and Photoshop because she was familiar with this software having used it to create patterns for silk-screens (Philpott, 2011, p.175) (see Fig. 4.10). She drew all the pleating patterns digitally in Illustrator and sent them through for laser-cutting and laser-sintering.

Philpott reflects on the advantages and drawbacks of the CAD and CAM processes she experienced during her making. She points out the reason why she chose to produce patterns digitally, was in order 'to achieve the high level of accuracy required for the realisation of origami folding' (ibid., p.128). However, she also identified a disadvantage of using CAD and CAM, which is that the easy adaptation shortens the time. 'The time spent redrawing or remaking by hand, although often perceived as onerous, is also time spent unconsciously but actively re-conceptualising a problem (Sennett 2009)' The time for absent-minded reflection which is essentail for new ideas, and creativity is lost (ibid., p.173).

Elisa Strozyk[69] uses computer software to draw the geometric shapes of her patterns. Thin veneer boards are cut into shape with a laser-cutter. She hand-places and glues these geometric pieces onto cotton fabric (Johnston,

67. The software that she experimented with but did not use included TreeMaker by Robert J. Lang, Tess by Alex Bateman, and Rigid Origami Stimulator by Tomohiro Tachi. She explains that TreeMaker is not suitable for tessellation patterns, while Tess offers limited options, and Rigid Origami Stimulator is no real use for her as she prefers to fold the paper to feel the movement.

68. She used the digital file to cut vinyl and textile flock, which were later adhered to fabric using a heat press (De Ruysser, 2009, p.93). She also used the digital file as a laser cutting guide while creating the frame for stencil printing, and the small cut pieces to form folding patterns (De Ruysser, 2009, pp. 94-95).

69. German textile designer, who has worked with German furniture company Böwer to produce foldable wooden textiles since 2009.

2015, p.227) (see Fig. 4.11). A gap is purposely left to create spaces which act as folding lines to enable the pattern to contract and expand (Campbell, 2014, p.173). This half-wood-half-fabric textile blurs the boundary between materials and their traditional uses. These 'wooden textiles' are both hard and soft, transcending people's expectations about these materials (ibid., p.174). Strozyk's materials–wood, cotton, glue–have been used to make things for thousands of years. Nothing she does would have been 'impossible' before the advent of digital drawing and cutting. However, due to their accuracy and speed, digital drawing and cutting make it practicable. The availability of the technology also stimulates designers to consider what they can do with it (Sennett, 2009b, p.25). Originally, Strozyk designed this fabric as carpet, and later she expanded its application in a collaboration with Icelandic designer, Sruli Recht, for his 2013 Autumn/Winter collection (Johnston, 2015, p.227) (see Fig. 4.12).

As Lucy Johnston comments, the impact of laser-cutting on Strozyk's work is that:

> Laser-cutting allows Strozyk to prepare the many tiles she needs with speed and efficiency, as well as the geometric precision to produce the folding qualities necessary to achieve the tactility of the finished textiles.
>
> (Johnston, 2015, p227)

De Ruysser, Philpott, and Strozyk rely on CAD and CAM for the precision of their patterns and the speed of production. However, it is one thing for digital technology to aid pre-existing production processes, and another for it to actually form the pleats themselves.

I began to use Illustrator to draw digital patterns (see Fig. 4.13) after 2015 and it helped me to speed up the process, when I needed to build moulds to pleat textiles or garments. I did not need to hand draw every sheet of paper to demonstrate the folding process during a workshop, and I could easily alter the size of patterns with a few clicks.

I constructed a Cubic Pattern shoulder on a jacket (see Fig. 4.14) I made in

2011 using interfacing cut pieces. The segments of the pattern were hand cut from interfacing. Laid flat they formed a series of 2D geometric shapes. These geometric pieces were ironed onto the fabric before stitching into the jacket. I then pleated the area of the shoulder and steamed the 3D cubic pleats to temporarily fix them (see Fig. 4.15). In both the Recht/Strozyk collaboration, and in my own interfacing cubic pleat, the material that allows the structure to be formed (the geometric pieces of wood, or of interfacing) must remain in the garment in order that it maintains its shape. The garments are therefore difficult to wash and care for, and need to be resteamed after laundry to reform the shape. Using digital tools does not necessarily mean the garments themselves are more practical.

One of the preeminent examples of using cutting-edge technology to create fashion and textiles is the Dutch designer Iris van Herpen. Since 2007, she has adopted 3D printing and received wide international acclaim. Thereafter, she adopted various digital technologies, including laser cutting, and unusual garment materials, such as P.V.C. and plastic, to produce couture. Her catwalk garments are very intricate, usually joining hundreds of organic shapes rather than using a traditional cut and sew technique. The joining methods are layering, stacking or piling these small cut pieces. Although pleats are a common element in her designs, she produces these pleated garments with soft textiles, such as chiffon (see Fig. 4.16), and, as yet, I have not seen her use 3D printing to form pleats. I believe that adopting 3D printing technology to produce pleats is worth exploring, and this study can contribute to the development of this technology from the perspective of conventional pleats and craft knowledge.

Rob Thompson references 3D printing as a groundbreaking method to produce material for fashion and textiles. One case study he presents is an experiment conducted by textile artist Elaine Ng Yan Ling. Ling folded a pleated structure using paper, and then scanned it with a 3D scanner. The scanned data is visualised in CAD compatible software for amendment and the manual reconstruction of missing parts. After these adjustments, the file is ready for printing. In this experiment, Ling uses ABS[70]. The result is very hard and is not bendable (see Fig. 4.17). The forming process creates folding lines and overlapping surfaces which are similar to pleated fabric (Thompson,

70. Acrylonitrile Butadiene Styrene, a type of plastic.

2014, p.472).

Ling's design process – hand-forming to 3D scanning, digital correction to 3D printing – denies the full potential of digital modeling. Software such as Rhino or 3D Max do not require the designer to start with a 'real world object' but rather allow for the creation of structures which might not be possible through hand-forming[71]. If one of the main benefits of adopting cutting edge technology is to create a form or outcome that cannot be achieved by hand or traditional tools (Shillito, 2013, p.22), then Ling's practice, which skips the stage of modelling, does not fully take advantage of 3D printing technology.

The examples outlined in this second section demonstrate a range of ways in which pleats are formed. There is a constant exchange between hand-eye coordination and the use of tools and technologies. Even the most mechanised of examples (Ling's 3D experiment) involved a fundamental use of hand manipulation. Available technologies alter possibilities, and ask us to reconsider the composition, formulation and definition of pleats.

Pleating is usually considered a form created with fabric. As the majority of pleats in the commercial market are achieved through thermal processing, 100% polyester is the most effective material to use. It is most responsive to the thermal moulding. Textile thinking and digital technologies deepen our understand of what a pleat means and what it can be. What are the boundaries of pleating? When can we say a pleat is formed? What other materials can we use? If we fold a sheet of paper, which is rigid, and it still functions as a garment, can we call it pleated, or is it simply folded? If we 3D print a pleat-like-form that does not act like thermal pleats, would they still fall into the category of pleats? Can we define what pleats are through their form alone, or do we need to consider how they act in relation to the body, to movement, and to gravity? What are the essential criteria that would validate whether a form is a pleat or not a pleat?

71. From the perspective of pleating, in which the expansion and contraction of the fabric is an important consideration, it is interesting to note that in Ling's experiment, she replicates a folded paper structure in a rigid plastic that does not have the elastic properties of the original object.

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Fig. 4.7 Handmade sunray pleats moulds. Video still: How to make a sunray pleating pattern (2018), video by Ciment Pleating (04’30”)

Fig. 4.8 Kraft paper moulds stored on shelf in pleating factory, Sinta

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Fig. 4.9 Tine de Ruysser's digital folding pattern made in Rhino. Image: Tine de Ruysser
Fig. 4.10 Rachel Philpott's digital folding pattern made in Illustrator. Image: Rachel Philpot

Redacted Image

Fig. 4.11 Elisa Strozyk's *Wooden Textiles* production process. Image: gestalten.com

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Fig. 4.12 Sruli Recht and Elisa Strozyk
Lo/Rez (2013)
Wooden Textiles
Image: scrulirecht.com

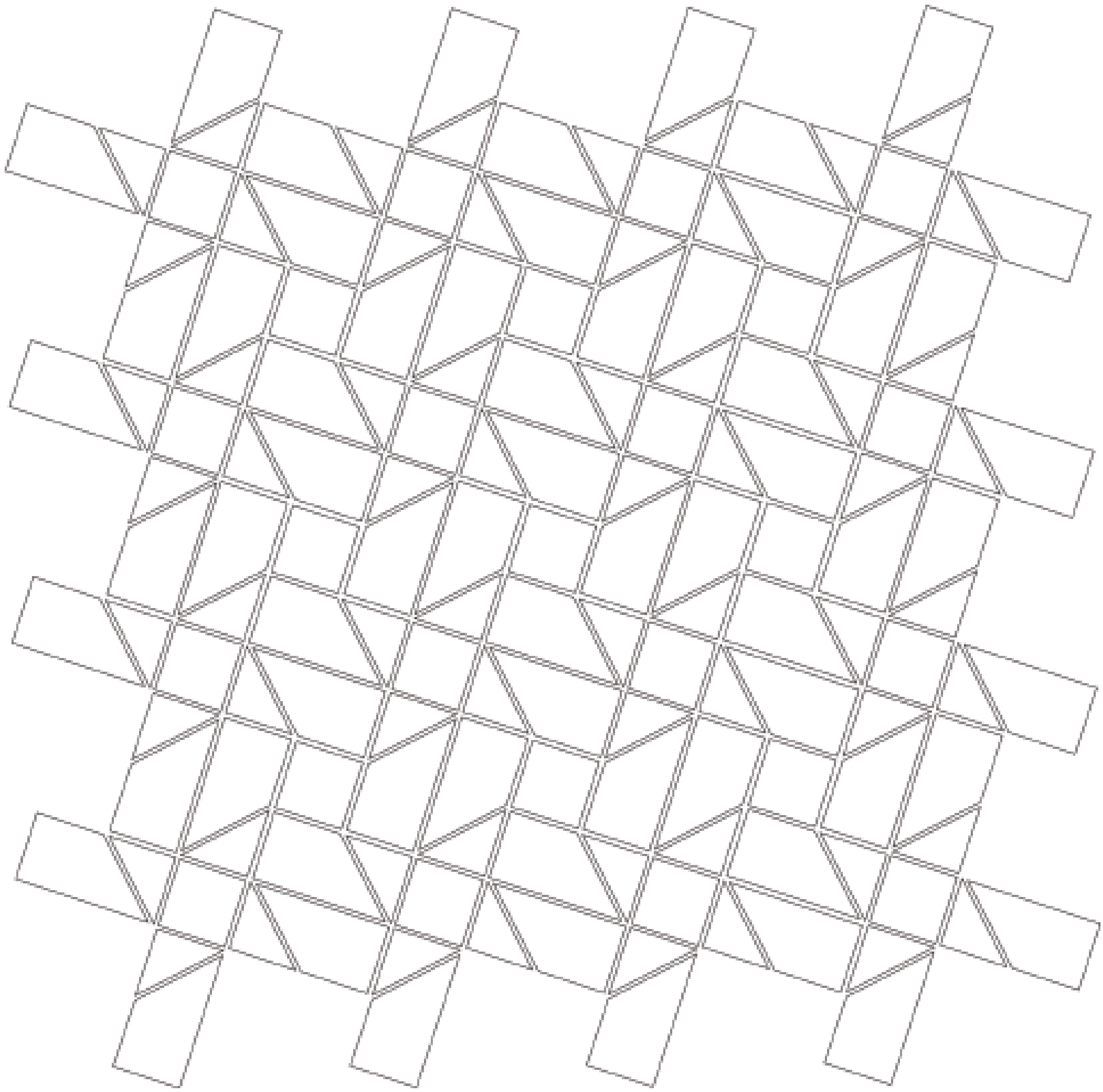

Fig. 4.13 Cubic Pattern digital folding pattern made in Illustrator

Fig. 4.14 Tsai-Chun Huang
Cubic Manic jacket (2011)
cotton, interfacing, 60cm×50cm

Fig. 4.15 *Cubic Manic* jacket (inside) Cubic Pattern interfacing

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Fig. 4.16 Iris Van Herpen's pleated garments from different collections are made by chiffon. From left to right: Autumn 2017, Spring 2019, Autumn 2019. Image: irisvanherpen.com

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Fig. 4.17 Elaine Ng Yan Ling 3D printing experiment. Image: *Manufacturing process for textiles and fashion design professionals.*

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05

PLIABLE LOGIC :

Pliable logic is based on three premises. They are 'softness', 'recursive sequence' and '*plica ex plica*'.

Reviewing my experiences of pleating practice as outlined in *Chapter 2: Pleating Practice (i) Experiment* and answering my research questions for the first time in *Chapter 3: What is a pleat?, What is in a pleat?, What do pleats do?*, I have become conscious that pleats and pleating have their own conceptual frame of thinking, distinct from other types of textile production methods and textile properties. This chapter considers pleats and pleating as part of textile thinking, and names the thinking that emerges from pleats and pleating as 'pliable logic'. I have developed this 'pliable logic', a textile research methodology which references a malleable, recursive procedure, to encourage the researcher to search for meaning in between stages. (In the subsequent chapter 'pliable logic' is employed as an exclusive methodology to re-interrogate the research process.)

Pliable logic is based upon three premises. They are 'softness', 'recursive sequence' and '*plica ex plica*'. (See Fig. 5.1)

The discussion of 'softness' starts from Pennina Barnett's text *Folds, Fragments, Surfaces: Towards a Poetics of Cloth* (1999) and expands to include other related references which consider the soft and pliable, especially those proposed by textile practitioners, researchers and engineers. I will explain why pliable logic is different from existing theories and makes a unique contribution to textile thinking.

The concept of 'recursive sequence' is derived from Sarat Maharaj's description of Janis Jefferies' creative process. I alter and expand Maharaj's analysis and propose an alternative sequence based on my own research development. Through my making experiences, I elaborate Maharaj's linear sequence to a recursive sequence, to reflect on my research route.

The last element of pliable logic is '*plica ex plica*', which layers various ideas in between the conceptual spaces of pleats. I visualise this notion with a pleating sample inspired by Gilles Deleuze's concept of '*plica ex plica*' to illustrate the approximation of the pleated surfaces.

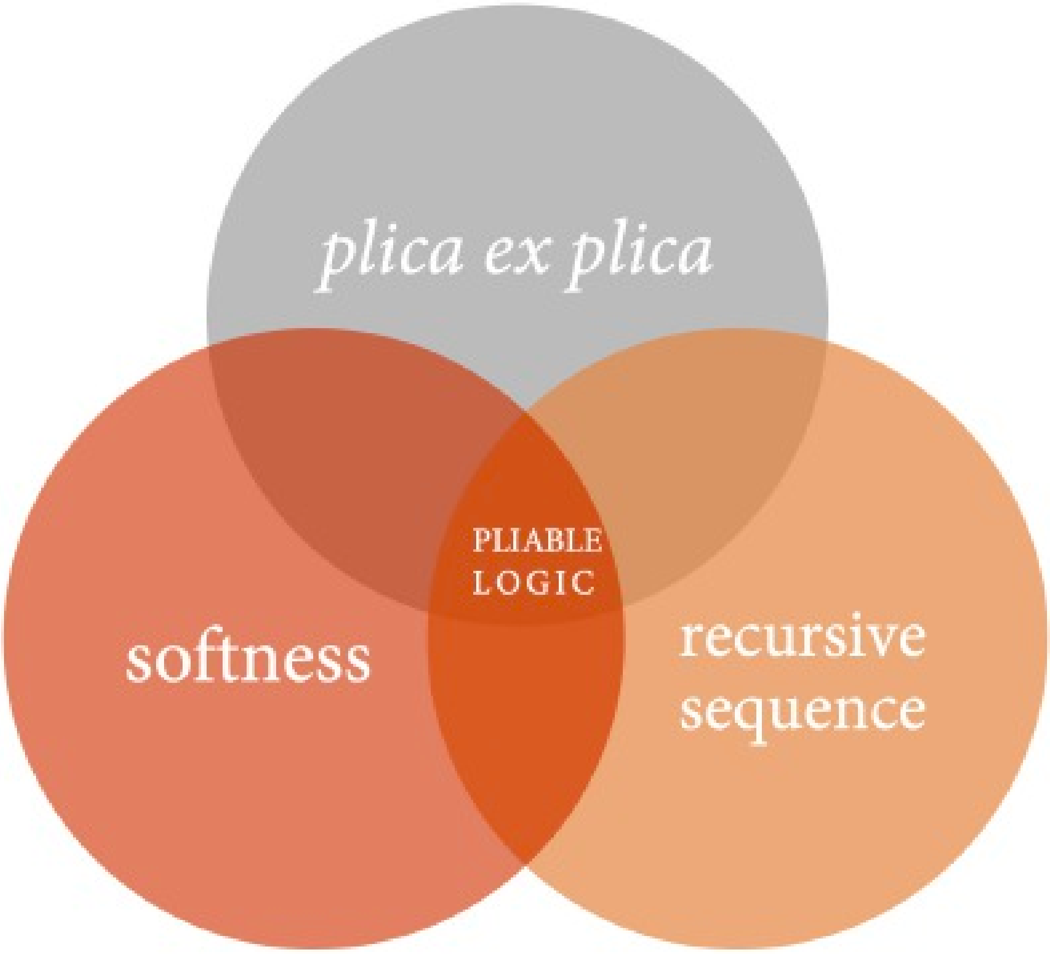


Fig. 5.1 a diagram showing how pliable logic sits between softness, '*plica ex plica*' and recursive sequence.

Pleating is conceptually different from existing textile thinking

From the beginning of this study, I aligned my research with textile thinking, using it as a guideline to conduct my practice. When I read how textile practitioners document and theorise their knitting, weaving and stitching experiences (Hurlstone, 2010, p.34; Owen, 2011, p.92; Hurlstone, 2012, p.149; Dormor, 2014, p.2) and paralleled this thinking with my pleating research, I inferred these existing propositions did not apply to what pleats and pleating are, and were inadequate for my research.

Based on textile fundamentals and methods (Albers, 1965, p.13), it is common that textile thinking is discussed through stitching, embroidering, weaving and knitting. In this way of thinking "…the thoughts …can …be traced back to the event of a thread" (ibid, p.15). These textile formations have become the foundation of textile thinking.

Some theorists approach textile thinking from a material perspective, examining threads, yarns and fabrics. Others consider the motion of actions (Goett, 2016, p.130). For example, the way a yarn shuttles across the loom, knitters' gestures to loop yarns back and forth, or a maker's posture in stitching lines on textiles (Hurlstone, 2012, p.150). Both the material properties and makers' motion provide a rich ground for interpretation. These two aspects are inseparable in that thinking is generated within both realms simultaneously.

If pleats and pleating are post-processed manipulations, not fundamental to textile manufacturing, can they form their own thinking, and if so, how?

Additionally, theorists connect 'text' with 'textile'. Victoria Mitchell traced back the origin of the words 'textiles', 'text' and 'techne' to justify the legitimacy of adopting the conceptual frame of the 'text' to develop a theory of textiles (Mitchell, 1997, p.326). Catherine Dormor reverses the conventional language of making and writing, proposing that we 'write textiles' and 'make texts', in order to illustrate the interchangeability of texts and textiles, using 'seaming' as a metaphor to bind texts and textiles (Dormor, 2014, pp.3-12). These configurations establish a relationship between texts and textiles.

Claire Pajaczkowska mentions pleating and folding in her textile toolbox. She identifies the pleat in categories of plaiting, connecting these two techniques with their Latin etymological roots: 'pli' (see *Chapter 4: Field Mapping*). Both pleating and folding have been traced back to their historical origins by Pajaczkowska to illustrate a rich cultural background of the techniques (Pajaczkowska, 2016, pp.88-89). In addition, the conceptual idea of folds has been explored by Gilles Deleuze through the figure of the Baroque chamber, and is frequently adopted by fashion and textile theorists. Anneke Smelik (2014) elaborates the Deleuzian concept of 'becoming', a process in which the fold is not considered static but is rather in a continual condition of transition between stages, and applies it to fashion in order to consider the folds on the garment and the wearer themselves as both in the process of 'becoming'. Catherine Dormor (2012) in her research (PhD, Norwich University College of the Arts and University of the Arts, London[72]) further expands the Deleuzian fold into a space for reciprocal exchange between practices and theories, to generate textile thinking. These concepts develop rich ideas about folding, folds and 'pli' and are derived mainly from the structure and materiality of pleats. However, I posit that from a textile thinking perspective, there is additional conceptual possibility if we look beyond the structure and materiality of pleats. The action of making pleats, the process of pleating and the thinking of pleats within pleating itself, should all be included to support this research.

Following the existing textile thinking, which mainly derives from the actions of weaving, knitting, the pattern of knotting, and the properties of fabric, I acknowledge the necessity to build up my own textile thinking based on pleats and pleating (Mills, 2014, p.36). This methodology is pliable logic.

Integrating my research practices and study theories, I conclude that my research route, thinking structure, and decision-making process, all follow what I have come to term 'pliable logic'. These reflections evidence that pleats

72. *Material Matrices: haptic, scopic & textile*

and pleating are different from other fabric production and manipulation methods. This research argues that pleats and pleating are as valuable and important as weaving and knitting in textile thinking.

Naming pliable logic

'Pliable', which I use to name my methodology, can be found in Anni Albers' and Rachel Philpott's writing to describe a methodology for textile design and research. In *The Pliable Plane: Textiles in Architecture*, Albers explains how pliable planes change the interior atmosphere more easily than conventional building materials such as wood or concrete. She describes how architects adopt these textiles in different iterations to achieve various purposes, such as sound absorption (Albers, 1957, p.39). At the heart of Albers' theory is an exploration of the power of the 'soft'. Rachel Philpott uses the term 'pliable research' to articulate how she evolves her methodology from a scientific and design approach to one that includes the autoethnographical, bricolage, and artistic orientation. She believes that being an art and design researcher, one needs to be very flexible and adopt different methodologies (Philpott, 2013, p.38). Her pliable research mixes various methodologies that can generate new thoughts and be the catalyst for her making practice (ibid, 2013, p.43).

'Pliable' shares the same prefix, 'pli' with the French/Latin origin of the word pleat (plie) as outlined in detail in *Chapter 4: Field Mapping*. Furthermore, 'pliable' has the additional meaning of 'bendable' which matches the property of pleats and pleating. This 'pli' prefix is unique to pleating and this represents essential qualities of this research.

In the upcoming sections, I will focus on the three elements of pliable logic: softness, recursive sequence, and '*plica ex plica*', in turn, to establish a thorough understanding of this methodology and determine the differences between pliable logic and existing textile theories.

Softness

In contrast to engineering's 'hard logic', which people perceive it as rational, logical and sensible, with definite figures and theories (Igoe, 2013, p.39), Pennina Barnett introduces Michel Serres's 'box-thought' which Serres believes can be further elaborated into a theory of fabric. Barnett quotes Serres in her writing *Folds, Fragments, Surfaces: Towards a Poetics of Cloth*.

> I believe that there is box-thought, the thought we call rigorous, like rigid, inflexible boxes, and sack-thought, like systems of fabric. Our philosophy lacks a good organum of fabrics.
>
> (Serres, 2015[73], p.196)

Barnett continues to cite Serres' proposal on soft logic.

> Let us learn to negotiate soft logics. […] And let us no longer scorn what is soft.
>
> (Serres, 2015, p.196)

The term 'soft logic' is named by Serres, but Barnett applies this concept to textile properties and asks, 'what if the poetics of cloth were composed of 'soft logic', modes of thought that twist and turn and stretch and fold?' (Barnett, 1999, p.26). She believes that these properties of textiles are not hard and rigid, they are supple and elastic, and move beyond the constraints of binary ideas (either/or), blurring divisions (and/and), offering multiple opportunities and possibilities (ibid, 1999, p.26).

She later incorporates Max Kozloff's citation of Oyvind Fahlstrom's comment on soft sculpture by Claes Oldenburg into her writing.

> …an object that gives in is actually stronger than one that resists, because it also permits the opportunity to be oneself in a new way.
>
> (Kozloff, 1968, p.233)

It is rational to apply soft logic to the majority textiles which contain the features of softness and elasticity. This perspective offers a distinct viewpoint for textile researchers, allowing them to establish a paradigm, claiming a

73. *Rome. Le Livre des Fondations.* French in 1983, English in 1991 and 2015.

space in academic research (Dormer, 1997, p.15; Jefferies, 2016, p.9; Rossi, Campbell and Olding, 2018, pp.29-38). Soft logic provides a platform for textile researchers to explore intrinsic textile qualities and has helped us to interpret textiles from varying perspectives (Hemmings, 2012, p.182).

After Barnett's claim, 'soft' has been widely used by textile practitioners, theorists and engineers. Marte Danielsen Jølbo, both a curator and a writer, adopts soft logic to examine Navajo woven textiles and three contemporary Norwegian textile artists' work[74]. Jølbo reflects that 'materially speaking, a textile is full of contradictions: it is flexible and strong, it can appear both soft and hard, and be geometrical and flowing' (Jølbo, 2018[75]).

Catherine Dormor cites Janis Jefferies's seminar presentation at Manchester School of Art[76] to identify the 'ambivalence' of textiles, which resist bounding and can be seen as the representation of softness. Glenn Adamson talks about 'soft power' in relation to the way in which gravity affects a soft sculpture to become a limp phallus (Adamson, 2016, p.144). This resonates with Kozloff's comment on Oldenburg's soft sculpture creation, *Soft Dormeyer Mixer* from 1965 (Kozloff, 1968, p.231). Amy Winters in her PhD research[77] proposes the concept of building a soft machine (Winters, 2016, p.401). Even though the concept of soft logic is proposed by the philosopher, Michel Serres, and linked to textile practice by Pennina Barnett, 'soft' can still be found in some textile engineering contexts. For example, Morehead, *et al.* (2016) highlight a new design paradigm by coupling material science and design for the purpose of human centred design methodology in the article *The Power of Soft*. Additionally, in *Soft Computing* in Textiles, R. Guruprasad and B.K. Behera specifically use soft logic as a non-deterministic modelling methodology for woven textiles. They cite from P.D. Dubrovski and M. Brezocnik:

> Nowadays, more and more processes and systems are modelled and optimized using non-deterministic approaches. This is due to the high degree of complexity of systems, and consequently, the inability to study them efficiently with conventional methods only.
>
> (Dubrovski and Brezocnik, 2002, p.187)

74. The artists and their works are Elisabeth Haarr: *Strid*, 2015, Ann Cathrin November Høibo:*Untitiled(36)*, 2016, Ann Lislegaard: *Spinning and Weaving Ada*, 2016.

75. The original Swedish text appeared in the exhibition catalogue *Ode to a Dishrag, Hymn to a Tiger–Norwegian Textile Artists 1977-2017.* English translated by Arlyne Moi and published on the gallery website [kunsthallstavanger.no/en/news/towards-a-soft-logic, accessed: 4th Apr, 2018]

76. 26th April 2016. *Caressing Cloth: The Warp and Weft as Site of Exchange* from *The Erotic Cloth*

77. Her research title: *Why does soft matter? Exploring the design space of soft robotic materials and programmable machines.*

Guruprasad and Behera later elaborate the concept into soft computing. They write that a soft logic approach offers 'a flexible means to provide solutions to a wide variety of textile problems with reasonable prediction accuracy' (Guruprasad and Behera, 2009, p.238).

It is evident that there has been a plethora of uses of 'soft'[78] across textile research. However, can soft represent every type of textile manipulation, technology and methodology? Is soft applicable to pleats and pleating?

At the beginning of my research study, I looked to textile thinking as a tool with which to try and understand what was happening in the process of pleating. The concept of pleats and pleating could not be fully developed by the notion of 'soft logic' as it has been articulated. It did not seem to do enough work when applied to pleating. I realised pleating is an action, movement, and structure, which is very different from soft logic, insomuch as soft logic focusses on the supple character of textiles. It is undeniable that the most common material for pleating is soft textiles, and soft logic may well serve the purpose of understanding those properties. However pleating practice, as outlined in *Chapter 3: What is a pleat? What is in a pleat? What do pleats do?*, also emphasises the repetitive action of making, the space between surfaces, and the structure of pleats.

In order to see if there was a way in which soft logic could become more applicable in terms of the repetition of action that is needed to form a pleat, we could look to Yve Lomax's 'baker's logic'[79]. In *Folds in the Photograph*, Yve Lomax proposes baker's logic, which she also derives from Michel Serres', in his description of how a baker kneads dough (Serres, 2015, p.69). Lomax intends to challenge the 'either/or' binary logic in thinking, and proposes a model in which there are a multiplicity of layers. 'I wanted binary opposition to find itself breaching itself and there become exposed to multiplicity and the uncontainable' (Lomax, 1995, p.51). Through continuing kneading a dough, the baker 'stretches it, spreads it out, then folds it over, then stretches it out and folds it over again' (Serres, 2015, p.68).

78. Soft gallery in Oslo, Soft Picture exhibition at Fondazione Sandretto Re Rebaudengo, Turin in 2013.

79. Barnett states that she benefits from Yve Lomax writing in the Notes after the article *Folds, Fragments, Surfaces: Towards a Poetics of Cloth*.

Nevertheless, I do not think baker's logic, as part of soft logic, can serve pleating even though it contains movement. This is because, according to Lomax, the dough does not maintain individual surfaces as they all become one after each kneading, showing no structure and losing the surface of the folds in the dough. Every time when a dough is kneaded, the surface is joined together and dissolved within the whole. I believe that the surface is an important feature of pleats which cannot be neglected, and that 'dough logic' may diminish this important character as we try to better understand what a pleat is.

Soft logic and baker's logic encompass softness and physical action, however what makes pleats and pleating so distinctive from other textile formations is the structure and the order of back and forth pleating actions. This repetition is a clear sequence and leads to the second element of pliable logic: recursive sequence.

Recursive Sequence

The second property of pliable logic is the sequence that is generated by a pleating action to create pleated forms.

This section introduces two types of sequences, the first is modelled on 'think-speak-write', Sarat Maharaj's interpretation of Janis Jefferies' creative route, as a model to show how this study connects various aspects of research together; the second is a helical sequence borrowed from an action research methodology and describes the analysis of one project cycle to the progression of the whole research.

- Make-Think-Write sequence

Pleaters need to follow a certain order when pleating. It sometimes begins from a valley fold, is followed by a mountain fold, then a valley fold, and then back to a mountain fold; or, it can follow a sequence in which all the mountain folds are made before folding valley folds (see Fig. 5.2). The sequences vary depending on the pattern and the pleaters' intuition. This "… should not be understood as a divisive process, but rather as a continuous movement of folding, unfolding, defolding, enfolding, and refolding" (Smelik, 2014, p.49). The back and forth recursive process of folding can itself be seen as a way of thinking about research processes. This recursive structure, as part of pliable logic, resonates not only to the tangible pleated structure, but also to my creative process of doing research. (see Fig. 5.3)

Sarat Maharaj concludes that Janis Jefferies practice of bringing theories and making together begins by visualising theories, she "opticalizes" them and "thinks" for the possibilities to join them together. Maharaj describes Jefferies' voice and narrative as soft, persuasive and concise, which makes her unignorable when she "speaks". In the end, she "writes" down her experiences of textiles from different perspectives, including that born from her education, and with a focus on feminisms (Maharaj, 2000, p.8). Maharaj articulates a sequence: think-speak-write, which expresses stages in a research process, and as a textile artist I am able to form a discourse based on this.

This knowledge formulation process can also be seen in Nigel Hurlstone's essay 'Speaking up for Silence'. Hurlstone reflects on Tamsin Casswell's creative practice. He relates her creative process to Colette's description of her daughter, Bel-Gazou, where the act of stitching is inseparable from the act of thinking (Hurlstone, 2012, p.149). Casswell, Hurlstone argues, then writes down her thoughts and then speaks them out directly (ibid, p.150). I would say that this knowledge generative process can be considered as a 'stitching(thinking)-writing-speaking' process.

These sequences are how textile practitioners accumulate their tactile knowledge and textile thinking emerges from this process. The identification of these sequences encourages me to examine my own creative process.

I tend to begin from making as a precursor to thinking. I make to lead the direction, as I believe intuitive and bodily knowledge can pave the way. I do not anchor the questions at the start of my research process because the making raises questions itself. When the making is complete, I deduce the possible questions. I rethink my works through reflection on my research questions. This process is critical, as new interpretations and analysis are generated during this stage. I then write down my thoughts to formulate a proposition. The writing process is not a static condition. Thinking and writing are reciprocal and symbiotic. My textile thinking path can therefore be summed up as: make-think-write repeated sequence.

Moreover, when I review my research path, it is not a straight-forward trajectory in the way that 'make-think-write' implies. The research process rarely proceeds in a rational, clear order (Watson, 1968, Preface). It is usually very chaotic and opportunistic. It is common that researchers move between different ways of inhabiting the research depending on the situation at any moment (Cross, 2006, p.84). Instead of following a predetermined and logical path, researchers have to adapt to ever changing conditions. I oscillate between make, think and write depending on the research context. This oscillation can be drawn as a zig-zag creative process; a recursive route (see Fig. 5.3).

Pliable logic is a methodology that incorporates both practice and theory. One element of pliable logic is the process 'make-think-write', which can be understood as the overarching structure of the total body of this research. Within this overarching structure there are interior research cycles, which I will now go on to describe.

- Helical sequence

The helical sequence describes the research path within separate elements of the total body of research. My thoughts oscillate between theories and maker's knowledge. The route is like the back and forth of pleating itself.

Mc Neill *et al.* (1998) propose a process for design practice. They state that a '…designer cycles between the three activities of analysing the problem, proposing a solution or partial solution, and evaluating a proposed solution' (Cross, 2006, p.87). Bruce Archer proposes a similar process: conjecture and hypothesis at the start of the research, handling the data or argument during the process, and analysing the findings and interpretation of the result of the research (Archer, 1995, p.8). I summarise these research cycles in Fig. 5.4.

From an action research perspective, Stephen Kemmis (1981) proposes that a design cycle should contain four steps: plan, act, observe and reflect (O'Brien, 2001, p.3). This cycle has been augmented by David Hopkins (1985) to create a continuous cycle in which 'reflect' leads back to 'plan' and so on. Kemmis and McTaggart (1988) name this self-reflective cycle: 'action research spiral'.

I followed this spiral to conduct my textile experiments and creative works, and gradually discovered that my research journey follows a repeat circuit. Through each experiment, I obtained new knowledge which led me to the next project.

After I visualised the structure of my research journey, it appeared like a pleated structure, with back and forth repetition (see Fig. 5.5). Furthermore, I noted that as the research develops, the progression of the design cycle narrows in focus as it reaches its apex. On this discovery, I realised that the pattern of my research journey was already latent in my study and had become my research methodology. The helical pattern resonates with the pleated fabric, the source of pliable logic.

Examining the research cycle (see Fig. 5.4) in more detail and thinking about the linear order: research question, aim, making/experiment, evaluation, I became sceptical about this theorised order. When I reflect on my real making experiences, I do not see them aligning so smoothly with what is proposed. In *Designerly Ways of Knwoing*, Nigel Cross states that sometimes it is important to include some freedom, to deviate from the planned structure, as this may help designers to obtain a better result. Cross quotes from Gerd Fricke (1996) who found that designers tend to generate a better solution if they can follow a 'flexible-methodical design process' (Cross, 2006, p.87). It is to be expected that there are many unpredictable components that will happen during any given making process. Conducting project-led research requires agility, a bendable and pliable approach to decision making (Albers, 1944, p.22).

Reviewing my creative process step-by-step I discovered that as a maker, I revisit decisions several times before any final validation and evaluation.

This can happen more than once in a cycle. It is usual that during making, designers or makers face changing circumstances, such as material scarcity, machine malfunction, financial issues, which force them to go through more than one decision making process before entering the evaluation stage. My understanding of the creative process aligns with Willemien Visser's observation that original plans are only followed until there is a 'cognitive cost' that renders them reductive. He points out that designers will alter plans to fit the most profitable situation as the project progresses (Visser, 1989, Abstract). This cognitive cost is also recognised by Raymonde Guindon. She believes '…designers find it advantageous to follow a train of thought temporarily', which gives ways to the opportunistic nature of design activities (Guindon, 1990, p.333).

Through examination of my own practice and an acknowledgement of the effect of Visser's 'cognitive cost', I propose that a design cycle can be illustrated as a circle in a circle, like a fold in a fold (see Fig 5.6).

The research develops through time and can be described as a helical structure with different stages within each practice. Designers reflect on their making at each stage.

Within each level of the helix, there is already an evaluation, research question and aim. Figure 5.7 shows this evolved structure.

The analysis of my research journey, adapted from Sarat Maharaj's creative sequence, and reshaped via Mc Neill, Gero and Warren, establishes the fundamental structure of my research. The helical structure of research is analogous to a set of pleats, one fold giving rise to another, folding with a fold. The genesis of this structure echoes Gilles Deleuze's concept of '*plica ex plica*' (every fold originates from a fold) which I will further explain in the next section.

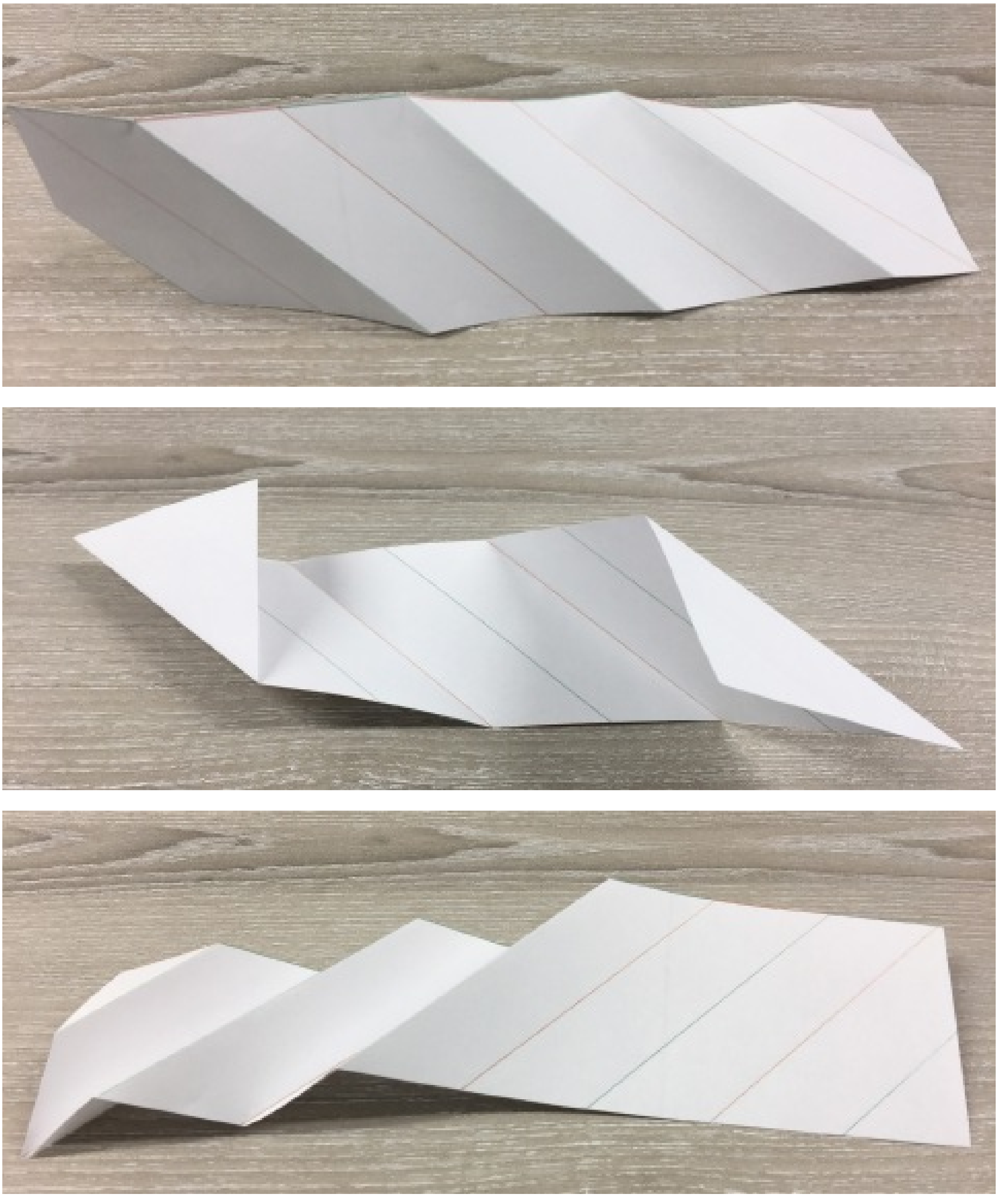


Fig. 5.2 Folding sequence between mountain/valley lines can be inferred as a recursive sequence.

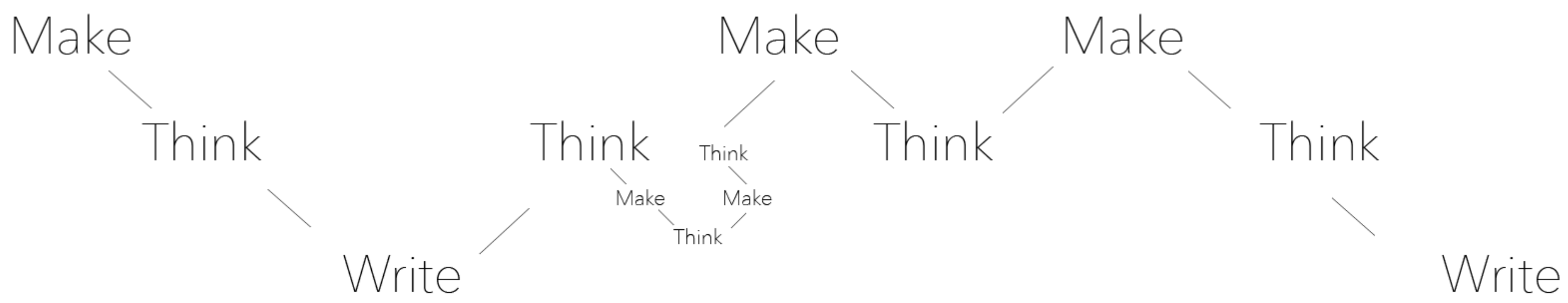


Fig. 5.3 Tsai-Chun Huang Recursive creative route (2017)

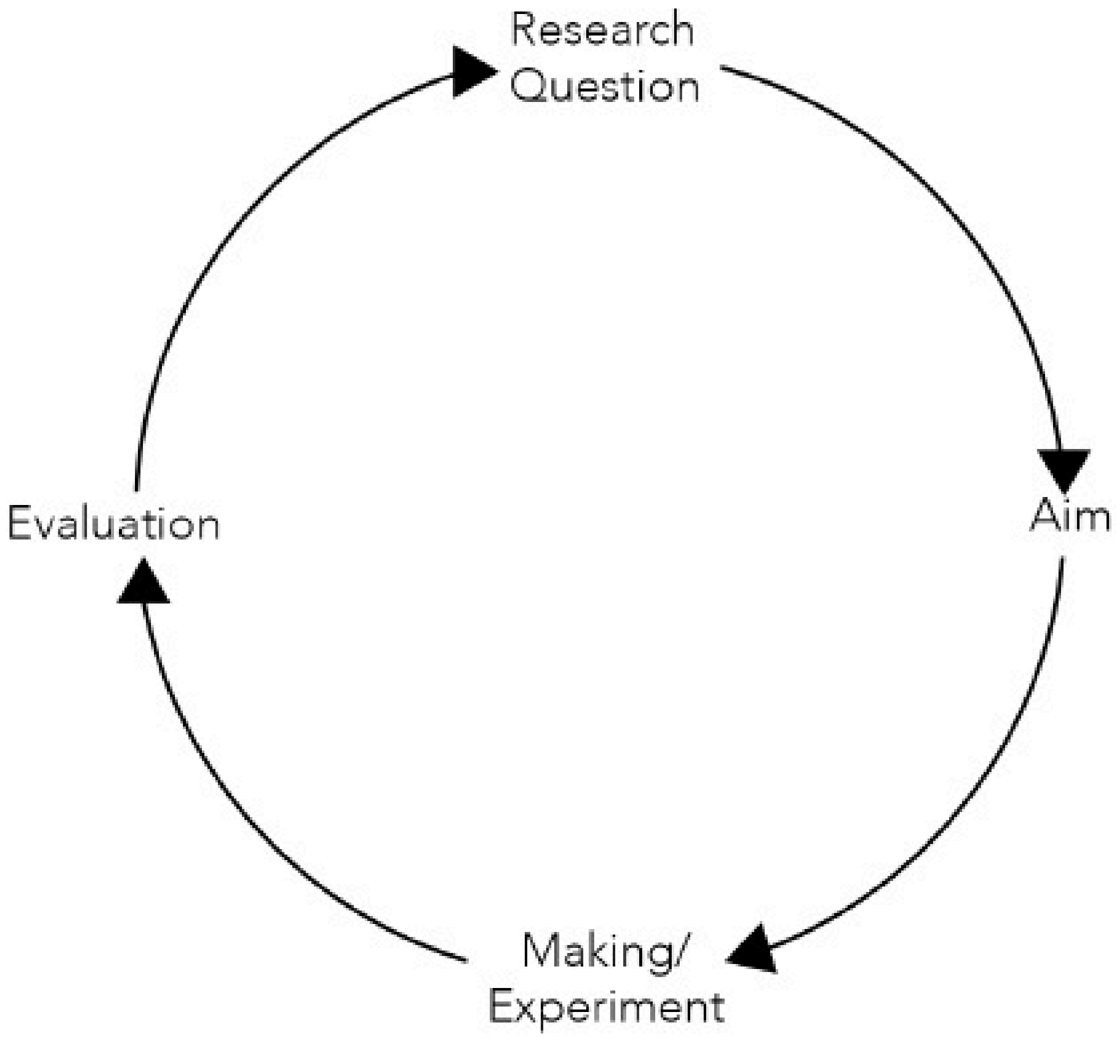


Fig. 5.4 Research Cycle (2016)

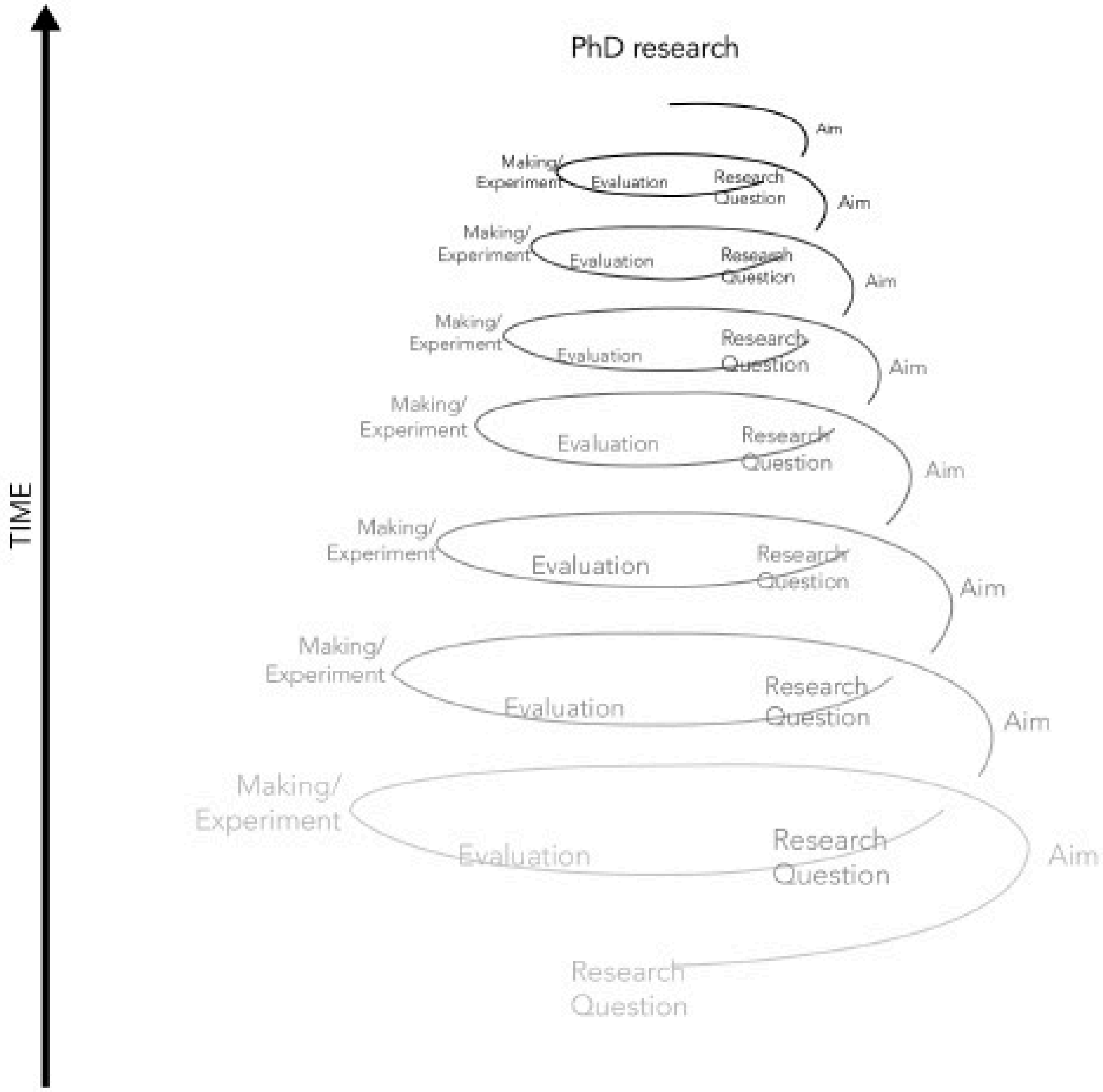


Fig. 5.5 Helical structure for research (2016)

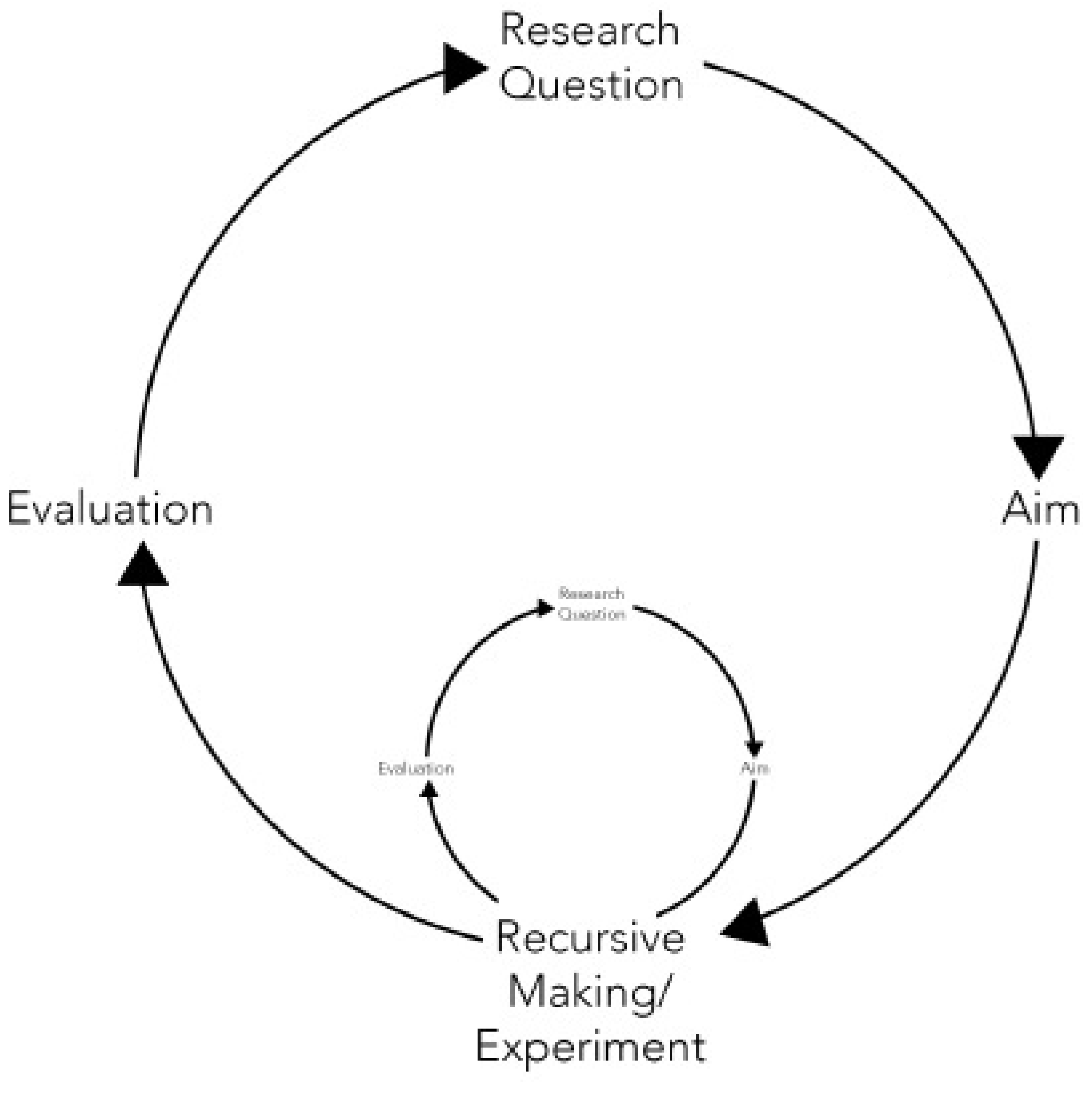


Fig. 5.6 Cycle within research cycle (2018)

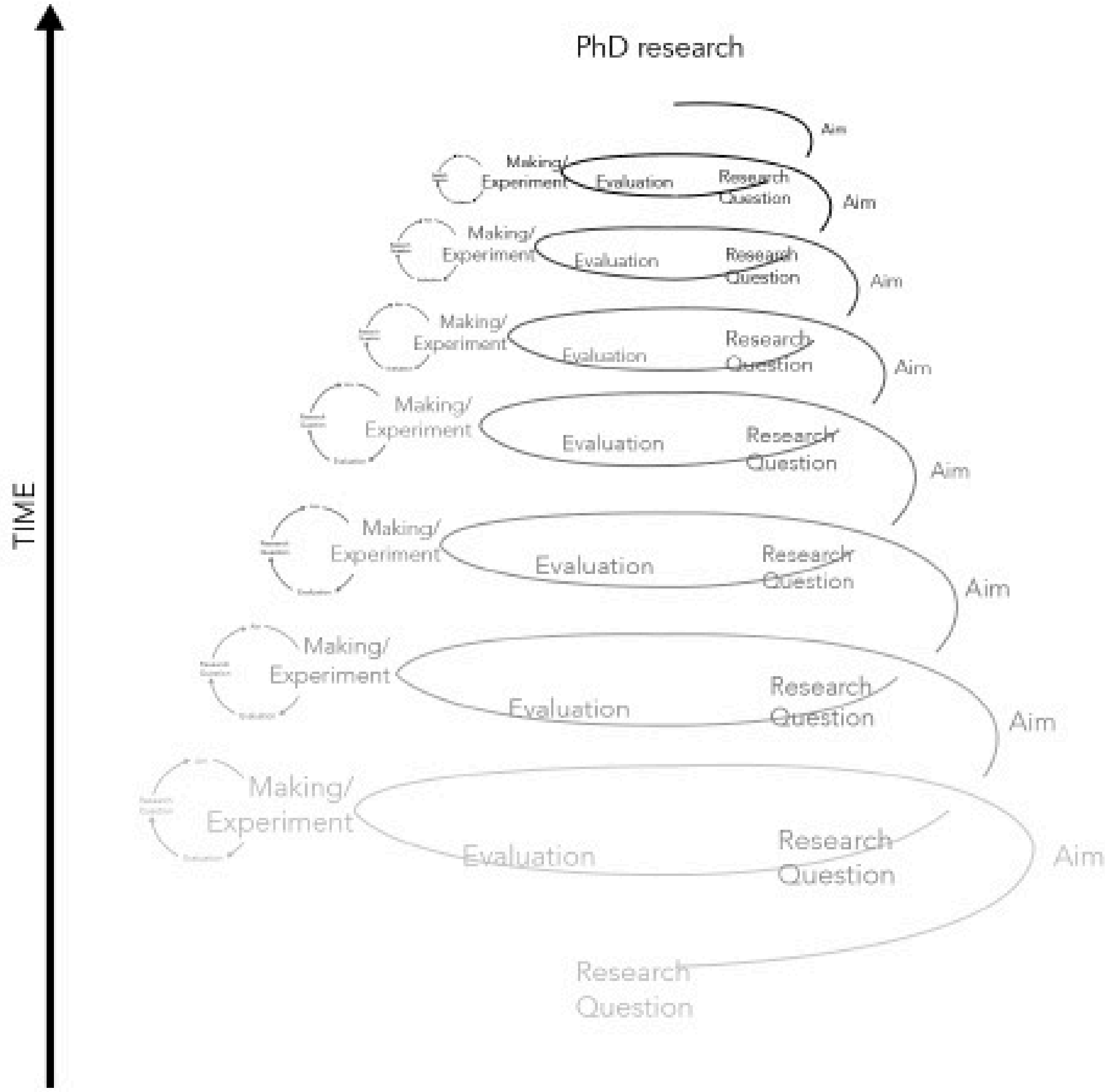


Fig. 5.7 Helical structure for research (2018)

Plica ex plica

The last element of pliable logic is '*plica ex plica*', from the Latin, literally 'fold from fold'. This concept, adopted from Gilles Deleuze, can make a new contribution to textile thinking. I propose that '*plica ex plica*', the model of forming pleats, can be used as a way to interrogate the relationship between theory and practice. The 'fold from fold' draws attention to the space in-between folds, the fold in the fold, and this 'in-betweeness' (see Fig. 5.8) becomes a space for conceptual investigation.

- Fold from Fold

In the first chapter of *The Fold: Leibniz and the Baroque*, Deleuze proposes two different means by which pleats can be thought to generate. The first is through 'epigenesis', a process in which the pleat 'is pushed up from a relatively smooth and consistent surface' (Deleuze, 1993, p.10). The second is through a process of 'preformism':

> [W]ith preformism an organic fold always ensues from another fold, at least on the inside from a same type of organization: every fold originates from a fold, *plica ex plica*.
>
> (Deleuze, 1993, p.10)

I visualised this second means of pleat formation – preformism – and made a pleated sample (see Fig. 5.9). I began with a common pleating pattern, knife pleats, and inserted six extra pleats to create a '*plica ex plica*' structure (see Fig. 5.10). These extra pleats grow the number of in-between spaces within the layers of fabric. This study wants to consider these tangible spaces as theoretical spaces for emergence of new thoughts (see Fig. 5.11).

Before I encountered this concept of '*plica ex plica*' I considered pleating in terms of functionality and fashion aesthetics. The theoretical frame gave me new understandings of what a pleat is and what it could be. I used the theory as a way of creating new pleating structures and in turn tested the theories by making. This oscillation between theory and practice has become the working pattern of my research methodology.

- Unfold

Barnett introduces the Deleuzian fold as "an image of conceptual space, a mental landscape" (Barnett, 1999, p.26). Extending the idea of the fold as concept, she goes on to write,

> New concepts unfold in ways we cannot anticipate, and bring into consciousness significant or important events.[80]
>
> (Ibid., 1999, p.26)

Barnett uses the term 'unfold' to show how new thinking is revealed. I can imagine that when the pleats are unfolded, new concepts are revealed, layer by layer. The folds themselves are, somehow, layers of concepts. The pleats lay ideas together which when unfolded, can be examined and explored. My approach is to bind various concepts in the pleated structure to conduct my research and to acquire new knowledge. Through different ways of pleating, one concept on the plane can join another concept, and different ways of pleating can suggest distinct new knowledge. Through pleating, planes meet other planes just like ideas meet ideas. This is the process that helps new thought to emerge (see Fig. 5.12).

This research project adopts a range of conceptual ideas and my task is to pleat them, to lay them over each other, in order that their combined effect is greater than any single component.

The pleated surfaces touch each other, leaving '*plica ex plica*' space for inquiry. In *Toward a Soft Logic*, Marte Danielsen Jølbo comments on how Rosalind Krauss develops new perspectives from an in-between space:

> …it was precisely in-between the marked positions of sculpture, landscape and architecture that she saw the possibilities for other art forms and the understanding of them.
>
> (Jølbo, 2018)

Jølbo is identifying a space of creative possibility in-between dominant cultural forms of artmaking. An analogous space of creative and conceptual possibility is the '*plica ex plica*' space, the space between folds, which

80. 'Introduction', in Paul Patton (ed.), *Deleuze: A Critical Reader*, Blackwell, Oxford, UK and Cambridge Mass, 1996, p.13

generates new thought. Depending on approaches and the number of surfaces folded, this action can create various outcomes for new knowledge. Catherine Dormor proposes the space of the 'fold' and the 'seam' as ones in which textile thinking emerges. She states that in these methodological models "practice and theory, practice and practice, and theory and theory come together" (Dormor, 2012, p.21). Rachel Philpott writes:

> While tangible folds may have been the catalyst for physical and theoretical evolution it is dynamic thought that has endeavoured to actively fold materiality and concept together into a cohesive whole more profound than the surface appearance of the physical fold.
>
> (Philpott, 2011, p.43)

I began to reflect on how I have merged making and theory into pleated structures. I illustrate my recursive process and examine closely how I reached each step. When I draw the figure for the recursive creative path (see Fig. 5.3), I become aware that it is a zig-zag folding route with '*plica ex plica*' space in-between each stage rather than a smooth linear process.

The newly revised research cycle (see Fig. 5.13) shows that the process is a little bumpy for researchers. Moving from aim to experiment, for example, I undergo several folds, a zig-zag path of turning thoughts. The conventional model of research hypothesis defines a smooth path as articulated in a perfectly planned proposal. However, from my experience this is rarely the case. But it is in the turning zig-zag '*plica ex plica*' spaces in-between concepts that new thoughts emerge.

Later, I closely examined each stage and reflected on the thinking that pushes me to make a turn. The detailed figure of a section of the research cycle, is an example which attempts to show how I oscillate between different notions before arriving at the next design stage (see Fig. 5.14).

The above-mentioned premises of 'softness', 'recursive sequence', and '*plica ex plica*' form a new contribution to textile thinking: pliable logic. In *Chapter 6: Pleating Practice (ii) New Technology*, I utilise pliable logic to examine my pleating practice in relation to the creation of a new pleating techniques and two dance works for which I made the costumes.

Fig. 5.8 In-betweeness in the pleats gives spaces for '*plica ex plica*'.

Fig. 5.9 Tsai-Chun Huang
Plica ex plica (2016)
Pencil marks and cotton calico 20 x 50cm

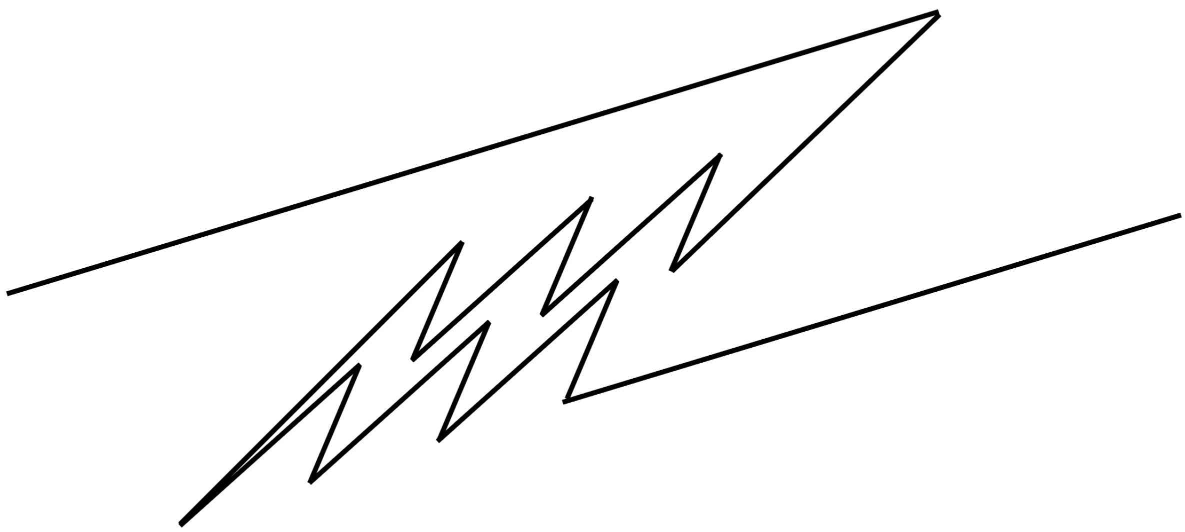


Fig. 5.10 *Plica ex plica* structure

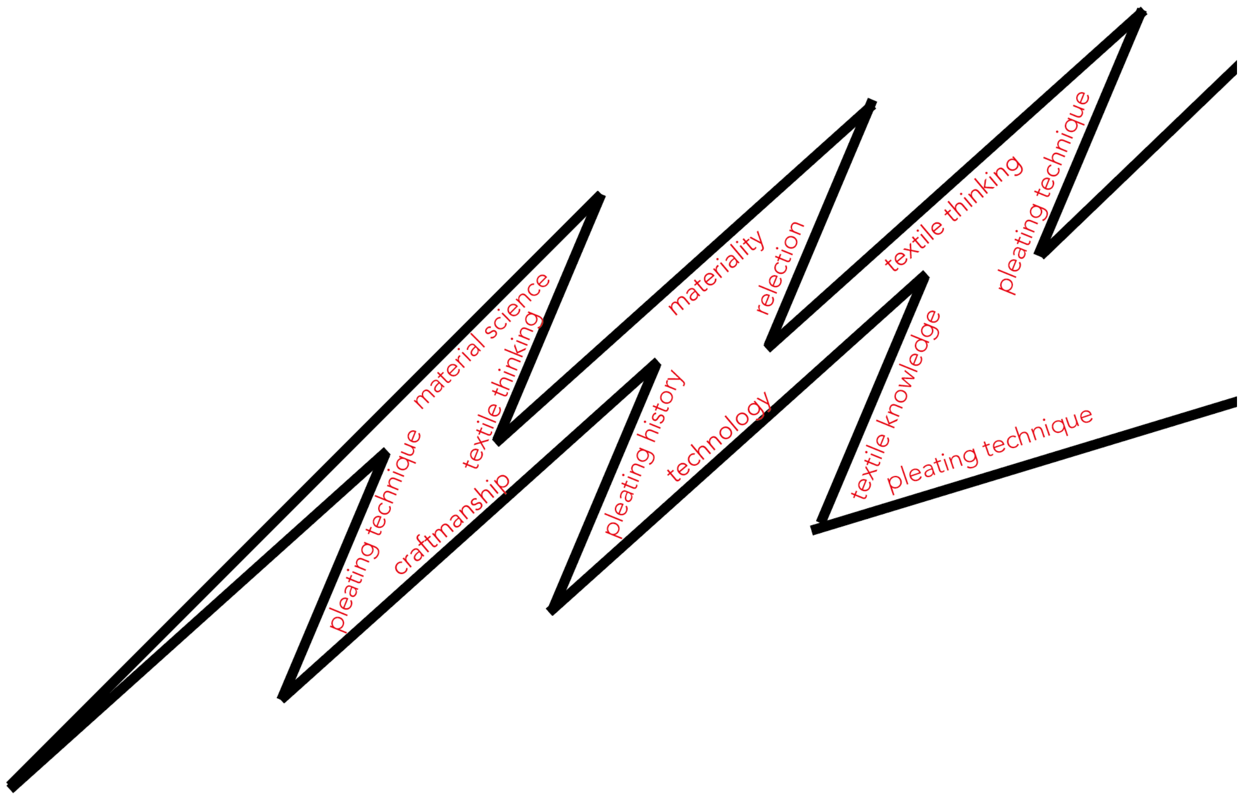


Fig. 5.11 There are concepts in the folds.

Fig. 5.12 Colours touch each other in response to different folding pattern and can be understood as various concepts meeting.

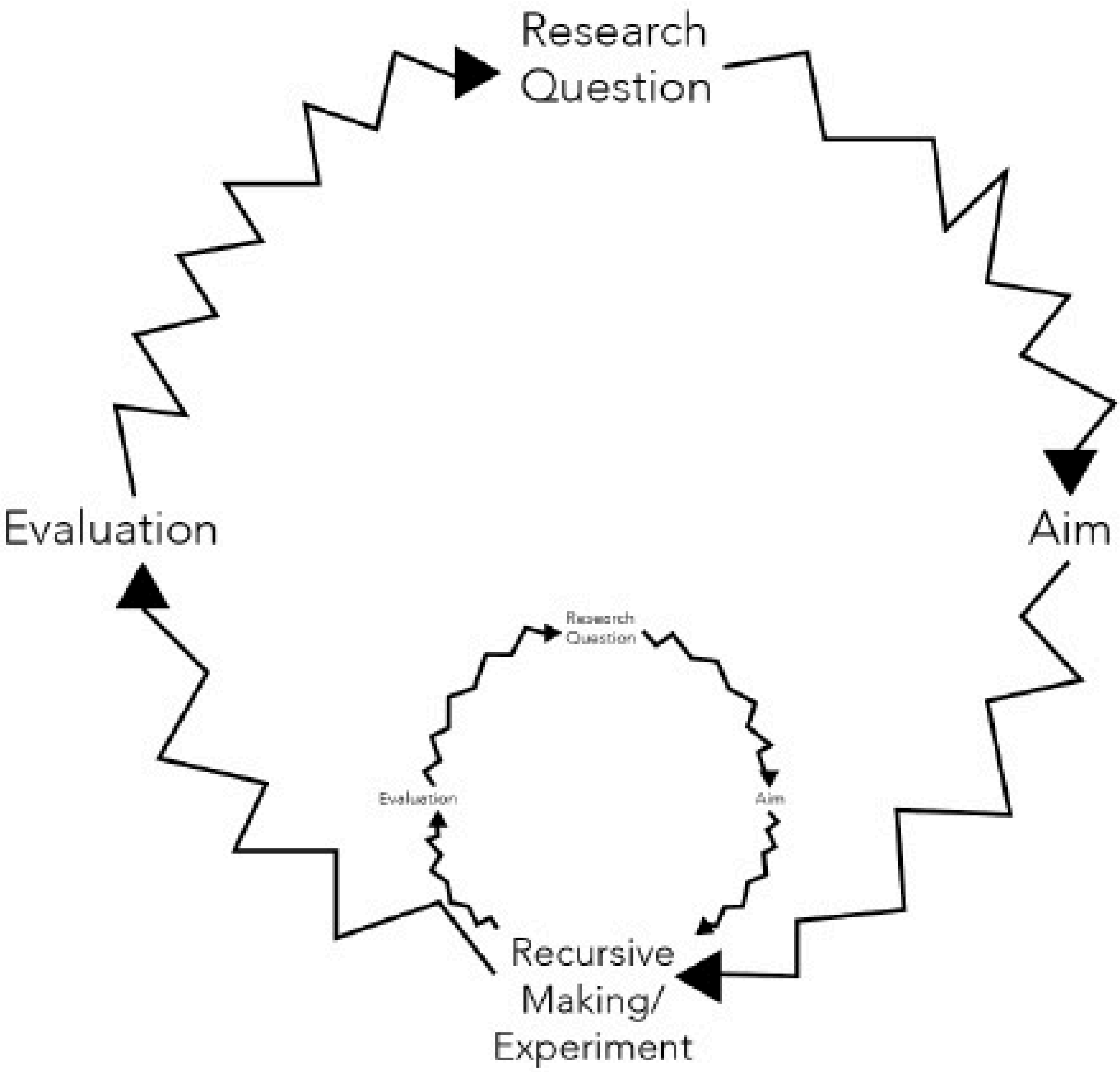


Fig. 5.13 Tsai-Chun Huang
Research cycle (2018)

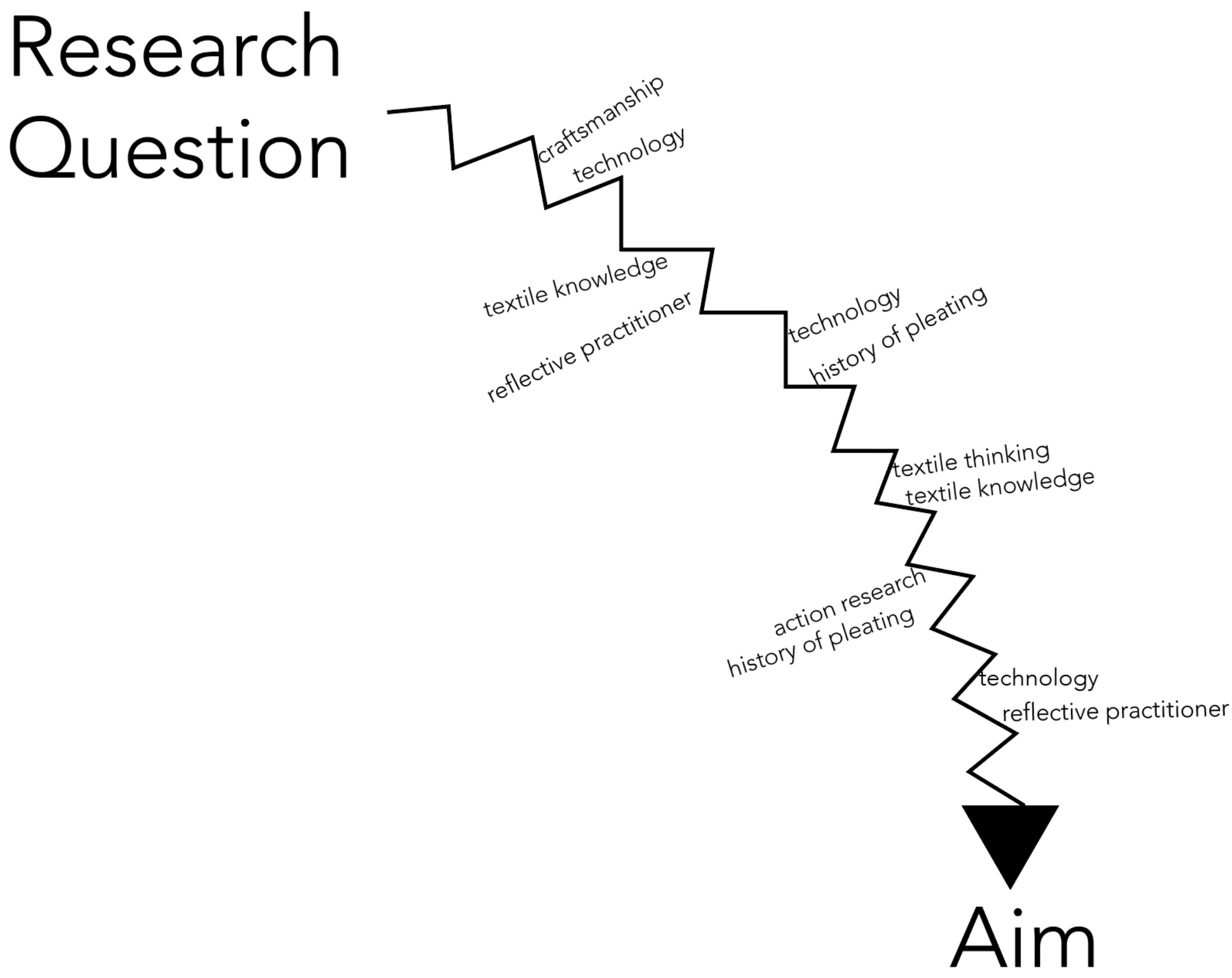


Fig. 5.14 Tsai-Chun Huang
Research cycle (2018)
detail

06

PLEATING PRACTICE (ii) NEW TECHNOLOGY

This chapter introduces two redevelopments of pleating techniques. The practical application of the results of these techniques is tested in two separate dance productions.

Claire Pajaczkowska points out that folds can be well examined in the time-based medium of film, which shows the textile in movement (Pajaczkowska, 2016, p.89). Observing the movement of textiles is perhaps even more crucial in the context of pleating, where the remodelling mechanism between 2 dimensional plane and 3 dimensional form takes place in action. My background as a costume designer, where my concerns focus on the relationship between garments and actors' movement on stage, comes into play here.

The first redevelopment is of paper moulds to fabric moulds in the hand pleating procedure, which has the effect of making pleating accessible in domestic situations. The second redevelopment is of the process itself, by adopting 3D printing technology to produce innovative forms of pleats which interrogate the definition, and the functions of pleats.

Both redevelopments and the case study dance productions which test results, follow the structure of pliable logic. The research cycle begins with a research question and then defines an investigative aim which gives rise to an experiment. In the next stage the experiment makes a zigzag path, oscillating between recursive making and reflective thoughts. There then comes a reflection on the whole, in relation to the research questions: What is a pleat? What is in a pleat? What do pleats do?

PROJECT 1

FABRIC MOULDS

After working as a technician at Ciment Pleating I endeavoured to replicate Issey Miyake's 'inversion process' in my studio, using the steam from a domestic iron. When the paper moulds were opened (see Fig. 6.1) it became apparent that the materiality of the paper prevented the steam from reaching the fabric when steaming from the outside of the moulds. The results were unsatisfactory. The edges were soft, different from the sharp creases I produced in Ciment Pleating. The difference between the two, encouraged me to examine the roles steam and moulds play during the pleating process.

Research Question

Pleating is a process of destruction and reconstruction. The fabric needs to be damaged and rebuilt by the steam. I began to examine the process and to rethink how professional technicians pleat. At Ciment Pleating, after placing fabric in between the paper moulds, they then either roll or contract the mould into a tube, or squeeze it as much as they can. Temperature and pressure are two important factors to consider when pleating.

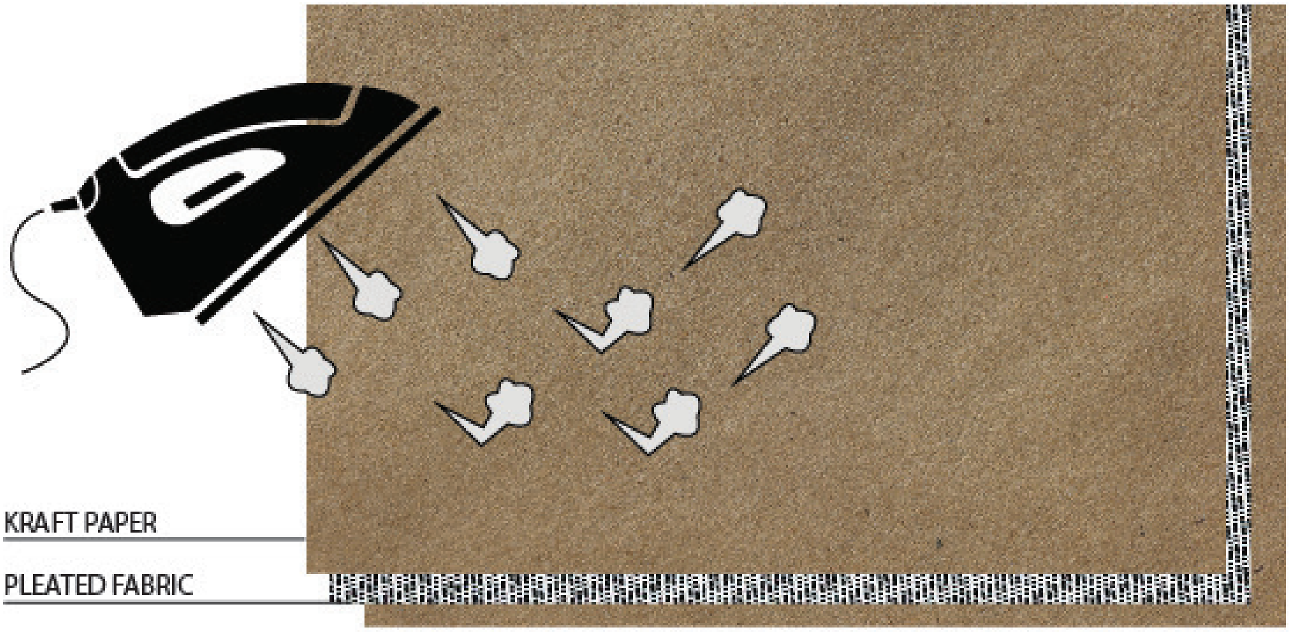
I started to reexamine my own pleating process, and I could confirm that, as for pressure, the moulds I was using were already compressed with batons and ties in the same way as the pleating studio. As for temperature, the steam is naturally 100°C. I began to wonder: if these two elements are fixed, what else can be done to improve the pleating result? What choices do I have to change the production result? If I do not have professional steamers, how can I optimise the pleating outcome with the use of steam from domestic irons?

Aim

If the ultimate goal is to force the steam to damage the fabric and rebuild the texture, the moulds need to easily allow for steam to reach the fabric. During the steaming process, the kraft paper moulds actually prevent the steam from reaching the fabric that needs to be pleated (see Fig. 6.2). As a result, I came up with the idea to create a woven cotton mould that naturally contains space between wefts and warps, so that the steam can easily penetrate the moulds and reach the pleated fabric (see Fig. 6.3).

In addition, from the experience of creating *Cubic Wallpaper* (2015) in which I used interfacing to support a calico pleating form, I became aware that woven cotton fabric can be temporarily fixed by steaming (see Fig. 6.4). This temporal memory function could be very helpful as a moulding tool. I can manually manipulate the structure and apply steam to temporarily stabilise the forms. This process could help to reconfigure other textiles.

Fig. 6.1 Taking *Inversion Top* out from the kraft paper moulds. Video still: Opening paper moulds (2015), video by Tsai-Chun Huang (00'53")



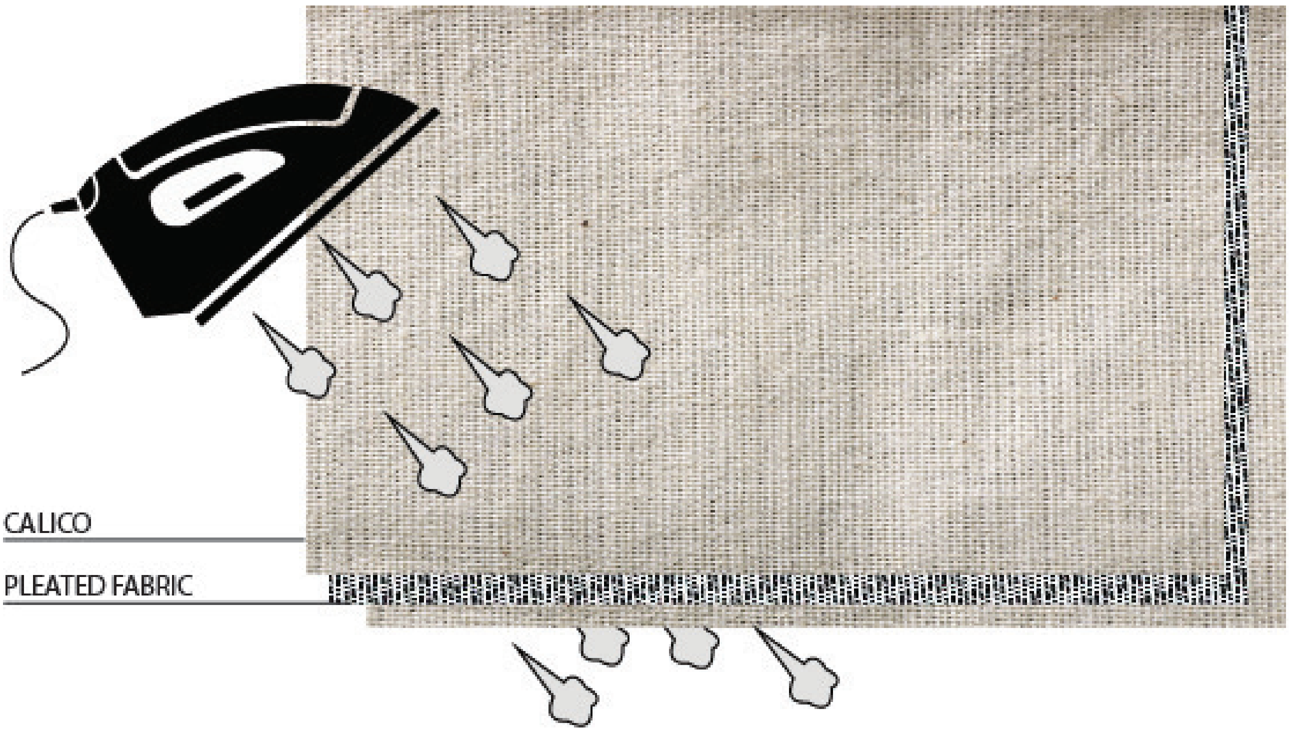
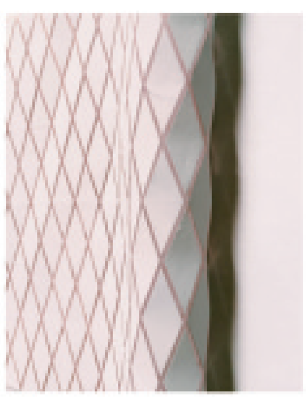


Fig. 6.2 Kraft paper mould pleating prevents steam from reaching the pleated fabric.
Fig. 6.3 Fabric mould pleating allows steams to reach the pleated fabric through the weft and warp.

Recursive making	Reflective thoughts

Kraft paper prevents the steam from reaching the fabric. How can steam easily penetrate the moulds?

Searching for materials that allow steam penetration.



The substrate has to have the capacity to be pleated in order than it can be both flat and 3 dimensional.

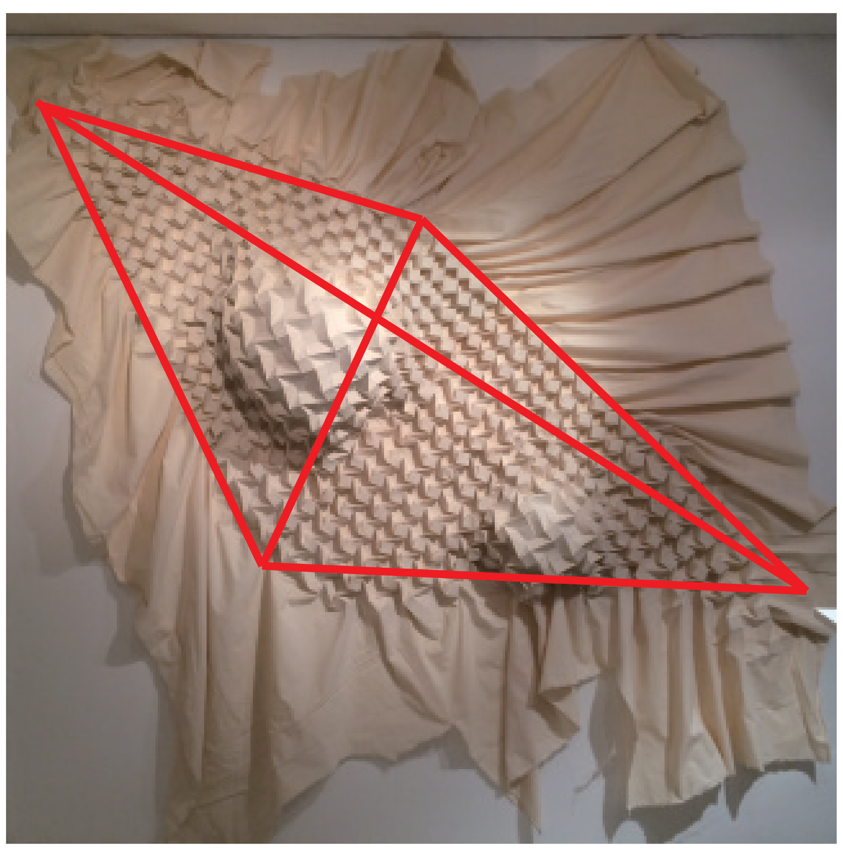
Visit RCA 2015 Graduate Show and saw a piece by Alicia Nader.

Woven fabric naturally contains space between the wefts and warps, and this space allows steam penetration in the way I was searching for. Alicai Nader's work reminds me of my *Cubic Wallpaper*.

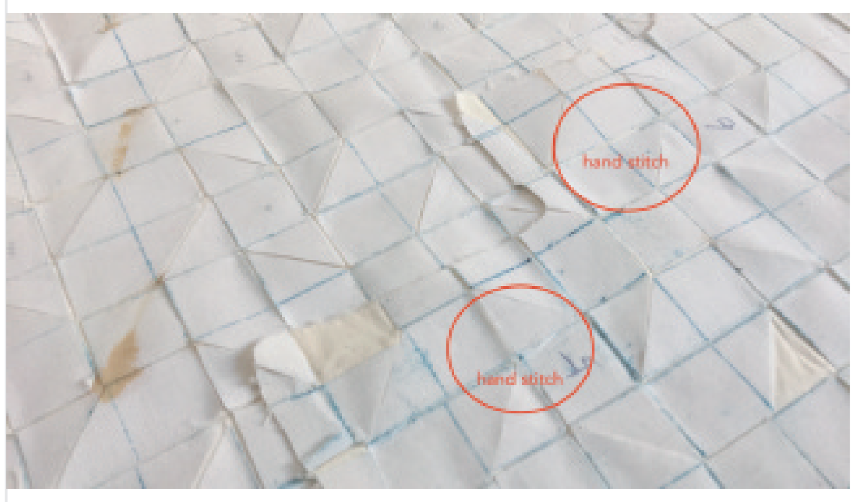
Examine my work, *Cubic Wallpaper.*

Remembering making *Cubic Wallpaper*, I observe that woven cotton fabric can be temporarily fixed by steaming. This temporal memory function could be very helpful as a moulding tool. I can manually manipulate the structure and apply steam to stablise the forms. This process could help to configure other textiles. Why not modify the calico pleats into fabric moulds?

How would such a mould be constructed? In analysing the orientation of *Cubic Wallpaper* and I observe a diamond shape.



If I divide the diamond with a cross in the middle, I will acquire four right-angled triangles which can make up to two squares when I join the legs. These two squares could become the moulds.



Divide the diamond shape *Cubic Wallpaper* with a cross in the middle. Stitch the long legs of two right-angled triangles to form a piece of square sheet.

The seam lines do not have supporting material to form calico pleats. I can cut extra interfacing to fill the gap.

Cut extra interfacing in three basic forms, square, triangle and trapezoid, and then iron them on to the joint edges to complete two squares. *Cubic Wallpaper* has been turned into two 140cm by 140cm moulds.

I should be able to use this mould in a similar way to a kraft paper mould.

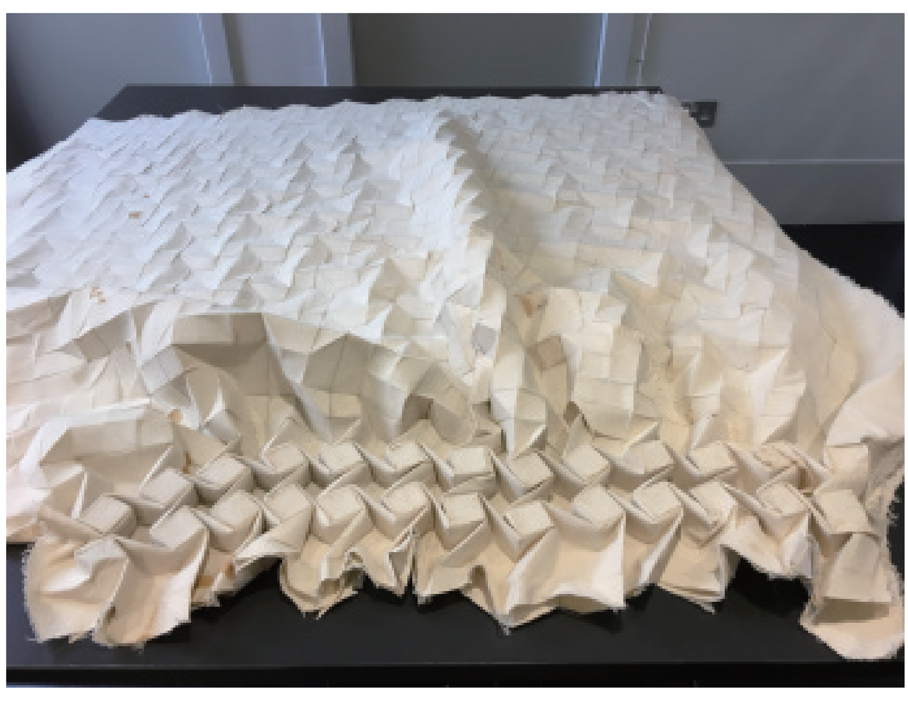
Flatten the bottom layer of the mould.

Fabric mould does not need to be clamped in the same way as paper because fabric does not contract when laid flat.

Place garment on top of the bottom mould.

The alignment needs to be considered in the same way as for a paper mould in order to obtain the ideal outcome.

Carefully put top layer mould on top of garment and align the edge with bottom layer mould. The fabric mould is ready for pleating. Start from one corner and steam with a domestic steam iron to temporarily fix the pleats. Place weight on top of the mould.



This stage is different from Ciment Studio practice as they put on weights before pleating the fabric while I move one weight along the garment during the steaming process.

The weight does not need to remain in place for long. It is moved along with the progression of the steaming process.

This is because cotton fabric can be temporarily fixed by steam so the weights are not required.

Gradually pleat the whole piece.

The pleating process takes more time than it would using a paper mould since I need to manipulate every pleat separately. By contrast the paper mould contracts as a whole.

Tie the mould with sticks and strings.

The tying is to secure the mould so that it will not fall apart during transportation to the extractor fan bed.

Use iron to steam the moulds with the extractor fan underneath to draw the steam for 20 mins.

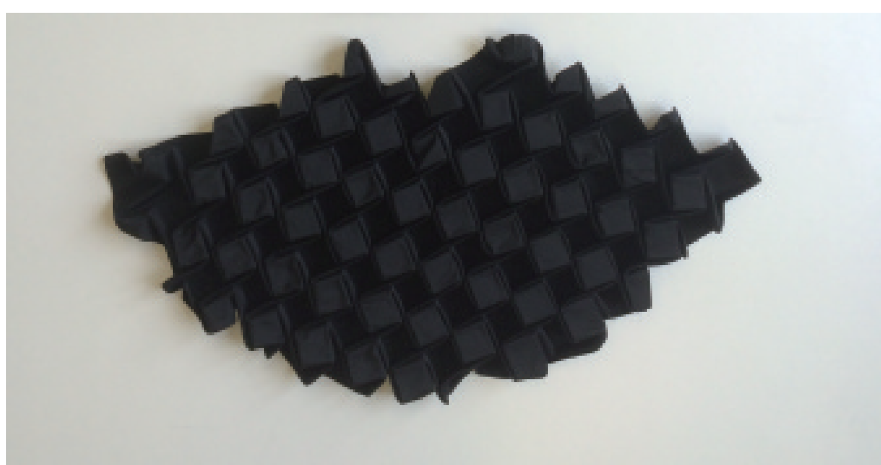
During the steaming process, be aware that the steam is applied to every pleat. I need to match the total time of 30 mins steaming at each point in the fabric as Ciment Pleating would. This will mean a greater overall steaming time as not all of the mould can be exposed to the steam at any given time.

Flip the mould to the reverse side and steam for another 20 mins.

I am afraid the steam will not reach the bottom of the pleat because my cubic pattern is 3 cm deep. This problem will not occur if using profession steamer.

The fabric moulds are left to cool before opening.

Usually moulds are left for 30 mins to cool. Perhaps I should leave the moulds overnight to completely cool.



Open fabric moulds and take out the pleated garment.

The pleated garments are precise, with sharp edges. The outcome is better when compared to the paper mould process.

Fig. 6.4 Cotton is temporarily fixed by steam

<u>Reflective Evaluation</u>

What is a pleat?

<u>Valley and mountain lines and surfaces</u>

Through the process of converting *Cubic Wallpaper* (2015) into a fabric mould, I realised that a pleat is actually a composition of two types of folding line (valley and mountain) and surfaces. It is these creases that make a 2D flat plane into a 3D structure.

This analysis of the composition of pleats is better investigated by examining moulds rather than the pleats themselves. This is because the moulds and moulding process produce pleats, and consequently the properties the moulds carry, such as expandibility, reflect the essential elements that pleats require.

In order to produce an effective fabric mould with better accuracy and less labour, I tried to advance the technique by ironing a whole piece of interfacing onto the calico mould first, and then laser cutting the interfacing into the three types of shape, peeling off the necessary gaps between shapes to create folding lines which would allow steam to penetrate the moulds. However, the trial showed that it was very difficult to laser cut the interfacing after it was bonded with the calico (see Fig. 6.5). The interfacing was also hard to remove.

Searching for a better solution to achieve the same affect, I came across a geometric pattern designed by Alicia Nader in Royal College of Art 2015 MA Graduate Show (see Fig. 6.6). Nadar was concerned with creating geometric patterns on flat textiles (and not with pleating) but I saw in her design the potential for creating a new form of pleating mould. Nadar screen-printed fabric with a heavy paint and then used a devoré technique to create pattern lines. Inspired by her process, I consulted the college printing technician. She explained that a layered geometric pattern could be achieved more easily with textile vinyl, a type of thermal adhesive material. Textile vinyl can be easily purchased and cut by machines according to plans in digital files.

I understood that this could be the technique I was looking for. I built the digital file for the Cubic Pattern and had the vinyl cut accordingly. After the machine cutting, the mountain and valley folding lines were peeled off before the vinyl was heat pressed onto a piece of calico. Only the cut shapes that stood for the surfaces of a pleat were transferred to the substrate.

The moulds need to permit the maximum amount of steam at the valley and mountain folding lines to reach the fabric to form a firm pleat. Therefore, loosely constructed cotton gauze was the testing material for this stage (see Fig. 6.7 and Fig. 6.8).

The process produced a very precise layout of the shape of the Cubic Pattern which seemed to guarantee better accuracy when compared with manual cutting and bonding. Nevertheless, the result was not as good as expected. The adhesive textile vinyl which stood for the surfaces of a pleat on the substrate cotton gauze was too thin to support the pleating process (and certainly much thinner compared to the stiff interfacing I had cut by hand). The vinyl moulds are too soft during the hand pleating process and it becomes too difficult to hold the shape during steaming.

What is in a pleat?

Folding pattern and thermal process

In response to the research question 'What is a pleat?', I claim that the compositions of a pleat are the creases and surfaces. These elements imply that the folding pattern and thermal process are in the pleats, and it is these valley and mountain folding lines that are the nexus required to be thermally processed, not the surface.

Arguably, the contracted formation of a pleat has become what we understand a pleat to be. This neglects the fact that the formation of pleats come from a flat plane (see Fig. 6.9). Looking at the structure in detail, it is actually a folding pattern embedded in the textile which permits the contraction. Moreover, the same sheet of textile could contract to different structures when various folding patterns are applied to it. Therefore, I claim that it is the folding pattern in the pleats. Through my research process I have come to appreciate that every 3 dimensional pleated structure originates in a flat pattern (see Fig. 6.10).

Furthermore, an embedded folding pattern alone will not establish pleats. Without the thermal process, the textile embedded with various patterns is no different to other textiles because the pattern does not contract. It is moulding through the thermal process that contracts the textile.

As described in *Chapter 4: Field Mapping*, fabric has to contain synthetic yarns (polyester is better than other types of material) to be permanently pleated. It can be said that pleats have thermal mouldable yarns in them. However, it is only the folding lines that require the thermal process, so technically, the thermal mouldable yarns only need to exist at the nexus of the surfaces on the valley and mountain folding lines (see Fig. 6.11). Thermal mouldable yarns do not need to appear on the flat surfaces themselves.

This research proposes that it is the folding lines, which need to be able to be thermally processed on the folding pattern, which can be understood as a skeleton (see Fig. 6.12) of valley and mountain folding lines, of mouldable yarns, that is in the pleat.

What do pleats do?

<u>Pleats pleat pleats</u>

The use of fabric moulds suggest another layer of '*plica ex plica*', fold from fold: A pleat can produce another pleat (see Fig. 6.13). The fabric moulds I produced were converted from the *Cubic Wallpaper.* Pleats become pleating mould, generating more pleats.

As has already been described, in order to better allow the steam to fix the fabric, a fabric mould, with its permeable warp and weft, is a good choice compared to a sheet of paper. But a piece of fabric on its own lacks the structural properties necessary for pleating. I saw *Cubic Wallpaper* laid on my shelf and I realised it could be a potential material for me to experiment with. Each surface is strengthened by a piece of interfacing, while leaving the folding lines fully exposed to the steam.

This process shows what pleats can do, they generate more pleats. The fabric mould was an installation in the RCA 2015 Work in Progress exhibition (see

Fig. 6.14). *Cubic Wallpaper* became a mould to produce more pleats. What were once pleats are now used to pleat pleats, a pleat comes from another pleat, '*plica ex plica*'.

This conceptual frame, '*plica ex plica*', does not stand with the use of paper moulds. Paper moulds are the industry standard for the creation of pleats. Paper moulds are folds not pleats. Pleating studio technicians produce folded paper moulds to pleat fabric, not pleats to pleat fabric (see Fig. 6.15). The concept of '*plica ex plica*', fold from fold, pleat from pleat, issues from the use of the fabric mould.

Nigel Hurlstone highlights that 'fabric is not as passive as the sheet of white paper' (Hurlstone, 2010, p.44). Although, Hurlstone focuses on embroidery, his opinion about fabric and paper is applicable to pleats and pleating. Fabrics have properties which make them superior to paper for moulding. Fabrics are more durable, with an 'intensely habitable surface', and show 'more skeletal structure' with warp and weft, which permits steam to pass through. More importantly, fabric 'is sensitive to the element of heat and water' (ibid, p.44).

Compared to paper moulds, fabric moulds have advantages and disadvantages. One disadvantage of a fabric mould is that it takes much more effort (of labour and material) to build fabric moulds than traditional paper ones. There are only two steps to create a paper mould – drawing the pattern and hand-folding the kraft paper. Fabric moulds require cutting interfacing (by hand or machine) which adds extra weight, hand-placing interfacing onto a substrate textile, and heat pressing. However, the fabric mould is accessible to both professionals and the general public, and with such moulds it is possible to obtain sharp pleats with domestic steam. Practitioners are not restricted to professional steamers to produce the desired outcome.

For *Little Girl Inside Me* I used a fabric mould to form the pleats for the dancers' costumes. In the following case study, I explore the potential of these costumes through the lens of pliable logic.

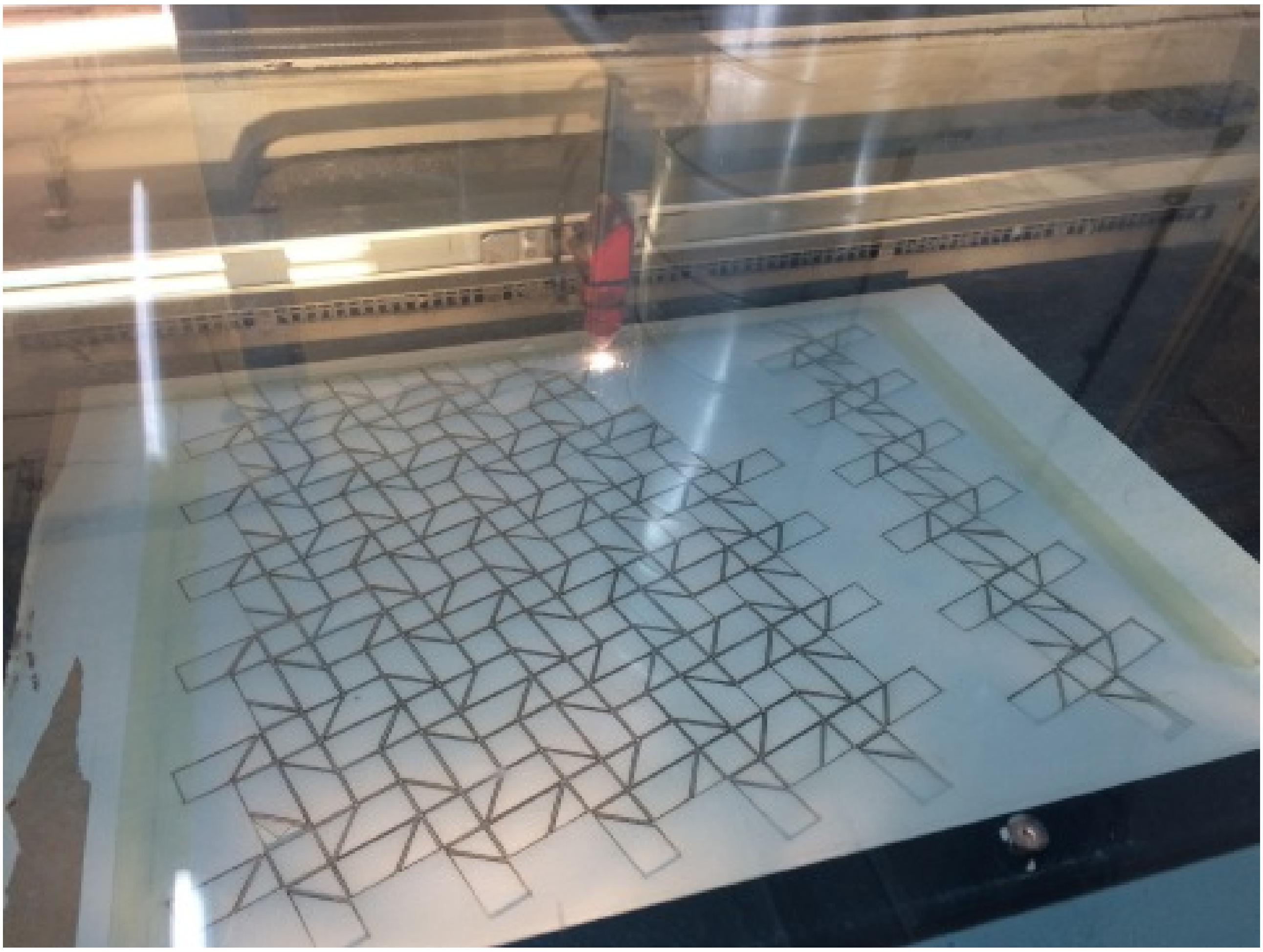


Fig. 6.5 Laser cutting interfacing into Cubic Pattern (2015)

Fig. 6.6 Alicia Nader
Untitled (2015)
organza, paint

Redacted Image

Fig. 6.6 Alicia Nader
Untitled (2015)
organza, paint

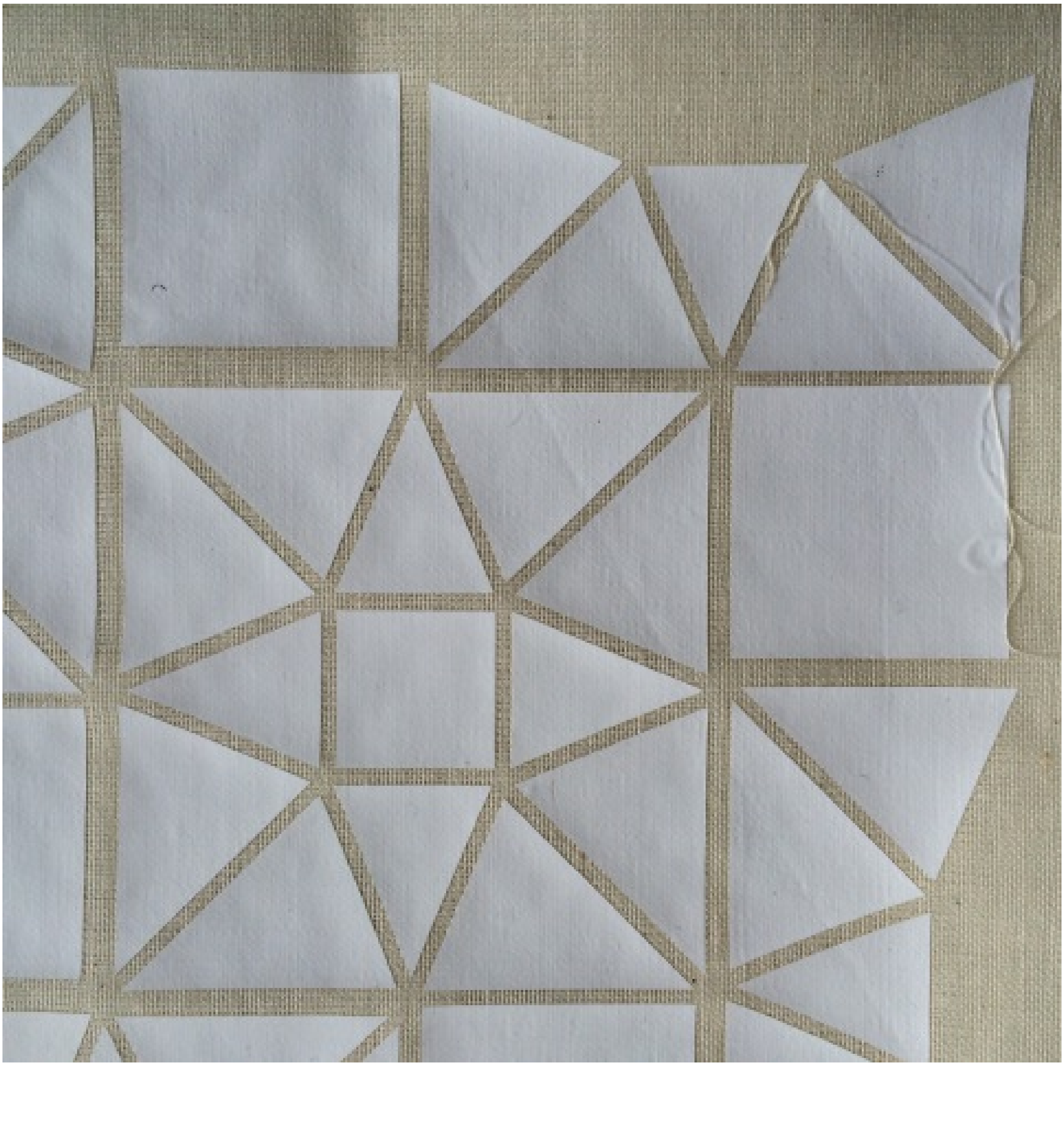


Fig. 6.7 Tsai-Chun Huang
Textile vinyl mould (2016)
Textile vinyl, calico, 35cm×35cm

Fig. 6.8 Tsai-Chun Huang
Textile vinyl mould (2016)
gauze, textile vinyl, 35cm×35cm

Redacted Image

Fig. 6.9 Chevron pleating pattern by Paul Jackson

Fig. 6.10 Tsai-Chun Huang
Pleated bag (2016)
Polyester, 40cm×25cm

Fig. 6.11 The nexus of surfaces in the chevron pattern.

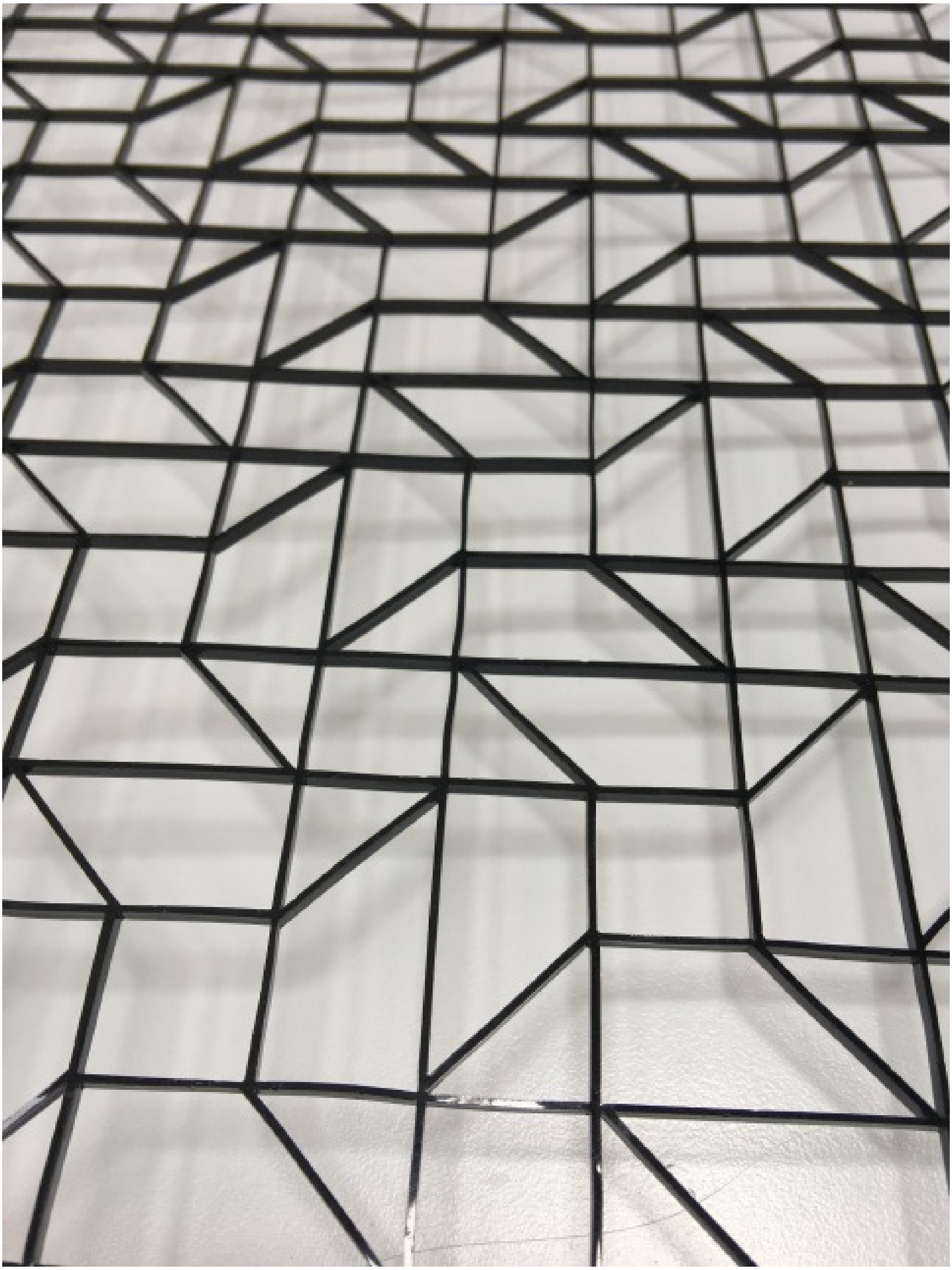


Fig. 6.12 The acrylic frame used as a template for the Cubic Pattern shows the skeleton lines of a pleated pattern.

Fig. 6.13 Taking out pleated skirt from the fabric moulds (2015)

Fig. 6.14 Tsai-Chun Huang
Cubic Wallpaper (2015)
Cotton, interfacing, 200cm×80cm

Fig. 6.15 Conventional paper mould pleating.

PROJECT 1

CASE STUDY:

Little Girl Inside Me

Invited to design the costumes for the dance production *Little Girl Inside Me*[81] (2016) I took advantage of the opportunity to incorporate my Cubic Pattern and to test out fabric mould pleated garments. This design and production process followed pliable logic: research question, aim, recursive making, recursive thoughts, and reflective evaluation.

Research Question

During the design process, I have to take the storyline and dancers' movement into consideration. At the same time, I hope to be able to test out the most appropriate parts of the garments to insert pleats.

I want to use this dance project to explore the flexibility of pleats. Do the elastic qualities of pleats help or hinder dancers to follow choreography?

Aim

In this project, I extended my experiments in material, using polyester organza as the main fabric. This is because the predominant element of the scenography is a 4 meter square white cube made with a semi-transparent polyester fabric. In order to cohere with this main image, I face the challenge of pleating soft organza and at the same time preventing the costumes from rehearsal damage.

81. Directed by Marie Yagami. Premiered at Platform Theatre, Central Saint Martins College of Art & Design, 27th May 2016.

Recursive making | **Reflective thoughts**

The story is Marie Yagami's life narrative across Japan, the US, and the UK from 1997 to the present.

Through discussion with director, we agree the costume style should be simple and contemporary, integrating the cubic pattern as an aesthetic mirror to the larger cube form that is part of the scenography.

During the rehearsal, dancers have many movements that put their bodies in contact with the floor, and many movemements in which dancers' bodies collide.

The garments have to be robust enough to survive rehearsals and performance. The positioning of the cubic pleats needs consideration as they will affect both the look and movement.

At the centre of the stage is a semi-transparent cuboid structure.

Both director and I like the idea of mirroring the scenography with the costumes through the use of similar fabrics. Therefore, the pleated parts will be organza.

Run a pleating test on a piece of 30cmx30cm organza fabric.

The result is too soft and the pleated forms are not easy to maintain. Perhaps, I can use bonding web to double up the layers to make it stiffer.

Ironing bonding web to join 2 layers of organza before pleating.

I mix 1 layer of coloured organza with 1 layer of white organza rather than 2 layers of coloured organza to maintain the light colour tone.

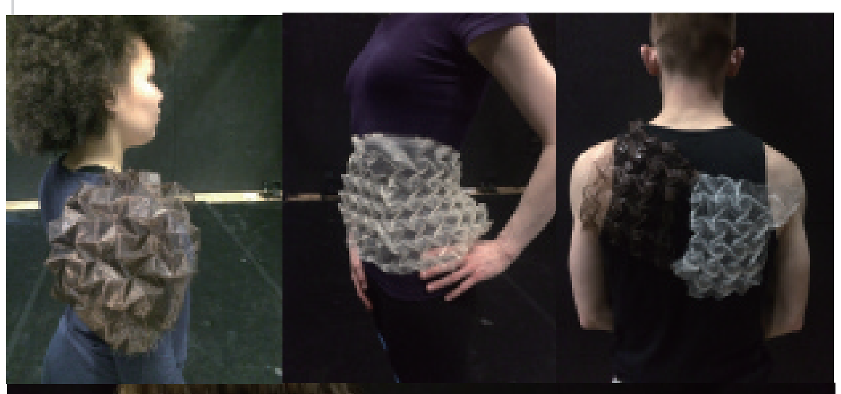
Pleating the bonded fabric.

The outcome was stiff and sleek, however it did not retain the pleat. In performance the costumes need to be more robust. A more effective way to bond 2 layers of organza is necessary. I think perhaps I can try fabric stiffener.

Applying fabric stiffener as a glue to bond 2 layers of organza. Spraying diluted stiffener before formation of pleats in a fabric test.

This is much more successful than the bonding web. Doubling up and using the fabric stiffener strengthens the fabric.

Use fabric mould to pleat the doubled and stiffened organza, after glue is dry.



The outcome is still too stiff. The fabric does not retain the pleat after pressing. Maybe I just need a small amount of stiffener to maintain the shape, rather than making paper-like organza.

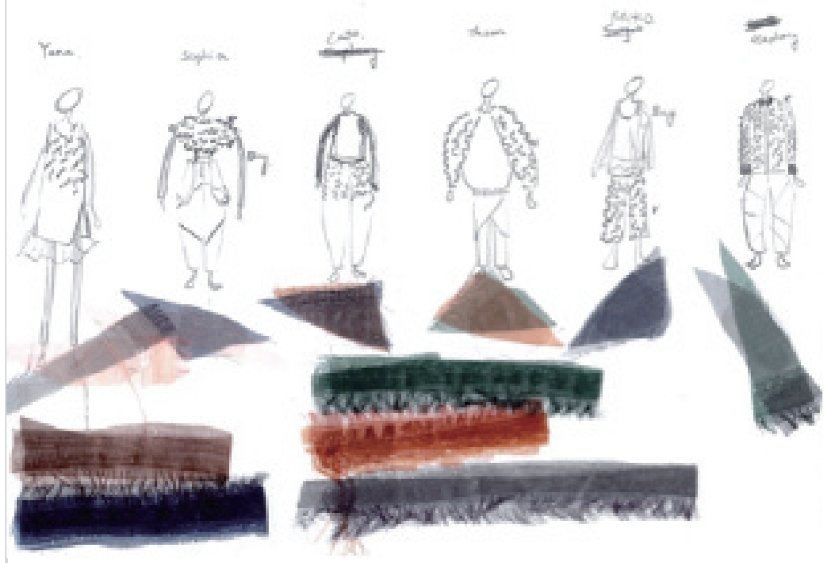
Pleating 2 layers of organza at the same time and spraying a small amount of diluted stiffener after the pleating process.

With a small amount of stiffener the fabric looks natural and maintains its softness. It also binds the two layers together successfully.

Positioning test: fitting sample pieces on dancers after rehearsal.

The cubic pattern expands well on the dancers' bodies. It allows for freedom of movement. However, the stiffener is not waterproof and the body sweat may damage the pleats. The colours are overly simple and separate. Yagami would like a more complex and subtle colour palette.

In order to unify the different costumes and create subtlety, I bond two colours of organza together.



The two tone fabric unifies the costumes as a collection. Yagami loves the result. The material experiments, colour matching, and sample fitting have been successful. Now it is time to finalise the design.

Finalise the design of all 6 costumes. I use the steam from industrial irons and an ironing board with extractor fan to pleat the garments.

The proportion of the pleated garments is always the most difficult to calculate. Even though I carefully estimate the shrinkage of the pleats, the garments are often too large for the dancers.

Before the final production, I adjust the pattern and downsize the garments to fit the dancers' bodies better. After the adjustments, I begin to produce the final pieces at home, as the studio is not open. (This means I do not have access to the industrial steam irons nor the extractor fan table.)

The result is disappointing. The pleats are loose. I am very confused. I examine the whole production process carefully, including the material, stiffener, and steamer. I realise that even though the steam is strong, it does not penetrate the moulds into the garments, as there is no extractor fan to pull the steam through.

I use a handheld vacuum at the back of the pleated moulds to suck the steam through.

The result looks much better. It is as rigid as the sample I made in the studio.

Now is the time to use diluted fabric stiffener to glue 2 layers of pleated fabric together.

Spraying the stiffener has the effect of mixing the colour, creating a two-tone fabric and at the same time maintains the softness of the garments.

The garments are worn by the dancers for the premier of *Little Girl Inside Me*.

Unfortunately the pleats did not stay intact during the prolonged body movements of the dancers. The thermal process did not permanently reconfigure the fabric.

Fig. 6.16 Tsai-Chun Huang
Little Girl Inside Me (2016)
Director: Marie Yagami
polyester, 65cm×70cm

Reflective evaluation

Before engaging with the research questions: What is a pleat? What is in a pleat? in relation to this case study, I would like to commence with: What do pleats do? Pleats, or pleated garments, can be defined when their functions are fully explored. In order to analyse the dance performance, *Little Girl Inside Me*, I would like to reference Fortuny's application of the Delphos dress in the context of ballet performance, and Miyake's Pleats Please design for William Forsythe. Fortuny and Miyake explore the potential function of pleats in the costume for dance performance in contrasting ways. Fortuny pleats the fabric before garment production, while Miyake cuts and stitches the garment before the whole piece is pleated. These distinct production processes provide useful inspiration for my own costume design.

What do pleats do?

What do Fortuny's pleats do?

With the aim of creating a new style of costume for the 'free dance' movement that was emerging in Europe at the beginning of the 20th Century, Fortuny looks to pleating. He clothes the body almost entirely, at the same time as allowing freedom of movement to dancers by using hundreds of tiny pleats on their costumes. By chance then, he designs what will become his defining feature: the Delphos dress.

Fortuny designed a costume for Eleonora Duse in Gabriele D'Annunzio's *Francesca da Rimini* in 1901. Critics complained that his costume did not show off the movements of the actress to her best advantage (Brandstetter, 2015, p.101). As a result of these criticisms, Fortuny examined the dancers' movement carefully in order to provide a costume that would allow full mobility for the performers. Fortuny followed the early 20th Century trend towards 'exoticism', specifically the 'Grecian'. "Greek, everything must be Greek" (Diane Cooper, quoted in Brandsetter, 2015, p.107). This desire to change the aesthetics of the era produces fertile ground for Fortuny.

The Delphos dress achieves its task of offering the dancer freedom of movement. Studying extant archival images (see Figs. 6.17, 6.18) and editions of the dress now in museum collections, it is easy to see that although these silk pleated Delphos dresses clung to the body, revealing their silhouette, the body can still move freely, due to the tiny Fortuny pleats. 'In Fashion the fold is engaged in a game of concealing and revealing the body in-motion' (Smelik, 2014, p.37, p.42, p.44). Ruth St. Denis improvised a Greek style dance in the Delphos dress, commenting, "I can think of nothing more exquisite than these veils or his Greek gowns" (St. Denis, 1939, p.112). The dress was liberating. Hugo von Hofmannsthal described St. Denis as, "… completely free of airs, without all pomp" (Von Hofmannsthal, 1937, p.301). Dance historian Gabriella Brandstetter writes that Isadora Duncan's dances were in no way restricted by the Delphos dress, which gave her freedom of movement (Brandstetter, 2015, p.105).

The process of designing and making costumes for *Little Girl Inside Me*, gave me the opportunity to understand how the Delphos dress achieves mobility, through pattern, production method, and material.

- Pattern

The Delphos dress clothes the body from neckline to ankle. Paradoxically, Fortuny allows complete freedom of movement by putting the body in a sheath. When designing costumes for dance, my basic approach has been to use pattern cutting to give dancers more space to move within the costume, especially if the fabric does not contain elasticity. The costumes are consequently loose fitting. Inspired by Fortuny's fitted style of Delphos dress I considered alternatives. Rather than producing loose fitting costumes with space between body and clothes, I sought to make costumes that moved with the body and allowed full mobility.

- Production method

As discussed in *Chapter 2: Pleating Practice (i) Experiments*, Fortuny could have created the Delphos dress with a shibori technique. This hand technique, in conjunction with pure silk fabric, creates the unique flowing property of the Delphos dress, and cannot be reproduced by machine. The properties of hand pleated silk versus machine pleated polyester can be seen by comparing the Delphos dress with the Ciment pleating studio sample of 5mm accordion pleats[82] (see Fig. 6.19).

82. The reason why I do not compare the Delphos dress with Issey Miyake's work is because Miyake's *Pleats Please* collection adopt knitted textiles which have a flowing property of their own.

The machine manufactured accordion pleats are more rigid. Each pleat is in the same size. Shibori pole wrapping hand processed pleats are more organic and wavier with a curl shape to cling to dancers' bodies.

- Material

Now that we have polyester, using silk[83] for pleated costumes is counterintuitive. Silk does not hold pleats well and the costumes may not survive through rehearsals and performances. The durability of silk pleats in the Delphos dress was weak, they required a curled form for storage (See Fig. 2.4) and had to be sent back to the Fortuny studio for washing and repleating (Kearney, 1992, p.87; Carrara, 2010, p.352). It could be argued that the Delphos dress is not suitable for dance performance. However, the silk has a natural property which flows and is therefore good for enhancing the elongation of movement. I used a piece of thin polyester satin to test the shibori pole wrapping technique, and, as expected, the result was very rigid and stiff (see Fig. 6.20).

Fortuny's Delphos dress flows across the silhouette of the body, offering mobility to dancers as part of a new wave of 'free dance'. He achieves his affect through pattern, production method, and material.

<u>What do Miyake's pleats do?</u>

Issey Miyake's pleats create new aesthetics. The mobility of the body, however, comes not from the contraction and expansion of the pleats themselves but from the elasticity in the fabric and the cut of the garments.

In catwalk shows, television advertisements, and product launches, Issey Miyake casts dancers, to demonstrate the qualities of the clothes. He took the suggestion of a friend that the Pleats Please garments might look very interesting on dancers (Metropolis, 2016). In the documentary *Issey Miyake Moves*, Miyake emphasises the relationship between body movement and garments during a fitting. He instructs his apprentice to pay attention to the way the pattern cutting affects movement (see Fig. 6.21). It is clear that body motion is central to his design.

Before Issey Miyake launched *Pleats Please* in 1993, William Forsythe

83. Fortuny also makes the Delphos dress in cotton gauze but in much smaller quantities than the silk.

proposed a collaboration on *The Loss of Small Detail*[84]. Miyake decided to use pleats as the main feature. When Forsythe toured in Japan, he and his dancers came to Miyake's studio for a fitting and the dancers had fun trying and exchanging the costumes among themselves regardless of gender, body shape, or garment style (Miyake, 2012, pp.34-38). This is because pleated garments do not have darts or tucks which usually appear on women's dresses. The costumes give dancers a full amount of flexibility in which their bodies can move freely. At that moment, Issey Miyake realised that he had made something that had achieved his aim of creating a designer garment that everyone could wear, "Like jeans, or T-shirt" (Sato, 1999, p18).

Whereas Fortuny used silk for his dance costumes, Miyake uses polyester. The material provides strong durability during rehearsals. Whereas Fortuny cuts close to the body, Miyake cuts the garments to be loose fitting. Miyake's pleated garments follow the Japanese clothing culture of flat structure and loose fit (see *Chapter 2: Pleating Practice (i) Experiments*), so his design gives a lot of freedom to dancers to move. The costumes are also interchangeable between genders. However, from my experience of wearing Pleats Please, this is because the garments are usually so baggy that they can fit people from size XS to XL. For example, a pair of 'Homme Plissé Issey Miyake' sized 2 trousers can be stretched to 120cm at the waist and 160cm at the hip, which is normally the measurement for DXL. It is the loose-fit pattern of the costumes that gives the dancers mobility to move freely, rather than the space released by the open and close action of pleats (see Fig. 6.22). Furthermore, Miyake adopts a piece of knitted fabric, tricot, to produce Pleats Please garments. These knitted textiles naturally contain elasticity. No matter whether or not the tricot is pleated, the fabric provides the stretchiness dancers would need.

<u>What does Cubic Pattern do?</u>

Cubic Pattern offers mobility to dancers to move without restrictions.

'The drapes, pleats, and folds move with man, but they are not an actual part of his body' (Lehmann, 2000, p.212). Throughout the design period of *Little Girl Inside Me*, I kept asking myself where the most appropriate locations were to insert the pleats and how I could increase the freedom of movement

84. 21st December, 1991, Frankfurt

with the help of the Cubic Pattern.

I struggled to decide if I should pleat whole garments using Issey Miyake's inversion process, or if I should insert sections of Cubic Pattern at the crucial points, such as the shoulders and elbows, which I have already practiced since 2010. In order to be flexible and create various costume styles, I took both design approaches together. The design outcome shows that the mixture of these two approaches has more varieties of style, to blend with the director's desire for a 'non-costume' daily wear look and at the same time incorporating the Cubic Pattern (see Figs. 6.23, 6.24). The audience could concentrate on dancers' movements and the production storyline, without being distracted by overbearing pleated costumes.

Anneke Smelik states that it is the '…gap between body and folds that allows for opening up a freedom of movement' (Smelik, 2014, p.51). My understanding is that I need to create the openness of pleats for movement. Therefore, in terms of the fit of the costumes, I decide to take Fortuny's approach of creating a fitted garment that moves with the body rather than Miyake's baggy style.

Due to the contraction of the Cubic Pattern, the costumes cling to the dancers' bodies and move along with their motions. Dancers responded that they were not aware of wearing the Cubic Pattern costumes when performing, that they were allowed the same freedom of movement as in their training clothes. The approach of mixing partly pleated and wholly pleated designs, and creating a fitted style rather than a loose-fitting one, was successful.

The pattern making avoided a loose-fit style and adopted non-stretch woven organza. Dancers were still able to move freely with the costumes. The Cubic Pattern achieves the aim of providing mobility to dancers.

What is a pleat?

As has been discussed, pleats offer freedom of movement, in this case study, specifically to dancers. At the same time, I want to suggest that the pleats also act as a motion stimuli to activate the way in which dancers move their bodies.

<u>Motion stimuli</u>

Sections of the pleated Cubic Pattern were inserted into several different areas on a variety of garments. I observed the rehearsals to see if the Cubic Pattern would interfere with the dancers' movement. I also interviewed the dancers.

Most of the answers from the dancers were as I expected: they were not hindered by the costumes because of the elasticity of the pleats, the lightness of the fabric and the fact that the pleated Cubic Pattern sections were inserted at the joints, where greater mobility is necessary. However, one unexpected response the dancers gave me, was that they would purposely augment their movements in relation to their costume to exaggerate the impression of the contraction and expansion of the pleats. They said that the Cubic Pattern gave both the costume and their stage character a distinct sensibility. For example, when gravity pulled down one performer's dress, flattening the Cubic Pattern around the chest area, she tried to activate the movement of the pleats by twisting her upper body through shoulder rotations (see Fig. 6.25).

Yagami also stated that she was encouraged to add specific body movements such as the twisting of the torso, swirling elbows, or bending at the waist, when she saw the effect of the opening and closing of the Cubic Pattern. In this way she could demonstrate the contraction and expansion of both the dancer and the pleats. This activation echoes Smelik's opinion that pleats are '…an invitation to engage the wearer in the creative process of becoming, by transforming the body, and perhaps reinventing the self' (Smelik, 2014, p.52).

The Cubic Pattern creates a two-way effect. It allows performers to move their bodies and at the same time they are stimulated by its appearance to optimise the open and close movements of the pleats. The Cubic Pattern costumes generate a positive cycle to activate performers, performance and pleats as a motion agent.

What is in a pleat?

A designer's vision

At the end of the Victorian era, people were looking for a liberal spirit for the new century. A romantic notion of Ancient Greek culture was the zeitgeist (see Fig. 6.26). It was in this atmosphere of exoticism that Mariano Fortuny designed the iconic Delphos dress.

The Delphos dress was designed to match Knossos (see Fig. 6.17), which was a long scarf used in the burgeoning movement of free dance. Isadora Duncan wore the Delphos dress to see how the unconventional costume could inform a new type of dance (Osma, 1985, p.85). Women who wore the design in daily situations were perceived as avant-garde (Deschodt and Poli, 2000, p.171). They abandoned not only corsets but also any undergarments, as the Delphos dress was so soft that it revealed everything underneath.

Fortuny did not design for the sake of dance. Rather, he designed from his vision of the ideal, and tested the resulting garments in performance. Fortuny's pleats are an attempt to realise his ideal.

Issey Miyake's vision for pleats can be seen in his fashion label rather than in his costume design. The necessary compromises made in the process of collaborating with other artistic needs, results in a lack of autonomy. This situation can be observed in the collaboration with William Forsythe. The pleated designs Miyake proposed were rejected by Forsythe. In *Issey Miyake Moves*, it was clear that what Miyake had proposed was a series of costumes that included tying and wrapping styles (see Fig. 6.27). Forsythe did not appreciate the concept and requested that Mikyake use a previously created fashion collection called *Twist* that had been designed for ready to wear (see Fig. 6.28). Issey Miyake's vision, is then, not given its full potential to flourish in the context of costume design.

Though Miyake's pleated designs for dance did not receive wide acclaim[85], his fashion garments became popular immediately after the launch of his first collection.

85. In the reviews and analysis of the dance works choreographed by Forsythe, Miyake's costumes are rarely mentioned.

Miyake has full autonomy when deciding how his fashion garments should look and feel. He can choose an exaggerated silhouette that could be considered unsuitable for dance performance. A model can gently swing their body to trigger the motion of pleats and to show the elasticity (see Fig. 6.29). The garments do not need to be physically robust in the same way that is required in a stage performance where the dancers' bodies are in physical contact with each other, and the dance floor. In other words, the catwalk can convey Issey Miyake's aesthetics in motion, without the compromises of working in collaboration.

When creating the Cubic Pattern garments for *Little Girl Inside Me* I need to reflect the characteristics of each role, respond to the design concept of the dance production, and consider the dancers' movement. These are the kinds of considerations that result from a costume design training, which foreground the goal of serving the dancers' movements. The dancer's body, the director's instructions, and the movement of pleats are at the centre of the design process. The costumes for *Little Girl Inside Me* realise my vision as a designer, for the use of the Cubic Pattern.

Fortuny's starting point of an ideal Greek culture is encompassed in his pleats; Miyake's catwalk shows deliver his aesthetic while his collaboration with William Forsythe yields to the whole dance production; Cubic Pattern design for dance began from my interpretation of the story and an understanding of the dancers' movements. These three types of pleat demonstrate different way in which a designer's vision is exemplified by the pleats they create.

Redacted Image

Redacted Image

Fig. 6.17 Mariano Fortuny
Knossos scarf (1907)
Silk, 200cm×60cm
Image: fortuny.com

Fig. 6.18 Mariano Fortuny
A ballet by Charles-Marie Widor (1906)
silk veil later known as *Knossos*

Redacted Image

Fig. 6.19 Ciment Pleating
5mm chevron pleats (2018)
ployester, 150cm×200cm
Image: Ciment pleating

Fig. 6.20 Shibori pole wrapping of polyester; the result is stiff.

Redacted Image

Fig. 6.21 Issey Miyake emphasised body movement during fitting. Video still: *Issey Miyake Moves* (1992) Video by Sestuko Miura (53'30")

Redacted Image

Fig. 6.22 Irving Penn
Issey Miayke (1989)
photograph

Fig. 6.23 Tsai-Chun Huang
Little Girl Inside Me pleated t-shirt (2016)
Directed by Marie Yagami
polyester, 70cm×45cm

Fig. 6.24 Tsai-Chun Huang
Little Girl Inside Me pleated trousers (2016)
Directed by Marie Yagami
polyester, 90cm×60cm

Fig. 6.25 Tsai-Chun Huang
Little Girl Inside Me pleated trousers (2016)
Directed by Marie Yagami
polyester, 90cm×60cm

Redacted Image

Fig. 6.26 Pythagoras of Regio
The Charioteer (c. 478-474 BC)
copper, 182cm
Image: Archaeological Museum of Delphi

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Fig. 6.27 Issey Miyake's original proposal for *New Sleep*. Video still: *Issey Miyake Moves* (1992) Video by Sestuko Miura (53'30")

Fig. 6.28 *Twist* collection on dancers after Forsythe rejected the original proposal

Redacted Image

Fig. 6.29 Issey Miyake
Spring/Summer 1995 Catwalk show (1994)

PROJECT 2

3D PLEATING:

The most important part in making clothing is to start to design the fabric.

Designers have expressed how they start their design process from materials, or around the material, emphasising the role of material science and technology. Cristóbal Balenciaga (1895-1972) identified the critical role of fabric in design.

> Balenciaga began with the fabrics and designed around them. 'It is the fabric that decides,' he said.
> (Victoria & Albert Museum, 2017, Shaping Fashion)

Issey Miyake, too, has responded directly to the textile.

> …the most important part in making clothing is to start to design the fabric.
> (Constantine and Reuter, 1997, p.199)

At the beginning of this research, in 2014, the common 3D printing material on the market was ABS (acrylonitrile butadiene styrene). This material only produced hard shell objects which is not suitable for the properties of pleating. New materials were introduced over time. TPE (thermoplastic elastomer, usually referred to as thermoplastic rubbers) became available in 2015, but the printed layer has to be minimum 1mm, which is too thick to form pleats. In late 2016 the powder-based TPU (thermoplastic polyurethane) laser sintering technology became available and could build 0.4mm planes. This was the appropriate technology to print pleats.

Research Question

Through this research journey, creating new pleating methods has been a central concern. It is in the process of creating new pleating methods that we can reach a better understanding of what a pleat is. Traditionally, the pleated textile arises from a flat sheet. This restricts the final form. The 3D printing project wants to know: is it possible to create a free form pleat, without the limitations of a flat surface, with the help of technology?

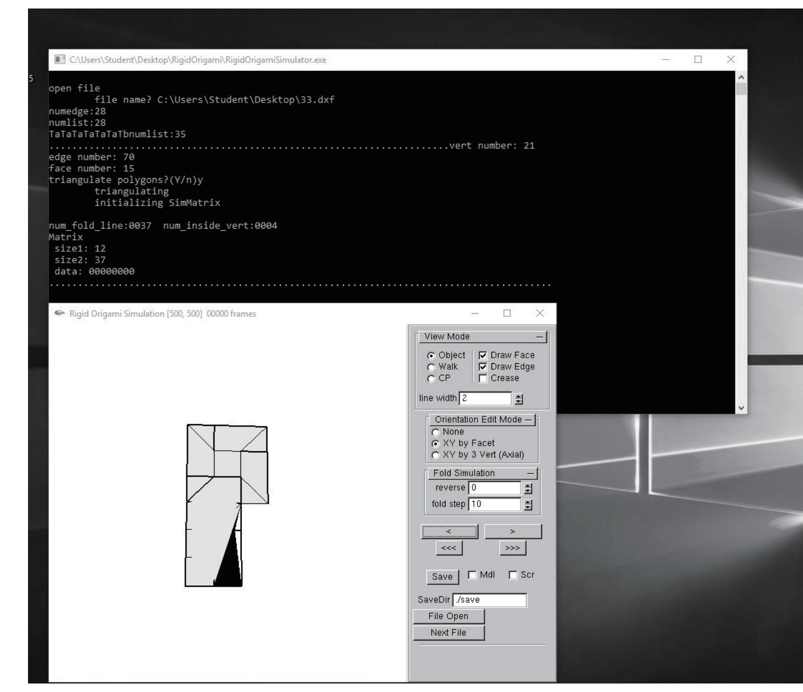
Aim

Instead of producing moulds for pleating, the 3D printing project aimed to produce pleats directly from material and machine. The experiment wants to create pleats in an unconventional way, and to test the attributes of the new pleats.

Recursive making | **Reflective thoughts**

In 2015, with the support of the technician in the Rapid Form 3D printing centre at RCA, I revised the cubic pattern 3D digital file to make it suitable for 3D printing, giving the flat template a thickness. However, there was no suitable material to print an object with the necessary elasticity that I required, so the exploration of 3D printing did not progress. In 2016, Mingjing Lin, whose focus is 3D printing and fashion, and I, agreed to form a collaborative project which would explore the potential of 3D printing pleats.

In order to render a virtual pattern, it might be of use to have a physical form to hold and examine. It will be easier to understand the relation of surfaces from different angles.



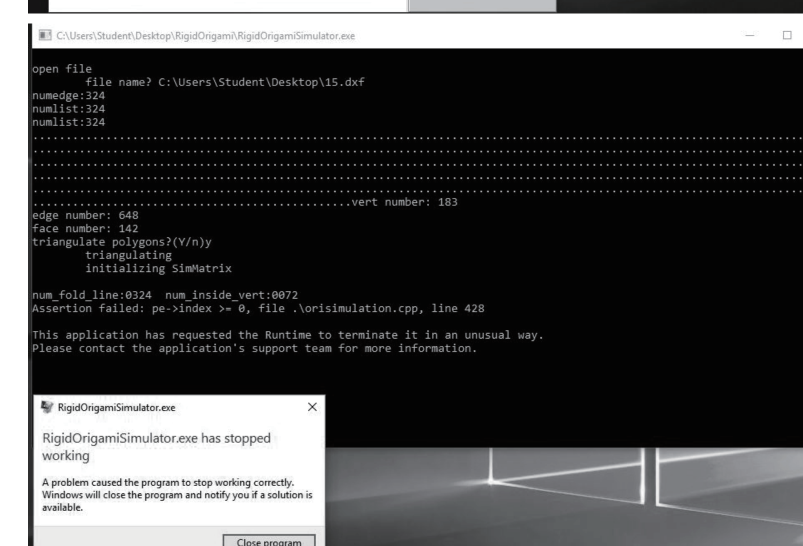
Fold a paper prototype.

The physical form is really helpful because it can be rotated in front of me when drawing edges in the computer.

Mingjing's understanding of drawing the digital structure is to create the look of the pleats (at a particular point in the process of contraction).

Build the 3D form of cubic pleats in Rhino software based on the prototype.

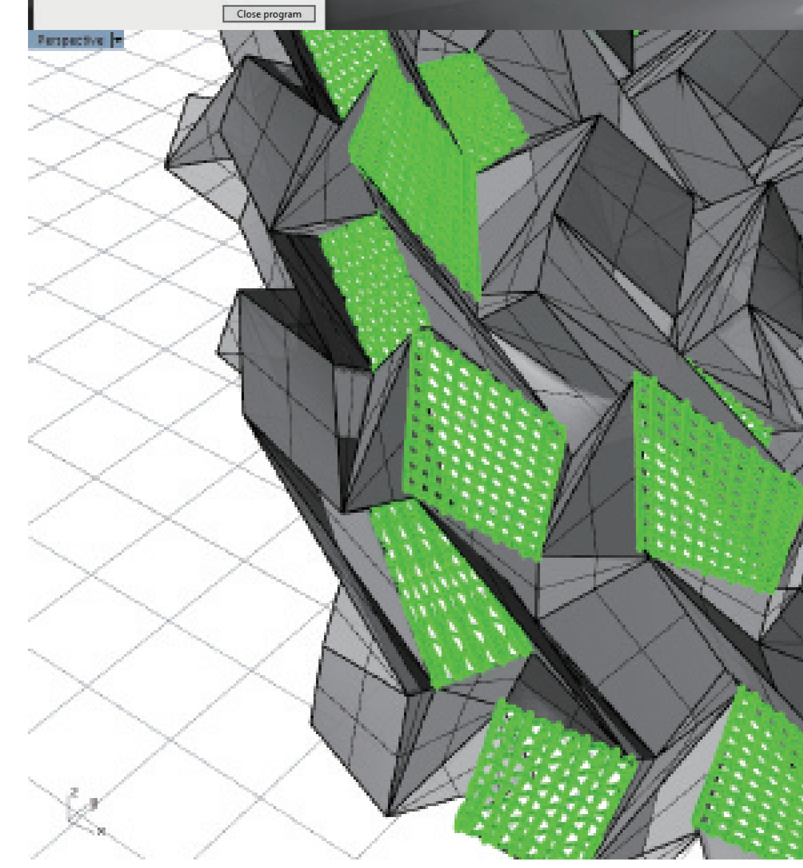
When we examined the digital form, we can rotate the structure but cannot expand or contract it. In general 3D printing creates a static object and prints out the form.



The virtual structure cannot expand like a paper pattern and the essential quality of pleats, that it shuttles between 2-dimensional plane and 3-dimensional form, is lost. We realise we need to adopt software that can design specifically for a pleating pattern.

Flatten the cubic pattern and analyse the mountain and valley fold lines and mark those lines in 2 different colours.

It is these creases that activate the pleating movement. It seems that a general 3D modelling software does not suit our need.



If I want the outcome to expand and contract, I need to imitate the structure of the paper fold from 2-dimensional to 3-dimensional form.

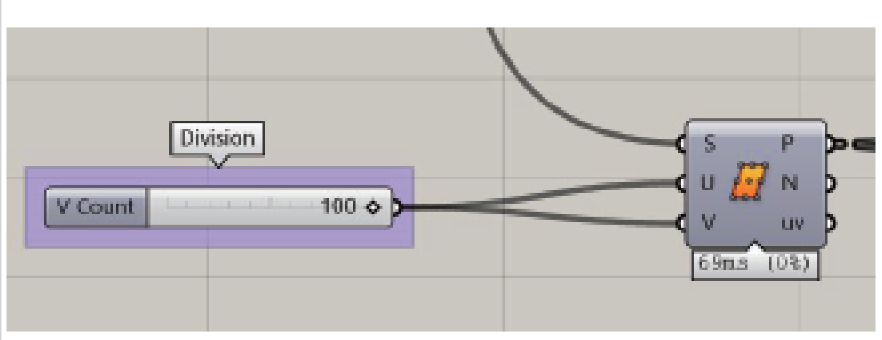
Search for other 3D rendering software that suits our need of forming pleats from flat plane.

There are several software programmes developed by origami artists and researchers, incuding TreeMaker by Robert J. Lang, Tess by Alex Bateman, and Rigid Origami Stimulator, Origami Anything and Freeform Origami by Tomohiro Tachi.

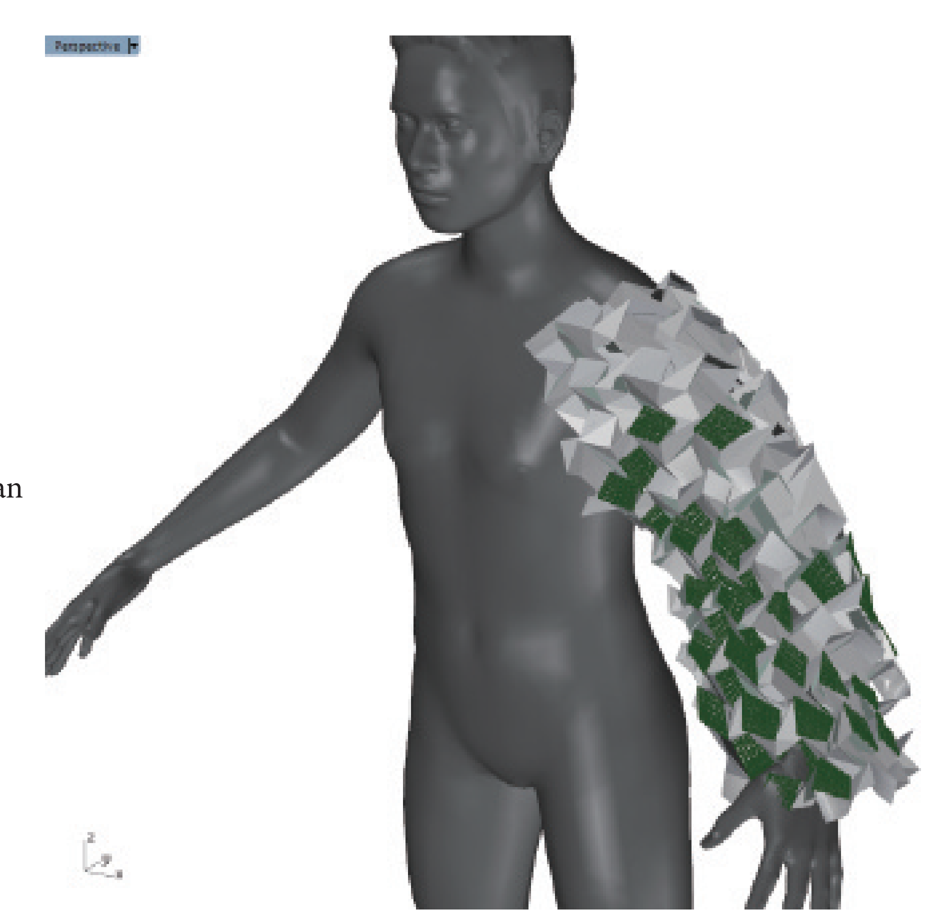
Digitise the grid in Freeform Origami.

Freeform Origami and Rigid Origami Stimulator suits our need to create the structure and export to the file that the 3D printer accepts.

There is a paradox that in aiming to build a 3D structure we actually build a 2D plane with mountain and valley folding lines.



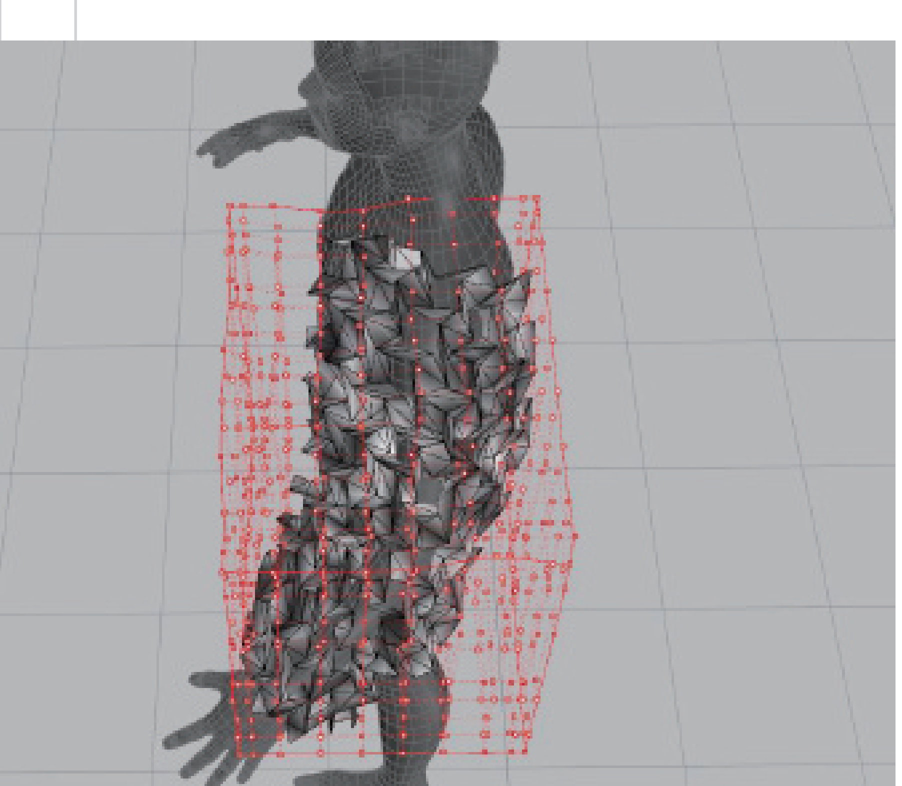
We modify the grid by pulling and dragging in the software. Mingjing entered different parameters to change the texture of the surface.



The rendered result was something that is beyond the capacity of either hand or machine pleating methods. We decided to keep this feature.

Weh increase the variety of surface treatments.

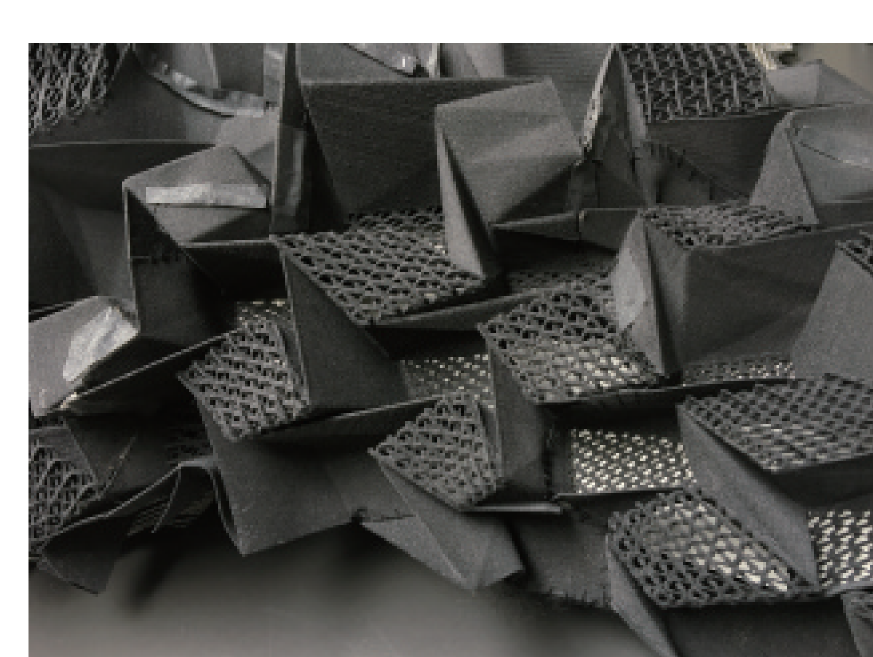
The potential to vary the surface texture in an individuated way specifically belongs to 3D printed pleats. In conventional thermal pleating the whole piece of fabric is treated the same way without the possiblity to vary individual surfaces.
I believe this feature is a new discovery for pleats.



Send the file to the 3D printing company, Sinterit, to print the Cubic Pattern.

The printing time is 1 day, including laser beam joining and cooling down, which is similar to the time length of ABS 3D printing.

Receive the printed Cubic Pattern from Sinterit.



The Sinterit process uses TPU, a thermoplastic polyurethane, formed through joining powder. The printed result is delicate and pliable giving the pleat a little flexibility.

However, the 3D printed pleats cannot achieve full expansion and contraction in the way that fabric pleats do. It is a shell of the pleated form.

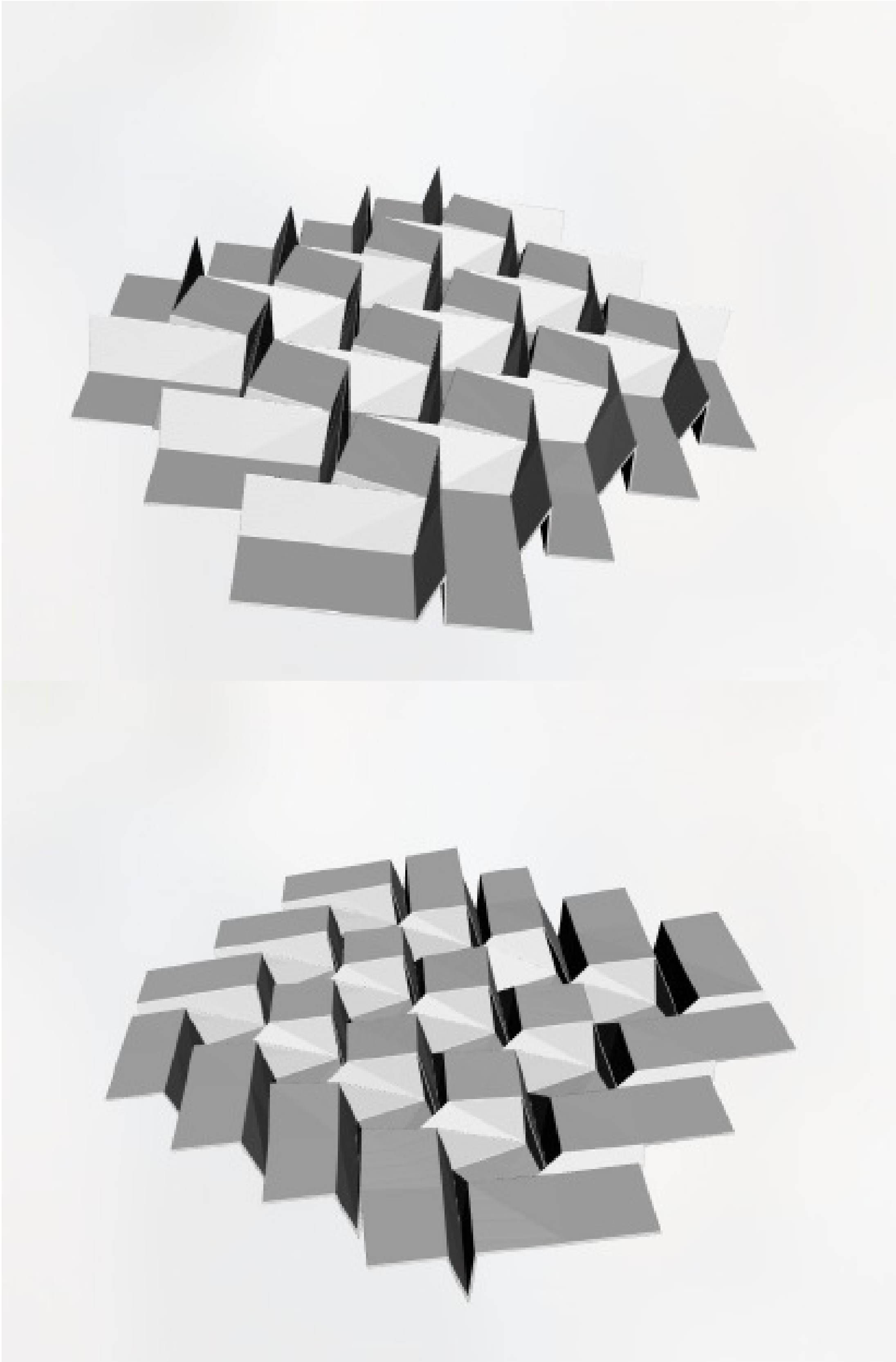


Fig. 6.30 Cubic Pattern digital pattern

Reflective evaluation

The digital pleats experiment generates thinking which is distinct from that in relation to thermal pleats. These thoughts lead the discussion of 'What is a pleat?', 'What is in a digital pleat?', and 'What do pleats do?' to new territories. For example, 'When a pleat can be called a pleat?', 'Can a pleat-like form be defined as a pleat?', 'Does the conventional definition of pleats need to be modified?'

What is a pleat?

Remodelling between 2D–3D

The 3D printed result opens up a discussion as to whether this type of pleat can in fact be called a pleat. This goes to the heart of trying to better understand the intrinsic quality of pleats.

Mingjing Lin and I began working directly with the digital file. This is different from the experiment conducted by Ng Yang (see Fig. 4.18) as described in *Chapter 4: Field Mapping*. We used Rhino to build our pleated structure on the screen. However, we soon realised that building 3D forms in the computer would follow the 'replica' method of forms, as Ng Yang did. We turned to a paper folded Cubic Pattern and observed the difference between the virtual 3D form on the screen and the physical paper form. It was clear that while the 3D form on the screen (as created by the Rhino software) could be rotated and distorted, it could not be opened or expanded. The paper form however, could be stretched to a flat surface and returned to its 3D structure. At this moment we understood the distinction between static form and elastic form. Therefore, we decided to build a 2-dimensional plane in the computer and to fold the plane through the help of software: Rigid Origami.

Through this exercise, I understood the essential criteria that need to be met, in order to define a pleat. Scanning a folded object (see Fig. 6.31) and building a folded structure are different. Scanning a folded object just replicates the shell of the structure with folding lines and surfaces. But pleating is intrinsically an operation of contracting a 2-dimensional surface into a 3-dimension form, and this is why pleats are expandable and contain elasticity. A pleat is a remodelling between 2-dimensions and 3-dimensions, encompassing the properties and potential of flat surface and solid form at the same time.

Moreover, even when we start the process by building from a flat plane in the digital model, and imitate how a tangible pleat behaves, the 3D printing only produces one instance in the continuous movement of expansion. The result is still a static form rather than an object that can shuttle between 2-dimensional planes and 3-dimensional forms (see Fig. 6.32).

The remodelling between dimensions is a critical character of pleats and could be regarded as its most cherished value. Although the softness of the 3D printed material[86] gives potential for movement, the 3D printed pleats are stiff. As a result, in terms of elasticity, 3D pleats can only be defined as 'form-like' pleats.

What is in a pleat?

<u>New forms in the pleats</u>

3D printing makes it possible that each individual surface within any given pleat can have its own appearance. Conventionally, thermal pleating is post processing, following fabric production, therefore pleating is a manipulation that does not in itself incorporate adding fabric pattern or texture. The colour and texture are limited to the fabric itself.

There are some examples of craftspeople and designers creating textures and colour to go along with pleats. In the Qing Dynasty (1636-1912), patterns were embroidered onto the surface of pleats, differentiating the inside and outside (see Fig. 6.33). After Yushiyuki Miyamae was appointed creative director of Issey Miyake in 2012, he released steam stretch technology which permits him to differentiate the surfaces of the pleats, weaving different colour yarns for the outside and inside. Miyamae's coloured pleats help to demonstrate the shape (see Fig. 6.34). The contrasting colour definition articulates the pleated patterns. In 2016, Stella McCartney attempted to break the colour boundary between in-pleats and out-pleats through heat transfer sublimation technology (see Fig. 6.35). These are some examples of the way in which designers have integrated textures and colour with pleats. However, due to the production process, these textures and colour are still limited.

86. The exact composition of Flexa Soft is a trade secret. A thermoplastic polyurethane, it is advertised as a 'Low Shore-A material that could be used in design, art and simulation of really soft materials'. [https://www.sinterit.com/flexa-soft/, Accessed 18th June 2019.]

This situation can be changed if pleats are 3D printed. Through digital modification, changing parameters, the texture of the surface of each pleat can contain its own texture, structures and patterns. Furthermore, the texture is not limited to the 2-dimensional plane as with conventional pleats; it is possible to create a 3-dimensional structure on a pleat (see Fig. 6.36).

During this experiment, the parameters were changed to create woven structures and holes on the surface of some pleats. This outcome cannot be achieved by traditional pleating process.

Additionally, 3D printing achieves a new type of pleats by printing curved pleats on a curved surface.

Traditionally, pleating is a manipulation that changes the form of the fabric. In this context pleating only serves an outcome where the pleats are uniformly emerging from a single flat plane (see Fig. 6.37). However, in the 3D printing experiment, the Cubic Pattern is transferred to digital file and can be easily modified virtually on screen. By inputting different parameters, or simply dragging the mouse, the virtual pleats on screen can be distorted to become a curved surface. The virtual space on screen offers possibilities that cannot be achieved with physical textiles. A kraft paper pleating technique sandwiches flat textiles, and the mould itself is flat as well. If I want to pleat a curved surface with a kraft paper mould, I would need to start with a piece of curved kraft paper and a piece of curved fabric. These things do not readily exist. Even if they did, it would not be easy to fold a curved sheet as the overlapping sections of the pleats would generate extra allowance, causing the pattern to be uneven.

With the help of 3D printing technology, the virtual curved surface can be printed out easily (see Fig. 6.38). This effect cannot be achieved by conventional pleating procedures. The 3D printed outcome had potential for future study.

Redacted Image

Fig. 6.31 Elaine Ng Yang Ling's process of scanning a physical paper fold and importing as a digital file. Image: *Manufacturing process for textiles and fashion design professionals.*

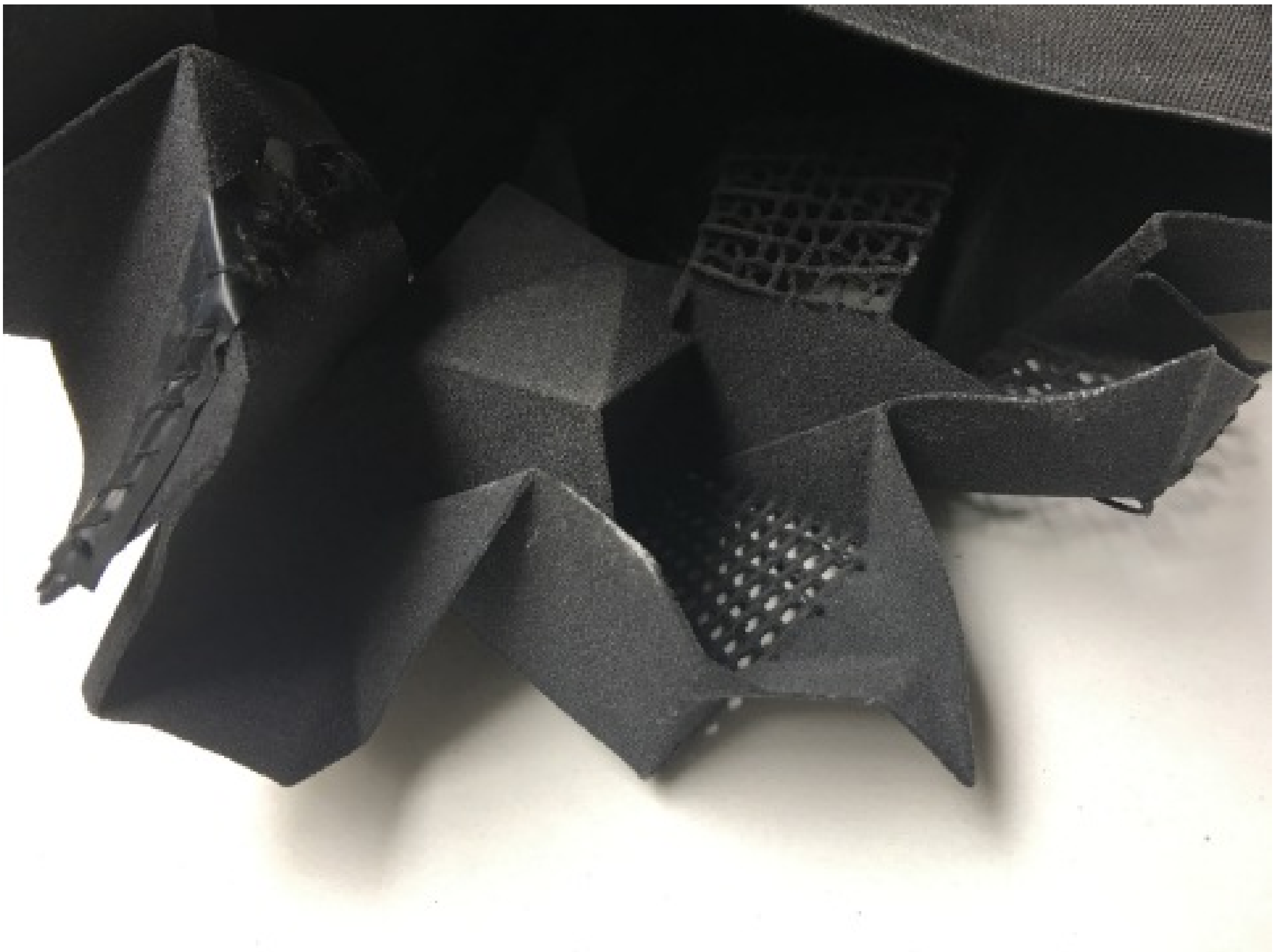


Fig. 6.32 3D printing only replicates the form of the pleats in a single instance, a shell-like static pleat.

Fig. 6.33 *Gao's Grand Courtyard Qing Dynasty Costumes Exhibition*
Pleated skirt (c. 1850)
Silk, 90cm×70cm
Xi An, China (2017)

Redacted Image

Fig. 6.34 Issey Miyake
Autumn/Winter Collection (2015)
Steam stretch technology
ployester, Image: Vogue.com

Redacted Image

Fig. 6.35 Stella McCartney
Spring/Summer collection (2016)
colour sublimation technology
ployester

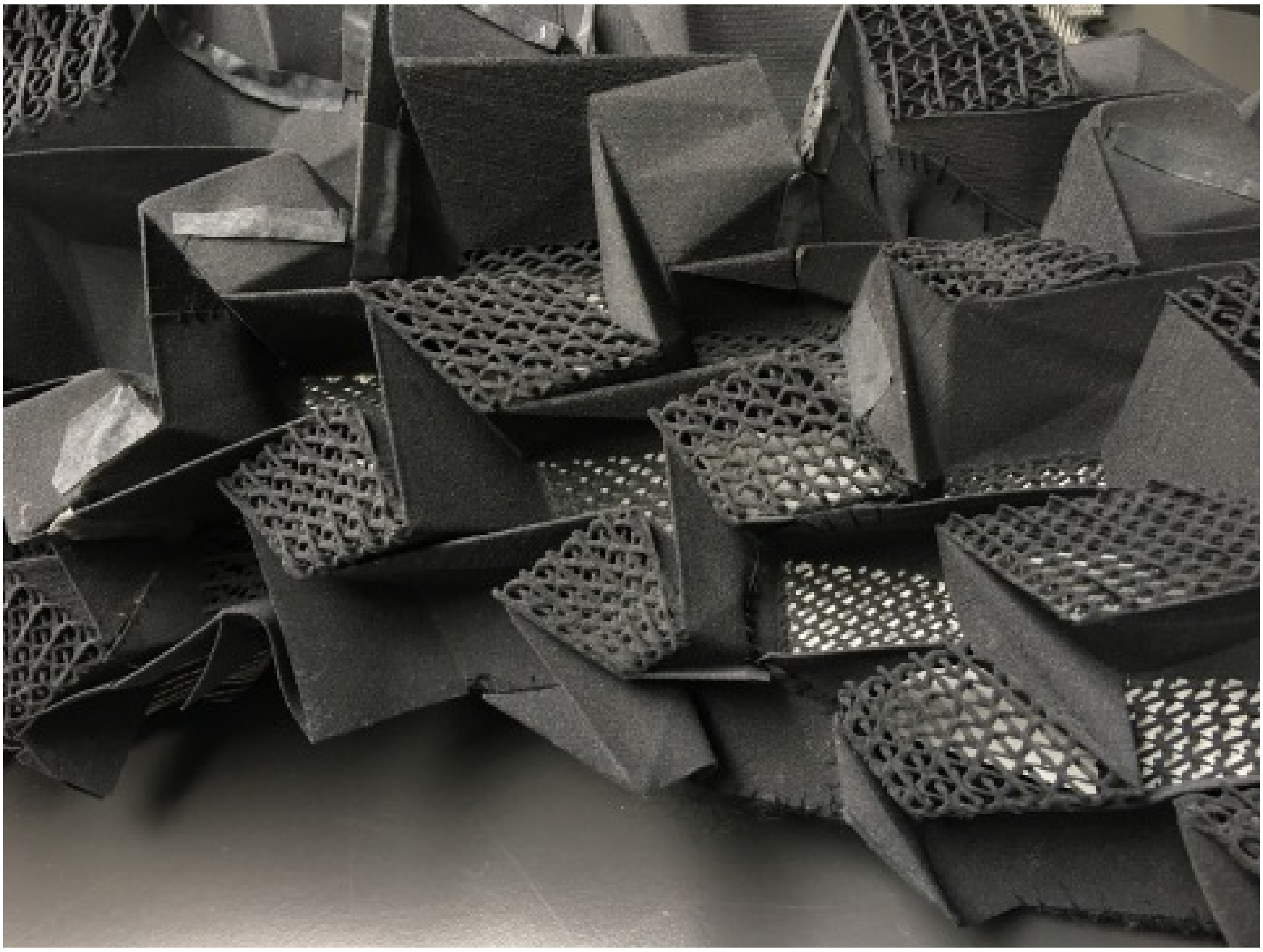


Fig. 6.36 The texture of each surface can be customised to show its own individual feature through 3D printing.

Fig. 6.37 Although thermal pleating creates 3D texture, it is ultimately a flat plane after pleating.

Fig. 6.38 With 3D printing it is possible to produce a curved pleated surface.

What do pleats do?

Efficiency and interrogation

It is apparent that digital pleats increase production efficiency.

The production process for the first 3D printed prototype was protracted. This was due to the fact that we were getting familiar with the software, and also that the computational rendering of the digital file took time after each change. This process cannot be skipped. As Kavanagh *et al.* say, '…in order to develop a rounded practice that fully exploits the benefits of CAD/CAM technologies, the designer must understand, at least in part, the technical aspects of the technologies used' (Kavanagh *et al.*, 2008, p.733). Once the digital Cubic Pattern is created, it can be easily and accurately modified to alter the size, alignment, and space of each pattern.

My experience using this software corresponded with Rachel Philpott's statement about how digital tools increase production accuracy (see *Chapter 4: Field Mapping*). Also, my experience was that the digital production shortened the time to complete a design, avoiding unnecessary trial and error. Perhaps this is partly an evolution in the software capabilities, which offer parameters very close to reality, with the result that the final appearance and function of the tangible outcome can be rendered in the computer with a great degree of accuracy.

The printing for this project took a small percentage of the overall time. The majority of the production time was taken with drawing[87]. The drawing process was a kind of 'slowing down' process (Hurlstone, 2010, p.39) which delayed the outcome and which '…expands the maker's vision allowing the development of ideas' (ibid, p.39). Philpott also determined that minor alterations would often lead to complete redrawing in the software, lengthening the time to complete a design (Philpott, 2011, p.123)

This '…process is what opens up a space in which perceptions and decisions about the work are shaped, evaluated and re-evaluated over a considerable period of time' (ibid, p.38). In these moments of reflection and interrogation, both Yang's 3D printed outcome, and my experiment with Lin, made me

87. The printing took 2 days. This might be considered a long time. But the drawing phase took 4 weeks, as we explored different permutations of the pattern.

question whether these works are 'digital pleats' or simply 'analogue pleats' created digitally? Is it possible to produce 3D printed pleats which remodel between plane and structure, or is current 3D printing technology only capable of producing static objects?

In *Chapter 4: Field Mapping*, I listed several examples in which digital tools are employed to produce pleats. Through this 3D printing project, a critical question is raised: Is a pleat produced through digital tools really a type of digital pleat? Do we categorise output because of the production method, or because of its behaviour?

> …the traits and potentials of the technology should lead us to question how 'communication via digital files and video screens fundamentally changes the culture of the practice'[88].
>
> (Campbell, 2016, p.XII)

When I examined in detail the 3D printing results, I found that there was something new. A curved plane and individual surface treatments are not achievable using traditional hand pleating methods. This newness leads me to the conclusion that the project can delineate a new category: digital pleats. They are digital pleats not just because digital tools were used to create them but because those tools give rise to a new form of pleat.

88. Campbell quotes from Yehuda E. Kalay, 'The Impact of Information Technology on Design Methods, Products and Practices', *Design Studies* 27 (3) (2006), p.378

PROJECT 2

CASE STUDY:
Farewell My Concubine

When looking for an application for the 3D printed experiments with my research colleague Mingjing Lin, we turned to our shared cultural heritage, and the traditional costumes of Beijing Opera (also known as 'Peking Opera' in the West). The text, music, movement, and costume of these works are set. There is very little room for development. To go to a Beijing Opera is to experience an interpretation of something that is predefined. What might it mean to bring the latest digital tools to represent this traditional form?

Farewell My Concubine is a classic in the Beijing Opera repertoire and tells the story of Concubine Yu's suicide in order to save her lover, Xiang Yu.
In the traditional costumes, pleating is used as part of the undergarment, hidden from public view. For our version of *Farewell My Concubine*, we transfer the pleats to the outside of the costume, to observe their effect.

Research Question

Beijing Opera is known for its choreographed movements which represent fixed emotions. How do digital pleats affect these choreographed movements, and consequently the emotions that are evoked?

Aim

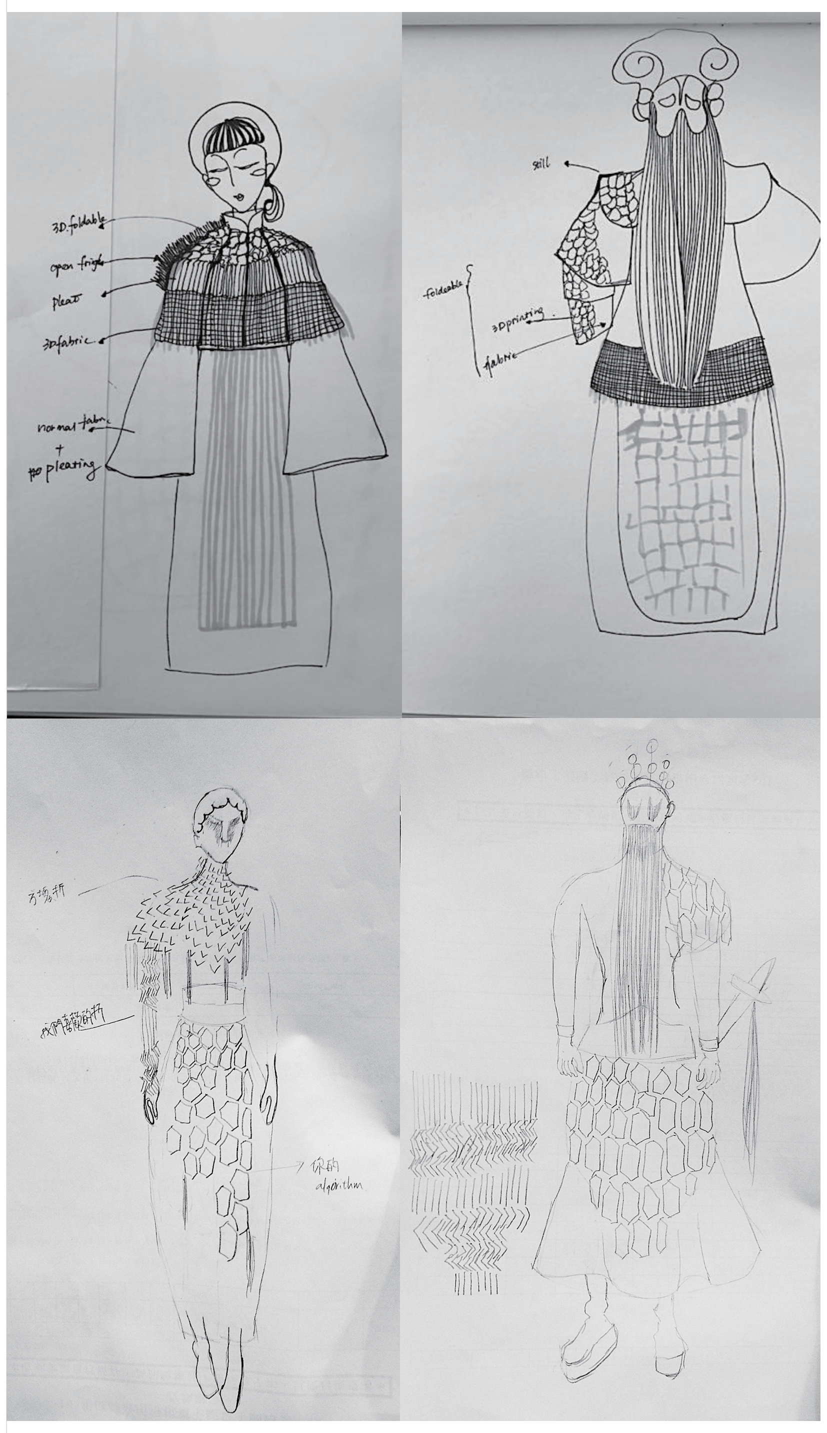
In this performance project, I would like to determine how the performers interact with the 3D printed pleated garments, and what, if any, physical restrictions or emotional characterisations, are generated.

Recursive making	Reflective thoughts during making

I want to see my Cubic Pattern as a 3D printed structure and express my interest to my research colleague Mingjing Lin for a collaboration.

Mingjing and I agree a collaboration, working together on a 3D-printed pleats project. Mingjing suggests we adopt performance as a way of exploring the application of the pleats.

I happily agree with this orientation and believe that it would be meaningful to adopt Beijing Opera, which is from our shared cultural heritage. I am familiar with the way meaning is conveyed through movement and think this is worth exploring.



Mingjing and I agree on a piece full of hand gestures (*Pick Up the Jade Bracelet*) and contact Beijing Opera performers in London. They advise us to choose the well-known *Farewell My Concubine*.

At first, I am reluctant to change, as I have a clear vision of *Pick Up the Jade Bracelet*, however, according to the performers, this piece does not have a high aesthetic value and is not presentable to a large audience. The performers also suggest we select an emotionally powerful extract. Therefore, we agree to change to *Farewell My Concubine*.

We watch a production of *Farewell My Concubine* made for film (2015, Dir., Teng Junjie), to obtain a thorough understanding the storyline.

We select the most famous scene, the sword dance, which only requires one male and one female performer. This number of actors is manageable, and gives us the chance to test out the motion and garments.

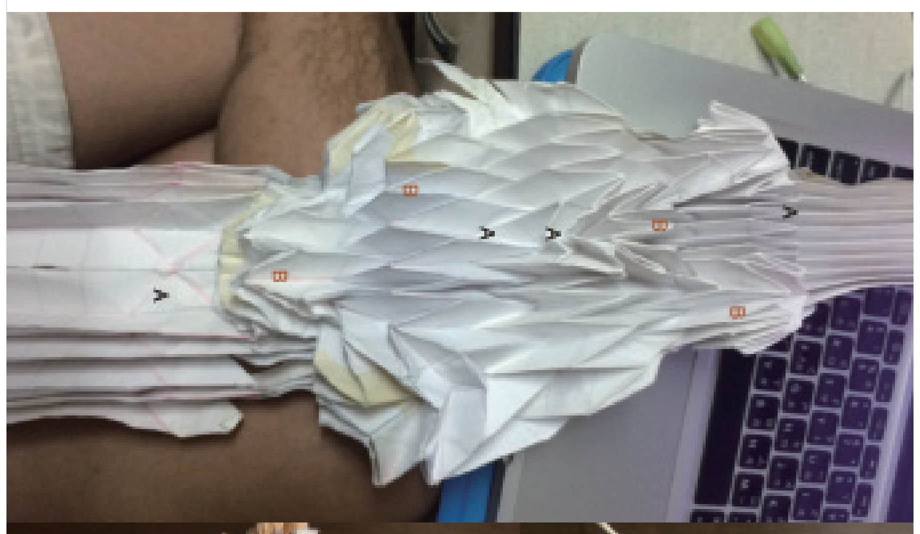
Analysing the film, we assess the appropriate locations on the body to place the pleated structures.

The locations are important because they affect how performers move and therefore potentially generate new meaning.

We also agree to tone down the traditional colours of yellow, red and blue and bring in our colour palette of black, white, and silver to reflect our aesthetic.

We design our ideal costumes separately and combine through discussion.

We reach agreement on the design details surprisingly quickly. We know each other's taste well.



3D modelling pleated structure in computer.

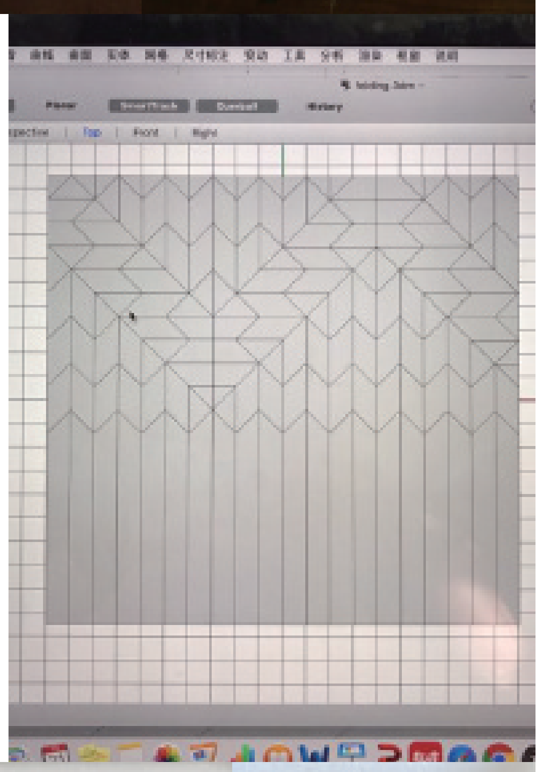
When we try to draw patterns in the graphic software, we realise it is easier to begin from physical folds and transfer something we can literally see to the computer, instead of drawing from our imagination.

We fold physical pleats to help visualise the scale, position and motion on the body.

The folded paper is really helpful. I place it on my elbow to test its flexibility. I think that I can probably use the paper as a mould to pleat a piece of fabric to see how it works on my joint.

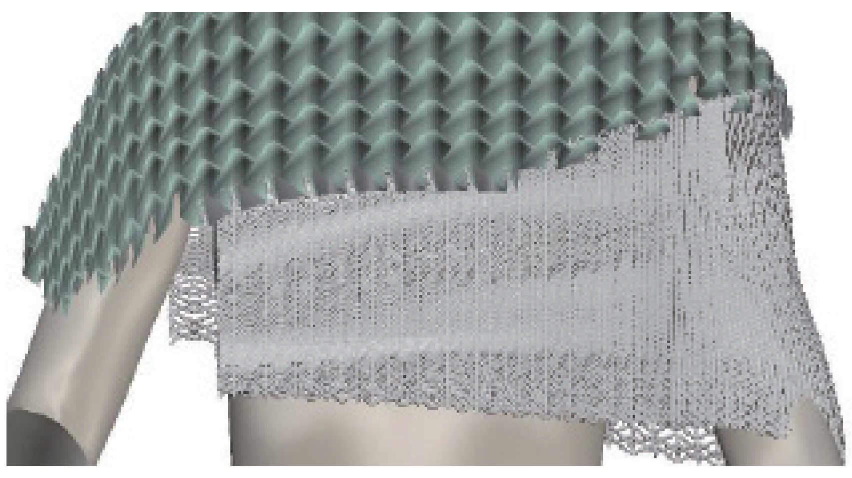
I conduct a trial, pleating fabric by hand, and observe how the pleats stretch with my joints.

This process is helpful as I can get a sense of the scale and size of the pleats.



Once we have finalised the size of the paper and fabric pattern, we begin to digitalise them in the graphic software Freeform Origami

I mark the valley and mountain fold lines on the flat paper plane so that Mingjing can easily input these lines using parametric coding into the software.



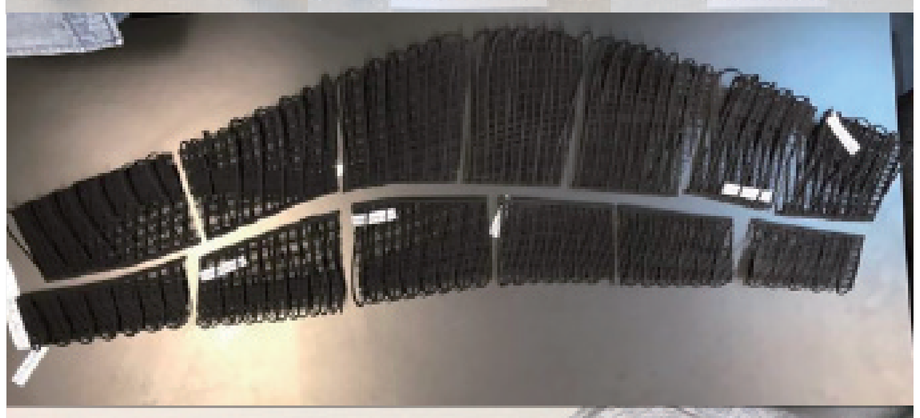
This parametric process is very new to me and Mingjing creates an unexpected weaving structure by entering a wrong code. The outcome surprises us and we decide to keep the rendering.

We send the digital file to the 3D printing company Sinterit, who are sponsoring the production of the sample.

Sinterit is very efficient. They are keen to see the results of our design process and value the collaboration. (They show the sample pieces in an industry showcase in Frankfurt.)

The samples are sent back in 3 weeks, and I hand stitch the pieces together.

The 3D printed pieces are very supple and bendable which is totally different from the conventional 3D printing. Due to the machine scale, the largest printable size is 150×200×150mm. This limitation necessitates a maker's intervention and creates a bridge between craftspeople and technology.



Fitting garments on human to test the mobility after combining the 3D printed parts and conventional fabric.

We are really pleased with the flexibility of the 3D printed parts and the effect of combining 3D printed and conventional textiles.

3 dress rehearsals before the performance

Even though we hire experienced Beijing Opera singers, it still takes some time for them to get accustomed to the costumes, music and stage as we intend to bring new aesthetics to this classical piece.

One performance on 1st December, 2017 with a week long exhibition.

We receive feedback from the audience suggesting that we apply the pattern and technology to other designs. Curators from the V&A pay a visit to the exhibition and invite us to give a presentation at the V&A. Sinterit proposes future collaborations. The 3D printed garments do not seem to hinder how the audience perceive the emotions generating from performers.

Fig. 6.40 When conventional thermal pleats collide with 3D printing pleats on the same costume. *Farewell My Concubine*–Concubine. Hockney Gallery, Royal College of Art, London (2017).

Fig. 6.41 When conventional thermal pleats collide with 3D printing pleats on the same costume. *Farewell My Concubine*–King. Hockney Gallery, Royal College of Art, London (2017).


罢!
Consort Yu
Goodbye!

Fig. 6.42 Tsai-Chun Huang
Farewell My Concubine (2017)
Hockney Gallery, Royal College of Art, London

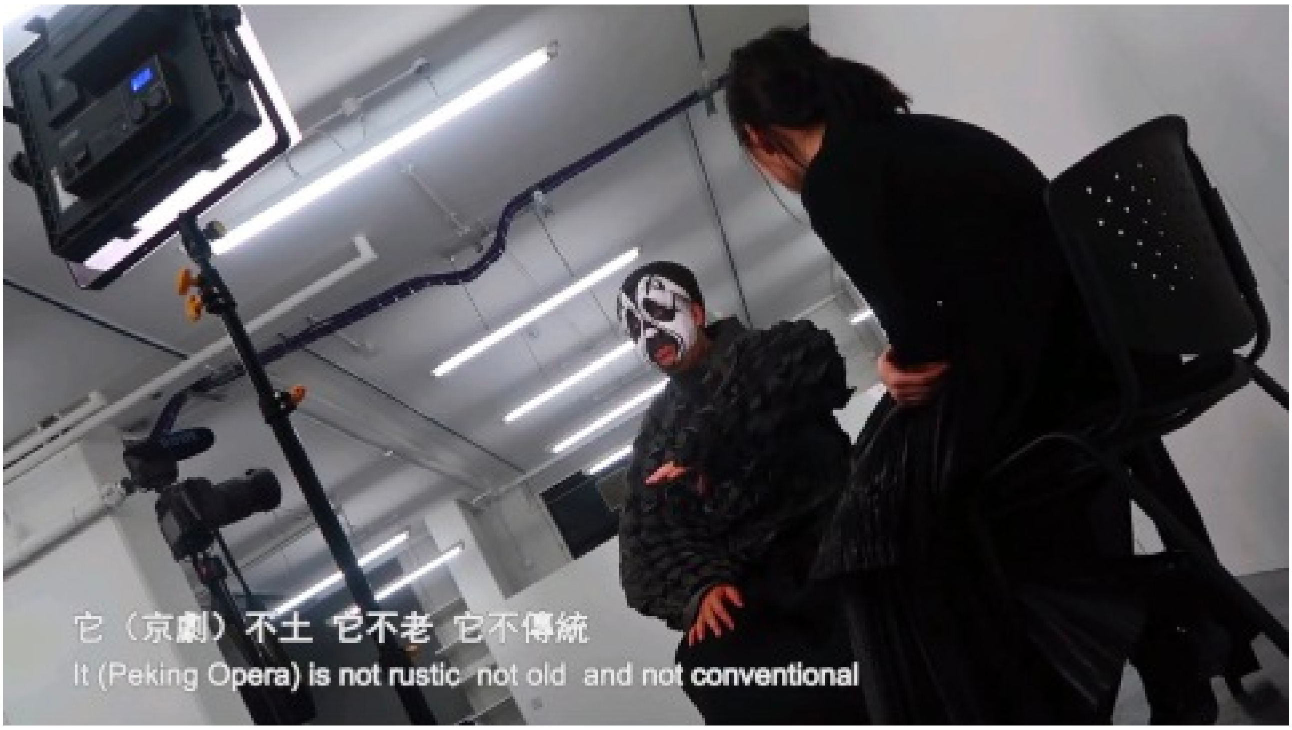


Fig. 6.39 Interviews with performers. Video still: *Fold the Interfashionality* (2018) Video by Red Boy Cultural and Creative LTD. (5’23”)

Reflective evaluation

Based on this experience, the questions for this research are: How does human body movement inform a new type of pleats? What does a pleat do during the movement, as an agent between the body and garments? Can pleats exist without the body and movement?

What is a digital pleat in performance?

Emotion stimuli

In *Little Girl Inside Me*, Cubic Pattern pleats act as motion stimuli to encourage dancers to physically move more. The 3D printed Cubic Pattern in this Beijing Opera acts as emotion stimuli to deepen the performers' characterisation.

With the worry of introducing digital technology to conventional performance, I regularly interviewed the performers to ascertain how they feel when wearing these armour-like costumes. The 3D printed parts are stiff when compared to the traditional silk costumes that Beijing Opera performers are used to. The performers were surprised with the new material and the aesthetics we proposed and were keen to try the new look. I was very curious about whether the garments would hinder their movement and how the performers would become accustomed to these newly designed garments.

The actress, Tianxia Xu, expressed her concern that she might not be able to perform the sword dance, as the 3D pleated part hindered her movement. However, she later indicated that she could accustom herself to the new material after a few rehearsals. The 3D pleats did not really change the movement, as the material is soft and bendable.

Xu's concerns, were perhaps, not really about being physically restricted but rather about the effect the new costume would have on her characterisation. In interview, she reported, "It is a big change to anyone who is familiar with traditional Beijing Opera. When I was young my master told me 'rather torn than false' which refers to the fact that we would rather wear shabby clothes than the wrong type of clothes, which do not represent the character." However, after she saw the garment with 3D printed pleats, she immediately identified the character. She responded in interview that the pleated costume, which combined contemporary technology and traditional craft, gave her a feeling that the character of Concubine Yu could “time travel”, and that the costume helped connect her with the past.

The male actor, Yongning Zhang, who played the king, reported in interview that his left arm could not move freely in the costume, but that the design gave him a strong connection of being a king when wearing it (see Fig. 6.39). “Although the garment is stiff, I search for the character through that stiffness. The pleated structure helps me to feel that I am a warrior.” The costume may not be as free moving as the traditional Beijing Opera costume, however it still transformed him to the character he played.

Zhang further reported that the costumes were permissive, insomuch as they encouraged him to explore ways of acting outside of the conventions. “These costumes remind me everything is new and the centerpiece is the costume. I don’t need to follow the conventional rules of acting.”

From the performers’ feedback, emotion activation can be seen from two perspectives: The first is a reaction from the performers to experience something ‘foreign’ or ‘new’ in their costume, which demands that they rethink, or reinterpret the gestures that have been predetermined by tradition. The physical limitation here gives rise to an emotional reinterpretation. The second is a response to the look of the costumes. The monochrome digital pleats, with their armour-like appearance encourage the performers to reinvest in their characters with emotional force[89].

Given what the performers reported, I want to suggest that the 3D printed Cubic Pattern acts as an emotion stimuli. This echoes Anneke Smelik’s opinion that the ‘…fold is connected to the expression of e-motion (pathos)’ (Smelik, 2014, p.37).

What is in a digital pleat in performance?

<u>Maker’s Involvement</u>

3D printing technology provides new production methods and materials for designers and artists. Before making the costumes for our production

89. The audience too gave feedback. One audience member who was familiar with Beijing Opera traditions reported that toning down the colour, and the placing together of a visual contradiction of rigid 3D pleats and supple traditional pleats, demonstrated the conflict at the heart of the story and helped them “perceive the deep sorrow”.

of *Farewell My Concubine*, my understanding was that 3D printing was a technology that replaced human hands and eliminated the maker's involvement from the process of manufacture. However, through the creative process, I realised that the maker's involvement not only exists in the practical application of digital technology but also in the mindset we bring when engaging with digital tools.

During the production process, the main tasks were to transfer the physical folding pattern into a digital form and to partition the digital file for printing. Due to the size limitation of the printer bed, the maximum object size could be 150×200×150mm (see Fig. 6.43). The smallest 3D printed part of the costumes was 450×200×100mm. Therefore dividing the digital renderings for 3D printing was unavoidable (see Fig. 6.44).

Faced with the task of stitching back together the portions of 3D printed pleats which had been separated for machine printing, I was forced to rethink my assumptions about the relationship between technology and my role as a maker. Up until this point, I had understood that human intervention in a digital process diminished technological integrity. I had thought that the technology should be smart enough to run on its own without further hand manipulation.

My doubts about the autonomy of machine production were supported when I explored the collaboration between Iris van Herpen and New York City Ballet from 2013, in which she was asked to create ballet costumes for Benjamin Millepied's *Neverwhere* (2013). Together with Marc Happel, the New York City Ballet costume director, van Herpen reshaped the tutu and pointe shoes. They adopted a computational calculation for the sizing of every single PVC piece they needed (and admitted that the computer software really reduced the workload). The PVC pieces were laser cut before being hand-sewn onto a flexible mesh substrate (Steele, 2014, p.98). A similar example can be found in the 2014 ready to wear collection by Noa Raviv (see Fig. 6.45).

An understanding of the relationship between machine and hand in van Herpen and Happel's collaboration produces a rethinking of the role of machine technology in the creative process. My own experience of working between software, machine production, and hand creation in the Beijing Opera project have changed my attitude towards technology and maker involvement. Whereas once I had seen them as incompatible, or at least that the existence of one would decrease the effect of the other, now I perceive them as mutual and complementary.

Through the hand stitching the 3D printed parts (see Fig. 46) which are larger than the size of the printer bed, the Beijing Opera costumes could now be understood as a platform in which the maker's involvement bridges the gap between technology and traditional handicraft.

What do digital pleats do in performance?

<u>Bendability versus Stretchiness</u>

In the analysis of *Little Girl Inside Me*, I state that the Cubic Pattern pleats grant mobility to dancers, they can move freely in the garments. I concluded that there is mobility in the pleats. With a new type of 3D pleats being created for the Beijing Opera project, it is worth exploring the property of movement again.

As has been observed, the 3D printed pleats are a 'shell' of the pleating structure. Do these shell-like digital pleats contain mobility?

Both performers expressed their uncertainties of moving in the garments but reported that they became more confident over time. Ultimately they did not see a major difference in the operational capacity between the traditional costumes they were used to and the new ones we had created (Petch, 2017[90]).

Once the performers were used to the feel of the costumes, I observed that the shell-like 3D printed pleats were twisting when the body moved, rather than expanding and contracting as a conventional pleat would. It became clear that bendability replaced stretchiness. This bendability comes from the properties of the material, while stretchiness derives from the pleating structure. The material Sinterit has developed is a composite thermoplastic polyurethane which exists in the form of a black powder (see Fig. 6.43) the particles of which are joined by laser beam, creating very pliable planes.

90. https://3dprintingindustry.com/news/interview-3d-printed-fashion-designer-researcher-mingjing-lin-125912/, accessed 14th, Dec 2018.

These pliable planes allow for a high tensile bending and twisting. A low degree of stretchiness is added from the semi-open structure of the Cubic Pattern which Lin and I programmed in the digital file.

Sharon Baurley's Cube Pleat (see Fig. 1.13) is another example of a 'shell-like' pleat. Baurley's Cube Pleat pattern tucks in the extra ease into the fold, which results in a static structure without the possibility of expansion. The form is locked. The appearance of the structure resembles pleats but the form is stiff and does not offer mobility.

This analysis leads to the question: If the mobility of a pleat relies on material rather than structure, can it be categorised as a pleat?

Following my understanding that a pleat is defined by the remodeling between 2D plane and 3D structure, and that this is effected by the operation of the valley and mountain folds, I would argue that the mobility of pleats should be defined according to the act of expansion and contraction, rather than the property of bendability. Nevertheless, bendability is still critical because all pleated structures rely on the bendability of the material on the folding lines. No matter what it is made of, if the material on the folding line cannot bend, the structure will not be a pleat.

Both material and structure determine mobility. If the 3D object was not in the form of the Cubic Pattern (or another pleating structure) the material would only offer bendability. If the 3D object had the form of Cubic Pattern without bendability, then it would, at best, be a pleat-like shell. In neither of these situations, could we say the 3D object was a pleat. The mobility of pleats should be understood as including both the bendability at the folding lines and the stretchiness from the contraction and expansion of the structure.

The 3D printed pleats made for *Farewell My Concubine* can be understood as pleats because they have both a low degree of stretchiness from the semi-open structure and the bendability of the thermoplastic polyurethane.

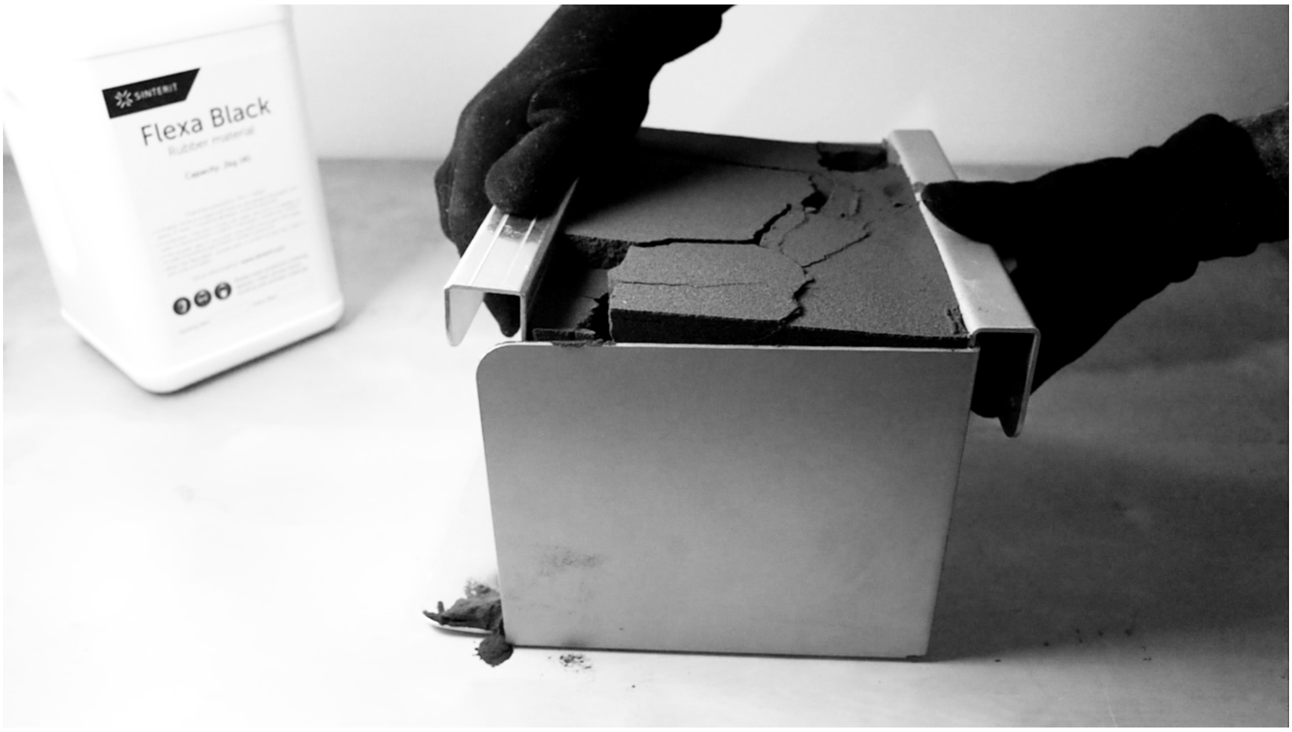


Fig. 6.43 Sinterit SLS 3D printing using powder. The product size for each object is up to 150x200x150mm.

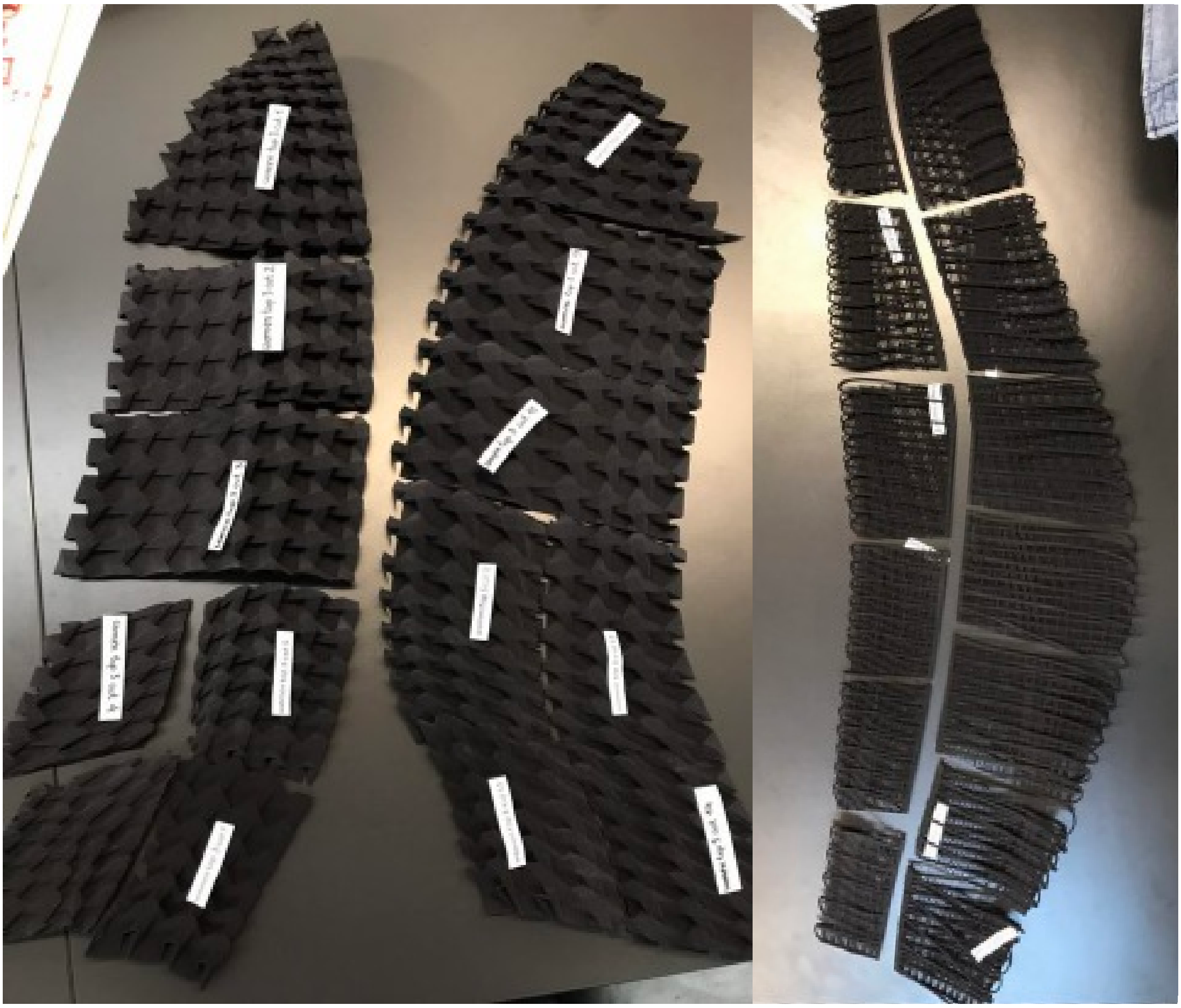


Fig. 6.44 Printing parts reassembled after partition.

Redacted Image

Fig. 6.45 Hand stitched 3D printed polymer parts onto a white synthetic tulle substrate. Noa Raviv, 2014, Prêt-à-Porter. Image: *Fashion at the age of technology*. Annotation: Tsai-Chun Huang

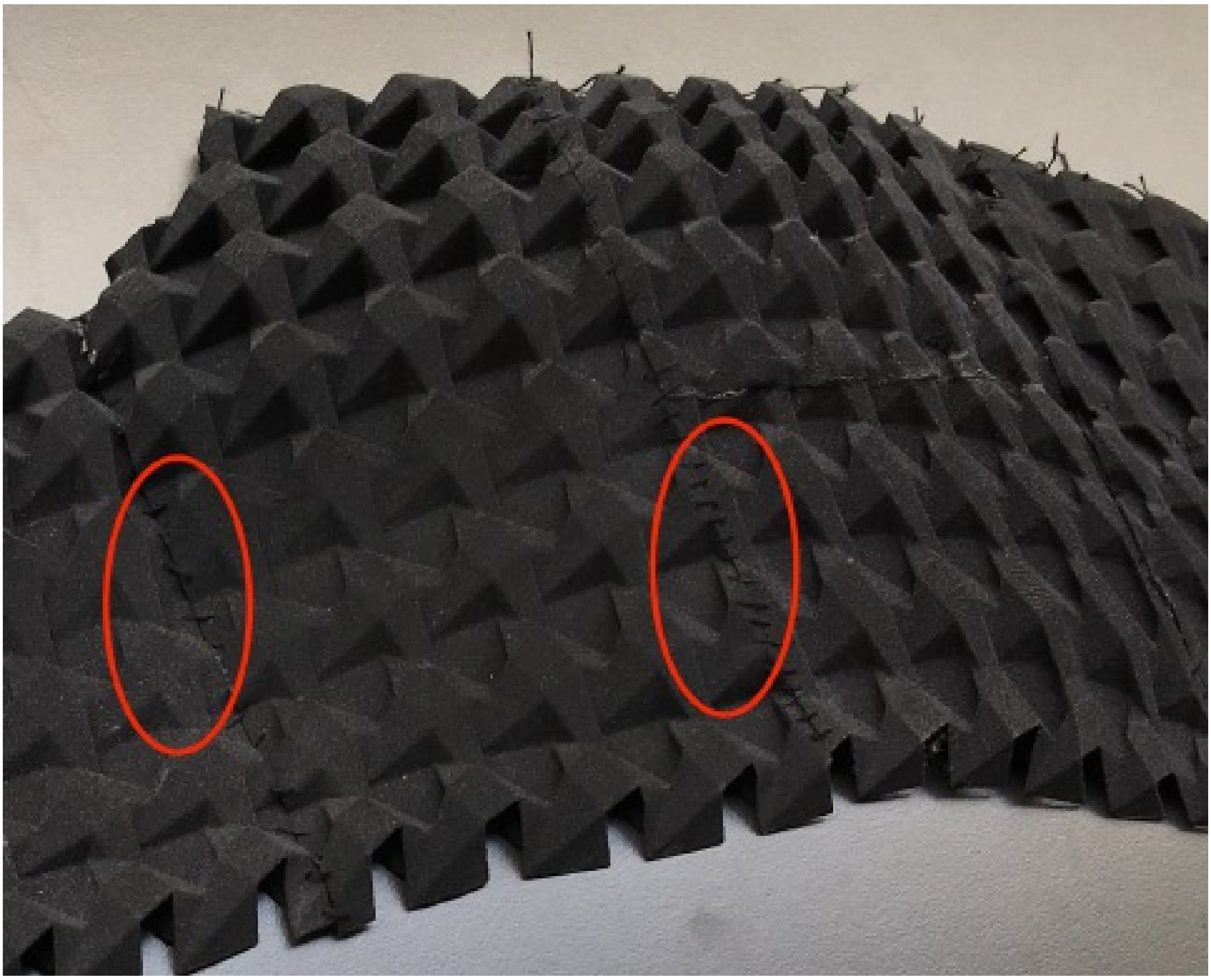


Fig. 6.46 Hand-stitches on Sinterit SLS 3D printed parts, necessary due to printing size restriction. Annotation: Tsai-Chun Huang

Fig. 6.47 *Farewell My Concubine* 3rd rehearsal on 26th November 2017

07

WHAT IS A PLEAT? WHAT IS IN A PLEAT? WHAT DO PLEATS DO? (REVISITED): Shuttling Luxury Mobility

Folding back. After developing pleating techniques (fabric mould and 3D printing) and designing costumes for two performances (*Little Girl Inside Me* and *Farewell My Concubine*) it is useful to revisit the research questions: 'What is a pleat?', 'What is in a pleat?', 'What do pleats do?'. At the beginning of this research project I defined 'pleat' with regard to its etymological origins from Latin and Chinese. After the first stage of making I found space, colour, fabric, my labour, and stories of life, in the pleats (see Fig. 1.1). My predominant understanding of the characteristic of pleats was their capacity to open and close. However, the research process has offered different perspectives toward the quality of a pleat. This chapter explores some of those perspectives. Key concepts that have emerged from the second stage of making, include: 'shuttling', 'luxury', and 'mobility'.

7.1-1 Shuttling (Process)

I propose that movement of the pleat between 2 dimensional planes and 3 dimensional forms is a transitional process of 'shuttling'. The critical element that permits the movement between these two conditions is the folding crease. Mountain and valley folding lines are not separating surfaces, they are the transitional nexus in the action of 'shuttling'.

Shuttling refers to a continual movement between states without any singular direction. When a piece of cloth, which is given a pattern of mountain and valley folding lines and fragmental surfaces, is activated to conduct the motion, to move between 2-dimensional plane and 3-dimensional form, there is no terminal of the morphing, as the pleating, unpleating process is a conceptually smooth and continuous operation that shows no regression or progression. The pleating, unpleating, depleating, enpleating, and repleating[91] stages are equally a start-point, end-point and mid-point of an ongoing cycle (Stagoll, 2005, p.26). I argue that pleats move between dimensions: this is a process of 'shuttling'.

7.1-2 Shuttling (Antithesis)

Shuttling implies that there are conditions, states, extremities, or points from which the movement operates. To think back to the costumes for *Farewell My Concubine*: the design includes both 3D printed pleats and hand pleated pleats, the latest in a technical evolution, and an ancient fabric manipulation

91.Unfolding-Defolding-Enfolding-Refolding is derived from Anneke Smelik (2014).

technique. These two ‘conditions’ represent conceptually oppositional points on a continuum in the process of shuttling.

Digital pleats sit together with hand pleats on the same garment, forming a kind of antithesis. The folding lines between digital pleats and hand pleats echo lines in poetry that reflect opposite ideas, lines in folds and lines in poems, which join contrasting concepts by approximating the surfaces. Guo-Ying Wang writes that traditional Chinese poetry engages two concepts in order to help the reader establish a complete vision of the described image. The whole is greater than the sum of its parts. Contrasting concepts create a third space for readers (Wang, 1986, p356).

James Liu explains this dualistic existence in Chinese poems. He illustrates some simple examples from language expressions in common usage, to help the reader easily understand Chinese concepts and ways of thinking and feeling.

> [I]n Chinese, instead of saying ‘length’, ‘height’, ‘width’, etc., one says ‘long-short-ness’, ‘high-low-ness’, ‘wide-narrow-ness’, etc., which show a dualistic world-concept and a relativistic way of thinking.
>
> (Liu, 1962, p.48)

The juxtaposition of two contrasting elements demonstrates harmony and acts as a reminder to be inclusive of opposition.

In his lecture series on the classic Chinese epic novel *Dream of Red Chamber*, Xun Jiang (2003) explains this principle of antithesis as a method to strike a balance between two contrasting concepts. Chinese poetry is the embodiment of Chinese aesthetics, life, and worldview. When a poet writes the word ‘mountain’, they immediately follow with ‘water’ at the correspondent position in the next sentence. Similarly, the word ‘spring’ would be followed by the word ‘autumn’. The reader is encouraged to look at both at the same time without favouring either, to achieve balance.

Pleats are able to shuttle between 2D planes and 3D forms. They are in a process of shuttling. The process is a continuous dynamic between events (conditions) without any progression or regression. In *Farewell My Concubine*, the costumes juxtapose contrasting digital technology and handicraft as antitheses. These pleats are activated by the movement of performers, opening and closing the pleats, shuttling between oppositional conditions of new and old, cutting edge technology and conventional handicraft, East and West.

7.1-3 Shuttling (Non-Binary)

As a maker, I was concerned that the 3D Pleating project risked a 'trap' of dichotomy. New versus old; technology versus craft; and West versus East. In fact, fashion designers often '…problematize the binaries to harness the transformative potential in both bodies and material in order to imagine a radically open future' (Seely, 2013, p.251).

In the creative process I tested eliminating half of this dichotomy (for example, removing the hand pleated sections eliminated the 'old', 'craft', 'East') but the result was that the aesthetic was reduced. On their own 3D printed pleats became a chunky object that did not demonstrate the impact of cutting edge technology on traditional craft. There was nothing for the 3D printing to contrast with, no context to balance their form.

Through discussions and feedback from audiences at rehearsals and performances, I came to the conclusion that it is necessary to put contrasting elements together to better explore the possibility of pleats.

Bringing contrasting elements together follows 'and/and' logic, part of Pennina Barnett's 'soft logic', an inclusive logic to break binary thinking. This thinking is beyond the constraints of the binary; it is a logic of and/and, rather than either/or, providing multiple possibilities (Barnett, 1999, p.26). Barnett believes that the fold in soft logic helps people 'to think without excluding' (Serres, 1991, p.78), a notion of connecting, not splitting. This inclusivity is demonstrated as the surfaces of pleats meet each other as the cloth contracts.

Fortuny's Delphos dress can also be understood as 'non-binary antithesis' in the way that it manages to simultaneously reveal and conceal. The Delphos dress acts as a membrane which covers the flesh and at the same time reveals the contours of the wearer's body (Smelik, 2014, p.40) bringing body and clothing together as one (Doy, 2001, p.88). This follows the ancient Greek ideal (Hollander, 1975, p.9). The pleats simultaneously dress and undress the body (Smelik, 2014, p.40). The Delphos dress can therefore be regarded as embodiment of an inclusive and/and logic by juxtaposing contrasting concepts.

As this research shows, the inherent properties of textile materials directly affect the pleating result, and the quality of those pleats. Fortuny created his Delphos dresses almost exclusively in silk but he did also produce a limited quantity of cotton gauze pieces in the same Delphos design. As I have discovered in my own research experiments, animal fibres contain proteins which react to the heat and fix after cooling, while plant-based fibres do not fix so well. This could explain why Fortuny released so few cotton editions. Petroleum based synthetic materials were not released until 1941 (Bolton, 2016, p.93), so Fortuny did not have polyester, nylon, or other synthetics available to him.

Natural materials and synthetics have their own pros and cons. Petroleum fibres are essentially a type of plastic and they are particularly sensitive to high temperatures, fixing when cooled. Synthetics therefore retain pleating formations much longer than natural fibres (including plant-based and animal fibres). While silk held the pleats better than the cotton gauze, Fortuny still had to include a 'repleating' service when he sold his Delphos dresses. But it would not be quite right to imagine that if synthetics were available to him, Fortuny would have opted for polyester, the textile that holds pleats perhaps better than any other material. As this research discovered (Project 1 Case Study: Little Girl Inside Me, see Chapter 6: Pleating Practice (ii) New Technology) natural fibre pleats, when compared to those formed with synthetics, flow with more grace, are less stiff and unforgiving, and provide a softer and more gentle flow of the pleats across the body.

The concept of shuttling, through process, antithesis, and the non-binary, is made manifest in performance. The body takes on the properties of the pleats. The costumes in *Farewell My Concubine* grant the performers an opportunity to fold between performing a character and performing themselves. As the pleats on their garments move between 2-dimensional planes and 3-dimensional forms, in a continuous and seamless process of shuttling, the performers themselves acquire the conditions of shuttling between traditional Chinese and contemporary Western, between mannequins and characters. In a process of reciprocal shuttling, between the performer and the garment, the performers move through the antithesis and the non-binary. The folding lines in the pleats are the transitional nexus that help to articulate the dividing surfaces, keeping the cloth as one, while also articulating separate planes.

7.2-1 Luxury (Liberation)

Pleats used to be a sign of luxury as they required a lot of fabric, they were expensive to make, and difficult to keep. Issey Miyake wanted to democratise fashion, to make designer clothes accessible to everyone. It could be considered a paradox that he chose the pleat to do this.

Miyake's design philosophy emerged, in part, from his experience of the student riots in Paris in May 1968 (Isozaki, 1978, pp.54-55). During his apprenticeships in the couture houses, Guy Laroche and Givenchy, in Paris, he felt distant from society and the working environment. He thrived on the rebellious, liberal atmosphere on the streets, and he sought to challenge conventionality and conformity (Sato, 1999, p.34). This alienation liberated him from the traditional constraints and the conventional rules of etiquette of haute couture, and he came to the realisation that his design should easily be worn by anyone.

7.2-2 Luxury (Democratisation)

After 5 years of research with his chief textile designer Makiko Minagawa, Miyake believed that he had achieved his goal of creating garments which had the feel of couture but were affordable like jeans or T-shirts[92]. Miyake once said that he did not want to repeat what Fortuny had done, producing luxurious pleated clothes for an elite class (ibid, p.107). He used low price fabric to make pleated garments affordable to the general public. At the

92.The key moment came when Miyake attended rehearsals for William Forsythe's production of *The Loss of Small Detail* in 1993, for which he was designing the costumes. Miyake noticed that the flexibility of the costumes meant that the dancers would swap costumes. He deduced that one single 'cut' could fit many different body shapes (Chandès, 1998, p.24).

same time, the flexibility of the pleated patterns lowered the production cost by eliminating the need to produce complex and diverse garment styles, permitting a wide range of ages, body shapes, and genders to wear a single style. Miyake believed that pleats were his method of democratising luxury and popularising fashion in daily life (Benaim, 1997, p.16).

As part of his process of democratisation, Miyake emphasised that his garments should be easy to look after, especially for frequent travelers, and that the garments should not require ironing when arriving at a destination (Miyake, 2012, p.59).

7.2-3 Luxury (Success and Failure)

My experience of making the costumes for *Little Girl Inside Me* echoed Miyake's collaboration with Forsythe. I too underwent the situation that the pleated garments were swapped between dancers. The pleated garments were not limited to performers' ages, body shapes and genders. These circumstances reassured me that pleats democratise fashion, like jeans or t-shirts, making high-fashion accessible to everyone in their daily life.

However, during the production period and the preparation for the restaging, it was a challenge to keep the pleats in shape after every rehearsal. The performers were working the costumes hard. They were crawling on the floor, hugging each other, and performing lifts. They also generated sweat. The pleats struggled to survive. How to keep the pleats became the biggest problem.

As well as adding layers of fabric and fabric stiffener to increase the durability of the pleats, I needed to repleat the garments, several times, before the premier. The additional labour that was needed to keep the garments in their best condition is part of why they maintain their luxurious status.

The same point can be made for Miyake's ready to wear collection. Despite his intention and the fact of polyester's high resistance to humidity and pressure, none of these pleats are truly permanent[93]. Every garment sold comes with a clothes label indicating that the pleats are not permanent and wearers should avoid sitting for long durations. In terms of laundering, it is

93. This is controversial. Bolton argues that they are (Bolton, 2016, p.93). In conversation with staff at Issey Miyake flagship shop in London (12th Nov, 2018), I was told that the pleats were marked as 'not permanently pleated' to avoid customer complaint (but if they were permanently pleated there would be nothing for customers to complain about!). The website suggests customers should, 'Avoid leaving it hanging for long periods of time, as this may change the shape of the pleats.' https://www.isseymiyake.com/en/faq/basic/, accessed 12th Nov, 2018

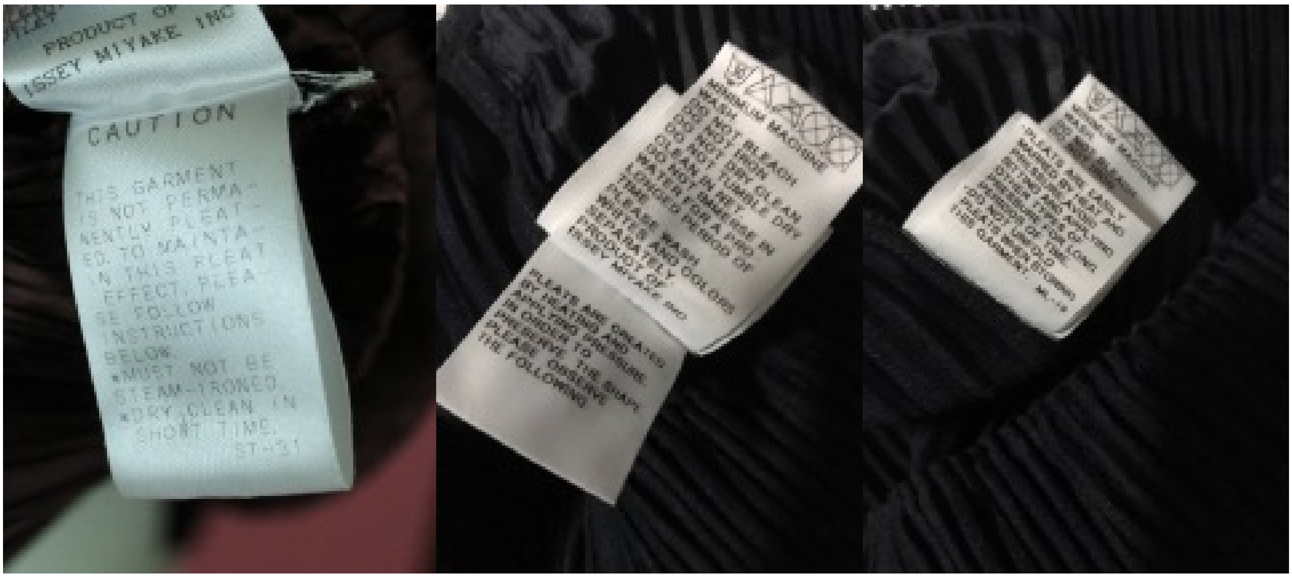


Fig. 7.1 Pleats Please washing labels

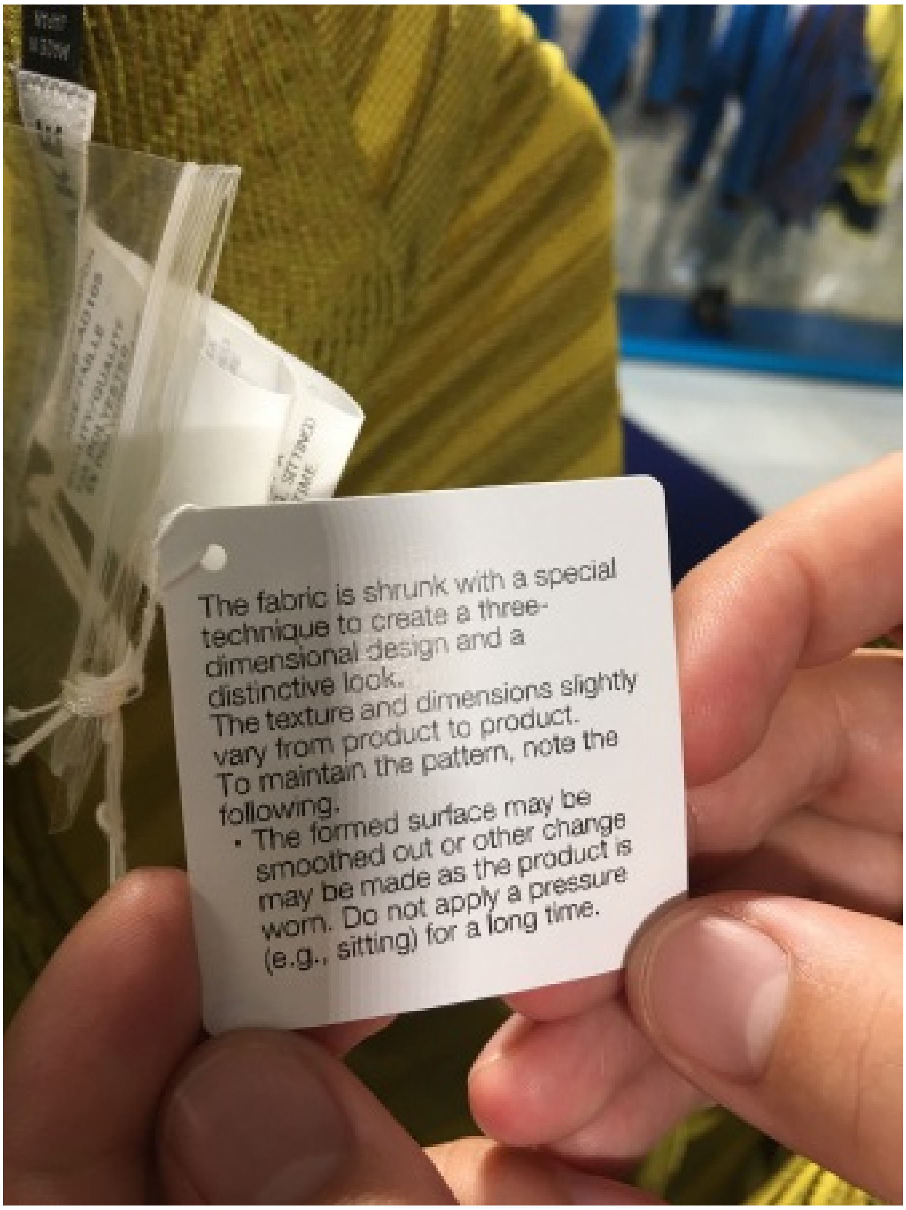


Fig. 7.2 Steam stretch collection washing labels

suggested that the garments are washed in cool water without long periods of immersion (see Fig. 7.1). In addition, it is recommended that garments are laid flat for drying rather than hung, in order to prevent the pleats being pulled out by gravity.

Even though Miyake has invented a new type of steam stretch technology that structurally weaves the stretch yarn into the fabric in order to create a pleated effect, customers are still advised to avoid squashing the pleats, and to steam the garments to maintain the integrity of the geometry and prolong their lifespan (see Fig. 7.2).

This protracted series of suggestions for the use and care of the garments, together with their high price tag, do not engage the wearer in a similar accessibility to t-shirts and jeans. Rather customers are encouraged to pay extra attention to the care of their clothes. Miyake's pursuit of a democratic and popular pleated material has ultimately backfired. He has rather created a label which is associated with luxury and high-end design. These garments are not suitable for daily use. Miyake's Pleats Please collections ultimately highlight what the designer had intended to eliminate; reinforcing the unavoidable luxury embedded in pleats.

7.3-1 Mobility (Properties)

Across this research project, a key factor in the application of pleats and an understanding of what they do, comes back to the issue of mobility. The concern of mobility was crucial for the analysis of the costumes in *Little Girl Inside Me*, and *Farewell My Concubine*. In dance, Fortuny takes the method of fitted cutting, with tiny straight pleats that offer mobility, while Miyake offers mobility through loose garments made from a knitted fabric rather than figure-hugging pleats. I took Fortuny's approach to design fitted costumes for *Little Girl Inside Me* using the Cubic Pattern to release space between garments and the body. In the 3D pleated costumes, the form needs to allow for expansion and bendability at the folding lines to permit mobility. Mobility is what pleats do.

Pleats and motion have a close relationship (Barnett, 1999, p.26), and my experiences demonstrate that pleats are better observed during movement rather than in a static condition. Are pleats inseparable from motion? Can pleats exist without movement?

I would argue that a pleat, as a tangible object, can exist on its own without movement. According to my analysis, when a piece of material contains a folding structure which provides expansion, and folding lines that have thermally reconfigurable properties or bendability to allow the shuttling between 2D plane and 3D structure, this is qualified to be considered pleats. In terms of the form itself, it does not need force to activate the motion, only the potential of that motion. In this case, I would define the physical object as a pleat.

From a material and philosophical perspective, pleats have largely been conflated with 'folds' and examined through static formations[94]. For example, folds in architectural forms, folds on the clothing of figurative statues. Even when theorists include the formation of pleats (Deleuze, 1993, p. 10), the majority of literature still concentrates on the static condition of pleats, elaborating the philosophical discussion through structure and form.

But the methodology this study proposes, pliable logic, distinguishes itself from current textile thinking and related theories on folds by including the action of making pleats; also, by exploring the use of pleats in dance, this study gradually leads to the detailed observation of the motion of pleats. These research methods inevitably include the movement of pleats as part of their fundamental quality.

7.3-2 Mobility (Autonomy)

In *The Fold: Leibniz and the Baroque*, Deleuze looks to painting and sculpture to argue a case that the fold is autonomous from the body.

> We only have to consider the manner by which the elements are now going to mediate, distend and broaden the relation of clothing to the body. [...] A supernatural breeze, in Johann Joseph Christian's Saint Jerome, turns the cloak into a billowing and sinuous ribbon that ends by forming a high crest over the saint. In Bernini's bust of Louis XIV the wind flattens and drapes the upper part of the cloak in the image of the Baroque monarch confronting the elements, in contrast to the "classical"

94. A detailed definition, stating the differences between 'fold' and 'pleat', as used in this research, are given in *Chapter 1: Introduction*.

> sovereign sculpted by Coysevox. And especially, is it not fire that can alone account for the extraordinary fold of the tunic of Bernini's Saint Theresa? Another order of the fold surges over the Blessed Ludovica Albertoni, this time turning back to a deeply furrowed earth. Finally, water itself is creased, and closely woven, skintight fabric will still be a watery fold that reveals the body far better than nudity: the famous "wet folds" flow over Jean Goujon's bas-reliefs.... […] In every instance folds of clothing acquire an autonomy and a fullness that are not simply decorative effects.
>
> (Deleuze, 1993 p.122)

Although Deleuze describes acts of movement: 'billowing', 'flattens', 'turning', all of the examples he gives are in fact static representations in types of stone. However, his point is that the fold has a life separate from the body: it has autonomy from the structure of the clothing that might pin it to the human form. Folds are formed and transformed by the elements. They compose and recompose without inside or outside, beginning or end. During the movement, folds encounter and separate, continuous and discontinuous (Barnett, 1999, p.26). Folds that cannot be explained by the body, multiply and become autonomous (ibid., p.27).

Deleuze separates the fold from its relation to the body. The forming of a fold and its movement are given to the elements. However, from my experience of using pleats to make costumes for dance productions and from my analysis of pleats in a wider fashion and textile context, pleats require body motion to bring the expansion and contraction to life. They require the body to become themselves. They cannot move on their own without additive force.

Whereas Deleuze's folds are formed through forces autonomous of the body, I argue that pleats demand the body for both their fabrication and the process of shuttling between 2D plane and 3D form.

7.3-3 Mobility (Future Pleats)

Pleats offer mobility to the body, but they are not able to move on their own without being activated. Perhaps the next evolution of pleats, in a world of technological advancement, would be that they can move on their own.

Nature has already been unfolding leaves for millennia. NASA's satellites unfold in outer space, stent grafts formed through origami folds expand in weakened arteries[95]. Smart textiles already engage body responsive fabrics but what if the body were to respond to the pleat, rather than the other way round. What if a pleated fabric collar could sense air pollution before its wearer, and expanded to create a mask? What if a pleated coat contracted in the cold to create warm air pockets around the body? This research set about asking the questions, 'What is a pleat?', 'What is in a pleat?', and 'What do pleats do?' As technology advances, these questions remain pertinent. It is the answers that will evolve alongside what becomes possible. In the future, when pleats acquire autonomy and move on their own, the research questions will remain the same, but the boundaries of both the application of, and thinking about, pleats and pleating will shift and expand.

By studying traditional hand craft and 3D printing technology in relation to pleating and the incorporation of textile thinking, the stage is set for the next phase of innovation in pleating, unpleating, repleating and enpleating.

95.These examples are from documentary *Origami Code,* directed by François-Xavier Vives, 2015.

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08
CONCLUSION:
A pleat only fully reveals itself through motion.

A pleat has to be studied in the dynamic process of shuttling between 2D plane and 3D form.

This research journey has also been a dynamic one, shuttling between theory and practice, between histories and experiments. The aims of this research were to interrogate the meanings of pleats, develop a taxonomy, and a new thermal pleating technique, produce 3D printed pleats, generate a methodology, and explore the potential of new forms of pleats.

I started by asking three questions: 'What is a pleat?', 'What is in a pleat?', and 'What do pleats do?' The study was led by practice but the outcomes moved beyond the tangible form and included a methodology for textile research practice and a new perspective on pleats and pleating. I have augmented current textile thinking and proposed that pleats and pleating should be understood as possessing and promoting specific and unique meaning.

Originality

- Fabric Mould

The need for the fabric mould came from the unsatisfactory results when using conventional paper moulds for pleating in my studio space, with the steam from an industrial iron. The fabric mould is made with calico and extra stiff interfacing following the pattern surfaces, allowing the maximum amount of steam to penetrate the warp and weft of calico at the folding lines of the fabric.

Based on the experiences of reproducing Fortuny and Miyake pleats (as described in *Chapter 2: Pleating Practice (i) Experiments*) I reflected on the intrinsic qualities of pleats and pleating. Thermal pleating is a moulding process formed through heat and pressure. Adhering to these two principles, I can reproduce the outcome which is normally only available in a professional workshop, with domestic equipment, in the most basic of settings. The newly invented fabric moulds allow makers to pleat polyesters with the steam from domestic irons at home. The liberation from professional industrial machinery is part of the originality of this study and the fabric moulds are a tangible outcome.

While synthetic materials fix when cooling, cotton calico can be formed, flattened, and reformed multiple times through ironing and steaming. The structure of weft and warp leaves gaps for steam to penetrate which allow the heat to pass. These qualities of natural fibre make cotton calico an ideal material for pleating moulds.

Conceptually this fabric mould is an embodiment of the Deleuzian term '*plica ex plica*', as it is the pleats that produce pleats from within. This is not the case with the traditional pleating method of paper moulds which are folds, not pleats. Only when pleats are produced through fabric moulds, which are themselves pleats, can the state of '*plica ex plica*' – pleats from pleats – be truly found.

- <u>3D Printed Pleats</u>

Adopting new technologies to produce new forms of pleating has been one of the aims of this study from the start. These technologies can create structures which cannot be achieved through traditional techniques, opening up new lines of inquiry of what a pleat is and what pleats do. They trouble conventional definitions of the pleat at the same time as helping understand how those conventions function. One conclusion is that pleats have to contain both the conditions of 2-dimensional plane and 3-dimensional structure to qualify as pleats. If new technologies are going to be used to develop pleats in the future, they need to allow the temporality of the pleats, not forming only a static shape. Pleats are always in a movement, are always in-between. 3D printing technology helps me to understand how a pleat performs by creating a 'non-pleat', pushing the ideas at the edge of conventional pleats.

In terms of the creation of 3D printed pleats, the structure is manipulated virtually on screen which allows the formation of curved pleats which cannot be achieved through a traditional pleating method. In addition, the input parameters can easily alter the textures of individual pleat surfaces, creating weaving structures, perforation lines, punching holes, in a potentially endless series of permutations. The properties of curve and individual surface variation cannot currently be created using traditional pleating techniques and are offered as another part of the originality of this study.

Contribution

- Pliable logic

Pliable logic arises out of acknowledging that pleats and pleating have their own conceptual frame of thinking, distinct from other types of textile production methods and textile properties. It is a textile research methodology which references a malleable, recursive procedure, and encourages the researcher to search for meaning in between stages. The movement between 2D plane and 3D form in pleating, described in this research as 'shuttling', has influenced the establishment of pliable logic, as a contribution to textile research.

Jane Mills encourages researchers conducting qualitative research to establish their own methodology through adopting and adapting existing methodologies to match their research context.

> Flexibility in the use of qualitative methodologies is essential to create a best-fit with the research question, and to optimise the desired outcome.
>
> (Mills, 2014, p.36)

This study was led and guided by practice. The research commences with hands-on experimentation. I was inspired by Kim Vincs' idea that art and design research should raise, explore and answer the questions through action rather than from literature review alone.

> I felt that I needed to produce some dancing in order to see which questions and issues the dancing brought forward. This, in essence, was my methodology. I made a series of dances, and gradually identified the issues each one presented, and the questions that they raised about dance. I then used these questions to fuel the making of further dances and the development of a methodology for the project as a whole.
>
> (Vincs, 2007, p.101)

This research project began with the idea to build a piece of cloth that has the capacity of contraction and expansion. I started with what was familiar to me – making – and used that experience to find my research questions. The research context gradually became clear and shifted from developing a piece of technical fabric to an examination of the quality of pleats and pleating.

Pliable logic results from the need to find a 'best-fit' methodology, and the need to 'produce', shuttling between making and theory. This methodology augments soft logic, including recursive sequence and '*plica ex plica*' to allow textile research to be conducted in a more pliable way. Textile researchers can adopt this flexible research path to reflect and speculate between theory and practice, to obtain results that are distinct from other methodologies.

Pliable logic suggests a permeable and flexible research approach which incorporates abstract thinking into making, to elaborate the complexity embodied in materiality, avoiding the cul-de-sac in production, and vice versa, that during abstract thinking, researchers can employ tangible making for visualisation and to expand the boundary of thinking. I propose that pliable logic is part of textile thinking and that it broadens the way we can think and make.

- <u>Taxonomy: 4 Types of Pleat (and beyond)</u>

This research classifies pleats into four groups, 'stitched pleats', 'thermal pleats', 'structural pleats', and 'digital pleats'. These four types of pleats are distinguished according to the process of their formulation. Stitched pleats are formed by a process of threading; thermal pleats are formed through heat and pressure; structural pleats are formed during their textile fabrication; digital pleats are formed through digital technologies and onscreen manipulation. This categorisation is inspired by Sharon Baurley and Matilda McQuaid's classification of pleats (see *Chapter1: Introduction*), and Andrew Bolton's organisation of couture techniques for exhibition (see *Chapter2: Pleating Practice (i) Experiments*).

The research questions play an important role in forming this categorisation. The questions posed by the study help to identify categories of pleats, which in turn narrow the focus of the study (to new thermal processes and new digital possibilities).

I have already seen this categorisation working productively. In pleating workshops and lectures, participants from both design and non-design training, respond that these categories help them to better understand the multiplicity of pleats they encounter in professional and daily life. This categorisation is offered as a contribution that provides a grounding for related research in the future.

Where do pleats take us and what do pleats teach us?

3D Printing an object that is like a pleat does not make it a pleat, because the technology is not in sympathy with how a pleat is formed and how it functions. A 3D printed pleat only resembles a pleat at a certain static moment. Deleuze argues that the baroque folds billowing around *The Ecstasy of St. Theresa*, simultaneously reference their 2D flat and 3D form of folds in the static sculpture. Flatness and full billowing are both caught at the trajectory of an infinite moment. One fold becomes another fold, flat and full folds, at one moment. 3D printing reproduces the shell of pleats, it is only able to present one slice of the movement of pleats, which cannot look back or forward. It does not hold the memory of the 2D plane from the past, nor the imagination of the fully contracted pleats of the future. Thinking in pleats is about thinking backwards and forwards together, and all the moments are distilled, containing unpleating, depleating, enpleating and repleating.

This study has come to an understanding of the potential of pleats as a conceptual tool that can shuttle back to redevelop itself. If the fabric moulds embody the possibility of pleats pleating pleats, reinterpreting '*plica ex plica*', creating new ways of making, what do the digital pleats reinterpret? The 3D printing provides freedom and freeform to interrogate again the qualities of pleats.

I will continue to explore the possibilities. Using pliable logic, I will explore 3D printing technologies with the intention to contribute to the development of 3D printed materials. For example, drawing on a maker's knowledge of conventional textiles to interrogate the potential of 3D printing technology, just like a weaver changes the pressure of the reed to create a looser or softer

The pleat is only just beginning to unfold.

For my own future contribution to the field, I intend to continue using pliable logic, shuttling in-between pleats, making and thinking, craft and technology.

It will not only be the production methods that change, or the materials which are used, but as maker's knowledge is brought together with new technology, we will encounter new forms of pleats, hitherto unthinkable folding structures, and unexpected applications.

As the technology advances, so too will pleating techniques.

This research project has benefitted from, and contributed to, technological advancement in textile development.

All this research was made through the key methods of learning, making and workshopping.

Through the study of pleats in dance projects, I have addressed my research questions, 'What is a pleat?' 'What is in a pleat?' 'What do pleats do?' I have concluded that the aspects of 'shuttling', 'luxury', and 'mobility' are the core factors.

The concept of 'pliable logic' has been developed, which includes the ideas of 'softness', 'recursive sequence', and 'plica ex plica'.

A new way of categorising pleats has been proposed.

Using the latest technology available, the SLS Sinterit 3D printing has created something which troubles the conventional definition of a pleat, and allows us to consider what qualities are necessary for something to be understood as a pleat.

On a domestic-scale, the fabric mould technique is one that makers with the most humble of resources and equipment can use.

The research has developed new ways of thinking about and making pleats.

fabric, I would like to see if it is possible to change the density of the 3D printed material so that it is thinner. I would also like to experiment with perforating the layers of material to create a softer plane that is bendable and which reverses the pleating production process, building a 3D structure first that can then flatten to a 2D plane, inverting the order of a thermal process. The 3D printed pleats suggest a possibility of what future pleats could look like, will be made of, and how they will function.

Perhaps, in time, new categories of pleats will need to be described. Two potential categories already feel immanent: 'autonomous pleats' and 'virtual pleats'.

Pleats come into being through motion. In the context of fashion, that motion is created by the body. A fifth category, 'autonomous pleats' leaves the body behind, coming into being through non-bodily stimuli.

In 2012 Christophe Guberan, a textile researcher in Switzerland, printed folding lines of a pattern with a high-water content ink, onto tracing paper. As the water evaporated, the folding lines began to bend, and the 2D plane began to form into a 3D shape. This was a kind of proto 'hydro' formed pleat. In 2015 he printed plastic onto a tension stretched knitted fabric. When the tension is released, the elastic fabric contracts around the plastic shapes, pushing up a 3D form (to create a shoe upper). These examples open up the potential to think whether it is possible to 3D print two or more different materials together, in order to create a multi-composite object that matches the properties of pleats, expanding and contracting autonomously, without the movement of the body. Or, the future pleats could be a kind of 3D printed flat surface, programmed with a coding system for its mobility. When these autonomous pleats move on their own, how will the human body respond?

A sixth category: 'virtual pleats'. Like 'digital pleats' they are formed through coding, but unlike digital pleats which find a tangible outcome in 3D printing technology, virtual pleats remain as code. Deleuze describes two types of fold genesis, 'epigenisis' in which the pleat is pushed up from a flat plane, and 'preformism' in which a fold ensues from another fold (Deleuze, 1993, p.10). Virtual pleats demand a different approach, in which the pleat is formed by a series of 0s and 1s.

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Appendix 1
SUPPORTING PROJECT 1:
Cubicolour

Date: 21st January 2016; 30th November 2018

Place: Royal College of Art, London, UK; 798 Art District, Beijing, China

Material: Paper

Using Illustrator, I drew out my own Cubic Pattern and filled colour in the different blocks between folds, analysing the combination and variations. After playing with various combinations, putting colour together randomly, and printing out the results, I understood that it was better to calculate the possibilities by mathematical formula in order to see all the possible variations. In Fig. 9.1, it can be seen that there are 6 areas for one modular unit of Cubic Pattern. When each unit is filled with 2 colours there are a total of 64 colour combinations[96]. I selected 12 to work with[97].

I discovered that by altering the colour of the geometrical shapes, there is an optical shift in the perception of the form of the pleats, as 3-dimensional forms. The optical understanding of space, width and depth perception, play differently on the eye depending on where the colour is applied. Pleats become themselves through movement – expansion and contraction is part of their nature. The *Cubicolour* experiments show that even when static, and structurally identical, colour creates optical movement. It can be said that 'static movement' is in the pleats.

96. 2^6 (2x2x2x2x2x2) = 64. Initially I had worked with 3 colour combinations but 36 was overly complicated giving 729 possible combinations.

97. The 12 selected combinations form a colour gradation from turquoise to pink.

Fig. 9.2 Tsai-Chun Huang
Cubicolour (2016)
Laser printed paper, each 20cm×15cm

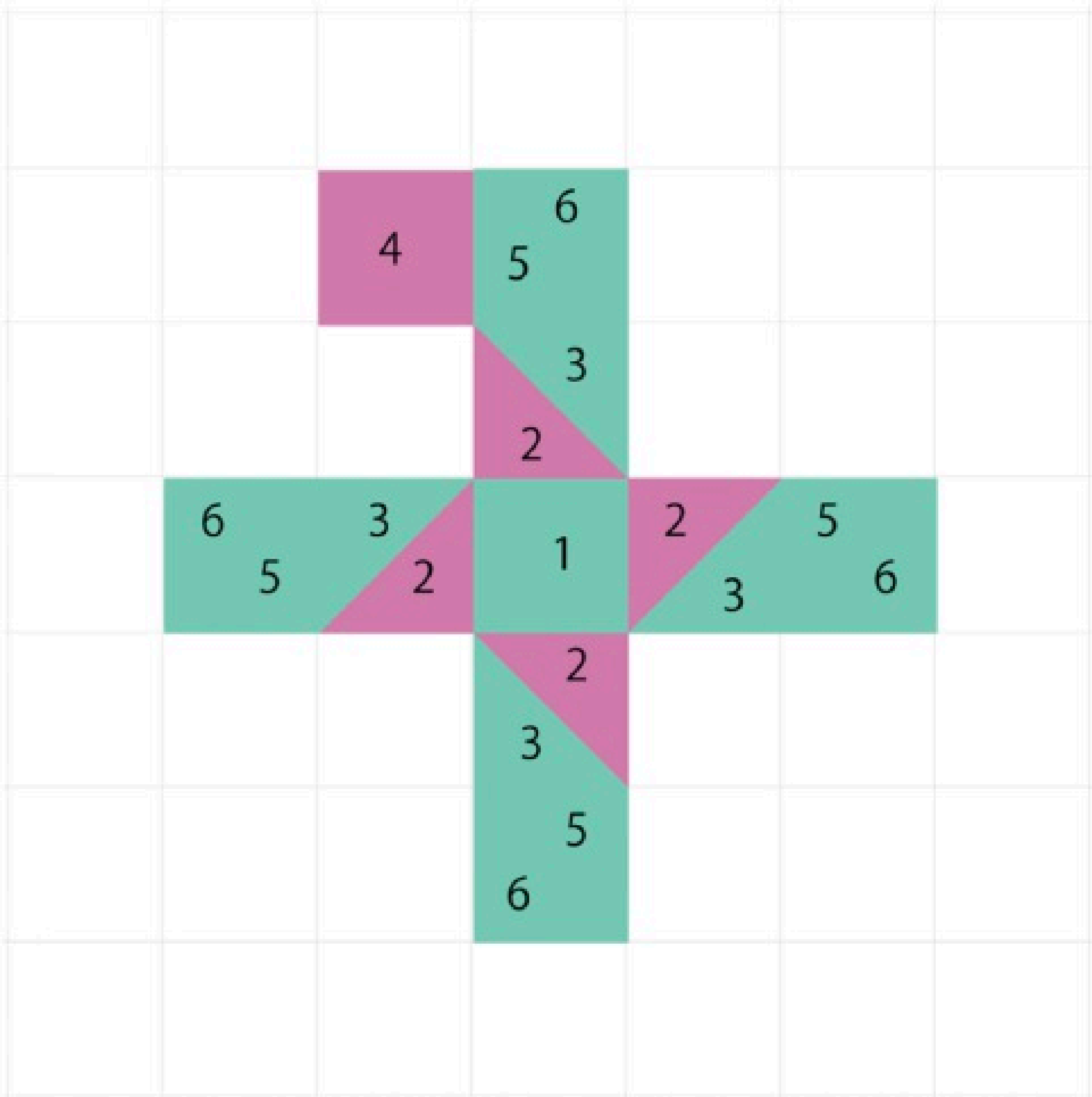

Fig. 9.1 *Cubicolour* pattern analysis

Fig. 9.3 Tsai-Chun Huang
Intimate Design Exhibition (2018)
Beijing 798 Art District

Appendix 1
SUPPORTING PROJECT 2:
Gold Nose of Green Ginger

Date: Parade, 21st June 2017

Place: North Point Shopping Centre, Hull, UK

Organisation: Joshua Sofaer Projects for Hull UK, City of Culture 2017

Material: Paper

Garment number: 7

According to Tara Keens-Douglas, carnival costumes only live for a very short period of time. Every year people prepare different garments and use them for just two days. After the two-day festival, people either neglect or abandon them. She thinks "[carnival] costumes are an ephemeral architecture – fragile, mobile and temporal." (Keens-Douglas, 2011, p169).

Due to the short life span, these costumes are usually made with cheap materials that are similar to Halloween costumes in the commercial market. The clothes may look colourful, but usually lack detailed quality. This phenomenon triggers my curiosity: is it possible to make the clothes look extravagant with a low budget by using pleats?

I worked with artist Joshua Sofaer, and created a series of costumes for *Gold Nose of Green Ginger*. We wanted to create vibrant, fun and sophisticated costumes for the parade. Through the design meetings, we decided to use folded paper, a very common material and relatively cheap compared to textile. I view this an exciting way to challenge the idea of luxury.

Fig. 9.4 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Trumpeters in procession

Fig. 9.5 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Folding garments interact with children

Fig. 9.6 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Friends play with the costumes

Fig. 9.8 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Nose Guardian

Fig. 9.9 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Assistant

Fig. 9.10 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Banner Carriers

Fig. 9.11 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Nose Guardian wears *One Pattern Fits All*

Fig. 9.7 Tsai-Chun Huang
Gold Nose of Green Ginger (2017)
Friends try on one pattern fits all collar

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Appendix 1
SUPPORTING PROJECT 3:
Oh No Pedro

Date: 30th September 2017

Place: London, UK

Director: Annlin Chao

Material: Polyester

Garment number: 1

Fig. 9.12 Tsai-Chun Huang
Oh No Pedro Music Video Costume (2017)
Polyester

Appendix 2
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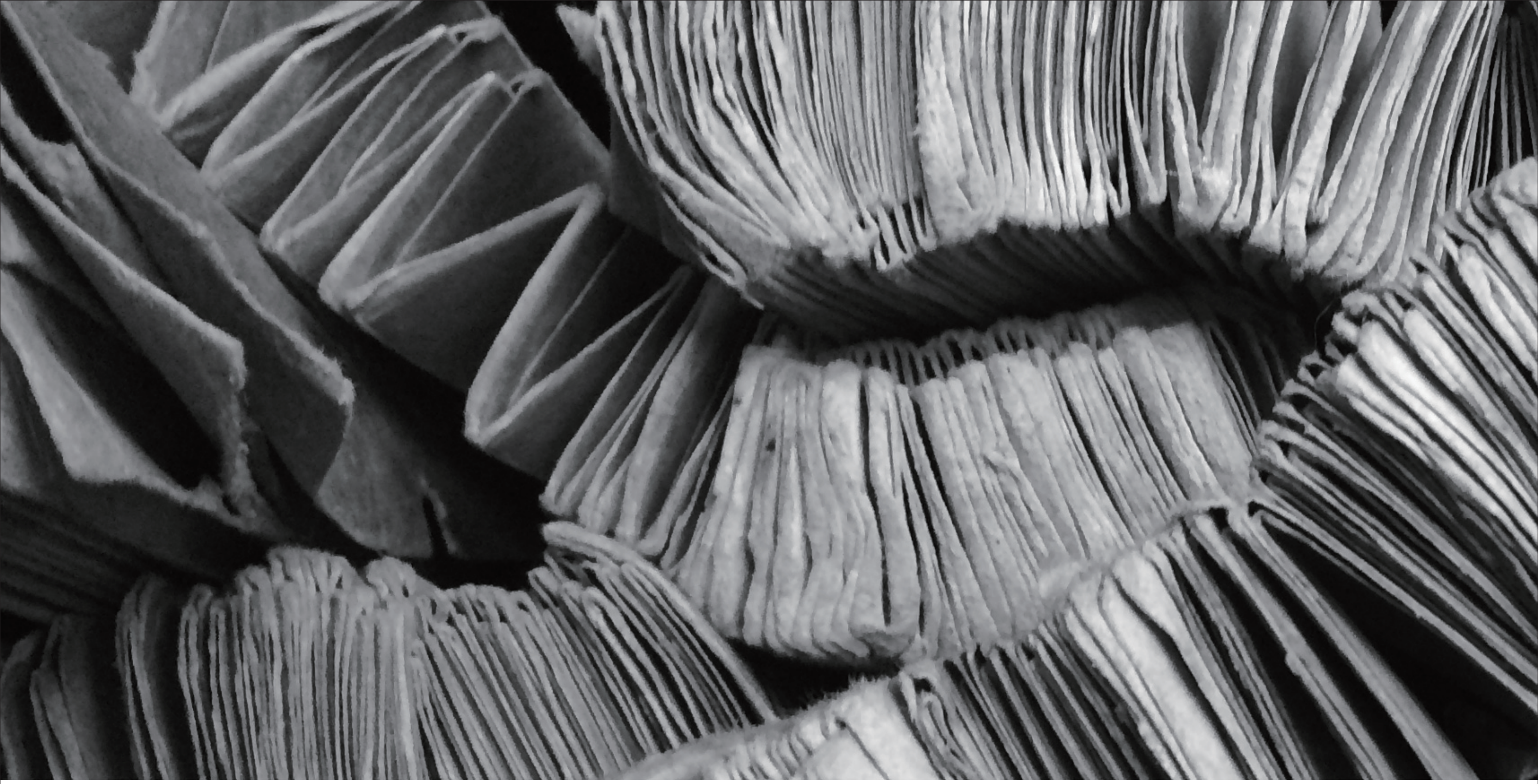


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