The Rays are Colouring

The encounter of a phenomenon

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Copyright statement

Abstract

This doctoral research, fusing the fields of Art, Science and Technology, explores the physical colour phenomenon of metamerism, by offering a theoretical account and aesthetic experience of the impact of light on dyed and knitted textiles through a series of artistic scenarios.
In the field of colour and colour management the focus of research has generally been on how to avoid 'problematic' metameric colours due to their shifting visual coherence in varying light sources. However, this 'practice as research' project investigates metameric colours through textile installations and performances, where the observer can experience the spectacle triggered by different spectra of white light, thereby revealing new opportunities for creative expression.
Quantitative science methods have been applied to produce the metameric materials (yarn and knitted fabric) utilized within the study, while the creation and staging of installations and performances involved the development of an artistic, explorative and iterative approach. Observations and analyses of the developing artistic and scientific processes and outcomes have been informed by constant 'reflection in action'.
Yarn has been dyed using carefully calculated and rigorously tested, contrasting recipes so that the resulting knitted textile samples appear evenly matched in natural daylight, in the knowledge that they will appear different under incandescent or fluorescent light. These strategically dyed yarns, featuring alternating colours, were used for the creation of a series of knitted artworks, including a metameric dress used in *green-green-green* performances. The various performances and installations at once revealed and, through divers applied texts, embedded the phenomenon in the wider context of light, colour and perception.
This investigation uncovered the beauty of the unexpected and demonstrated how light acts as a catalyst to provoke colour changes, thus breathing life into installations and performances. The offered encounters with the phenomenon of metamerism inspired thinking and astonishment and encouraged debates. Thereby a relocation of the 'problematic' physical colour phenomenon has been achieved, as the installations and performances affected a state of wonder within the observers and provided an appropriation and appreciation of its poetic.

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Performance *Q & I*

Nottingham Trent University, Nottingham, UK, 2015 July 09

- https://www.researchcatalogue.net/profile/show-work?work=397528

Performance *unravel wittgenstein*

Schneller Wohnkunstraum, Berne, CH, 2016 January 15

- https://www.researchcatalogue.net/profile/show-work?work=397532

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1 Preparing the threads

Outline

The cloth of this doctoral research project is knitted with manifold threads. These threads are thematic as well as material and the goal of this introductory chapter is to introduce those main threads, map and prepare the terrain. I explain where and how the research idea originated. I list the aims and objectives and present my own background, which strongly influenced this PhD project. I begin to set the context, to establish involved fields, and set out the methodology and methods, which guided me through this transdisciplinary project. I also give a short summary of the chapters of this thesis.

1.1 Impetus, aims and objectives

1.1.1 The impetus of this research

The impetus for this project emerged from the researcher's role as a knitwear designer, where the phenomenon this research explores was encountered in the daily routine of matching colours, as the following example illustrates:
In my office at Hugo Boss in Switzerland I would take a knitted fabric in the colour of a cardigan and search for a matching zip in the colour-card. A few weeks later the garment producer in Turkey calls to confirm that the zips I have selected do not match the colour of the cardigans. This is a regular occurrence in fashion knitwear production, caused by an optical phenomenon called 'metamerism'. The colour of a material may appear different under contrasting light sources. When the spectral composition of light changes it can result in differences in the spectral diffuse reflectance of the material surface, causing the initially uniform colour of the material to appear different (Hunt and Pointer 2011, p.117). As in this example, metameric colours are generally considered a problem within the colour industry.
In contrast, a fascination with these subtle colour-changing effects has driven this research. I set out to explore this 'error', uncovering the potentiality of this phenomenon. Viewers are invited to encounter the colour phenomenon of metamerism through art installations and performances, and observe, reflect upon and discuss their individual perceptions of colour and light. Here, the 'problem' with which I began is inverted, exploring metamerism's potential to become a poetic experience, focusing on its colour-changing facility to trigger moments of wonder.

1.1.2 Aims

- To relocate the optical colour phenomenon of metamerism by revealing it as an opportunity instead of a problem;
- To lead audiences to a new perception and appreciation of metamerism by offering aesthetic experiences through encounters of this physical colour phenomenon;
- To develop an appropriate research methodology and methods by applying a 'practice as research' and transdisciplinary approach;
- To describe and analyse the research journey including personal experiences;
- To employ Art practice:
  - as a means of exploring the phenomenon of metamerism.
  - as a way of communicating the research process and its results.
  - to provoke discussion regarding perceptions and sensations evoked by a specific colour phenomenon.

1.1.3 Objectives

- To identify recipes for dyeing metameric colours;
- To manipulate and influence the effect of colour metamerism;
- To explore and demonstrate the effect of colour metamerism using knitted fabrics/ textiles;
- To apply methods from different fields and disciplines (art, science and technology);
- To create a unique methodology and corresponding methods suitable for this research;
- To undertake and document technological processes and artistic actions and to analyse outcomes;
- To create art installations and performances;
- To present installations and performances, inviting audiences to encounter the phenomenon of metamerism by offering an aesthetic experience of its colour changing effects.

1.2 Background

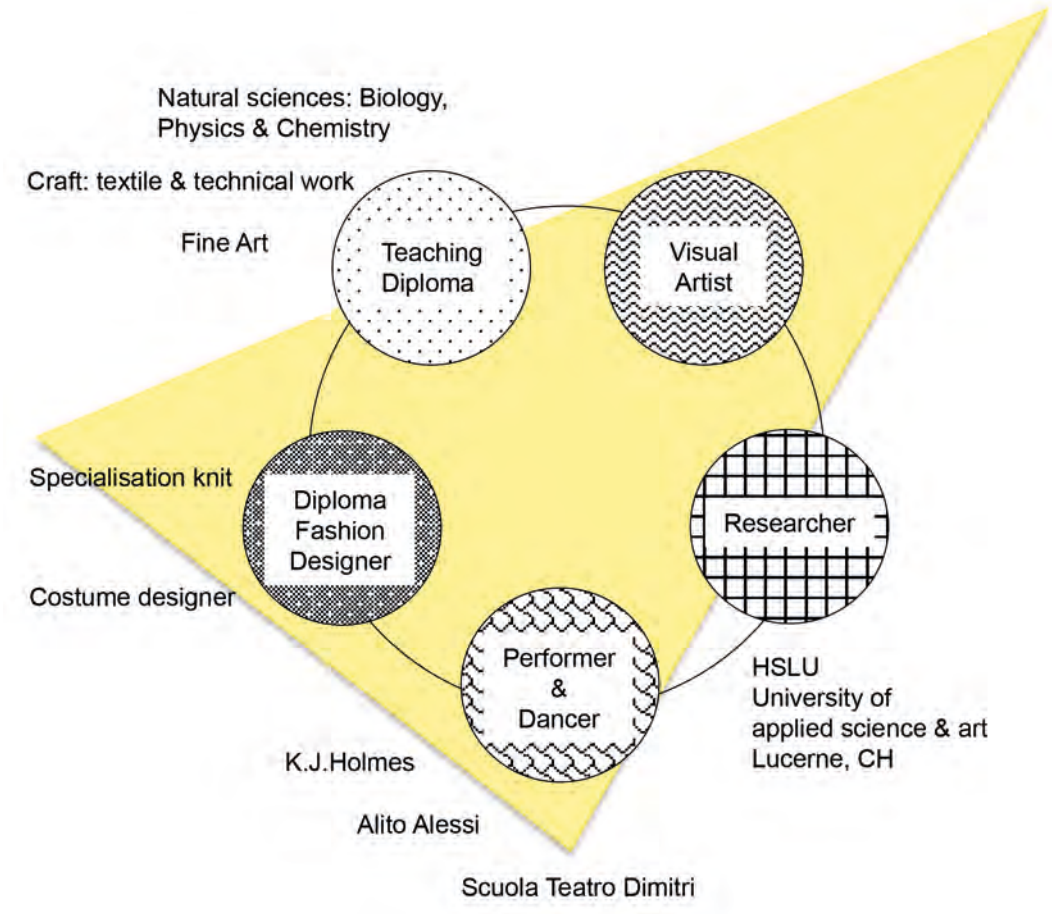

Figure 1 Spotlight on my skills, know-how and knowledge

In the following section I will set out my professional and personal background. I locate my position in this research project by evidencing my competencies. I bring with me knowledge and understanding regarding the topics involved, skills and know-how (techné) and experience in various relevant fields (Figure 1).

The appreciation, design and making of textiles runs as a golden thread through my whole life. My grandmother and mother inspired this affinity, showing me the beauty of materials and fabrics by teaching me various practical techniques from an early age. I spent hours in my room practising fibre-craft and nostalgic textile techniques, which demand patience and endurance. After high school I wanted to go to a performance school, but instead followed this other passion and undertook training for a diploma[1] for teaching craft, design and natural sciences. After some years as a teacher I had another trial to enter a performance school, passed the entrance exam but had to leave after the three-month trial period.

I continued to follow my fascination for dance and theatre by participating in workshops with teachers from all over the world. This brought me into contact with companies who asked me

[1] In 1994 I was awarded a diploma for teaching natural sciences, textile and technical craft and design in Berne, Switzerland. Back then teacher-trainings were at special schools. Nowadays this education takes place at the University. In Switzerland, although the change of status of art academies into Universities has taken place, still in 2017 they are only allowed to award the degree of Bachelor and Master, not a PhD.

to design and realise costumes. The urge to dig deeper into textiles and garments led me to start my education as a fashion designer (Istituto Europeo di Design, Milan, Italy) and pattern-maker (Istituto Secoli, Milan, Italy). Already back then, I realised projects at the intersection of fashion and art. I later joined the creative team of Hugo Boss Ticino Sa, Switzerland. Working in the knit division, I became fascinated by the fashion industry, though this also led to a need for more creative freedom and intellectual reflection. This was the moment, when I started my PhD.

Textiles were always the medium of my artistic practice, so their use as a vehicle for my PhD was a logical and natural consequence. I am a trained textile artist and artisan, with knit as my core competence. I am intrigued by the versatility of textile crafts and interested in setting traditional materials and techniques within new contexts.

At the beginning of this PhD I did not expect that I would also draw from my interest in the field of theatre and performance. But some of the turns taken by the research project could not be foreseen (Gray and Malins 2004, p.99) and in 2012, as a consequence of the development of the project (Ch 8.1.1), performance became an appropriate form for exposition of the research.

During the first two years of my part-time study, I worked as a researcher in the competence centre of Product and Textile at the Lucerne University of Applied Sciences and Arts, Switzerland, where I had the opportunity to learn the various skills needed to undertake research. From my education in natural science and technical craft I bring the necessary understanding for the scientific and/or technological aspects of this research (Ch 4 - 6).

I was always interested in the combination of creative and technical thinking and problem-solving, and I often searched for challenges which combined the technical and the artistic. ‘Knitwear design is the creation of a technically complex product according to aesthetic considerations’ (Eckert 2001, p.30) - this fact intrigued me and led to my specialisation in knitwear. In my opinion, technical understanding is a prerequisite for successful knitwear design. In industry, a knit designer collaborates with a technician (Ch 5.1) who programmes the knit machines in accordance with design ideas. During the process of development from sketch to product, technical know-how and understanding of industrial knit machines is therefore needed to enable productive communication and discussion. In my former career, knowing the ‘languages’ of both fields (design and technology), made it possible to translate between technicians and designers (Ibid., Taylor and Townsend 2014). From these years I bring experience in the fields of design development, creation and project management.

During these years I also accrued ‘extensive cross-training’ (Leavy 2015, p.30) covering fields in various disciplines as well as across different approaches to thinking and realisation, which also support me in bridging the Art-Science Divide (Ibid., p.290).

Furthermore I am curious and passionate, traits needed for good research. As Barthes (1989, p.69) stated in his text about the young researcher: ‘The task [of research] must be perceived in desire. If this perception does not occur, the work is morose, functional, alienated...’.

1.3 Location and Overview

This project was approached from an Art Research perspective. As Florian Dombois et al. (2012, p.10-11) suggest: I 'believe that artistic research should not be seen as a discipline or a topic, nor is it really a method': rather, it 'is an attitude, a perspective, a manner.'
At the Swiss Artistic Research Network (SARN) conference in 2012, Visual Art professor Sarat Maharaj started his keynote talk by stating that Art Research is a 'permanent provisionality', 'elusive and difficult to pin down' with 'a lot of vexed arguments'. I would endorse Maharaj's statement: it is this imaginative problem-solving which challenged me. To clarify my ideas and position myself within this field, I discussed various standpoints of Art Research with art researchers from the University of Applied Sciences and Art Lucerne, Switzerland, where I was researcher at that time, and within the student-led artist group from Nottingham Trent University, Thinking Through Practice, TTP.
In my opinion, the value of Art Research is given by the power and immediacy of its form, which Leavy (2015, p.291) formulates as follows:

> The arts can grab hold of people's attention in powerful ways, making lasting impressions. Art is immediate. […]; a piece of visual art can stop people in their tracks and jar them into seeing something differently.

Leavy (Ibid. p. 292) grants the arts in general a '*capability'* to affect people and 'to evoke emotions, promote reflection, and transform the way that people think.'
One aim of this research is to offer audiences opportunities to see a 'problematic' colour phenomenon differently and, in perceiving the beauty of this 'problem', to 'transform the way that people think'. In the following chapters (Ch 8 - 9) about art practice, presentation and dissemination of my artwork in support of this research, I will return to this comment.
Maharaj (2012) adds that Art Research 'possibly' is 'the emergence of a new continent of practice', 'a new continent of activities and engagements.' Later in this chapter (Ch 1.4.4) I introduce the 'continent of practice', which helped define the parameters of this project.

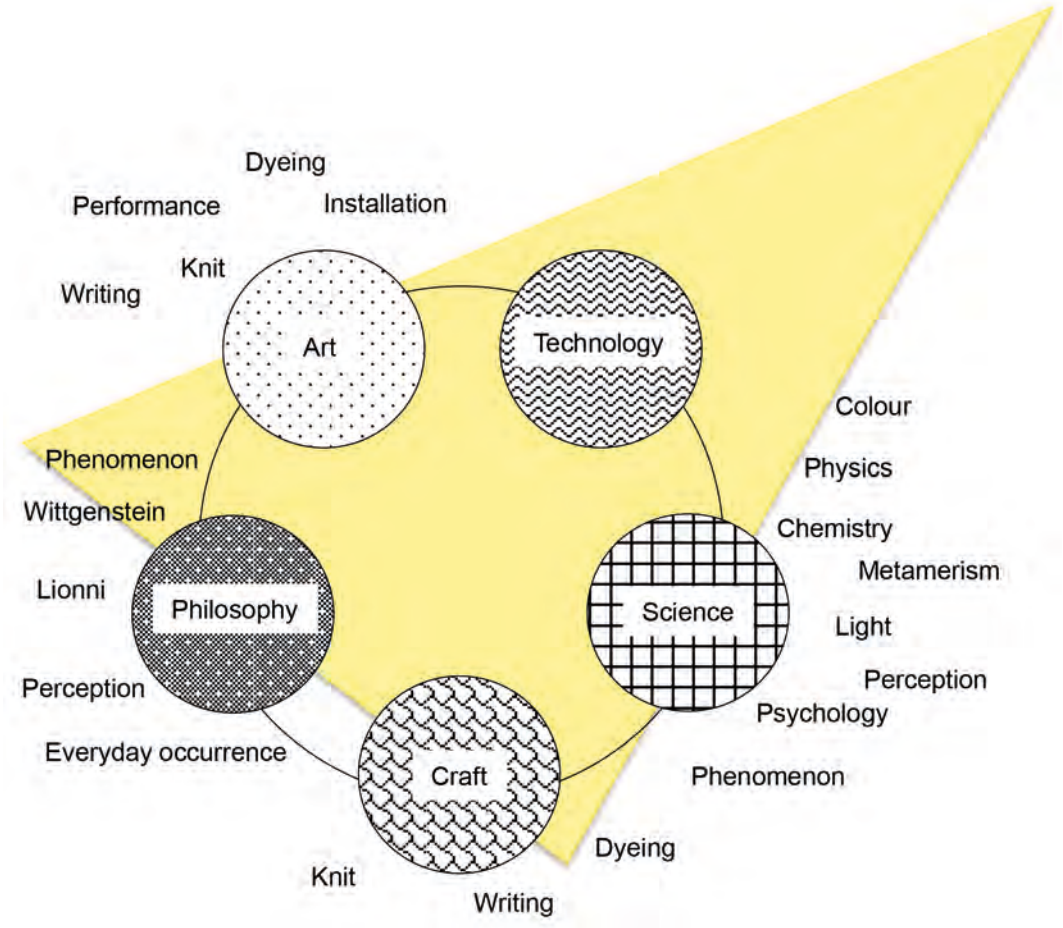

Figure 2 Spotlight on involved fields

This research is transdisciplinary (Ch 1.4.2) combining methods from art, science and technology. The term science here comprises ‘hard’ science (natural science and formal sciences such as mathematics) for the most part driven by quantitative methods (Ch 3 - 6), and ‘soft’ science (humanities and social sciences, such as philosophy, psychology and sociology), for the most part driven by qualitative methods (Ch 7 - 9). The project took a holistic approach to these seemingly disparate approaches. Mixed methods were applied and ‘arts-based strategies [are] used in concert with […] quantitative or qualitative method[s]‘ (Leavy 2015, p. 23), cross-fertilising each other. The overall approach is ‘practice as research’ (Ch 1.4.4) involving practices from the fields of craft, art, philosophy, technology and science (Figure 2).

1.3.1 Art and Science

This transdisciplinary research is underpinned by the twenty-first century Art and Science[2] movement (Wilson 2010) through its combining and merging of disciplines. Wilson (Ibid., p.6) regards art and science as ‘the twin engines of creativity in any culture’ and he underlines the importance of avoiding ‘the partitioning of curiosity, inquiry and knowledge into specialized compartments’. In ‘Art + Science Now’ he introduced and presented artworks and artists

[2] The umbrella term science also covers technology.

working within this field. In 'How cutting edge science is redefining contemporary art', Miller[3] (2014) identifies historical connections, separations and re-connections of art and science, noting that during the Renaissance 'to the great masters, Leonardo Da Vinci and Albrecht Dürer, there was no distinction between art and science' (Ibid., p.3).

The quest for beauty, generally attributed to art, matters also to science. This drives Wilczek (2015), the Nobel Prize winner in physics, and in 'A Beautiful Question, Finding Nature's Deep Design' he explores the scientific pursuit of beauty throughout history. In the chapter 'In Search for the Invisible' Miller (2014, p.27) references Poincaré: 'The scientist does not study nature because it is useful; he studies it because he delights in it, and he delights in it because it is beautiful'. However, art and science have different definitions of beauty, a point Miller (2014, p.27) identifies using the example of symmetry. In science, the symmetry of equations is considered beautiful; art instead plays with symmetry and asymmetry and sees beauty in the play of balance and tension.

As illustrated in the following chapters, this project enabled audiences to access the beauty and richness of a specific physical colour phenomenon.

Today the Art and Science movement is highly topical, having entered various universities[4], fostered debate[5] and found public platforms to present work: in 2013, at the exhibition 'AR – artistic research' at the Massachusetts Institute of Technology (MIT) (Bauer and Trummer, 2012), and, in 2007, the exhibition 'Say it isn't so, Art Trains Its Sight on the Natural Sciences' at the Weserburg Museum of Modern Art (Friese et al. 2007), during the annual festival Ars Electronica at Linz and the ZKM, Center for Art and Media, Karlsruhe, among others.

1.3.2 Composition of the research

This thesis consists of a written part, installations and performances. The written part represents the contextualisation, documenting the various undertaken actions and their outcomes and takes a critical stance to ensure rigour.

The installations and performances are presented, analysed and documented with selected visual material in Chapters 7 - 9. In addition, to give resonance to live performances, film documentation of three performances was edited with key moments emphasized.

The artworks are autonomous but go hand in hand with the written thesis and they inform each other. A full understanding of the PhD project asks for the consideration of both parts.

The written thesis, the product of 'a skilled joining of different materials to make single, whole, and strong stuff' (Schechner 2006, p.227), mainly has a chronological structure. But since the thesis maps the strictly non-linear process of this Art Research project and its inherent connections and complexities, there are cross references inserted in the text throughout, leading to other chapters and sections, where further information and explanations can be

[3] Miller introduces a new name for the field of Art and Science: 'Artsci'. 'Artsci' started in the 1960's with the appearance of new electronic technology.

[4] In 1967 the Massachusetts Institute of Technology (MIT) brought artists, scientists and engineers together in a research environment. Today various universities offer Artsci studies, which merge art and science.

[5] Literature such as: (Jürgens and Tesche 2015), (Schwab 2013), (Mersch and Ott 2007) among others, is mapping the debate.

found. This guides the reader, as with the thread of Ariadne (Jefferies 2015, p.5), through the complex fabric. Spread over the different chapters I introduce topics titled ‘Remarks on ...’. These refer to ‘Remarks on Colour’ by Wittgenstein (Wittgenstein 2007), an inspiration and source for this thesis, as I will show later in the text.
Names of artworks are written with an *italic font*.

1.3.3 Trichotomy of art research categories

Borgdorff (2006a, pp.11-12) adopts Fraylings (1993, p.5) trichotomy[6] of the categories of art research with a ‘slightly different twist’. He distinguishes between ‘research on the arts’, ‘research for the arts’ and ‘research in the arts’. This research covers, with variable emphasis, these three categories.
The category ‘research on the arts’, ‘that has art practice in the broadest sense of the word as its object’ (Borgdorff 2006a, p.12) ‘refers to investigations aimed at drawing valid conclusion about art practice from a theoretical distance’, requiring ‘a certain distance, between the researcher and the research object’ (Ibid.).
Embodying throughout the research journey the roles of researcher, practitioner, artist and scientist, I created the research object, so there is no distance between the researcher and the object, as I am ‘implicitly interwoven into’ the process and the ‘final representations in many ways’ (Leavy 2015, p.42). The implementation of this category is problematic, but I stepped back and tried to ‘deploy a meta-perspective in order to enable critical reflection on the temporary, operational parameters of [my] research’ (Slager 2009, p.53). This is the nature of Art Research: researcher and object are merged and reflection is always a perspective from within.

1.3.4 Overview of Chapters

The planning of this research envisaged two main phases:
The first phase of research from 2011-2015 (Ch 1.5.1) was determined by the exploration, development and realisation of metameric dyed yarn and knitted material.
The second phase from 2011-2016 (Ch 1.5.2) presented in Chapters 7 - 9, involved the creation of metameric art works to allow audiences to perceive the colour phenomenon metamerism as a subtle wonder.
Chapter 1 (Preparing the threads)
This introductory chapter defines the framework of this project and discloses my background and competencies. I situate this transdisciplinary research in the field of Art and Science and approach it with an Art Research attitude.
I specify the aims and objects of this research and expose the methodology, appertaining methods and practices applied to reach these aims. The introductory chapter outlines the

[6] In 1993 Christopher Frayling published a paper regarding research in art and design. He defined three categories: ‘research into art’, ‘research for art’ and ‘research through art’ (Ibid., p.5).

content of the chapters, introduces the first and second phases of research and shows their difference in focus.

Chapter 2 (Textile & Text)

Chapter 2 elucidates in depth upon textile, text and writing. Textile and especially knit are the medium and material of this project and are highlighted and contextualised. Writing is seen as a fundamental creative method within this research and forms of writing, and the craft of writing, are highlighted, described and analysed. Both the written thesis and the installations and performances are seen as a 'whole cloth' (Constantine and Reuter 1997). Through the metaphor of 'whole cloth', the knitted jacquard fabric of this research will be illuminated and explained.

Chapter 3 (Light, Colour and Metamerism)

Chapter 3 explains and elucidates the basics of colour management and clarifies key terms to familiarise readers with the various fields and their appertaining terminology. I demonstrate how I gathered information from experts in the field of colour management regarding realisation of the metameric material. I also show how I extended my knowledge of metamerism, light, colour and dyeing.

Chapter 4 (Light – the breadth of daily human experience)

Light, the intangible medium with intangible qualities, is a fundamental medium of this research. Chapter 4 spotlights light with its various facets (light history, light art, light and textile, metamerism and art).

Chapter 5 (The creation of metameric material and knit)

In Chapter 5 the investigation of metameric colours and the process of production of metameric material is described. The key issues of this chapter are colour management, calculating colour recipes and the dyeing and knitting of material. I introduce in this chapter knitting techniques, which are involved in this project.

Chapter 6 (Challenges in the dye lab)

In Chapter 6 the procedure in the dye and the knit laboratories is documented and analysed and the actual process with all its inherent difficulties and hurdles is depicted.

Chapter 7 (Art practice – part 1)

Chapter 7 presents the *Process Artworks* and reveals a visual methodology, which was not initially planned. The 'failed' dyed material, a by-product of the research, became material for the creation of artworks. It is an example of a methodology emerging from the research process. I introduce in this chapter knit as an art practice.

Moreover, at the end of this chapter, I establish various remarks and philosophical threads, which were later taken up again in performances and installations.

Chapter 8 (Art practice – part 2)

Chapter 8 illustrates the first part of the art practice of the second phase of this research: the conceptualisation, production and presentation of performances and installations. Here, the metameric material, whose development will be discussed in previous chapters, was essential. Based on my experiences and observation of metameric material, I built concepts for artworks. These were shown and tested in various contexts and will be analysed in this chapter.

Chapter 9 (Art practice – part 3)
In Chapter 9 I further describe the conceptualisation, production and presentation of performances and installations embedding metameric material. The core of this chapter is the art exhibition ‘grün!?’, which took place in January 2016. The exhibition showed an overview of metameric outcomes alongside the process by which the material was created. The exhibition, exposing the enquiry and the main findings, fostered audience interaction with artworks and served as a platform for questions relating to light, colour and perception triggered through experience of the exhibition.
In **Chapter 10** (Conclusion – Final junction of the threads)
In this chapter I draw the conclusions of this research by knitting together all the threads involved in the thesis. I recapitulate the journey of this research and I summarise the findings, insights and reflections, which emerged from this project. The aims and objectives, which I defined in Chapter 1, will be revisited and I will consider whether I succeeded in implementing them. I highlight the findings, originating from this study, and at the end of the thesis I discuss possibilities for further research.

1.4 Methodology & Methods

Slager (2009, p.54) states that ‘the methodological perspective of artistic research cannot be decided *a priori*, as it can in scientific research.’ Nonetheless, at the beginning of this research a distinctive methodology was developed and corresponding methods decided, which, at the outset, seemed the appropriate ways to reach the formulated goal.

> The journey of research is rarely straightforward: the destination is usually not clearly fixed, although you have a proposed route; the terrain you encounter may make you alter your route and may require you to travel using several modes of transport and various forms of all-weather gear! (Gray and Malins 2004, p.99)

The main principles did not change over the time of the research (2010 - 2016) but not all steps could be foreseen or detailed at the beginning. Some methods, the ‘modes of transport’ and ‘all-weather gear’, as Gray and Malins call them, were developed at the beginning while others became evident *en route*, as new insights claimed the reconsideration and adaptation of methodology and appertaining methods.

1.4.1 Literature review

The literature review informed the whole journey and covered multiple fields. The contextualisation of my investigation by means of the literature review was a great support to understanding, sharpening standpoints and establishing the originality of my research. There is no complete literature overview in the first chapter as, depending the terrain I encountered, I adapted the literature used. Therefore, corresponding with the content of the chapters, literature will be cited throughout the thesis.

The first step of my PhD journey was to understand Art Research. I reviewed literature in the field of Art Research such as: Ambrozić and Vettese 2013, Balkema and Slager 2004, Elkins 2009, Gray and Malins 2004, Leavy 2009, MacLeod and Holdrige 2006, Sullivan 2005, Wesseling 2011. For the execution of the first phase of the research I consulted literature regarding colour technology, metamerism, light and colour. Philosophical themes such as everyday occurrences and wonder were crucial to the second phase of the study. Regarding philosophical literature, I followed the advice of philosopher Tuomas Nevanlinna, who gave feedback related to an Art Research project (2011, p.29):

> You can use them unashamedly for your own purposes, misunderstand them fruitfully and not misunderstand them just because you are not well-versed in the tradition and imitate the jargon instead. Read the classics “sexually”, as it were, rather than dutifully and exegetically: love them, fuse with them, use them to your own enjoyment.

The reading of Wittgenstein’s ‘Remarks on Colours’ (Wittgenstein 2007) was a fundamental inspiration. This philosophical text influenced first of all my thinking, and later became the crucial text in the performance *unravel wittgenstein* (Ch 9.3). I used the Wittgenstein text ‘unashamedly’ for the purposes of this research even though I am not a well-versed ‘Wittgensteinian’.

1.4.2 Trandisciplinarity

Leavy (2015, p.294) crystallised the characteristics of quantitative, qualitative and arts-based research approaches and established the following main tenets (Figure 3).

Quantitative	**Qualitative**	**Arts-Based**
Numbers	Words	Stories, images, sounds, scenes, sensory
Data discovery	Data collection	Data or content generation
Measurement	Meaning	Evocation
Tabulating	Writing	Re(presenting)
Value neutral	Value laden	Political, consciousness-raising, emancipation
Reliability	Process	Authenticity
Validity	Interpretation	Truthfulness
Prove / convince	Persuade	Compel, move, aesthetic power
Generalizability	Transferability	Resonance
Disciplinary	Interdisciplinary	Transdisciplinary

Figure 3 Main tenets of quantitative, qualitative, and ABR [Arts-based research] approaches

> Higher in the typology is interdisciplinary where integration of the contributions of several disciplines to a problem or issue is required. Interdisciplinary integration brings interdependent parts of knowledge into harmonious relationships through strategies such as relating part and whole or the particular and the general. A higher level of integrated study is transdisciplinary, concerned with the unity of intellectual frameworks beyond the disciplinary perspective. (Stember 1991, p.4)

In accordance with these tenets and the statement of Stember, this arts-based research is transdisciplinary, as ‘disciplinary methodological and theoretical borders were crossed, blurred, and expanded’ (Leavy, 2015, p.22). The topic is not just illuminated from one or two different perspectives; various threads and perspectives are drawn together, integrating different disciplines (science of textile chemistry and physics; humanities, design and visual art) and their methods by knitting these together. The aim of this holistic approach is to reach a personified unity of the intellectual and practical framework.

In 1959 Snow ‘claimed to find a profound mutual suspicion and incomprehension’ (Collini 2012, p.VIII) between ‘hard’ and ‘soft’ science (Ch 1.3). As noted in Chapter 1.2 I have ‘adequate education in both branches of knowledge’ (Ibid.) and feel at ease working within and intertwining all the mentioned fields. I do not consider ‘hard’ and ‘soft’ science as ‘two cultures’ (Snow 2012) and align my approach with academics and artists such as Borgdorff, Dombois, Leavy, Mersch, Rheinberger and Wilson who agree that art, science and technology can offer fruitful common ground. There are intrinsic similarities; curiosity is an important driver, as is a striving for

uniqueness and originality. Slager (2009, p.49) ascertains that 'today's practice of visual art makes clear that it is time to declare monolithic thought framed in binary models of truth (the hermeneutic method) and illusion (the visual creative) as obsolete.' The hybridisation of these fields and the frontier-crossing of disciplines offers new ways of working and thinking.

1.4.3 Visualizing the journey

For art historian Philip Ursprung (2006) a fundamental requirement of research, as well as Art Research, is traceability. The tracing of the journey is a main thread of the methodological fabric of this research and the thesis maps and documents the journey in a verbal as well as visual way (Gray and Malins 2004).

1.4.3.1 Writing

Writing is one of the crucial practices and methods (Ch 2.3) of this research and has been used throughout. To master and disseminate the various fields of investigation, distinct writing styles have been required. Writing in this research can be contextualised as an art, craft **and/or** academic practice: it can be descriptive and ruminating; exploratory and reflexive; scientific and technological; reflective and analytical. Some texts are written on the spur of the moment, whilst others are crafted by an iterative process of rewriting, ordering, reordering, editing and revising until the text finds it's final form/format. Rheinberger[7] (2007, p.90) claimed that writing itself is 'not just a noting down of data' and 'facts', instead it is an 'experimental system', 'a test arrangement'. He notes that 'one has to speak not only of the production of thoughts, but also of their becoming fixed and changing while writing.'

I used writing as a practical tool to conduct and document this research, and applied writing as an experimental system (Ch 1.4.6), a form of problem-solving. In Chapter 2.3 I will scrutinize the various writing approaches I have pursued in the creation of texts to fulfil different purposes.

1.4.3.2 Visual material

Visual material is used to document, illustrate, visualise and explicate the research process and research output (installations and performances). This involved techniques such as charts and illustrations explicating issues regarding knit, light, colour and colour management and photo and film material (on enclosed USB stick).

In Chapter 7 I present in detail an original Visual Methodology, which was an unexpected but significant outcome of the research process. I created artworks, the *Process Artworks* (Ch 7), with by-products of the research. I documented the journey in the dye lab through artworks 'tied to the process of producing' (Leavy 2015, p.30).

Slager describes the visual work of artists as follows:

[7] Hans-Jörg Rheinberger, historian of science with a doctorate in molecular biology, is currently director at the Max Planck Institute, Berlin. He is engaged in the history of experiments and natural scientific research practices and wrote several articles about experimental systems.

> After all, through merely visual means, the artist succeeds in making visible what ordinary vision fails to see. Everyday categories of perception can be dislocated in a flash. The artist compels us to see the world in a different way, according to different norms and habits. Images do not replace reality, but reveal novel visibilities, and art proposes polymorphic kinds of observation. The artistic image provides an open view while liberating the spectator from a frozen perspective. (2009, p.54)

Various points in Slager's description can be applied to my final artworks. I compel audiences to see the colour phenomenon in a different way and thereby dissolve the frozen perspective of seeing metamerism just as a problem. This issue is the focus of the second phase of the research (Ch 8 - 9).

1.4.4 Practice as Research

Various literatures (among others Sullivan 2005, *Art practice as research*; Barrett and Bolt 2010, *Practice as Research*) attempt to define practice in the field of Art Research. Among the three suggested terms: practice-based research, practice-led research and practice as research, Borgdorff (2006a, p.13) states his preference of 'practice as research', 'as it expresses the direct intertwinement of research and practice'. In this research, situated in the field of Art Research, practice is fundamental and intertwined with research because 'the practitioner is the researcher' (Gray and Malins 2004, p.20), the 'generator of research material' (Ibid., p.21). Sennett (2008, p.65) states: 'In terms of practice, there is no art without craft'. In this project art and craft practices are strongly interlinked, likewise analogue and digital practices.
In addition, practices from the fields of science and technology are applied.

1.4.5 Process of practice

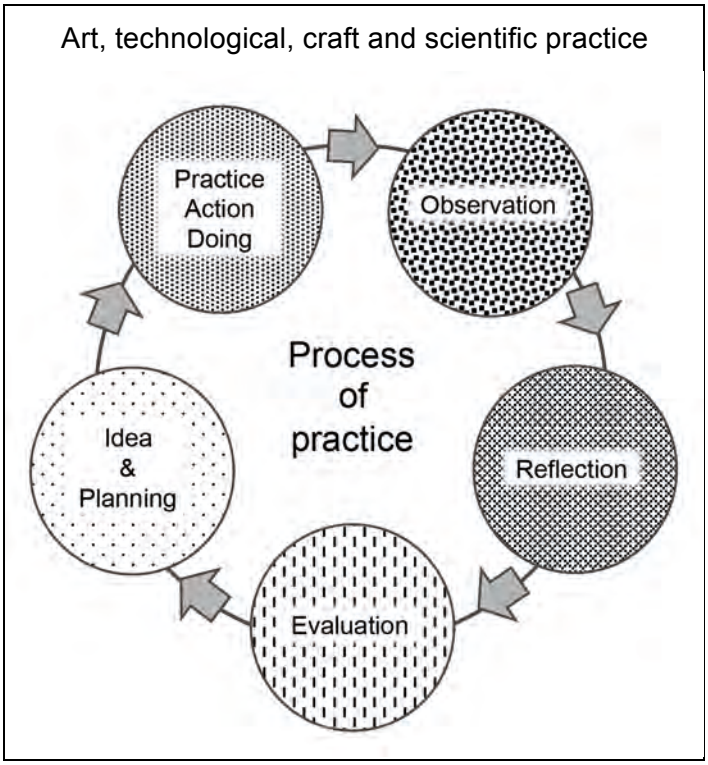

Figure 4 Visualisation of the process of practice

The iterative process of practice is a cycle (Figure 4), repeated again and again over the time span of the research. Depending on the practice applied, the process slightly changed. My cycle of practice is influenced by the experiential Learning Cycle of Kolb (2015), who 'proposes four stages of learning from experience: do, reflect, summarize, test' (Gray and Malins 2004, p.57). Observation, applied in science and art, is a key method throughout this research. The result of practice or action was always observed. During the first phase, characterized by work in the lab, defined criteria were applied (Ch 5 - 6). During the second phase, characterized by art practice, criteria were shaped by personal aesthetic sensation. I continuously observed myself in action, monitored my doing and its outcomes. Observation was always followed by reflection, reflection in action and on action, a concept borrowed from Schön (1995).
It was an on-going dialogue between 'concrete practice and thinking', 'hand and head' (Sennett 2008, p.9), generating experience-based knowledge. Dewey (1989, p.125) stated that 'thinking enables us to direct our activities with foresight and to plan according to ends-in-view'. The reflections always related to the successful realisation of subordinate targets, as the next required steps were planned. Slager describes the self-reflexivity in artistic research as follows:

> In artistic research one should speak of a continuous, self-reflexive movement questioning the situation and determining the artist's position with regard to the spaces of analysis. (2009, p.54)

Reflections laid the basis for evaluation and decisions taken regarding the next steps. In Chapters 5 - 6 the evaluation of dyed material colour will be explained in detail; in Chapters 7 -

9 the creation process, as well as the artworks, installations and performances produced, will be analysed and evaluated.

1.4.6 Experimental set up

A significant characteristic of the Art and Science movement is that artists conduct research in laboratories. In fact, the first phase of this research has mostly taken place in the dye and knit lab. The metameric material was developed and produced in the dye lab, where I used cutting-edge colour matching/mixing technology and software. Because of the particularity of my research into dyeing (Ch 5 - 6) I could not apply the technology literally, but had to tweak or subvert the general dyeing process supported by dedicated software in order to reach the goal of the first phase, the production of metameric material. My 'openness to experimental engagement' (Harris 2012, p.93) was necessary to figure out how the digital and analogue processes needed to be combined in order that the technology could be applied effectively for my purposes. The created metameric material was fundamental to the poetic installations and performances, hence 'central to the maker's art', as Bunnell stated:

> The skilled and sensitive human interaction with technology that is involved in poetic object making is arguably central to the maker's art. A direct relationship with tools enables the maker to engage intimately with materials and process to create finished objects with a high degree of autonomy and control over quality. (2004, p.2)

For this phase of the research a scientific attitude, as described by Rheinberger, Firestein and Alon, was required which will be further elucidated in Chapter 1.5.1 and in Chapters 5 - 6.
The knitted artworks were developed in the knit lab using hand-operated machines as well as computerised electronic knit machines (Ch 5 & 7).
I considered both lab situations as experimental systems, which Rheinberger, often cited in the debate of Art Research, described as follows:

> Experimental systems are the locations at which the new occurs in the empirical sciences. And I mean this in a very concrete way: the new occurs less in the minds of the scientists – where it lastly has to arrive – and more in the experimental system itself – at the workbench (2007, p.84).

'They are precautions for the production of unanticipatable occurrences', 'places of emergence' (Ibid.). He parallels the ways artists and scientists work and determines that both are dealing in their practices with the known and the unknown. Sarat Maharaj (2012) considers Art Research 'a journey in the unforeseeable' and scientist Uri Alon (2014) adds that 'truly innovative Science demands a leap into the unknown' and states: 'we [scientists] do something quite heroic. Every day, we try to bring ourselves to the boundary between the known and unknown'. In conclusion Firestein (2016, p.248) stresses the importance of ignorance in a research process.

1.4.7 Struggles and detours within the journey

Scientist Uri Alon (2014) states: ‘in science, we just learn about the results, not the process’ and blames his field for factoring out all the detours, which were needed. He invites scientists to be more honest and present the real journey, including encountered problems and failures, and states that ‘we'd all studied science as if it's a series of logical steps between question and answer, but doing research is nothing like that.’ Firestein also reproaches natural science for its tendency to ‘either hide those facets of the process or simply fail to make them explicit’ (2016, p.249). He (Ibid., p.248) emphasizes the significance of acceptance of failure and invites scientists to embrace uncertainty.

I encountered uncertainty and failure more often than expected in the dye and knit labs. However, Le Feuvre is right to state: ‘Through failure one has the potential to stumble on the unexpected’ (2010, p.12). In Chapter 7.1 I show how I conquered my frustration and visualized how beautiful dyeing ‘failures’ can be.

I mapped and reflected upon ‘the actual experimental’ and ‘intellectual process at work’ (Firestein 2016, p.4) and traced the encountered problems. By ‘expressing doubt and uncertainty’ (Ibid., p.249) and including failures, I provide an ‘accurate record of the way it actually happened’ (Ibid., p.4). This involved various emotional states encountered on the journey. Moon (2008, p.68) blames scientists that the ‘great richness in the emotional experience’, ‘which influenced the thinking process’ ‘never’ ‘finds its way into the formal writing up’. She states: ‘all human activity is influenced by and influences emotion’ (Ibid., p.69) and invites scientists not to dismiss it as ‘touchy-feely’. This thesis delivers a vivid illustration of the process, including struggles and detours, making emotion and thought visible.

1.5 First and second phases

The research process consisted of two searching movements, where explorative methods were at the core, one in the first phase and another in the second phase of research. The next sections will start to differentiate, clarify and elucidate the inherent differences.

1.5.1 First phase of the journey

The first phase of the research (Ch 3 - 6) covers the category of ‘research for the arts’ (Ch 1.3.3). Through applied technological research I explored metameric recipes, developed and dyed metameric material, then used this in the second phase of the research for the creation of artworks. In the first phase ‘art [was] not so much the object of investigation, but its objective’ (Borgdorff 2006a, p.12).

This part of the journey was based on science (physics and optics) and technology (colour, dye, knit and digital technology) and their quantitative practices (Figure 3: numbers, charts, measuring, calculation and so on). This period ‘strive[d] for generalization, repeatability and quantification’ (Slager 2009, p.52) ‘emphasizing the generation of “expert knowledge,”’ qualities not usually assigned to the domain of art. In this phase my organized and structured side supported me, but already the artistic ‘me’ was involved as I confronted failure.

During exploration in the dye lab, for example, because of the unusual requirements of this project, it turned out that the target could not be reached solely with quantitative methods. Hence, I had to develop an effective combination of qualitative and quantitative colour assessment methods and I handled this issue with an inventive problem-solving attitude. The target of this initial phase of research, the creation of metameric material, was clearly defined and all steps undertaken focused on this defined target. The results are verifiable and could be replicated.

1.5.2 Second phase of the journey

The second phase of the journey (Ch 7 - 9), the conceptualisation, realisation and presentation of artworks belongs to the category of 'research in the arts' (Ch 1.3.3) and required artistic modes of investigation. The artistic 'me' was the leader. The art practice involved the production of knitted fabrics for installations, a dress and text for performances, and creation of installations, performances and an exhibition.
At the beginning I was not able to clearly define and schedule the emerging artworks. I had only a vague concept of how the artworks could or should be. Rheinberger describes this condition as follows:

> The research experiment is structured to allow something to come to light of which one has no exact concept; on the other hand, however, if one has no vague concept of something, one can also not be surprised by something new. The experimental mind has to be constituted in a fashion complementary to the experimental structure. Researcher and object enter into a close relationship with one another; the better one knows 'his thing,' the more subtle the way it exposes its resilience (2007, p.86).

The concepts for the artworks could not be developed before the metameric material was available, as myself the researcher, and object had to enter a close relationship with one another. The development of artworks was based on the outcome of explorative work. With the first available metameric material, different fabrics were knitted and observed under different light sources (Ch 4.1.3 & 7.2.1). Observation was followed by reflection and consistent action (Ch 1.4.5). During the production of artworks I tried to define and understand my criteria, which I applied tacitly, and track my thought process in order to make it traceable. In this phase decisions were often based on tacit knowledge[8] and actions were mostly intuitively driven. Leavy states that an Art Research attitude implies 'the artist's subjectivity' and invites artists to 'trust one's intuition' (2015. p.30). I trusted intuition and subjective criteria and, informed by my former training (Ch 1.2), determined the aesthetic[9] for installations and performances.
In this phase philosophical questions regarding 'the everyday', 'wonder' and perception emerged and the literature review gives sources for these (Ch 7.3). The core of the second phase, the creation of artworks via art practice, involving methods such as observation,

[8] Michael Polanyi (2009, p.4) emphasised 'tacit knowledge', this kind of knowledge, which we know, but we are unable to 'put into words'.
[9] I use aesthetic here to mean an enjoyable, beautiful and interesting visual experience.

analysis, reflection, thinking, problem solving, knitting and writing, will be detailed in Chapters 7 - 9.

1.5.3 Generating meaning, generating knowledge

Since 'the scientific knowledge of the Renaissance and the Aufklärung the truth of aesthetic experience was constantly questioned' (Odenthal 2016, p.8). However, I agree with philosopher and artist Jens Badura (2013), who claimed 'art as a knowledge production practice'. His argument goes back to the 18th century, when Baumgarten established 'Aesthetics as a discrete scientific discipline' (Mirbach 2007, p.IX). Baumgarten (2007, p.11) defined 'Aesthetics […] as the science of the knowledge of the senses'. Badura substantiates that knowledge cannot be exclusively produced through theory, conceptual work, notion, and ratio. He states that 'the senses aspect is the one that enables us access to phenomena in the richness of their aspects' and suggests that the aspect of theory should be coequal with the aspect of the senses. Odenthal (2016, p. 8) affirms Badura's statement:

> However the mathematical formula did not replace in our perception to date the romantic fascination of a sunset. The aesthetic experience claims to date, despite the challenges and offences, an own relevance and autonomy.

This research, having at its core a physical colour phenomenon, is in strong congruency with these statements, as will be seen in the following chapters (Ch 8 -9).

1.5.4 Dissemination, dialogue and debate

Maharaj (2011) is convinced that research needs to be debated and communicated in the public domain. In his opinion:

> We not only have to invent a methodology, but also a language – not only a linguistic language, not only a word-based language, but a language as such for passage in the public domain. (Ibid, p.33)

This research and its embodied findings were presented and communicated in the public domain, both during the process and during the final stages, in various contexts. Formats of dissemination were performance, lecture performance, posters, talks, installations and exhibitions. As these had different focuses, I carefully noted the apposite content of each event.

1.5.4.1 Informal feedback

Over the time span of the research I captured feedback regarding the various exhibited artworks and performances informally. I considered the manifold audiences as focus groups and invited questions after performances (Ch 8 - 9) or in the exhibition (Ch 9), which often turned into discussions. After performances, sometimes myself, sometimes co-performers, posed questions, sometimes to groups, sometimes to single persons. We were curious to explore their experiences and learn more about my artworks by gathering thoughts and observations.

We conducted conversations, which were not 'real' interviews, as we used an unstructured method of data collection. I posed open-ended questions and chose this way of acquiring information in dialogue, as I was interested in 'a greater breadth of data'. Fontana and Frey (2000, p.652) state: 'Unstructured interviewing can provide a greater breadth of data than the other types, given its qualitative nature'.
Being involved as artist and researcher, I was not 'a cool, distant, and rational interviewer' (Ibid., p.653) and broke the fundamental rules of a structured interviewer by answering questions and talking about my 'personal feelings', impressions and aims (Ibid.): 'the research outcomes [were] negotiated between researcher and participants [ ] so as to create resonance and shared meaning' (Gray and Malins 2004, p.133). I recorded data[10] in the research journal (Ch 2.3.1) and used personal statements as 'the data to think with' (Ibid.). I noted comments from audiences and my own reflections, thoughts and analysis were executed on the basis of this qualitative gathered feedback. Hence the voices of participants supported my ongoing thinking and self-reflection.
I applied the collected feedback as 'data used to support the claim' (Ibid., p.97) and consider it evidence of the successful outcome of this research.
I am aware that 'the spoken or written word has always a residue of ambiguity, no matter how carefully we word the questions and how carefully we report or code the answer' (Fontana and Frey 2000, p.645), but consider unstructured conversations the appropriate research method for an Art Research project as these boost open-endedness and divergence.

1.6 Conclusion

The aim of this research strongly based on technical and conceptual thinking and doing, is to combine physical/scientific knowledge with ephemeral qualities of light and colour and play with these immaterial elements to create aesthetic experiences, which trigger the perceptions of audiences and provoke reflection upon what is seen.
I offer with this thesis a personal presentation of a project in the field of Art and Science approached with an Art Research attitude. I created my own field of 'reference and logic' and all argumentation of this thesis refers to this 'artistic setup' (Steyerl 2012, p.60). I claim originality by offering a poetic encounter with the physical colour phenomenon of metamerism, enabling experiences, which allow audiences new ways of seeing.
This project is concerned with physical, cultural and philosophical questions and constantly crosses the borders of different disciplines.
I invite the reader to encounter the phenomenon of metamerism and to enjoy this thesis as a knitted cloth, coloured by multiple threads.

[10] Some discussions / conversations were recorded on video (Ch 8.5.3)

2 Textile & Text

Outline

In this chapter I contextualise textile and textile art, as the medium for the realisation of this research is textile, in particular knit. Text and textile, having etymologically the same root, are interlinked. The technique of knitting, besides being the medium for the realisation of my artworks, will be introduced as a method of research design and an illustration of the process. Along with knitting, writing is one of the crucial methods of this research. Here, the various styles of writing applied in this research will be introduced and established alongside the structure/format of the thesis itself. The methodology of this research is textile and a method of textile thinking is incorporated. In addition, knit is presented as a metaphor for the whole of the research, which can be seen as a knitted fabric.

2.1 Textile and Textile Art

Diverse techniques enable the building of fabrics: knitting, weaving, crocheting, felting and knotting. For the most part textiles are flexible constructions built with natural or artificial yarn. As a means to think with, textiles have power because humans have been so intimately bound up with their use and production. They belong to our material culture and are part of our everyday lives; textiles, from swaddling at birth to shrouding in death, surround us. They have protected, warmed and embellished humanity throughout its multi-layered history. Textiles were significant in the past and will continue to be so in the future 'as a primary medium of cultural knowledge and experience' (Jefferies 2001, p.1).

2.1.1 Textile Art

In 2014 the German art journal 'Texte zur Kunst' published a survey of the 'significance of textile within contemporary forms of thinking and practice', which is 'situated distinctly within the context of contemporary art and exhibition practice'[11] (Buchmann and Frank 2014). The overarching question posed to curators, art historians and artists was:

> Why since the 60s textiles again are continually booming and if this popularity is due to textile's capacity for multiple interpretation and contextualisation (Ibid.).

In answer, one of these articles by Kapustka et al. (2014) asserted: 'the hybridity of textile as medium, technique, material and metaphor demand an inter- and trans-disciplinarity,

[11] Two examples to underline the popularity of textiles in art contexts are:
'Kunst & Textil', a remarkable exhibition in the Kunstmuseum Wolfsburg, Germany, in 2014, which provided a broad overview from modernity to the current state of textile as a material and idea in the field of art.
'Radical Lace and Subversive Knitting' at the Museum of Art and Design, New York. Chief curator McFadden (2008, p.9) stated that this exhibition 'acknowledge[d] the continual revaluation of fibre as a valid medium for art'.

which is hardly achievable'. It is exactly this challenge I was keen to explore during my PhD journey. I bring with me multiple experiences and skills in various disciplines (Ch 1.2), which is why I dared to approach this transdisciplinary textile project, where knit is the medium, technique, material and metaphor.

Textile, oscillating between craft and art, is often diminished in value because it is seen as 'just' craft or applied art. However as early as 1860 the German architect and Art Theoretician Gottfried Semper sought to assert the value and significance of textile art, saying that it is 'primeval art' and therefore 'should take undoubted precedence' (2004, p.113). Whilst craft or applied art is considered 'useful', having a purpose or intention, 'high' art can be 'useless'. Borchardt-Hume (2014, p.160) writes that 'Kant argued that art was to exist on its own terms, to develop by its own rules and to justify its existence on its own merits alone'.

Yet the inherent abstraction of weft and warp allowed certain artists to think differently about the production of art works. Sophie Täuber-Arp and Anni Albers, important artists of the 20th century, had a textile craft/applied art background and their practices definitively emerged from these experiences. Brüderlin (2013, p.34) attributes to these artists, working with abstraction, 'innovative strength'. Anni Albers' medium for the creation of artworks was weaving and her understanding of textile art was connected to the understanding of ancient societies where textiles had been seen as 'high art'. Sophie Täuber-Arp (Aargauer Kunsthaus 1989, Vögele 2002, Schmutz 2014) worked in her applied textile art practice with embroidery and beads, which, according to Hoch (2014, p.215) influenced the development of the abstract forms in Constructivist art; 'Sophie Täuber-Arp proved in 1915, with her *Compositions vertical-horizontales,* a pioneer in Constructivist Art'. In 1911, Sonia Delaunay created her first entirely non-representational work (Brüderlin 2013, p.34), a patchwork blanket representing the immediacy of colour experience.

I see a strong affinity in my practice to the work of these three artists; my textile background has substantially influenced my thinking and my art practice, and dialogues between craft and art practice have been important throughout my life.

2.1.2 Knit

Knit is technique, medium and metaphor for the realisation of this research. A main reason for my choice of this technique is personal background (Ch 1.2); I am a trained textile artisan, textile artist and fashion designer, with knit as my core competence. From this, I bring with me the required skills for the realisation of the project. Moreover, knit is the most suitable technique for this research, as knit allows the creation of fabrics incorporating different yarns so that colour changes can be achieved without visible joining of seams. The seamless combination of different yarns and colours supports concealment of inherently different metameric yarns, strengthening the specificity of my research investigation into metameric colour changes triggered by different lighting conditions.

The multiplicity of knit in general, and particularly in the context of art, is demonstrated in various recent studies (Hemmings 2010, Turney 2009, Mc Fadden 2008, Gschwandtner and Shirobayashi 2007). In her book '*The* CULTURE *of* KNITTING' Turney (2009, p.1) 'investigates

the cultural impact and meaning(s) of knitting and its development since 1970' and stresses the important cultural contribution of knitting:

> Knitting is no longer only an ordinary, domestic practice but can be fine art, craft, design, film, performance and fashion, as well as a leisure pursuit. It can – and frequently does – make social comment, political statements and questions issues of national and global importance. (Ibid., p.3)

Textile in general and knit in particular are commonly allocated to the female. Talking and writing about textiles often raises issues of gender[12] (Turney 2009, p.8). Several artists are engaged with such topics, as evidenced in the work of Louise Bourgeois, Rosmarie Trockel, Beryl Tsang, Ghada Amer, Freddie Robins[13], Danica Maier[14] and others. In addition, knit has more recently gained attention in the public domain as Yarn bombing and Guerrilla knitting became popular (Knitta[15], among others). Often these happenings were social events and the created knits were developed in communities and prevalently part of a DIY culture (Sabrina Gschwandtner, Cat Mazza, Rachael Matthews[16], among others). Other artists use knit for the communication of political statements (Lisa Anne Auerback, Jerilea Zempel, Mona Hatoum [17]). Kapustka et al. (2014) make clear 'that textile and its exploration is still entrapped in ascribed characteristics such as anonymity, femininity, materiality and craftsmanship'. I would agree that this remains the case but while my research acknowledges the valid approaches and hard-won respect that these artists have helped knit as a medium to achieve, this research will not explicitly investigate gender, femininity, DIY culture or craftsmanship. The project does utilise the critical, activist and philosophical potential of textiles and seeks to expand the contribution knitting can make to different disciplines.

Knit is the technique and the medium for the realisation of artworks here: it is used as the supporting material for carrying the physical colour phenomenon of metamerism *and* the knowledge generated through the process of thinking and making. As Turney (2009, p.221) writes: 'Knitting allows the maker to not 'just' make things, but to communicate ideas, forge relationships, and make sense of and comment on the world around them'.

This research 'using textiles as a route towards contemplation' (Checinska and Watson 2015, p.279) recognises textile practice as critically powerful. The project aims to communicate a colour phenomenon, to trigger new perceptions by showing the aesthetic aspects of a phenomenon generally seen as a problem (Ch 3.1.1). The knitted artworks should allow a clear perception of the colour change, through which viewers are prompted to feel wonder and consider the poetic dimensions of metamerism (Ch 8 - 9).

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[12] Turney (2009) wrote a chapter with the title: Knitting: A Gendered Pursuit? She mentions topics as 'education, employment, femininity, leisure and lifestyle'.

[13] In Gschwandtner 2007, Brüderlin 2013, McFadden 2008, Celant et al. 2010, Engelbach et al. 2005

[14] http://www.danicamaier.com/Danica_Maier/Home.html

[15] In Gschwandtner 2007

[16] In McFadden 2008

[17] In Gschwandtner 2007, Hemmings 2010, Brüderlin 2013

2.2 Knit as a metaphor

Along with knitting, writing, the activity of creating text, is another fundamental practice of this research. Writing and knitting are entangled. Text and textile have etymologically the same root, going back to the Latin word ‘texere’, weaving. Several philosophers, writers and researchers (among others Mitchell 2012, Ingold 2007, Kruger 2001) draw parallels between text and textile and show the analogy by using textile as a metaphor. Kruger for example, writing about this metaphor, differentiates between the activity (weaving) and the material (the woven).

> Hence in ancient Greece weaving comprised a tool for female signification, but a further distinction can also be made between the *weaving process* and the *woven textile*. Each represent modes of signification quite different from the other. One is process-oriented whereas the other is product-oriented; weaving becomes a metaphor for speech, something occurring in time, whereas the woven material becomes a metaphor for something written, and thus permanent unchanging. (2001, p.44-45)

Knitting is the technique of the construction of the fabrics/artworks of this project and as a consequence knit, not weave is the metaphor for the fabric of the complete body of research, installations and performances. Likewise, mirroring the research project, the written thesis is metaphorically a ‘whole cloth’ (Constantine and Reuter 1997). Barthes (1977, p.159) calls a ‘text a woven tissue, a woven fabric’ and for him ‘text is plural’ and the plural depends on the ‘*plurality* of its weave of signifiers’. The plurality of a knitted text fabric is adapted to map this transdisciplinary project. The written part knits together various topical threads and knit becomes a mode for researching through physical making, a different but parallel form of idea construction alongside the written form.
Multiplicity is one of the basic characters of this transdisciplinary research. To map multiplicity Deleuze and Guattari (1987, p.6) propose the metaphor of a rhizome, opposing their model to the arborescent model of the conception of knowledge, which operates with dualism and dichotomy. This could also be a felicitous metaphor to map this non-linear and complex art research process. Alternatively Von Busch (2008, p.29) used the metaphor of a Wunderkammer or Cabinet of Curiosities, wherein the reader wanders and wonders while encountering multiple objects and thoughts. As the notion of wonder (Ch 7.3.8) is involved in this research, this metaphor would be a valid one. I have chosen, however, to use a textile metaphor for my research, as it is more apposite to the investigation: it is a knitted fabric, built with various threads, through which I articulated my concepts, experiments and findings (Figure 5).

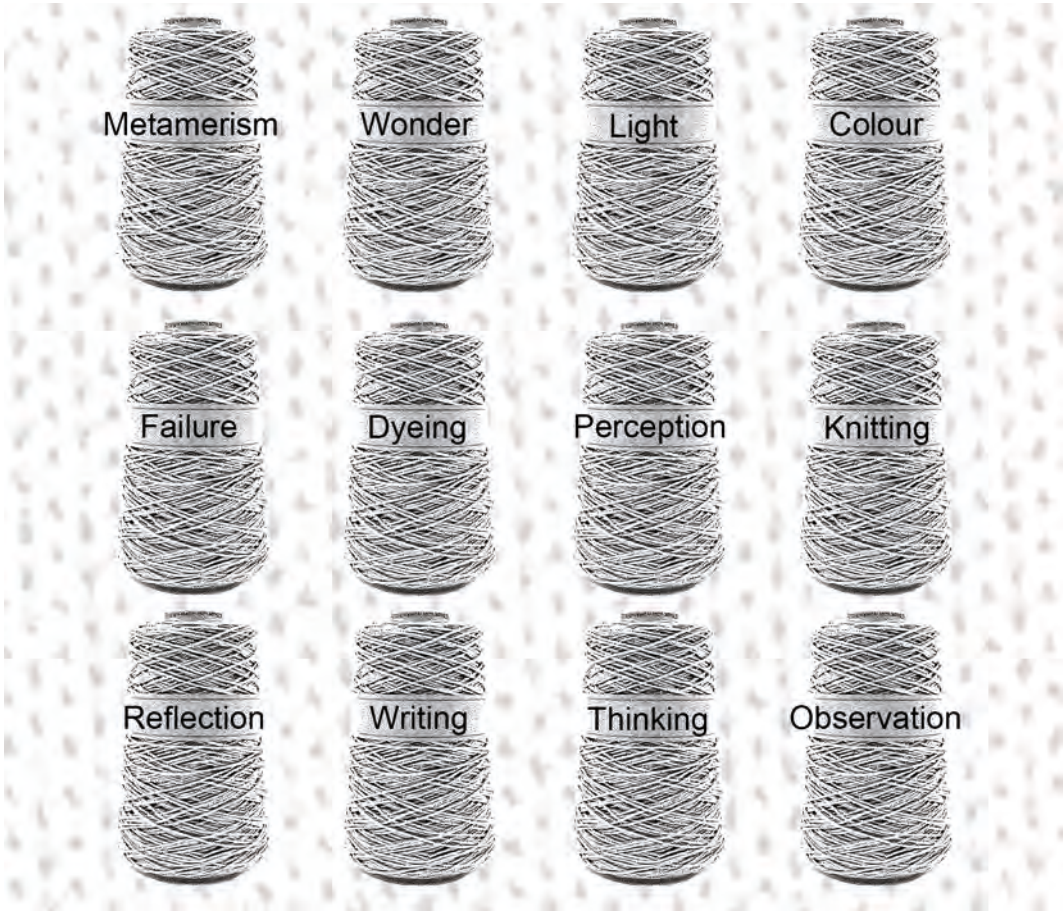


Figure 5 Visualisation of threads creating the fabric of the thesis

Collins (n.d.) stood up for textile metaphors in academia as

> … another way of thinking about the creative and generative practice of writing – and about how we write in relation to particular knowledge claims and communities – that is more about piecing together fragments of things of varying source and quality (at least, in conventional terms) that wouldn't necessarily fit together seamlessly in the more structured metaphorical tradition of theories-as-buildings.

The complexity of this research requires the knitting together of several topical threads at once and therefore as a suitable technique jacquard (Ch 5.1.2.5) has been chosen. The term jacquard embraces a double bed knit technique and a certain kind of knitted double-faced fabric, a fabric with a face and a reverse side. Jacquard fabrics require at least two plies of yarn, which differentiate between the following criteria: different colours; different materials; different yarn count.

These could be translated into the criteria and various topical threads of this research; therefore an incomplete selection is showed in Figure 5.

The main threads are light, colour and metamerism. But alongside the various methods and practices involved are threads such as knitting, dyeing, writing, literature review and others. Various philosophical questions emerged, such as the everyday, failure and perception.

These threads are knitted in all over the fabric, some visible at the front side, some visible on

the reverse side, creating double-faced cloth. Threads not involved in the creation of the image on the front side are embedded on the reverse side: even though they are not visible at the front side they are present in the whole fabric.
In the following chapters I will scrutinize the manifold threads and their varied combination.
In the course of the research, some new threads, performance for example (Ch 8), were introduced and became crucial, as the journey had taken an unforeseen change of course.
Each artwork, be it an installation or a performance, knitted together different threads and thereby gave new impulses to the research.
The exploration of different threads, different combinations of threads, variable kinds of knitted structures, were all preparations for the final research fabric and therefore fundamental to making the thesis as a whole a ‘whole cloth’.

2.3 Writing as method

Writing, introduced in Chapter 1.4.3.1 as a practice/method for visualizing the research in order to achieve traceability, will be further explicated in the following sections where the various writing methods applied in the execution of this research are scrutinized.

2.3.1 Research journal

Figure 6 Various diary and reflective journals

Over many years I had established a personal writing practice. There was a time when I wrote for twenty minutes daily following the briefing of Cameron (2000). Each morning I got up, had breakfast, and afterwards sat down, put on the timer and wrote, for exactly twenty minutes, everything, which came to my mind. This was a very helpful tool to start the day. I wrote down all the thoughts, which occupied my mind and body; I described experiences; noted feelings, facts and planned actions. This writing somehow functioned as a bin, where I was able to ‘’deposit’ ideas and feelings’ (Gray and Malins 2004, p.58) which bothered me at that specific moment. I did not rework this written verbal ‘output’. I wrote it down and left it as it was.
I stopped this strict daily writing practice several years ago, but still use it quite regularly as a method to get clarity and order in my thinking, feeling and actions. For Leavy (2015, p.271) this kind of writing is a ‘creative strategy for artistic inquiry translation’ and she calls it ‘spill writing’, writing ‘about the artistic experience without concern for grammar, form, or style’. She defines its objectives as being ‘to reduce anxiety, to increase creative flow, to document the process’.

I made use of this kind of personal writing throughout the research journey, using different formats to mark down my thoughts by filling various books, booklets and writing pads or by writing into electronic Word files. Sometimes, as a reflective practitioner (Ch 1.4.5), I started the day with twenty minutes of writing; sometimes I wrote during the practice, reflecting in action, and sometimes I wrote afterwards, as reflection on actions or in planning, through my writing, further actions (Gray and Malins 2004, pp. 57-58). I observed myself, scrutinised my journey, examined my practice reflexively and looked ahead to the next steps of the research, reflecting and preparing new actions, taking into consideration the new understanding coming out of evaluated experience (Ch 1.4.5).

These texts, collected over the time span of the journey, form my research journals. Gray and Malins (Ibid., p.113) propose the reflective journal as a 'good practice-based method that encourages and enables reflection'. As a practitioner and craftswoman I always link hand and brain, practice and reflection. I address my current problems in writing and by formulating them I begin to solve them. The writing can therefore be seen as a tool for problem solving. Sennett (2008, p.9) stated: 'every good craftsman conducts a dialogue between concrete practices and thinking; this dialogue evolves into sustaining habits, and these habits establish a rhythm between problem solving and problem finding.'

Writing in general and journal writing in particular was a crucial method to keep track of the various practices during the whole research journey. The research journals, as an honest documentation, are research evidence (Gray and Malins 2004, p.114). They 'contain different types of information' (Ibid., p.113): they include precise description of process in the dye lab and knit lab; quantitative data, facts and information for repeatability, qualitative thoughts, reflections, insights and comments regarding my emotional state.

The various journals are also a repository, consulted during the writing up of the thesis, from which I filtered, extracted and exposed the appropriate information or reflection needed for the topics I dealt with or was writing about. The texts of the journals, including very personal thoughts, are not written for the public realm. Information and data from the journals, as well as personal reflections, are incorporated through the whole text of the thesis when their evidence is appropriate. An example of my personal reflective writing is the following text, which I wrote on the 21 October 2015.

Writing as a practice

I don't have a plan for my writing. I cannot stick to rules. Piles of books surround me; I sit down each morning at ten o'clock at my desk in my studio space, the computer in front of me; that's the only rule I have set.
Locate the real issues of the research project.
My fingers involved in the process, the practice of typing. My eyes involved in reading and checking. My ears involved in listening to the loud outspoken text, controlling, checking if the text sounds good, a personal very important control tool, which goes over the sense of hearing.
From day to day the space on the desk gets smaller and smaller, as more information, more contexts are growing on my desk.
Collecting words, a collection of ideas;
An organizing and a creation of an overview;
A growth of a net, a net of thoughts; a net of titles and topics;
An interlacing of thoughts hanging in the net more words, adding words to the various topics, knotting together, weaving together;
The mesh of thoughts – a network;
Critical writing.
How many prototypes, how many drafts, how many versions?

The writing of a practitioner, who is writing about her own work;
Writing about various practices at which I am skilled, I know the material; I am writing about, I know the processes I am writing about, as I lived the process on my own. I struggled personally again and again.
This phase of the writing process is a discoursing practice, focused, but not yet confined. I consider this phase of collecting and clearing ideas as part of the writing practice, even though there is not a lot of writing done until now. But this preparation phase, where the textuality is still missing will be crucial for the actual writing.

Shifting words, down, up and to the right or the left, finding the right order, which gives the shape of the content. Preparing the different thoughts to be read by an audience.
Act of writing – continuous – discontinuous.
What is the meaning of fluid writing? Is it possible to write meaningful in a fluent way? Is it possible to weave thoughts quickly together, to build phrases?

Weaving together the various threads of the PhD, building, creating a fabric, a text. Texere a text. Changing colour, changing tension, changing structure. Observing the outcome of bringing together threads with different haptic characters. The shiny, the dull, the hairy, the rough, the soft, slippery, even, glossy, irregular, nubby. Deciding the look of the end product.

Conventional forms of writing, narrative writing;
Writing as a creative process, a creative practice. It is a playing around with thoughts and texts, searching for the accurate composition.
Writing in the mist of the research process, writing as a help to think through things.
Writing as a help to organize the various feelings, emotions, experiences and thoughts. Writing to test overlapping, juxtaposing the various topics, searching for the right neighbourhood.

Figure 7 Research journal 21 October 2015

2.3.2 Descriptive Writing

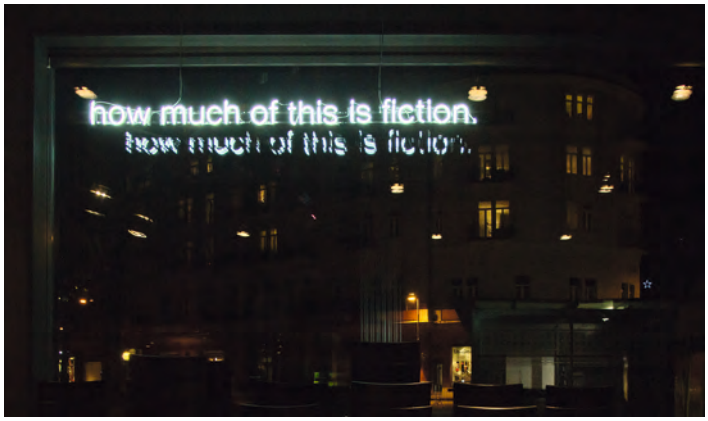


Figure 8 Artwork by Maia Gusberti, 2014, at Kunstmuseum Interlaken

As introduced in Chapter 1.3.3, I am the first-person narrator of these lived processes, which are then described and analysed. In my writing I do not claim universality. I am aware of the subjectivity of my experiences on the research journey. I personally lived my experiences: I failed, I struggled, I suffered, I enjoyed and I had success. I am not writing about the outcome of the practice of somebody else. I perceived and observed with my senses and my sensibility. I described and analysed my personal experiences from within.

> Although historically even qualitative researchers such as ethnographers were charged with rendering “objective” accounts of social reality, it is now well accepted that ethnographers are positioned within the texts they produce. (Leavy 2015, p.42)

As with an ethnographer I am ‘positioned within the text [I] produce’ (Ibid.) and explicitly linked with the process as well as the various forms of representation of this research.

> What I am considering here is that, but with the symmetrical addition of a written dissertation that asks to be understood as fiction. (Elkins 2009, p.159)

Elkins proposes understanding a written thesis in the field of Art Research as fiction. The question ‘how much of this is fiction’ (Figure 8) is therefore justified but cannot be answered. A substantial part of this thesis is executed in a descriptive writing style. The various practices and the resulting artworks, alongside being documented visually, will be described in the following chapters. These descriptions, relying on my personal experience, were underpinned by consideration of theory, context and history and built a foundation for analysis.

2.3.3 Writing for the dissemination of the research

As explicated in Chapter 1.5.4, research ideas, process and findings were communicated through the whole period of investigation to a broad audience, including other practitioners and researchers. Dissemination of the research was executed in various formats as well as written

form. I wrote abstracts to apply for conferences, texts for presentation at conferences, as well as a paper for the proceedings of the conference of the International Colour Association 2015. This paper complied with the topic of the conference (Ch 9.1.2.1) and followed the given academic rules (Abstract, introduction, methodology and method, result, discussion, conclusion).

2.3.4 'Performerly' writing

The neologism 'performerly' writing draws on the 'readerly' and 'writerly' texts, described by Barthes (1974). 'Performerly' written texts are intentionally crafted for public presentations; performances or lecture performances. These will be discussed in Chapters 8 and 9.
For presentations to TTP (Thinking Through Practice), a student-led art research group from Nottingham Trent University, I wrote 'performerly' texts. This group focused on the exploration of Art Research in the context of a PhD through various discussions, seminars and presentations. During my PhD journey, I used this context of art research peers as a testing ground and presented several texts, summarizing work done and reflecting on how I worked and how the work proceeded.
These texts are part of the methodology of tracking thoughts and processes, capturing facts as well as feelings; these feedbacks thereby informed further steps in the research. An example is presented in more depth in Chapter 8.2.3 and established as a valid research strategy on my journey.

2.4 Conclusion

This research builds upon the practice of textiles as an innovative means of thinking.
'Knowledge of materials and techniques can constitute a conceptual toolbox for thinking' stated Pajaczkowska (2015, p.92). Lindstroem and Stahl (2015 p.65) propose 'patchworking ways of knowing' and in a keynote Maharaj (cited in Checinska and Watson 2015, p.279) used the notion: 'Thinking through textile'.
I propose in my thesis to 'think through knit' and pursue 'thinking through knitting'.
Furthermore, this chapter presents knit as metaphor. This research, situated in the field of Textile Art, is a jacquard, knitted with threads of thoughts and threads of practice. The thesis and research are considered as a whole cloth created with various topical threads.
Knit is the medium but not the subject of this project. 'I unhinged the technique [knit] from the original "handcraft" and "domestic" context' and use it to explore a physical colour phenomenon and thereby planned to create 'novel modes of expression and aesthetics' (Ruhkamp 2013, p.327).
I delve into the topic of the various applied writing styles and depicted how and when I applied them on the research journey. I present the fundamental method of documentation, the research journal.

3 Light, Colour and Metamerism

Outline

Generally the physical colour phenomenon of metamerism has been considered a problem; this research, by contrast, unveils opportunities latent in the metameric effect; wonder inspired by lived experiences of these subtle colour changes. These are provoked by the change of illuminant, a parameter of any viewing condition. So, colour perception with the principal performers of light and colour is a matter of great importance for this research.
In this chapter I provide an overview of the context, including technical background information, for this research project, and lay a basis for the understanding of the following chapters. Literature was reviewed regarding the various fields involved, which this chapter describes, analyses and highlights from different perspectives.
The creation of metameric material was a first step on the research journey. The calculation and adjustment of the metameric recipes used is based on colour management. This project follows some aspects of common colour management, but in addition had to invent new ways of colour assessment: the creation of intentionally metameric material required a novel approach. Several terms are involved in colour management and will be introduced in the following sections.

3.1 Metamerism

Metamerism, the overarching phenomenon of this research, can be defined as follows: '… when two colours match one another, but are different in spectral composition, they are said to be metameric' (Hunt and Pointer 2011, p.117). Due to this colour phenomenon, a pair of colours could match in one set of viewing conditions (i.e. dependent on illuminant, observer, geometry of illumination and viewing or field size) but appear different when any parameter of these viewing conditions is changed.
Metamerism, a term built with two Greek words (meta: 'among, in combination with' and merós: 'part') differs from colour inconstancy, 'the change in colour of a single piece of fabric under different light sources' (Choudhury 2015, p.119). Metamerism involves always at least a pairing of the 'same' colours and the focus of this research project relies on working with **metameric colour pairs** (a pair of two colours only) or **metameric colour series** (a series of three colours), as further elucidated in this chapter (Ch 3.2.2.3).

3.1.1 Metamerism: problem or opportunity?

To date metamerism has been perceived as a significant problem in colour technology, colour formulation and production applications, and it affects many industries (amongst others Fashion, Automobile, Photography) where matching of colours is important. Therefore 'Colour Management' is a crucial issue and the focus of companies working in this area (Xrite, Datacolor, natific) is based on how to avoid this unwanted, disturbing colour change.

I was first confronted with this physical colour phenomenon while working in the Fashion Industry, approving lab colour samples, and at this stage considered it as a problem (Ch 1.1.1). But my interest in this phenomenon got under way at this time and a fascination with the beauty of these subtle colour changes emerged. I started to see this phenomenon as a great opportunity rather than a problem.

Online, I discovered the scientist Dr. Daisuke Miyazaki (2012, 2013), a researcher working in the field of information science and technology. One of his research areas is his project: Metamerism Art. He offers in his talks and papers, which are available online, mathematical calculations for the mixing of oil paints to allow artists to realise metameric paintings. Miyazaki considers metamerism as an opportunity for the creation of artworks. He shares my interest in this exciting colour change and states in his Youtube Video that metamerism is fun [18].

I consider metamerism more than just fun. As represented in the following chapters (Ch 8 - 9) this research goes further by proposing the colour phenomenon metamerism as an aesthetic experience triggering discussions about light, colour and perception. Through artworks, metamerism becomes experienceable and the vitality of light becomes reality.

As previously described (Ch 2.1.2) the medium for the realisation of this research project is textile and the technique is knitting. Hence, one of the first steps on the research journey was the development of metameric material (the dyeing of metameric yarn colours), which would later be used for the creation of artworks (Ch 7 - 9).

Having practical knowledge (techné) regarding yarn dyeing from my industry experience, I approached several representatives[19] of the colour technology industry to obtain information regarding the concrete implementation of this creation of purposefully metameric material. They were all experts in how to create 'non-metameric' material and were therefore surprised by the idea that the phenomenon of metameric colours might be an opportunity. All confirmed the complex of problems surrounding metamerism and Dr. Reidl (2011, 2012) from the company Clariant told me in the beginning about the difficulties I would encounter. In his opinion, certain instability would always remain in this project and I would only be able to tentatively approach my first goal of having metameric material ready for further research. The computer software calculating dye recipes works with an iterative method; there is no easy and straightforward way to find recipes for metameric colour pairs (Ch 3.2.2.3) meaning the exploratory search for visually interesting material had to be done experimentally.

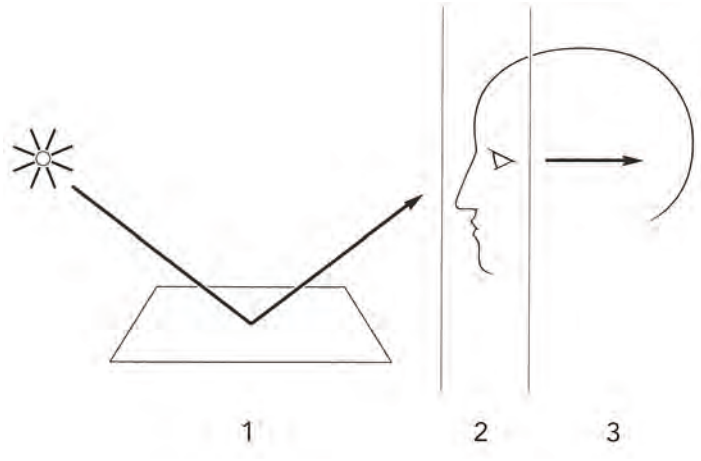
[18] There is another colour company offering fun with metamerism: https://www.youtube.com/watch?v=Qda1dVH1zGI [Accessed 15 September 2016]

[19] Dr. Frank Reidl from Clariant (2011, 2012), Clariant is a world leading company in the sector of specialty chemicals. They develop, produce and sell dyes and chemicals for various industries, including textile; Andreas Roth from natific (2012), The Swiss company natific offers a broad palette of services in the field of colour management and quality control; Michael Pieper from Datacolor (2011), Datacolor is a global leader in colour management solutions and colour communication technology. They offer different software for colour calculating and colour adjustments; Matthias Halbeisen from EMPA (2011), EMPA is a Swiss research institute, linked to the science and technology University ETH, in the field of material and technology.

3.2 Light, Colour, Metamerism and their connections

Artist James Turrell affirms the complexity of sensing colours and the connectedness of colour and light by stating: ‘There is no sense in talking about a colour that is made from a pigment, unless we also speak about the light which illuminates it and the visual context in which it is seen’ (cited in Bachmann 2006, p.11).

What is valid for the sensation of colours in general is also valid for the sensation of metameric colours. The sensation of an object’s colour arises from a combination of a light source, an object and an observer (Figure 9).



1. Physical occurrence outside the human body (light)
2. Reaction of the organ of sight on light stimulation
3. Formation of sensation of seeing in the brain (Zwimpfer 1985, preface)

Figure 9 Illustration of colour perception

Colour perception, as shown in Figure 9, involves physics (1.), physiology (2.) and psychology (3.) and is strongly influenced by viewing conditions involving illuminant, observer, geometry of illumination and viewing or field size. These parameters will be explained later on in this chapter.

3.2.1 Let's start to talk about light

Light, 'the physical occurrence outside the human body' (Zwimpfer 1985, preface) is a main player in this research, as the focus is on **Illuminant Metamerism** (Ch 3.2.2.1), where metameric colour change occurs because of the change of illuminant.
What is light? What are the differences between various illuminants, which contribute to changes in the perception of colour?
Without light, we cannot see anything; we see neither forms nor colours. The phenomenon of light is a basic requirement for sight. In addition, light determines how we perceive colours. Each day we are surrounded by **electromagnetic waves** (Figure 10).

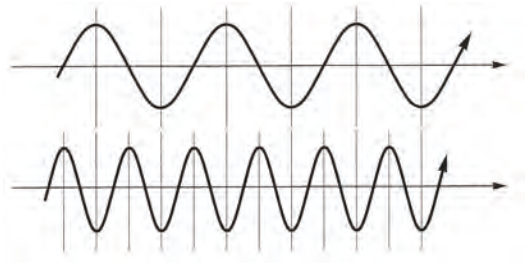


Figure 10 Schematic visualisation of electro-magnetic waves

Fischer (2006, pp.89-90) describes light as follows: 'Light is customarily represented in wave form and defined by corresponding parameters such as a wavelength (λ), for example and frequency (v).' The electromagnetic radiation that a human detects through visual sensation has a spectrum of wavelengths from about 380nm to 770nm (Figure 11). Hence, 'each energy source, which emits electro-magnetic radiation in the range of 380nm to 770nm […] is a light source' (Zwimpfer 1985, No.10).

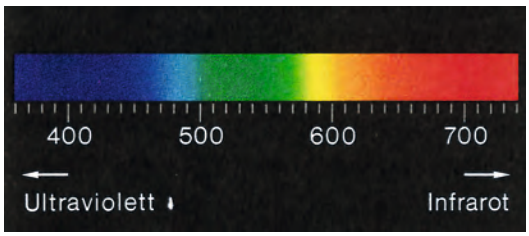


Figure 11 Spectrum of visible light

All light sources have properties and emit particular light qualities for their intended use. But the quality and energy of light sources is generally not defined and can vary, as with the light of the sun during the day. Therefore, at the beginning of the 20th century the International Commission on Illumination, CIE (Commission Internationale de l'Éclairage), started to define uniform standards for industrial production to reach consistency and reliability through standardization, formulation and definition of involved parameters (illuminant, observer, geometry of illumination and viewing or field size) in order to allow smooth handling and communication in the field of colour and light (Choudhury 2015, p.57). Amongst other things, they defined parameters for light: Standard Illuminants with a quantitative and mathematical consistent description.

The research planning set out from the beginning to involve only ‘white’ light sources, which Zwimpfer (1985, No.75) calls ‘colour neutral light sources’. These light sources consist of radiation of all wavelengths (380- 770nm), covering the whole visible light spectrum (Figure 11).

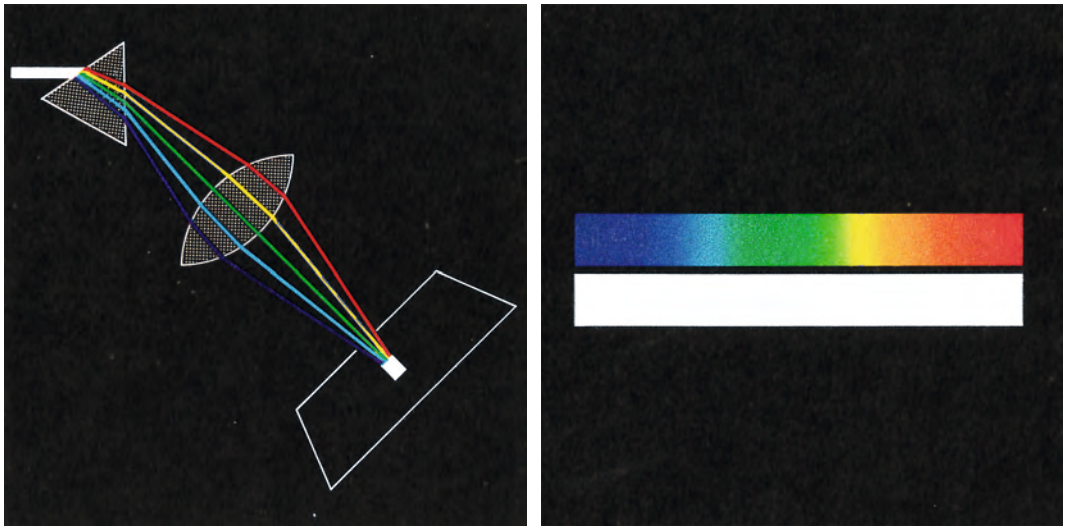


Figure 12 Illustration of light with all wavelengths and the colour sensation white

If a light source consists of limited wavelengths, for example has only wavelength from the long-wavelength spectrum (Figure 13, right) the colour sensation excited is red so it is a ‘coloured’ light. This research focused on colour neutral light sources, but I see potential to explore metameric artworks under coloured light in further research (Ch 10.3).

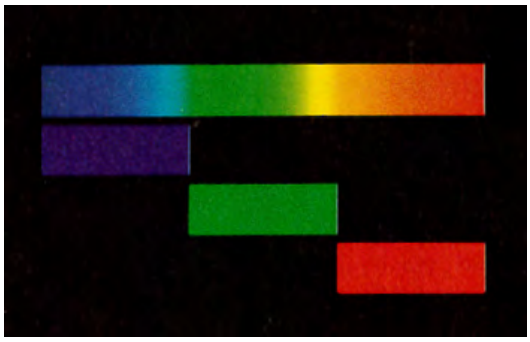


Figure 13 Left: Short-wavelength; middle: medium wavelength; right: long-wavelength

On the 18th February 2011, Dr. Reidl from Clariant[20] pointed out that a clear definition of the light quality required would be crucial for the development and realisation of the metameric material, and once fixed the illuminants should not be changed.
Following this advice three relevant illuminants for the development and realisation of the metameric material were decided: **D65, A, F11**.
The whole exploration in the dye lab (Ch 5 - 6) was executed on the basis of these three illuminants, commonly used in industry regarding colour checking for metamerism. So the same illuminants used to establish that a colour is not metameric, since this is unwanted, was for this

[20] Clariant is a world leading company in the sector of speciality chemicals. They develop, produce and sell dyes and chemicals for various industries, including textile.

project used to check that colours are metameric and that any colour change is clearly visually perceivable.

These specific illuminants were inserted into the settings of the software used for colour recipe calculation and they determined the colour recipe choice for the creation of the metameric dyed yarns (Ch 5 - 6), which once realized, would be the basic material for further steps of the research (Ch 7 - 9). Furthermore, the dyed metameric yarns were visually assessed, adjusted and judged in the light cabinet at Nottingham Trent University using the same commonly used illuminants (Figure 14).

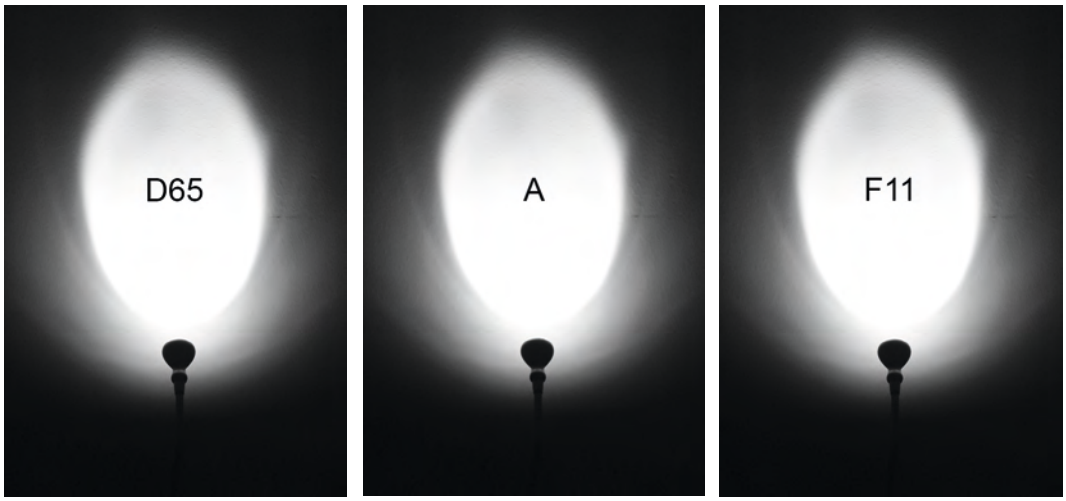


Figure 14 Visualisation of illuminants used by the software and the light cabinet

3.2.1.1 Definition of used Illuminants

D65 - Daylight

Natural daylight changes during the day and depending the season or the weather. Therefore even for the quality of natural daylight CIE Standard Illuminants were defined. Standard Illuminant D65 is a definition of daylight with a temperature of about 6504 Kelvin (Hunt and Pointer, 2011, p.94).

A - Incandescent light

'A stable and convenient light source can be obtained' by heating a conductor, enclosed in a transparent glass, 'that contains a vacuum or only inert gases' 'by passing an electric current through it'. 'The most suitable material found so far for the filament is tungsten' (Ibid., p.86). Tungsten filament light (the 'old' traditional light bulb) and tungsten halogen lamps belong to the category of incandescent light sources. The tungsten filament light, Standard Illuminant A, has a temperature of about 2856 Kelvin (ibid., p.92).

F11 - Fluorescent light[21]

> Fluorescent lamps are very widely used for general lighting, especially in industrial and commercial environments where high levels of illumination, high efficacies, and good colour rendering are required. These lamps consist of a glass tube containing low-pressure mercury gas, in which a gas-discharge is produced; and the inside of the tube is coated with phosphor which are excited by the emission of the ultraviolet lines of the mercury spectrum, particularly that at 253.7nm, to produce additional light. (Hunt and Pointer 2011, pp.78-79)

There are various fluorescent lamps with different definitions. This research works with illuminant F11, corresponding to TL84 in the USA. It has a temperature of about 4000 Kelvin.

The chosen illuminants are colour neutral light sources, consisting of all wavelengths from the whole visible colour spectrum, but the relative spectral power is unequally distributed. For each Illuminant 'an emission, respectively a diffuse reflectance curve [can be] generated' (Zwimpfer 1985, No 118). Figure 15 illustrates the chart in which 'in horizontal direction the wavelength and in vertical direction the measured radiation intensity is entered' (Ibid.).

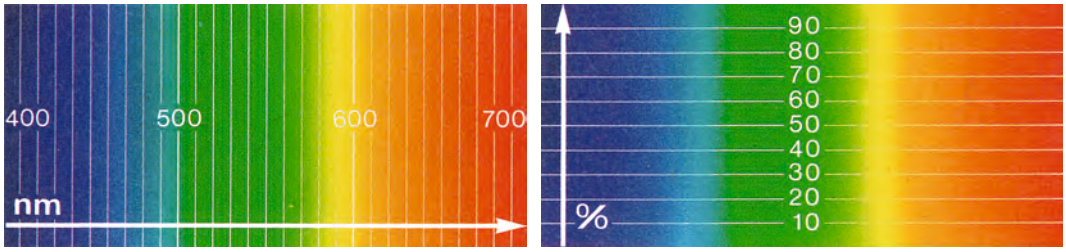


Figure 15 Illustration of the chart for an emission - diffuse reflectance curve

Figure 16 illustrates the diffuse reflectance curves of the relevant illuminants used in this project. Standard Illuminant A shows a high percentage of relative spectral power in the range of the long-wavelengths and as a consequence, being stronger in the range of reddish wavelengths, illuminant A could trigger the red component present in a mixed colour (Figure 22).

[21] 'There are no CIE standard illuminants representing fluorescent lamps' (Hunt and Pointer 2011, p.79). But Hunt and Pointer consider F11 as a typical illuminant representing the group of fluorescent light.

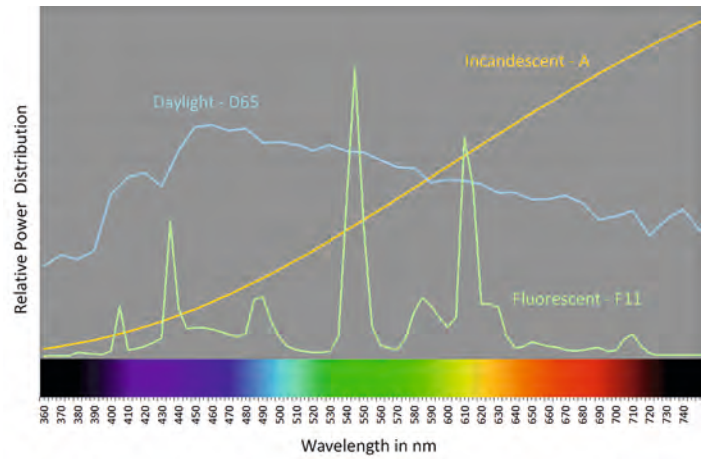


Figure 16 Illustration of Spectral Reflectance Curves of Illuminant F11, A, D65

The differences of spectral reflectance power in the fixed illuminants are a basic fact, which influences the perception of metameric colours, as I will show later on in this chapter.

The different modes of light reflection are a further aspect influencing colour perception. Figure 17 illustrates light reflection on impervious to light materials; on image a light is striking an impermeable material and is reflected to a certain amount. Light not reflected is absorbed by the surface (image b). Light is never reflected or absorbed totally, as shown on image c (Zwimpfer 2012, No. 054).

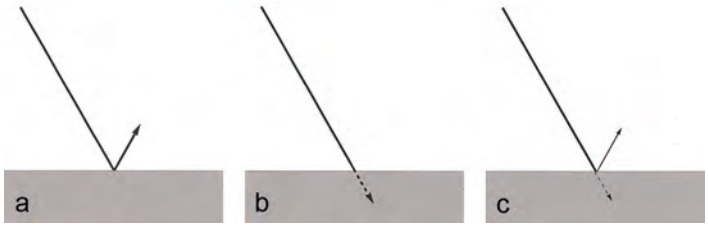


Figure 17 Illustration of light reflection

3.2.2 Following light, let's talk about colour

As shown in Figure 18, 'an area appears green if the penetrating neutral light reflects the medium wave radiation but absorbs the short wave and the long wave' (Zwimpfer 1985, No. 104).

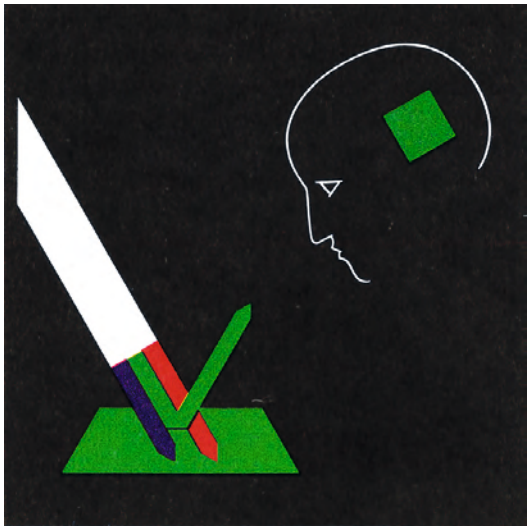


Figure 18 Illustration of colour sensation green

3.2.2.1 Illuminant Metamerism

The recognition of colour is a complicated sequence of steps, which Gage (2006) describes as follows:

> …, for the 'physical' element in colour is simply a set of wavelengths that impinge on the eye and have, as yet, no identity as what we understand as 'colour'. This physical element is not 'colour' but variable types of radiant energy which are 'really' out there in the world but invisible. Even the human visual system does not produce 'colour', since the mechanisms of the retina simply convert physical into electrochemical energy, which is fed into the nervous system, and ultimately into the cortex of the brain. [ ] The retina records and transmits sensation, not perception, and the recognition of even a single colour depends upon complicated cerebral processes, such as inference and memory. 'Colour' is thus, first and foremost, a question of psychology (Gage 2006, pp.7-8).

As Gage writes, the starting point of the sequence is the reflection of 'a set of wavelengths that impinge on the eye' and when different light sources are involved in colour perception (Figure 16) the set of wavelengths vary and as a consequence the relative spectral power is unequally distributed. Illuminant Metamerism, a colour change occurring because of the change of illuminant, is triggered by this fact.

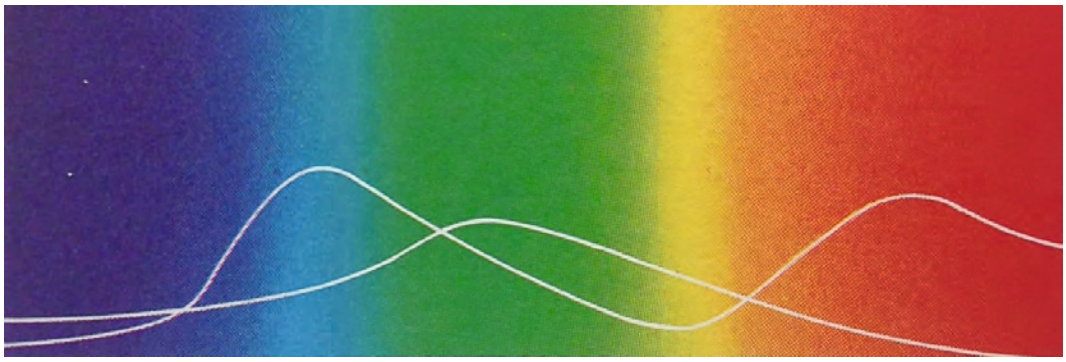


Figure 19 Spectral reflectance curves of a metameric colour pair

Figure 19 shows two spectral reflectance curves of a metameric colour pair, which was measured with a spectrophotometer under a specified illuminant, in this case: illuminant D65 and A. The spectrophotometer (Hunt and Pointer 2011, p.101) measures ‘the proportion of light reflected by a sample’ (Westland and Cheung 2006, p.9). This data, used to create a spectral reflectance curve, represents the physical colour fingerprint. The triple crossing of the spectral reflectance curves, the points of intersection, shows us that this colour pair would be a metameric match. The two colours would seem unicolor in illuminant D65 but two coloured in illuminant A.

The focus of this research rests on Illuminant Metamerism, one important aspect, amongst others, influencing colour perception. Another type is Observer Metamerism (Choudhury 2015, pp.176-178), occurring when a colour pair match for one observer but differ for another. This type is present in this research, but not especially examined, though it is recognised that due to Observer Metamerism, the installations and performances are individually perceived, as each observer's eyes and brain process observed the data differently (Aspland and Shanbhag, p.32). Therefore each observer lives a personal subjective experience (Ch 7 - 9). Also present, but not my focus, are Geometric and Field size metamerism (Ibid., pp.178-179).

3.2.2.2 Creation of colours

Colours can be created by mixing different components of dye and in this way the metameric material of this project is produced. Figure 20 shows an example of a subtractive colour mixture: a cyan blue substance (dye) is mixed with a yellow substance (dye).

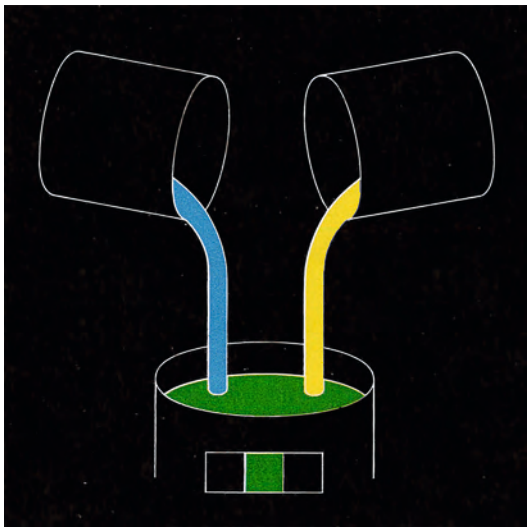


Figure 20 Subtractive mixing of dyes

Zwimpfer (1985, No 112) describes Figure 20 as follows: ‘The cyan-blue substance absorbs (subtracts) the long-wavelength part of the light, the yellow substance the short-wavelength part. Both substances reflect the radiation of the middle spectrum and hence the mixture produces a green colour.’ This is a way to create one colour with dyes.
This one and the same colour can be dyed with different recipes, each having different dye components and quantities as illustrated in Figure 21.

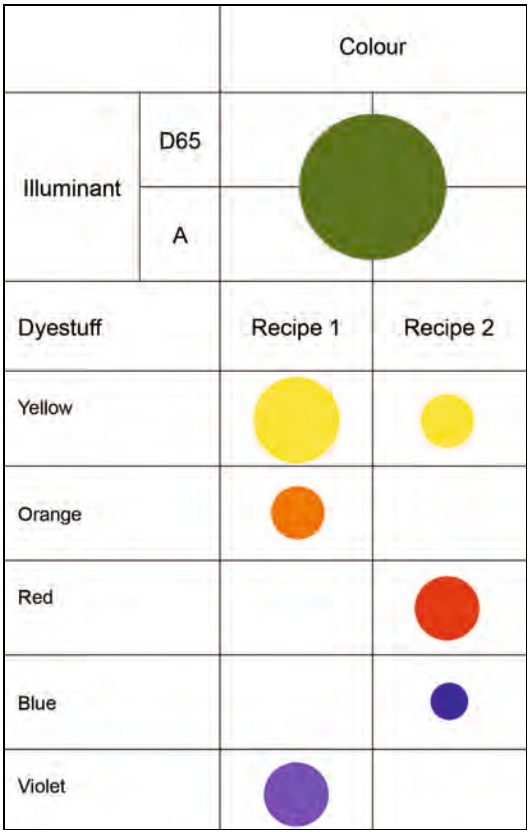


Figure 21 Illustration of differing dyestuff combinations for one and the same colour

The same colour can be dyed with different recipes, but these colours, having different dye components and quantities, carry the risk of becoming metameric (Figure 22) as the measurement data of such colours differ.

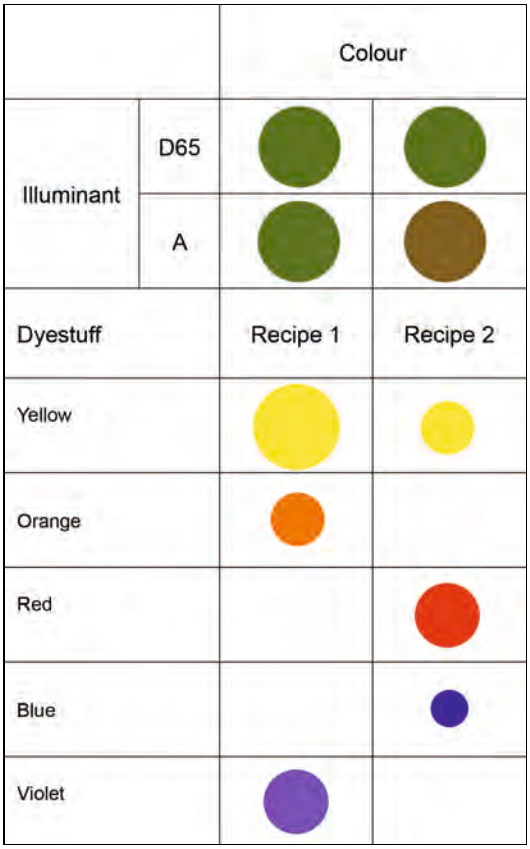


Figure 22 Illustration of dyestuff combinations of a limited equal match

This fact can lead in one set of viewing conditions (in this case illuminant D65) to the same colour sensation, a colour match; but a visual mismatch if the illuminant changes (in this case illuminant A). A metameric pair can also be called a limited equal match.

3.2.2.3 Metameric colour pair and metameric colour series

A first milestone of the research was to find recipes for the creation of a metameric colour pair; two limited equal colours dyed with two different recipes as illustrated in Figure 23:

Figure 23 left side

1. In illuminant D65, Colour of recipe 1, called ‘Stable colour’ and colour of recipe 2, called ‘Colour A’ would visually be perceived equal.
2. In illuminant A instead, the ‘Stable colour’ (recipe 1) remains stable (as in D65), but ‘Colour A’ (recipe 2) changes in colour visually.

Figure 23 right side

3. In illuminant D65, Colour of recipe 1, called ‘Stable colour’ and colour of recipe 2, called ‘Colour F11’ would visually be perceived equal.
4. In illuminant F11 instead, the ‘Stable colour’ (recipe 1) remains stable (as in D65), but ‘Colour F11’ (recipe 2) changes in colour visually.

Metameric colour pair: two colours					
Colour pair 1			Colour pair 2		
Illuminant	Recipe 1 'Stable colour'	Recipe 2 Colour A	Illuminant	Recipe 1 'Stable colour'	Recipe 2 Colour F11
D65			D65		
A			F11		

Figure 23 Visualisation of metameric colour pair: two recipes

In December 2012, I reached the first milestone by dyeing in the package machine the first metameric yarn pair (Ch 6.1.1) as shown in Figure 23, colour pair 1. Having reached the first goal, I increased the complexity and searched for a metameric colour series; three colours which would look nearly the same in daylight D65, one of them would be 'stable' in the three illuminants and one would change visibly in colour and look remarkably different under tungsten (A) while the other would change visibly in colour under fluorescent light (F11) (Figure 24).

Metameric colour series: three colours			
Illuminant	Recipe 1 'Stable colour'	Recipe 2 Colour A	Recipe 3 Colour F11
D65			
A			
F11			

Figure 24 Visualisation of a metameric colour series: three colours

3.3 Colour management and colour measurement

The calculation and adjustment of the metameric recipes is based on colour management. This project follows some aspects of common colour management, but had in addition to invent new ways of colour assessment, as the creation of intentionally metameric material required a novel approach. Several terms are involved in colour management and are introduced in the following sections.

3.3.1 Colour palette of this research & colour standards

In a conversation Dr. Reidl (2011) confirmed that metamerism could be achieved with achromatic mixed colours as beige, brown, olive and different shades of grey, which are not considered colourful. These colours would show significant colour changes, which are highly visually perceivable. This confirmation supported the colour palette of this research and in

September 2011 I started to explore colour samples in this colour range. For the first dye exploration I measured with the spectrophotometer[22] a grey and an olive green (Figure 25) and saved them in the colour management system as colour standards. The computer colourant formulation uses the calculated mathematical data thereby created for the creation of recipes.

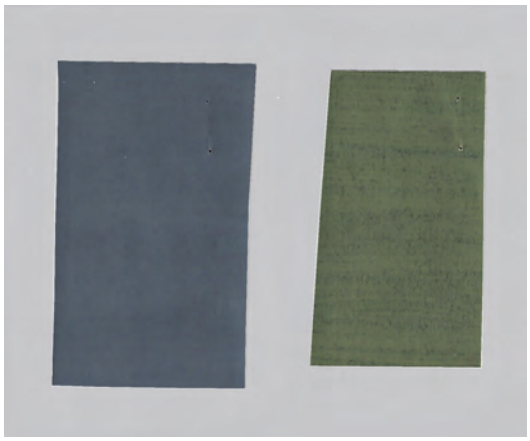


Figure 25 First colour standards: grey and olive green

3.4 Colour assessment: visual or instrumental

In commercial colour management a dyed sample is assessed in comparison to the standard and the aim is that standard and sample match in variable conditions.
Furthermore, with each dye repetition, each batch should match to the standard as well as to the other dyed batches.
The colour difference of a sample compared to the standard can be assessed visually or instrumentally. Both variations were needed during the exploration in the dye laboratory and also during the preparation of dyed metameric material, as further explained in Chapters 5 - 6.

3.4.1 Visual monitoring and evaluation

Light cabinets 'provide an environment for visual assessments under comparable, specified, lighting conditions' (Aspland and Shanbhag 2006, p. 32). Other parameters affecting visual evaluation are: 'sample size'; 'nature of illumination, i.e. type of illuminant; distance between the samples under observation; texture of material; colour of the surround; observing conditions namely: angle of illumination and observation, observation distance, duration of observation'; 'observer's variability of age, attention, attitude, level of training, etc.' (Choudhury 2015, p.57).
During the realisation of metameric material (Ch 5 - 6) colour samples were assessed in the light cabinet and in various present natural and artificial light situations at the university. In this way, the aspects mentioned above were considered.
Generally, we are not aware how differently we, as observers, perceive colours. We assume, that when looking at the same thing we all see the same. I have to admit that even I myself,

[22] 'Spectrophotometers can measure colours of diverse material, including fabric, plastic, paper and the measurement data from colour samples can become colour standards.

working for a long time in the Fashion industry approving colour lab dips, was not aware at the beginning of this research journey of these strongly subjective aspects of colour sensation and the huge differences between the observations of different observers. And I was not the only one to be ignorant, as Aspland and Shanbhag state:

> Yet, very few of the individuals making visual color decisions have any notion of how their own color vision compares with that of the people with whom they discuss and trade colored materials. Even fewer seem to appreciate that any color change that they perceive, as a result of changing light sources, might not be the same as those perceived by others. (2006, p. 32)

Aspland and Shanbhag, among others (Choudhury 2015, pp.3, 55, 62) assert that 'human visual assessment is subjective' and Rigg (2006, pp.24-25) adds to this statement: 'there is no doubt that different people do see colours differently'. But as we are not aware of the exact differences in our colour vision we are not able to talk about them.
Tests were therefore developed to check numerically how the colour sensation of observers compared to those of the standard observer. 'The first test to identify to what extent a test person shows a difference to the standard observer (assumed to be a person with average color vision abilities) was the D&H Color rule' (natific n.d.) (Figure 26).

> A new but similar test (Red-Eye Test) consists of one grey standard swatch and 13 metameric samples. One metameric sample represents a perfect color match when calculated by standard daylight CIE-D65 10° data and standard observer data CIE-1964-10°. Other samples go to the redder side in steps of approx. $1.5DC_{CMC(2:1)}$ while the remaining samples go to the greener side in steps of approx. $1.5DC_{CMC(2:1}$. (natific n.d.)

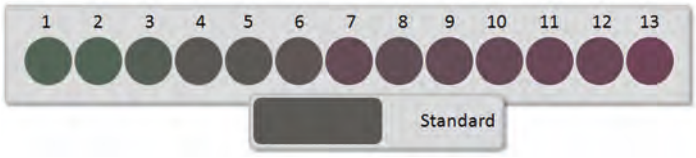


Figure 26 Red-Eye Test

The defined standard observer senses a match at nr. 6 while the average observer senses a match from nr. 6 to 8. On the 28 February 2012 I did the Red-Eye test and sensed a match at nr 8, placing me, luckily, among the average observers.
In the dye lab the dye technician and I always did the visual colour approval together, in order to broaden the validity of the assessment. But I am well aware that 'in order to establish a stable average while viewing a given pair of samples, it would take as many as 35 observers' (Choudhury 2015, p.62).

3.4.2 Instrumental monitoring and evaluation

In this research project the instrumental monitoring and evaluation of colour accuracy was executed with spectrophotometric measurement. Dyed material (knitted yarn) was measured under specified conditions (Illuminant/Observer) and compared to the standard, followed by evaluation and adjustment (Ch 5 - 6).
Four measurements of a colour sample are required and an average of these measurements will be calculated to fix the data of a colour. To facilitate the best possible measurement data, the dyed fabrics have to be folded in two to make an opaque solid colour.

3.5 Colour space, Colour models and representation

Colours can be represented in a three-dimensional spatial system, in a colour space. Each colour sample, defined by three numbers, can be located within this, and the distance between two samples is the colour difference. ‘In 1931, for scientific and technical requirements, the Commission Internationale d’Éclairage established the CIE system’ (Zwimpfer 2012, No.353). Over the years, based on this system, different systems for the quantitative description of colours were built. Colour system CIE L*a*b* and colour tolerance formula CMC (2:1) are relevant for this research and will be further elucidated. ‘The common ground of all actual professional colour systems is, that each colour shade has a physical defined profile’ (Ibid.).

3.5.1 CIE L*a*b* colour space

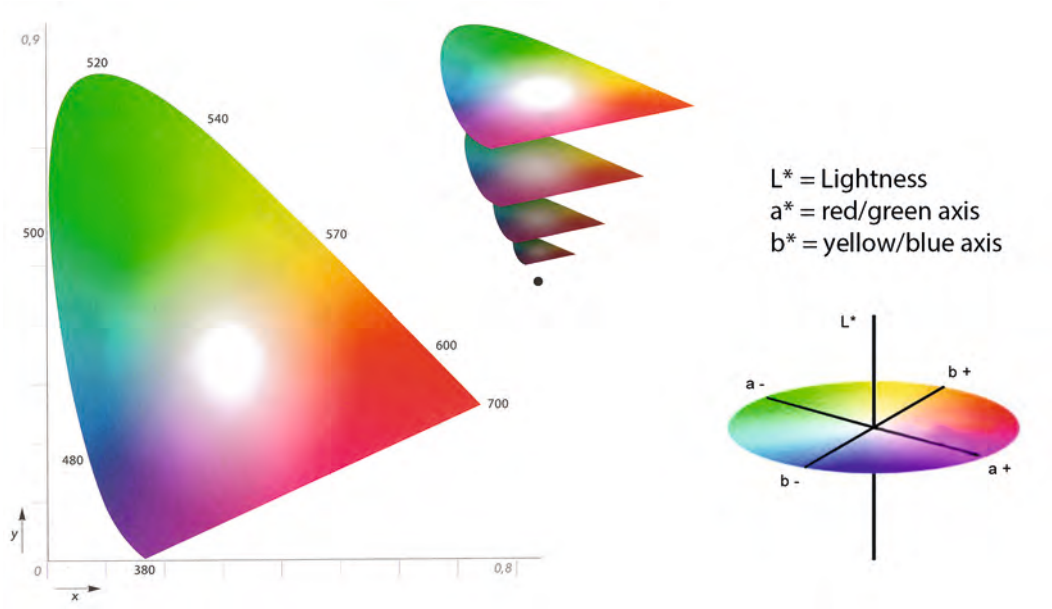


Figure 27 Illustration CIE L*a*b* Colour space

The CIE L*a*b* system was defined in 1976 for object colours by the International Commission on Illumination, CIE (Choudhury 2015, p.87). The colours are ordered in this colour space on the basis of three coordinates (Figure 27):

L*: The lightness coordinate

a*: The red/green coordinate /axis, with +a* indicating red, and –a* indicating green

b*: The yellow/blue coordinate /axis, with +b* indicating yellow, and –b* indicating blue

3.5.2 Colour differences and tolerance

Colour differences, common in textile dyeing, as there are so many variables involved, (Choudhury 2015, p.61-62), can be instrumentally quantified by colour management software. Differences are 'always calculated for a specific Illuminant/Observer condition' (Datacolor n.d.2, p.391) and the metric system thereof is designated as ΔE[23] (also DE).
In the CIE L*a*b* system, the differences can be differentiated for the single axis:

Da: Difference on the redness-greenness axis

Db: Difference on the yellowness-blueness axis

DL: Difference in lightness: CIE 1976 Lightness, L* (Hunt and Pointer 2011, p.52)

DE: The total colour difference incorporates the specified parameter of the various systems.

Variable tolerances can be established: 'limits within which a product is considered acceptable, while falling outside is unacceptable. The tolerances allow us to make quick and easy pass/fail [...] decisions' (Choudhury 2015, p.56).
Differences with a value below one are considered as visually not perceptible (Ibid., p.58) and so during the process in the dye lab (Ch 5 - 6) **the tolerance for the total colour difference** of a metameric series was **set to DE1.**

3.5.3 CMC (l:c): colour difference formula

The further development of the CIE systems succeeded with sophisticated mathematical formulae to define the distances between colorimetric loci correlating the calculation with the sensation of the human eye. (Zwimpfer 2012, No354). Though they weighted the various factors of colour perception and included the fact that human eyes and brains are more sensitive to certain colours than others. Luo and Rigg (1986, p.164) state that the CMC (l:c) colour difference formula, defined by the Colour Measurement Committee of the Society of Dyers and Colourists, UK, 'correlates with the visual judgement better' than former published formulae (among others the CIE L*a*b*) and is an improvement. This formula allows consideration of the characteristics of textile surface reflection to be taken into account and lightness and chroma weighted in relation 2:1 (Hunt and Pointer 2011, p.62). The colour difference formula CMC 2:1, which is 'typically employed as a tolerancing system in industrial applications' (Datacolor n.d.1.) was applied for the assessment of production yarn in this research (Ch 5 - 6).

[23] '…where delta is a Greek letter often used to denote difference, and E stands for Empfindung; German for "sensation" ' (natific AG, n.d.).

3.5.4 Colour management and assessment of this research

In contrast to commercial colour management (Ch 3.4) this research aims for a colour match of the colour outcome of three different recipes in illuminant D65 (Figure 24). Uniformity in illuminant D65 is crucial so the instrumental tolerance of a metameric colour series should be lower than DE1 in order to not show any perceivable colour difference. Colour samples of a metameric colour series can only be accepted if they visually match or show only a marginal colour difference.
The International Commission on Illumination (CIE) defined in the standard DIN 6172 the Metamerism Index for pairs of samples at change in illuminant. This index is a quantitative value, which defines the grade of metamerism of limited equal samples. Datacolor (2009) defines the change in illuminant as follows: 'The color difference (ΔE) between a pair of objects, under a test illuminant, assuming that the objects match ($\Delta E=0$) under the reference (primary) illuminant.' The more crossings (Figure 19) are present, the more metameric the colour pairs are, and the higher the mathematically calculated number of the colour difference (ΔE) is.

Metameric colour changes are generally unwanted. This project inverts this situation, searches for 'problematic' colour pairs and seeks visually remarkable colour changes in illuminant A and F11. As a consequence colours started to be interesting for this project only when the predicted difference would be significant, which means higher than DE1. Thus a sample of a metameric colour series is in this case accepted, if the change in colour is highly perceivable and significantly different form the 'stable colour' (Figure 24). The stronger the colour change is the better, as the intended application of the phenomenon in this project is artistic and audiences must perceive the mismatch (Ch 8 - 9).

Colours of a metameric colour series can be measured and the differences, marginal and remarkable, can be expressed through the language of physics/science. But it was also important to judge and compare colour series visually in the set light situation, as there could be a gap between the visually perceived and the instrumentally calculated difference (Ch 5 - 6).

3.6 Conclusion

In this chapter I introduce the physical colour phenomenon metamerism, which generally is perceived as problematic in the colour industry. In contrast, this research aims to turn metamerism into an opportunity and intentionally produce metameric material.
I explain and elucidate the basics of colour management and colour measurement and clarify involved terms to familiarise readers with the various fields and appertaining terminology.
I prepare the ground for further steps in the research by providing fundamental information regarding light and colour, and I outline the context from which the next steps on the journey emerged.
I describe in this chapter my approach to the process of decision making around some key parameters. Among others, the mathematically defined illuminants (D65, A, F11), which assure consistency in the development process of the metameric material, and the defined tolerance of DE1 of a metameric colour series in D65.

4 Light – the breadth of daily human experience

Outline

Light, the intangible medium with intangible qualities, is a fundamental medium of this research. This chapter spotlights light with its various facets (light history, light art, light and textile, metamerism and art). Literature was reviewed regarding the various fields involved, which this chapter describes, analyses and highlights from different angles. I present, by means of artworks using light as a main medium, my personal aesthetic experience of this (Ch 1.5.3) and back up my arguments with statements from other thinkers. Following this, I reflect on the effects triggered by these artworks and discuss them in relation to my own planned work.

4.1 Light – in the past, today and in this research

The phenomenon of light enables sight and determines how we perceive colours (Ch 3.2.1). In our daily life, as observers, we experience light and colour phenomena; we experience changing colours and changing light situations. Lefebvre cited Hegel, who said 'the familiar is not necessarily the known' (1991, p.132). Thus, are we really aware of these phenomena: do we overlook them or take them for granted?

4.1.1 The natural daily light

The sun is the main source of light and in our geographical position there is light during each day. At night it is dark, just the moon and stars are shining. Depending on the season, the bright day is longer or shorter, and depending on the weather it is a sunny light or it is dark even during the day. There is each day's natural light, which seems to be 'white', but over the day the colouration of the light changes, so at sunrise the light is reddish, changing later on to rose. At midday, when the sun is at the zenith, light has a blue tinge and at sunset it turns reddish (Ulmann 2009, p.24).

4.1.2 Light from the past to today

Humanity has always sought to control and conquer darkness and hence keen to find solutions for illumination after the sunset. Schivelbusch (2004) in his book 'Disenchanted Night' elucidates varied uses of illumination: light for security, light enabling artworks, light creating ambience, light for elongating working hours, and more.
Fire was an early light source. Further developments led to oil lamps, candles and torches. Already back then, humanity used light as an element of decoration. The next improvements were provoked by the necessity of longer working hours in industry, as the hours of daylight were not sufficient anymore (Ibid., p.16). This caused research into more efficient and more

intense light sources and the development of new technology. Gaslight had been invented for use as industrial lighting (Ibid., pp.22-27) which did not need a wick and offered very bright light. Later this new technology was introduced into the lighting of public space. But several gas explosions and the danger of gas intoxication frightened the public and the distrust regarding this new technology was huge. Another problem caused by gaslight was its intense consumption of oxygen, the lack of which in closed rooms or theatres provoked headaches. This novel light source produced soot, which blackened the walls of interiors. As a consequence, its meaning changed. From being the utmost in clean lighting techniques, it came to be regarded as a dirty and dangerous example of 'progress' (Ibid., pp.38-44).
Edison brought together knowledge and new inventions from several researchers and patented his solution: the incandescent light (Ibid., pp.60-67). Prior inventions in the field of electricity were crucial for the development of incandescent light. This brilliant progress was lauded as the light was steadily and bright, without creating headaches and blackening interiors. Lamps with tungsten filament bulbs were for a long time the most common light source. In the field of incandescent light several progressions were achieved, among them the tungsten halogen light. Today the traditional tungsten light is also disreputable (Ch 7.3.4). Over the years the rationale for the development of new lighting technology changed. Nowadays key developments in this field are ecological and economic, as researchers seek improvements in energy consumption. As a consequence, a commission of the European Union banned the traditional tungsten light bulb in 2012. More recent innovations are the fluorescent light, light-emitting diodes (LED) and organic light-emitting diodes (OLED). The field of electric light continues to develop.

4.1.3 Light for installations and performances

Dr. Reidl (2012) called attention to the difficulty of constant light settings within installations as the light quality of bulbs changes over time. Furthermore, light bulbs, even with the same specification, can show visible deviation in their distribution of radiation and this makes it hard to get scientific accuracy and constant light situations. Thus, a certain variation in the quality of light situations provided by installations would always remain.
Following the advice of Dr. Reidl (2011) the research planning intended to build appropriate light boxes using the defined illuminants (D65, A, F11), used for the production of the metameric material, in order to exhibit the artworks under consistent light settings. At this point of the research the development of the artworks was still pending, as was the building of light boxes for installations.
On the 17 September 2013 I knitted the first available metameric yarns (Ch 6.1.1) on a sunny day in the late afternoon. I took my knitted fabric from under the knitting machine and brought it up to the evening sunlight. Just this small movement, from under the knitting machine into the evening light, saw the colours of my fabric visibly change, turning reddish.
By and by I discovered that my fabrics were constantly changing, even in the available light sources at the University. I began to explore these ordinary light sources by walking around in the building and observing the striped fabric (Figure 28) in various light situations, experiencing and examining colour changes.

Figure 28 Metameric fabric photographed in three different light situation

Figure 28 shows the same fabric, photographed three times with an iPhone with the same setting, in three different light situations of the University. I realised even then, that cameras do not picture what I saw. The perceived visual changes were remarkable but not as strong as the photos suggest. Moreover, I wasn't able to photographically represent the fabric as unicolor in daylight, as I visually perceived it. In natural daylight the stripes nearly disappeared and the visual colour sensation of the fabric was almost unicolor.
The experience of subtle colour change in these everyday situations attracted my interest and this incident influenced further steps of the research journey (Ch 8.1.1). I realised, that rather than build special light boxes with fixed illuminants, I was keen to work with commercially available light bulbs and build the installations and performances using low-tech artificial light sources combined with natural daylight. This decision underlined the focus on everydayness (Ch 7.5.6.), which adheres to the various fields involved: light, colour and textiles.

4.1.4 Exploration of LED

For a long time, I excluded from the research all the newer light sources (for example: LED, OLED and so on), which would open a completely new field. I am aware that newly developed light sources could offer a huge potential for further research (Ch 10.3).
On the 22 October 2014 I visited the Regent Lighting Centre in Basel, CH, where I met Marcel Brodbeck and got the opportunity to test my metameric fabrics in their advanced LED lighting system Matrix Pal +[24], which offers a vast range of light temperatures and colours, and various ambiences of warmer and colder lights. I developed my yarn colours without considering and observing them under LED lights, so was curious to test and observe my artworks in their LED light setting. I was very surprised that in none of the possible light options could I observe a change in the olive colour to reddish green. The colour variation, which I could show in Tungsten light, was not visible with the LED Matrix Pal + system. However, the various visual changes triggered by their system were very interesting and these effects offered potential for further investigations (Ch 10.3).
Even the experience at Regent regarding the colour change from olive to a reddish olive was unsuccessful; I deployed an LED bulb during the exhibition 'grün!?' in January 2016. This will be elucidated in Chapter 9.1.5, where the exhibition is described and analysed.

[24] http://www.regent.ch/en/products/indoor/spotlights-and-track-systems/track-spotlight/matrix-pal/pro32752.html

4.2 Art in the context of Light and Colour

In order to gain understanding of my own artistic approach of light and colour as a medium and/or material for installations and performances, I studied artworks from various artists working in these contexts.
How are other artists working with similar or the same material and mediums? How do they approach them? How do others work with light or colour change? How do they integrate light in their work and what is the significance of light? Do they represent light with colour or replace colour with real light (Weibel 2006, pp.27-28)?
I play with colour, but light creates the artworks. I use light as a trigger for subjective perceptual experience because it might prompt a feeling of wonder. 'In visual perception, a colour is almost never seen as it really is – as it physically is. This fact makes colour the most relative media in art' (Albers 2006, p.1).
Colour, this most relative media in art, is a main player of this research. Colour is a phenomenon and with colours we create phenomena. Colours trigger emotion and have symbolic content (Ch 7.3.3). The field of colour is, like the field of light, complex and difficult to define: as Merleau-Ponty (2014, p.319) states: 'Physics and also psychology give an arbitrary definition of colour that in fact only works for one of its modes of appearance, and which has long concealed from us all of the others.'
Colours always surround us; we have distinct opinions on colour. We have favourite colours and colours we do not like at all. This research plays with a reduced colour palette of achromatic colours (Ch 3.3.1). During the phase of exploration, the colour palette was slightly broader, but in the end I focused on the metameric colour series of an olive green. Further specifications follow in Chapters 5 and 6.

4.2.1 Light Art

Over the centuries light was an important subject in art. Painters played with light and shadows, leading the gaze of viewers and setting clear focuses in their work. In the baroque era, the light of fireworks was part of the festival culture. Light is a versatile medium, as is artificial light. 'The use of electric light in art is, however, a more recent phenomenon, emerging in the twentieth century' (Lauson 2013, p.17). Artists included new technology and utilized the development of light sources for their artworks. Light Art is characterized by the use of light serving an aesthetic intention. Technical development in the field of light is still ongoing (Ch 4.1.2) and offers inspiration for the creation of artworks.

As a pioneer of Light Art, László Moholy-Nagy's interest in light as medium and material started at the beginning of the 20th century when he introduced artificial light into his artworks. In 1930, in the exhibition of the Deutscher Werkbund in Paris, he showed his kinetic Light-Space Modulator, which evidenced 'light's potential as a sculptural medium' (Lauson 2013, p.18).
The exhibition 'Lightshow' at the Hayward Gallery, London, in 2013 gave a broad overview of different aspects involved in Light Art: 'as sculptural form, as perceptual phenomenon and as a medium invested with specific social and cultural meanings' (Ibid.), likewise in 2014 during

the visit to the exhibition 'Aisthesis, The origin of sensations' at the Villa Panza, Varese, Italy, showing work from James Turrell and Robert Irwin.
These encounters with Light Art gave me an opportunity to see, and perceive live, some very impressive artworks using light as medium and/or material; to reflect upon and analyse the various standpoints adopted by these works.
Light, as a creative means, creates atmosphere, decorates buildings, can illuminate or even build rooms and establish ambience. Light can create drama, trigger emotion or transport messages.
Several artists introduced fluorescent tubes or altered LED, mediums of mass culture originally applied for advertising, in their artistic work. Some worked with straight tubes, marking the space with illuminated lines (Dan Flavin, Gerold Tagwerker, among others), while others bent light tubes to create words, texts and messages (Jenny Holzer, Bruce Naumann, Maia Gusberti[25] among others), which can be socially engaged or politically oriented light art, but also incorporates a poetic aspect.

In the 1960's James Turrell, Robert Irwin, Doug Wheeler and others formed the art movement Light and Space. The focus of this loose group was set on perceptual phenomena, working with artificial light and rooms. Light took centre stage in their work and was not just a medium but also a material. Irwin and Turrell were part of the art-and-technology program initiated by the Los Angeles County Museum of Art in 1967. The examination of light as a material with physical and optical properties, and the technological and scientific knowledge gained through this, strongly influenced the creation of their artworks. Peschke (2011, p.63) substantiates the impact of Turrell's background by stating: 'His works, besides being poetic, are informed by exact scientific calculations and planning and the outcome of his installations are based on scientific findings clarifying them'. Turrell, 'working exclusively with light since the nineteen-sixties' (Brüderlin and Kirschner 2009, p.7) uses natural and artificial light as his artistic medium. His artworks *Skyspaces,* cuts in the ceiling of buildings letting in natural light, direct the gaze of viewers to a clipping of the sky, joining the interior space with the exterior 'by bringing the space of the sky down to the plane of the ceiling' (Turrell 1990, p.47). 'An aperture cut into the roof acts as a simple but effective framing device in which to view the sky in all its changing moods and nuances of colour' (Alison et al. 2005, p.146), enabling a heightened conscious observation and perception of natural light.
In August 2014 I experienced myself the beauty of Turrell's works, visiting Villa Panza Collection, Varese, Italy, where Turrell built the first Skyspace in 1975 (Alison et al. 2005, p.146). In 2015 I also got the opportunity to observe and experience the artwork 'Open Sky' at the Chichu Art Museum, in Naoshima, Japan. The fascination of these cosmic circumstances lies in the poetic performance of the sky, which let time fly. Direct sunlight alternated with clouds passing by, covering the sun and changing the light drastically; a wonderful natural occurrence directed through the artwork to become an entertaining performance.

[25] In Domesle 1998; Gärtner and Schierz 2009; Lauson 2013; Lauter and Hirner 1999; Schwarz 1998; Weibel and Jansen 2006; Zentrum für Internationale Lichtkunst Unna, 2013, http://www.maiagusberti.net

'The works in which the viewer confronts a space that is completely filled with homogenous light are called the Ganzfeld Pieces' (Turrell 1990, p.43). In 2013 at the Hayward Gallery in the exhibition Lightshow, London, UK, my perception was challenged by the artwork '*Wedgework V'*. In 2014, in the exhibition 'Aisthesis – The origin of sensations', Villa Panza, Varese, Italy, I experienced another of Turrell's insubstantial and immaterial rooms, *Ganzfeld 'Sight Unseen'*, where coloured lights offer an emotive but also bewildering experience of room perception. Spatial visualization is tricked and for the viewer the dimensions of the real space remains non-comprehensible. Wrapped in light, the space is made illusory and elusive.

> Turrell was intent in shifting the viewer's awareness away from autonomous works toward a systemic internal process of looking. Through the careful articulation of illusion and spatial disorientation, Turrell succeeds in drawing attention to the act of seeing and the body as a site of perception. (Alison 2005, p.146)

Turrell uses light in a completely different way to myself, but it seems that an interest in similar issues drives us. As Alison (Ibid.) described Turrell's work, I am keen to set a focus on the process of looking and draw the attention of audiences to the act of seeing (Ch 8 - 9).
In 2013 I experienced the artwork *Model for a timeless garden* (2011) from Olafur Eliasson and the experience still stays with me. The work was installed in a dark room lit only with a strobe effect. It was a visual installation but also an auditory experience. The sound created by the trick fountains made it clear that water was splattering and falling, even though the movement of the water was not at all visually perceptible. Because of the strobe effect the water seemed to be stopped in time and/or frozen, and the fountains appeared as shaped glass sculptures. The strobe effect cheated the eyes, but the ears brought back the reality, the knowledge that the installation is not achieved with glass but splattering and falling water. The inability to see the splattering water created a very poetic room, a surprising and enduring wonder and the tension was created through 'knowing, but not seeing'. Seeing is often linked to knowing, proved by the saying: *Do you see what I mean?*

4.2.2 Light and Textile

When I started my PhD I was a researcher at the Lucerne University of Applied Sciences and Arts, Switzerland, and involved in the interdisciplinary research project e-broidery 1[26]. This had as its goal the integration of intelligent and electronic components in textile. The outcome of the project was a collection of curtains furnished with LED's, connected through embroidery and launched on the market[27].
Many researchers and designers are interested in the combination of light and textile, some of them looking for decorative and show effects (Cutecircuit, Moritz Waldemeyer, Fashion Designer Hussein Chalayan among others), others interested in a functional approach,

[26] This project was nominated in 2012/2013 for the Swiss Design Award.
[27] https://www.creationbaumann.com/de/eLumino-eine-Symbiose-von-Stoff-Licht-3674.html

integrating light into fabrics or creating wearable light, for example for security (Dashing Tweeds[28], Prof. Tilak Dias, Nottingham Trent University, UK).
Light can be attached to fabrics (LED) or light effects (reflective yarn as lurex or fibre optics) can be integrated into fabrics using textile techniques (for example weaving). Fabrics can reflect and filter light; 'surfaces of textiles that play with light are ever-changing' (Hemmings 2012b, p.28). 'Textiles that capture and reflect light range from the low-tech to the high-tech and often present shifting qualities as our physical location changes the way that we observe them' (Ibid.).
The intention of German artist Christine Keller (2012, p.36) was to weave something invisible, which can be revealed through light reflection. Hemmings (2012, pp.36-37) in her book 'Warp & Weft' presents Keller's woven series *Light Content: Points of View* (2004), which invites the viewer to be part of the artwork by manually directing a light and thereby discovering the hidden image in the work. The technical realisation of the weave to achieve the hidden image was an enormous challenge, even though the effect seems simple. I share an affinity to the hidden (Ch 9.1.2.1) with Keller and can well imagine the effort needed to solve the technical challenges of this concealment: her work uses the process of weaving to enable directed reflection, mine uses the process of dyeing in order to achieve colour changes.
'The viewing experience, alluded to in the subtitle – *Points of View* – is entirely individual' (Hemmings 2012, p.36). Keller draws a parallel between the perception of her artwork and perception in daily life, stating: 'This is happening in real life all the time. We think we talk about the same thing, at the same time, but everyone has their own perception' (Keller 2012, p. 36).

4.2.3 Metamerism in Art

I was interested to find out who else is working in the field of art with the colour phenomenon metamerism but in all the years I was engaged in this topic I met no one in person with the same interest. Through online research I found Dr. Regina Valuzzi (n.d.), who did seem to work in a similar field. Valuzzi, an artist with a background in science, states on her webpage that she is playing in her artworks with metameric colours. I contacted her via Email (2016) and asked her for clarifications regarding her 'metameric' work. It turned out that her understanding of metameric colours differs from my understanding and the general accepted definition (Hunt and Pointer 2011, p.117).

[28] In Hemmings 2012 b, p.31.

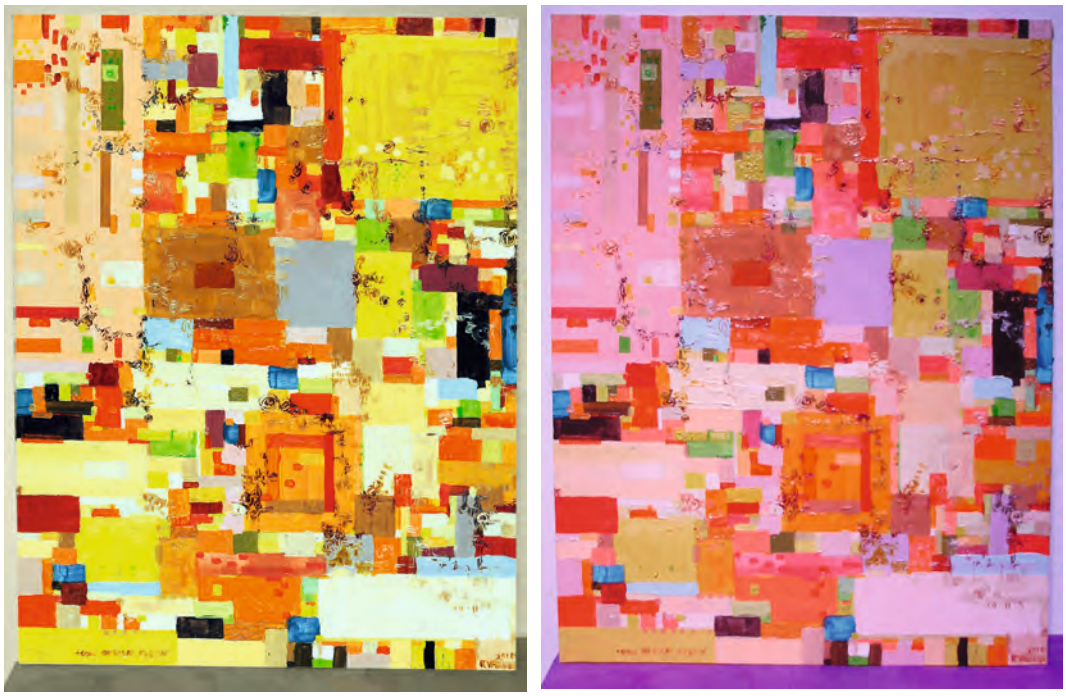


Figure 29 solar fusion, Artwork by Valluzzi

Figure 29 shows the artwork *solar fusion* by Valluzzi. It is the same artwork, on the left side in natural light and on the right side illuminated with an LED. In the right photograph it is clearly visible that the wall around the artwork has a violet tinge. The all-over colour change under different lights is clearly perceptible. But as Valluzzi's artworks are very colourful I cannot detect on her artwork any colour pair, a limited equal match, which would be the definition of metamerism (Ch 3.1). I do not deny that Valluzzi is playing with metamerism, or there could be metameric colours present in her artwork, but I find it impossible to locate them.
I reduced my own colour palette to one olive colour, and dyed three metameric colour recipes. I intentionally reduced the complexity in order to highlight the subtle effect of the colour changes so that it cannot be overlooked (Ch 8 - 9).

4.2.4 Light and my artworks

Light, being one of the principal performers of this research, is not incorporated in the fabric. Light is the vis-à-vis, creating interplay by shining on installations or the dress during performances. The only particular characteristic of the knitted artworks is the inherent varying colour scheme of the yarns, which reflect light in different ways. There is no particular technology or engineering trick involved in the colour change. The light sources deployed in this project, exclusively neutral 'white' light, trigger installations and the dress of the performer, provoking significant colour changes and challenging the human perception of an audience. My artworks are composed by light and the 'elusive character and fleeting quality' 'is particularly intriguing' (Jakob 2008, p.255).

4.3 Conclusion

Light Art is difficult to represent in another medium; artworks with light have to be seen live, have to be experienced with all senses involved – in an appropriate room where the poetic can unfold and flower out. It is difficult to capture the impact of Light Art in a photograph in a way that might live up to the original. Most of the content is lost. Light Art needs space to show all the dimensions of perception and allow interplay between the viewer and the work as Lauson states:

> If much of the sculptural and installation art of the 1960s depended upon the presence of the spectator in order to complete the work, this shifted the meaning of the artwork away from the object and toward the order of experience (2013, p.22).

For Böhme (1994) all Light Artists are tutors and their works are exercises in perception, as they offer the possibility to sense, observe and to feel the impact of light, to understand something of the context of light, space and perception, which is often overlooked or unobtrusive in daily life. I see my work as a contribution to this end.

Almost exclusively technological practices and processes shaped the first phase of the research, the production of metameric material. For the development of the metameric material the circumstances were specialized (Ch 5 - 6) but installations and performances used ordinary circumstances (Ch 4.1.3).
I give in this chapter an overview of light history and innovations in the field of light, which are still ongoing. On one hand, a scientific and numerical language, as described in this chapter, can physically define light and colour. On the other hand, colour and light are phenomena, which are difficult to grasp. I am interested in identifying the relativity of colour perception[29] by offering a visual experience using 'light for its potential' 'to create wonder and a sense of awe' (Lauson 2013, p.30). In subsequent chapters I pursue and detail these adumbrated topics in greater depth. It is an aim of this research to create a visual and aesthetic experience and to make the impact of light 'experienceable' through artworks (Ch 8 - 9).

[29] As Gage (2006, p.7) asserts, as well Albers had the same concerns: 'Albers's book [Interaction of color] is largely concerned with demonstrating the relativity of colour perceptions…'.

5 The creation of metameric material and knit

Outline

This chapter introduces the medium knit and the inherent technical craft practice aspects.
I describe and analyse the various processes in the dye and knit lab regarding the creation of metameric material. The realisation of metameric yarn was a crucial first step of the research journey, as the metameric material was the basis for the creation of artworks (Ch 7 - 9). The process included many errors, which occurred through experimentation with and testing of specific metameric colours. This caused the final goal of this research: 'to create a metameric colour series of dyed yarn' to be difficult and time-consuming to achieve. The distinct approach developed and adopted in this project regarding dyeing, which differs fundamentally from the commercial approach, will be identified.
The exploration in the dye lab, which was necessarily technical, covered the time span from 2010 until 2013. The process included the sourcing of material, the gathering of information, the building up of knowledge and skills and, unexpectedly, much iteration.

5.1 Knit as craft practice and knit techniques

All the knitted textiles involved in this project are machine knitted; some knitted on hand-operated machines and some on electronically operated machines. I am an experienced knitwear designer with good technical understanding (Ch 1.2) but as Taylor and Townsend (2014) describe, I am a typical industrial knit designer who never learned 'to work directly with the latest flatbed knitting technology' and am thus reliant on an experienced knit technician to program the knitting on electronically operated machines. Simon Johnson, knit technician at Nottingham Trent University, supported me in the development and achievement of my ideas on electronically operated Stoll[30] knit machines.
During the research journey knit has been deployed as both a craft and an art practice (Ch 1.4.4). The development and knitting of appropriate fabrics for the exploration of the dye recipes was explored and applied through craft practice supported by technology and software. However, the creation of artworks (clothing/ garments for performances, narrative artworks depicting images and three-dimensional structures) demanded both a craft and an artistic approach. The creation of concepts, the development and realisation of knitted artworks, will be described and discussed in the following chapters (Ch 7 - 9).
As described in Chapter 2.1.1, utilitarian thinking is one of the aspects that drives craft i.e. having a purpose or an intention. The knitted material prepared for the dye exploration followed a clear set of functional parameters. Craft can be considered in a rather limited sense as

[30] Stoll, a German company, is one of the leading manufacturers of flat knitting machines.

relating to objects or work made by hand (‘Handwerk’, the German translation of the word craft, incorporates ‘hand’ and ‘work’) and as a consequence, is often perceived as a hand making activity involving particular skills and knowledge. However, in this research, craft was used in a broader sense and involved technology and its related techniques. As Sennett (2008, p.9) expressed: ‘Craftsmanship names an enduring, basic human impulse, the desire to do a job well for its own sake. Craftsmanship cuts a far wider swath than skilled manual labor; it serves the computer programmer, the doctor, and the artist’. The development of the artworks in this research, as depicted in Chapters 7 - 9, required my experiential craft skills and knowledge, which I gained in my former career as a knitwear designer and developer, alongside artistic modes of investigation.

5.1.1 Material decision: yarn

Knowing that the phenomenon of metamerism occurs on a wide variety of substrates, the material decision-making took into consideration my experience and the requirements of the research project, which involved the dyeing and knitting of jacquard fabrics as well as three-dimensional structures. In general, a valuable characteristic of wool is elasticity, which offers a variety of options for the development of different structures. I selected a yarn quality with properties (consistent dye absorption and knitting) I knew well from my former work experience in industry. All the practical knitting was performed using the classic basic yarn, Cashwool, 2/30Nm, a 100% Extrafine Merinowool from Zegna Baruffa, Italy[31]. The chosen yarn count, 2/30Nm, facilitates the engineering of various thicknesses by combining multiple plies of yarn.

5.1.2 Involved knit techniques

In the following sections I introduce the knit techniques, which were applied in this research project. The knit was executed on double bed knit machines. On Figure 30, the two rows of dots visualise the needles (front and back bed of needles) and the two red circles show two stitches, one on the front bed, one on the back bed. One knitted course is also called a knitted row. The length of the fabric is defined by the quantity of knitted rows. The width of the fabric is defined by the quantity of used needles, forming stitches (also called wales).

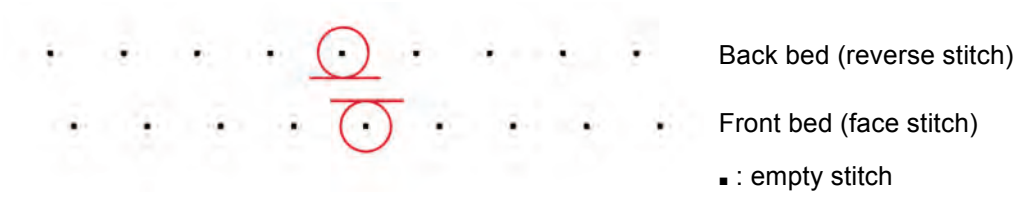


Figure 30 Visualisation of two stitches

[31] Hugo Boss Ticino Sa, director of knit unit Claus Mühlfeit, sponsored the yarn.

5.1.2.1 Plain knit

The most basic knit structure is ‘plain knit’ (also known as single bed, single jersey) (Figure 31 - Figure 32).

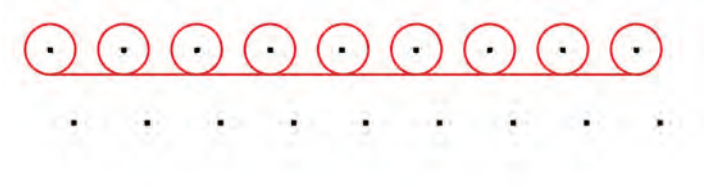


Figure 31 Visualisation of plain knit

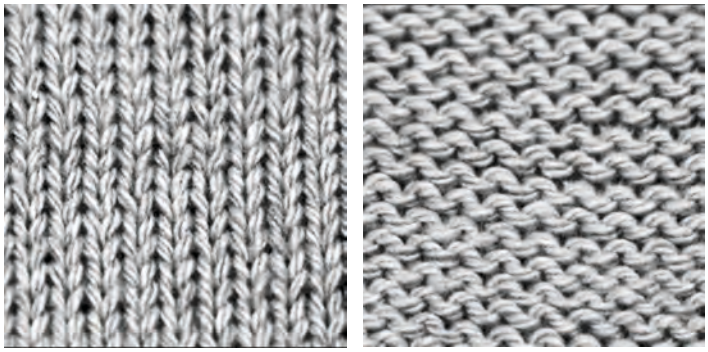


Figure 32 Plain knitted fabric: left: plain knit, right reverse knit

5.1.2.2 Tubular knitting (Knitting in a round, circle knitting)

This knit technique creates two-layer fabrics, which are circle knitted. The final fabrics for the dye exploration (Ch 5.1.3) were knitted so as to be tubular.

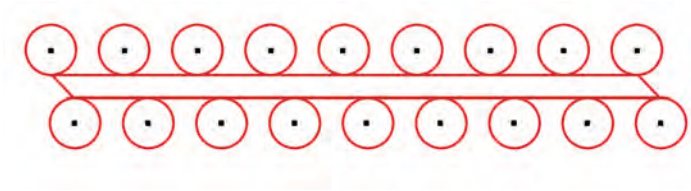


Figure 33 Visualisation of tubular

Figure 34 Tubular knitted fabric

5.1.2.3 Purl pattern

A purl fabric ‘contains both back and face loops in any one wale’ (Brackenbury 1992, p.183). The knitting of rib structures, purl pattern, requires two needle beds (Figure 30). Figure 35 shows the visualisation of a 1 x 1 rib, one stitch knitted on the front bed and the next stitch on the back bed.

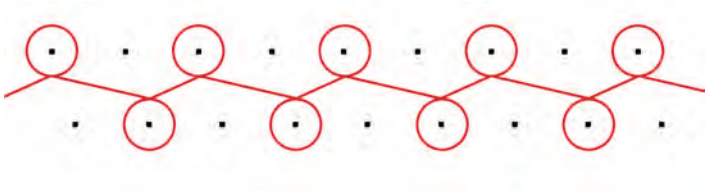


Figure 35 Visualisation of a 1 x 1 rib

Figure 36 Purl pattern, a 1 x 1 rib

5.1.2.4 Purl pattern plated

> Plating is a method of knitting two yarns at once so that one can be seen on the face of the stitch and the other on the reverse. The two yarns are knitted at the same time, but held in a staggered position during the knitting process (Ray, 2012: 58-59). This is a technique that can be used to create a pattern using a contrasting yarn. For example, a plated rib in two colours of yarn will appear as a vertical stripe when stretched with one colour showing on the face stitches and another on the reverse (Glazzard 2014).

This technique allows a colour change of the surface, provoked by the rib.
Figure 37 shows a visualisation of a plated purl pattern.

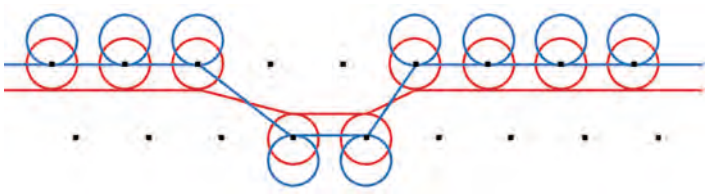


Figure 37 Visualisation of purl pattern plating

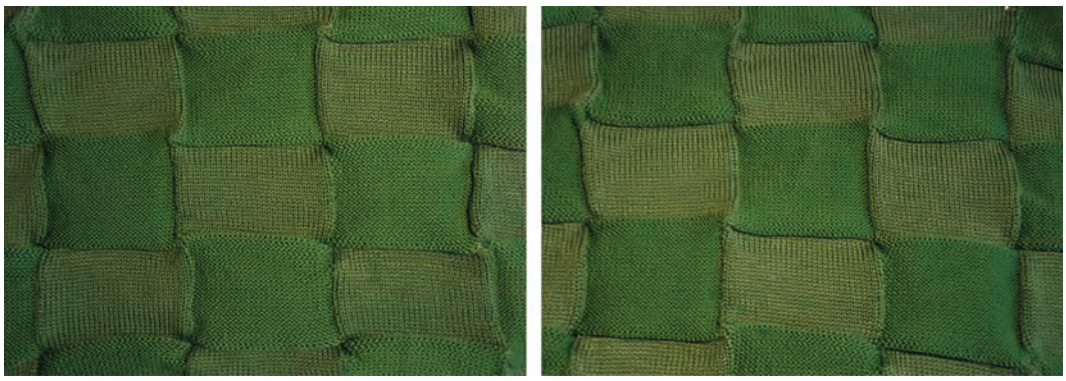


Figure 38 Plated purl pattern, left: front side, right: reverse side

5.1.2.5 Jacquard knit

The term jacquard, already introduced in Chapter 2.2 as metaphor for this thesis, embraces a double bed knit technique, which allows the creation of a double-faced fabric (Figure 40). Different coloured yarn plies can be combined in order to create knitted images. There are different options for the knitting of the backside; Figure 41 shows a variation.

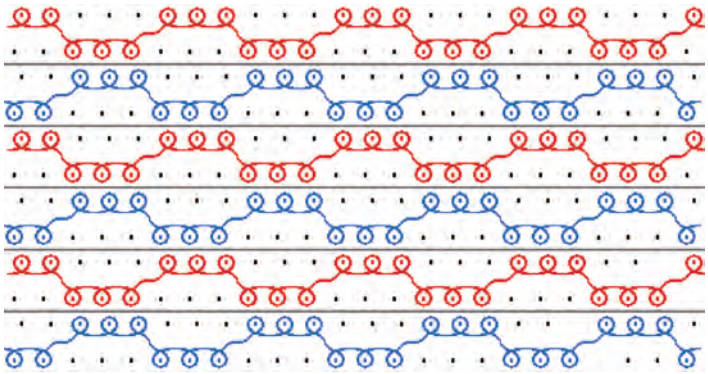


Figure 39 Visualisation of a double Jacquard

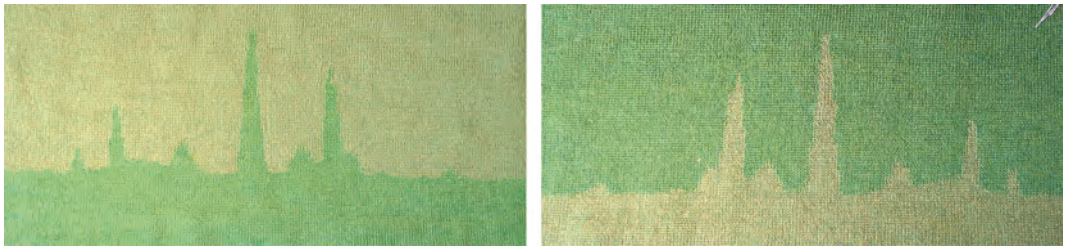


Figure 40 Double Jacquard fabric: left front and right backside

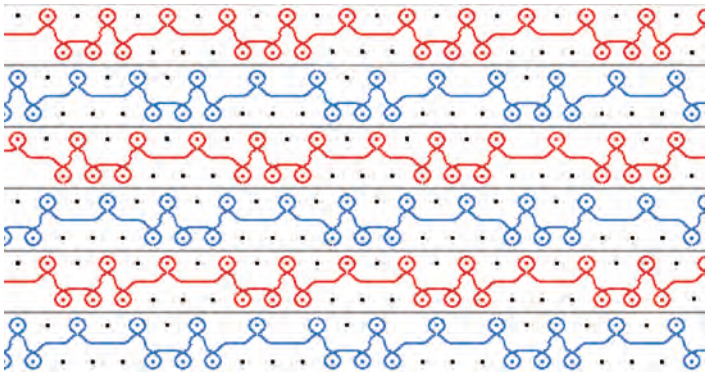


Figure 41 Visualisation of a Jacquard with twill reverse side

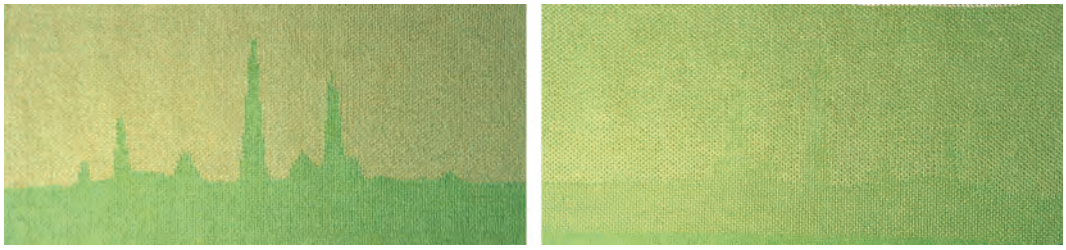


Figure 42 Jacquard fabric: left front side, right twill reverse side

Preparation of images for the translating to the knit software

In order to translate an image into a knitted jacquard fabric, the images have to be prepared beforehand, for example in Adobe Photoshop.

Each colour present on an image correlates with a yarn colour. Working with a metameric colour series of three colours, images needed to be reduced to three colours. The first step is therefore to transform the image in grey scale. The brightness and contrast of the grey scale image needs to be adjusted. This step, executed before the colour reduction to three colours (black, grey, white, Figure 43), already reduces contrasts and increases the readability of the final three-colour image.

Figure 43 Image reduced to three colours

The yarn colours of the metameric colour series have to be allocated to the three colours, black, grey and white. One pixel of the image correlates to one stitch (1 row/1 wale) but as the width and height of one stitch differ, the image has to be stretched and the measurements adapted (Figure 44).

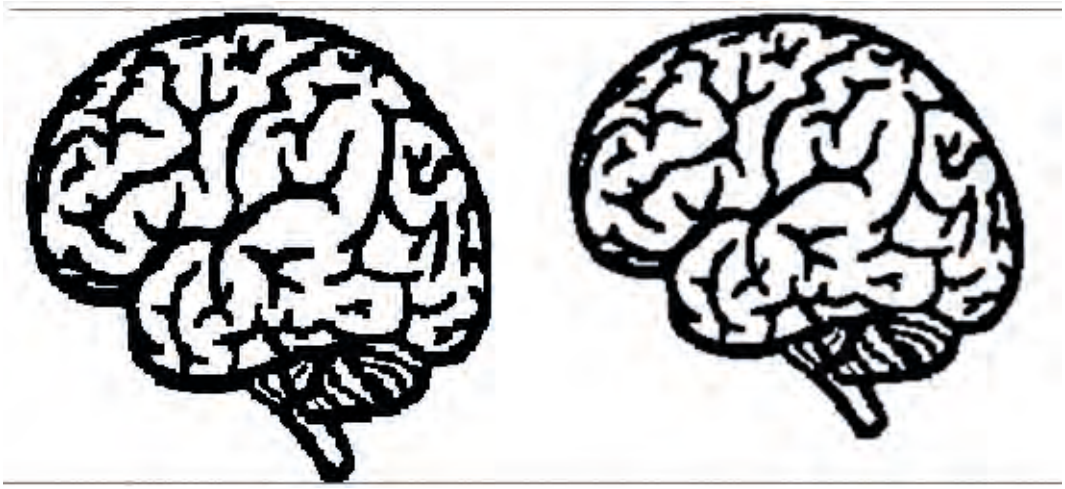


Figure 44 Left side stretched image, right side initial image

The prepared and finalised data of the image was transferred to the Stoll knit machine as a BMP or Tiff file and the jacquard produced.

5.1.3 Preparation of knitted material for dyeing explorations

To gain effective qualitative and systematic dyeing results I developed different knitted fabrics. To reach accurate colour measurements with the spectrophotometer (Ch 3.2.2.1) the fabric needs to have a smooth surface, which requires a rather tight knit tension. In September 2011, the first dyeing trials were realised with plain knitted fabrics, cut by hand into rectangular pieces of four grams[32] in weight. These trials were unsuccessful, as the fabric edges were rolling and therefore the dyeing of the fabric was uneven and so results were inconsistent. To avoid the rolling and to achieve an even, opaque colour density on the surface the fabrics were finally knitted in tubular forms (Figure 33).

[32] The adjustment of the various dye recipes has been done in a beaker dyeing machine and the fixed fabric weight of 4g was adequate for the small lot tubes.

Figure 45 Left side: fabric with rolling edges, right side stable tubular knitted fabric

From 2012 on these tubular fabrics were used, as described in the following sections, to dye selected colour recipes and to observe and adjust the outcome of the dyeing.

5.2 Dyeing

As described in Chapter 2.3.1 I kept records of the whole journey in research journals and documented the process with photographs. I recorded the procedure in the dye laboratory and reflected upon the outcome before taking new actions (Ch 1.4.5). The recorded phases in the dye lab contain quantitative information, using a more technological, scientific approach, supported by qualitative information regarding personal responses, including emotions, related to success or failure. The following sections are based on these dyeing experiments and corresponding journal entries (Figure 46).

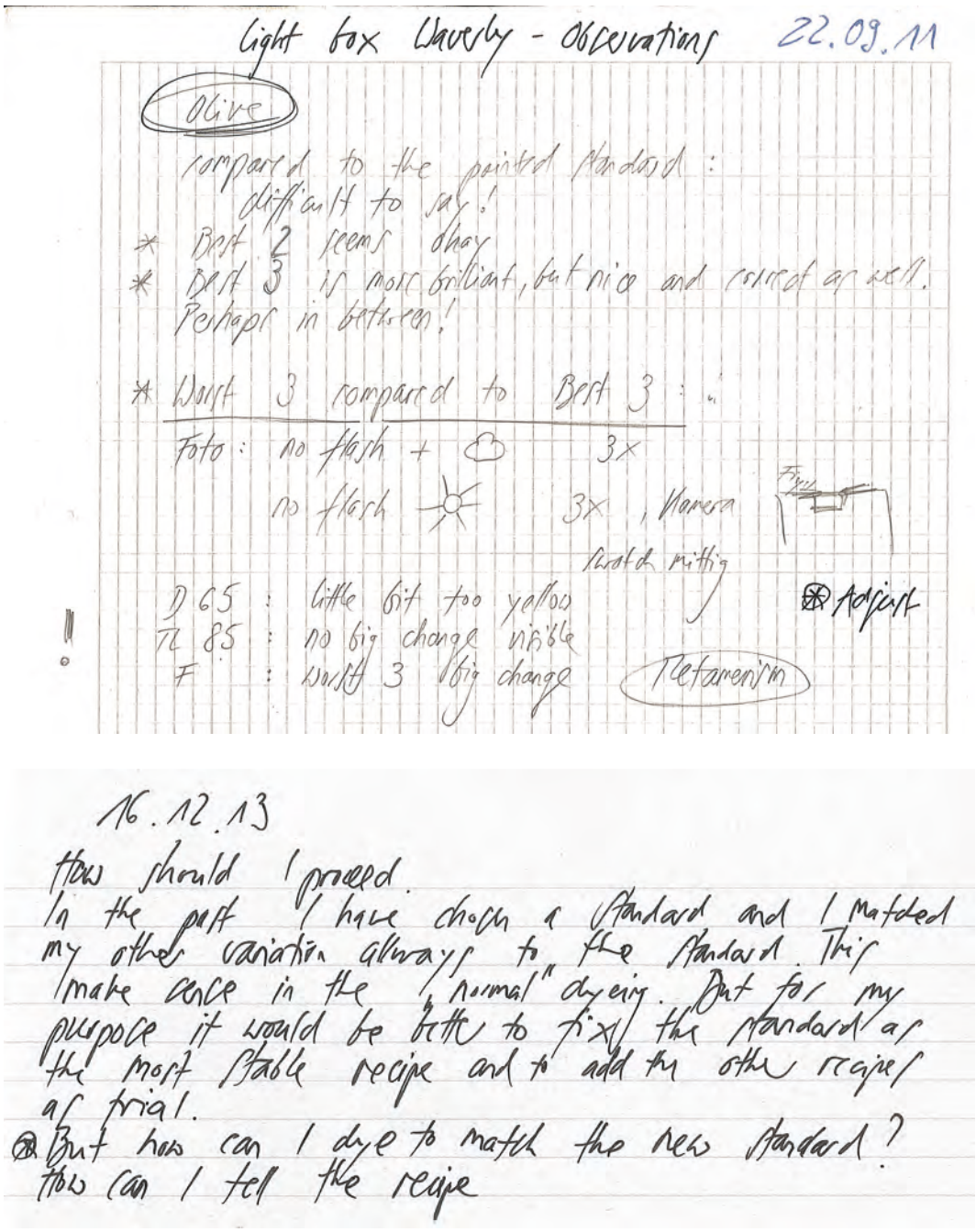


Figure 46 Research journal entry: September 22nd 2011 and December 16th 2013

When I started writing up the thesis, about two years after the process in the dye lab, I realised that the documentation, including my thinking process, was rather fuzzy as there were so many open-ended observations and unknown factors that I was not able to describe precisely, being in the middle of the process. Rheinberger (2005, p.79) confirms this problematic of the documentation of an exploration by stating that 'the terms of description therefore have a certain haziness'. He even attaches importance to this: 'to see haziness not as negative, instead to conceive of it positivity as heuristically appropriate modes of thinking'.

While undertaking the experiments, I researched appropriate technical literature on dyeing (Wilkinson and Hurst 2013, Bird 1972, Cotton Incorporated 2007, Choudhury 2006 and 2015, Xin 2006, Ingamells 1993, Lewis 1992, McDonald 1997, McLaren 1986, Rys 1972) and

improved my knowledge in order constructively to discuss my ideas and research with people in the industry: Andreas Roth from natific (2012), Michael Pieper from Datacolor (2011), Dr. Frank Reidl from Clariant (2011, 2012) and Marcel Halbeisen from EMPA (2011). I acquired information and hints on how to reach my set goal of dyeing a series of metameric yarns. I particularly benefited from the specialist expertise of David Hurst, dye technician at Nottingham Trent University, as we collaborated closely during the whole process in the dye lab.

5.2.1 Dyeing exploration

When I started my research in October 2010, Nottingham Trent University (NTU) was not yet equipped with a yarn dyeing facility. Fortunately, in summer 2011, Nottingham Trent University set up a dye laboratory, hired a dye technician, David Hurst, and acquired a spectrophotometer for the measurement of colours as well as two software packages (Tools and Match) from Datacolor for the calculation of dye recipes and the checking of outcomes.

To date metamerism is perceived as a significant problem in different industries where the matching of colours is important. The focus of companies working in the area of colour management (e.g. Xrite, Datacolor, natific) is on how to avoid this unwanted, disturbing phenomenon (Ch 3.1.1). As a result, 'computer colourant formulations predict low metameric recipes' (Choudhury 2015, p.175), recipes for colours that are nearly stable in all light sources. Thus, the software is not programmed to offer recipe options for a distinct metameric colour pair or a metameric colour series (Ch 3.2.2.3).

Just as NTU bought the software, Datacolor offered some complementary basic training for the use of the system so I was able to undertake some additional training related to my project. Through a lot of independent self-study throughout 2011 I achieved the required level of skill and understanding needed for the calculation and adjusting of dye recipes and yarn colours and towards the end of 2011 was ready to undertake the dye experiments.

At the beginning of the dyeing exploration I assumed I would achieve the set goal of realising dyed metameric yarns mainly through quantitative methods, such as calculating and measuring, and expected digital technology/software would 'serve [my] needs' and 'their judicious use will free up [my] time to engage in focal practices' (Bunnell 2004, p.6).

A main goal of the research was to find recipes for a metameric colour pair or a metameric colour series **(**Ch 3.2.2.3)**,** but this first step, considered research for the arts (Ch 1.3.3), was 'only' needed for the realisation of metameric artworks, the 'focal practice' of this project.

But, as discussed in the following sections, the various steps of the journey in the dye laboratory from the recipe search to the production of a series of metameric dyed yarns, was exhausting and time consuming. The intention to subvert the usual approach to commercial dyeing raised several technical issues, which could not be solved as straightforwardly as expected. This is because the software, which calculates colour recipes, is not programmed to perform the steps required to reach the set goal of this research. Therefore, the exploration was done experimentally and the search was undertaken by trial and error; problems were encountered again and again and creative solutions found. The dye practice required me to develop a technical/scientific approach using quantitative and measurable data with the ability to apply

visual subjective judgement of colour shades (Ch 3.4). Different experts from the colour industry (Andreas Roth from natific (2012), Daniel Aitken from Datacolor (2013), Dr. Frank Reidl from Clariant (2011, 2012)) confirmed this to be the only way to achieve a metameric colour series.

5.2.2 Selection of dyestuff

During our conversation Dr. Reidl (2012) confirmed that the phenomenon of colour metamerism can be created with dyestuffs from different suppliers and the effect does not depend on special dyes or chemicals. As wool is generally dyed with Acid dyes (Pailthorpe 1992, p.68), I used the nine Acid Milling dye colours from Dixon Chew[33], which were available in the NTU dye laboratory (Figure 47: highlighted with a cross).

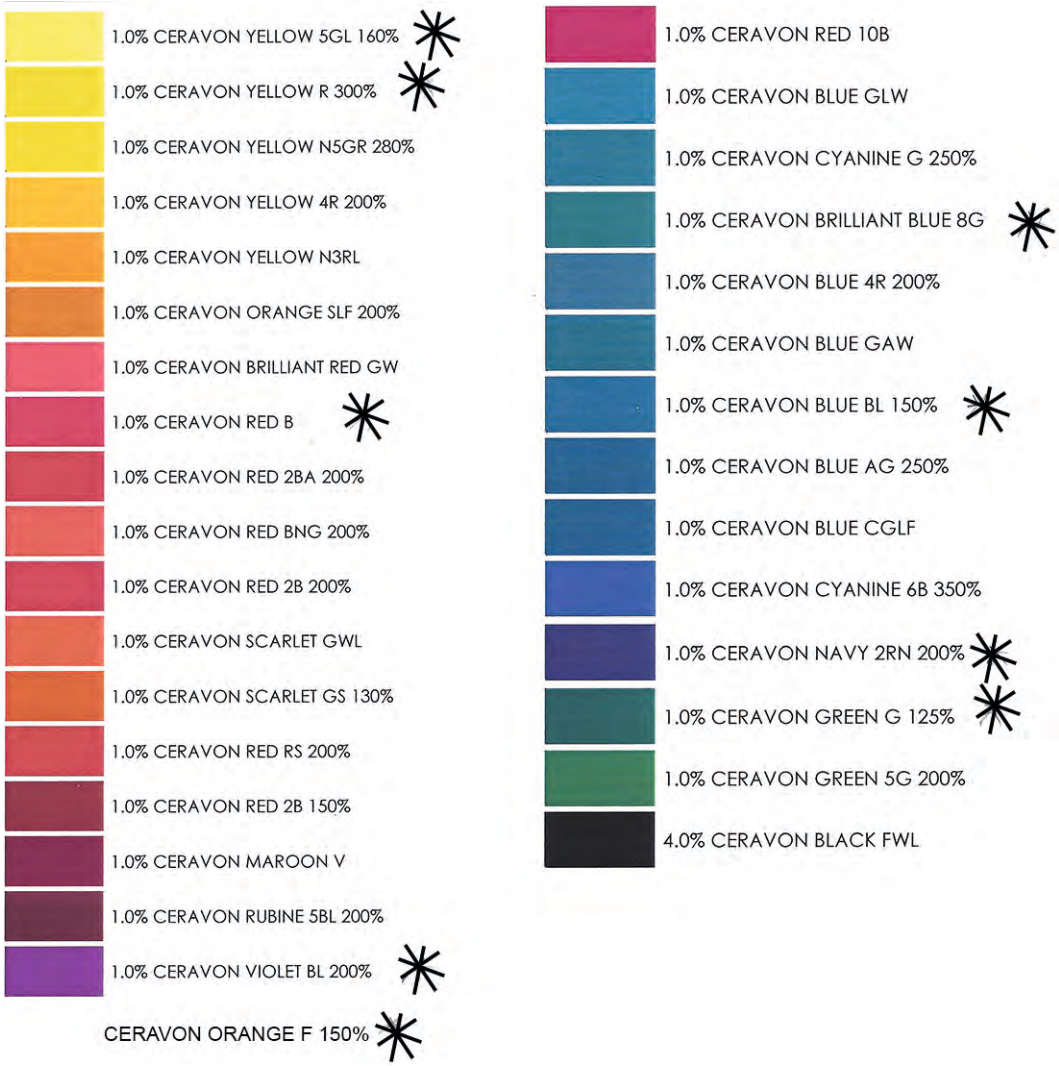


Figure 47 Colour card of Acid (milling) dyes from Dixon Chew

[33] Dixon Chew is a British company specialized in the manufacturing of a diverse range of colours. Their products are used in the textile industry as well as in markets such as automotives and paper.

5.2.3 Commercial dyeing process

The normal process in a textile dye laboratory is that the dye technician gets one ‘colour sample’, which he measures with the spectrophotometer and the data of this colour is then saved in the software as the ‘colour standard’. The software calculates recipes and dye technicians, considering dye knowledge and specific selection criteria, choose a recipe. Some colour components or combinations are more inclined to produce ‘skittery’[34], uneven dyeing, or poor colourfastness and therefore are discarded (Ch 6.3.4.1).

5.2.3.1 Lab correction

Using the chosen recipe, technicians usually dye a yarn sample (known as a substrate) in a beaker dyeing machine for small lot dyeing, measuring the dyed outcome with the spectrophotometer. The software then compares the dyed colour sample to the standard and approves or declines the outcome. If a colour is declined, the software proposes, based on the first recipe, a modification or ‘lab correction’. This new recipe is dyed and the procedure is repeated (modification 1, 2, 3 etc.) until the colour of the dyed fabric matches the standard and is confirmed by the client. The approved recipe modification, for example recipe 1208 modification xy, will then be used for dyeing the production yarn and all production batches.

5.2.3.2 Production correction

As soon as a colour (i.e. recipe 1208 modification xy) is approved the dyeing of yarn in the package machine is started, whereby the yarn is wound onto perforated cones for dye penetration (Figure 48).

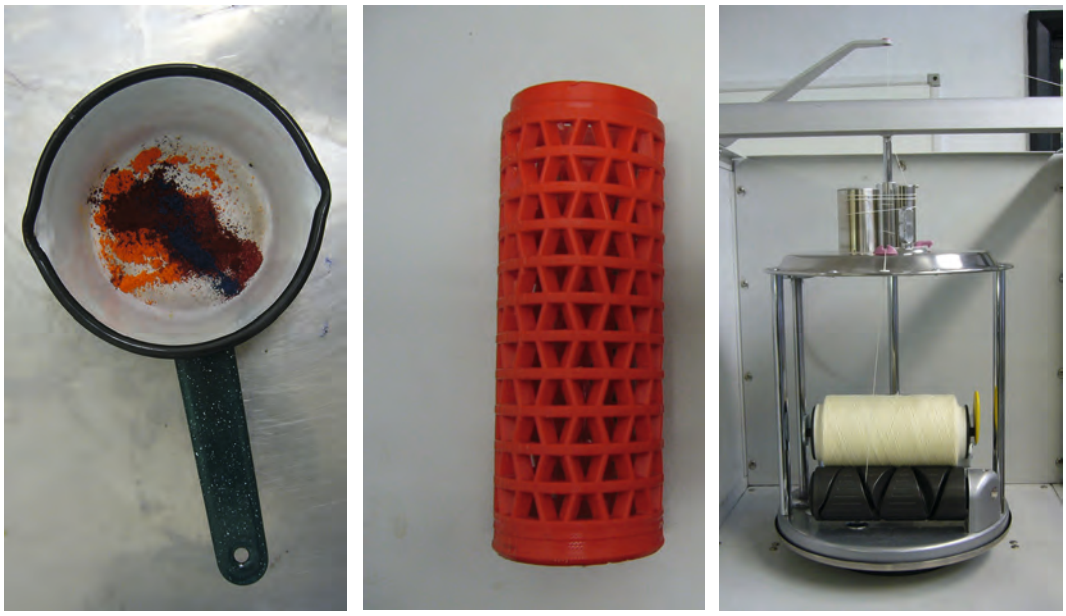


Figure 48 Left: dye solution preparation, middle: cone for dyeing, right: winding of yarn cones for packaging dyeing

[34] In the technical terminology ‘skittery’ means that the dyed outcome is all-over dappled. The reason for this is an uneven absorption of the different dye components.

Dyestuff and chemicals, as proposed by the recipe, are prepared (Figure 48) but the quantity of dyestuff is reduced to around 10% to achieve a tolerance in lieu of future adjustments.
After the first dye run a yarn sample from the dyed cone is taken and measured with the spectrophotometer. The software compares the sample to the standard. If the software does not approve the dyed colour of a production batch the production correction function proposes an adjustment. Following the proposed adjustment additional dyestuff can be added. If colour is missing or the dyed colour shade is already too strong, some dye can be *stripped off* with chemicals. These additions are added to the dye bath in the kier of the package-dyeing machine and in a second dye run the yarn gets re-dyed. This procedure is repeated until the software confirms the matching of the dyed colour compared to the 'colour standard' (Figure 49).

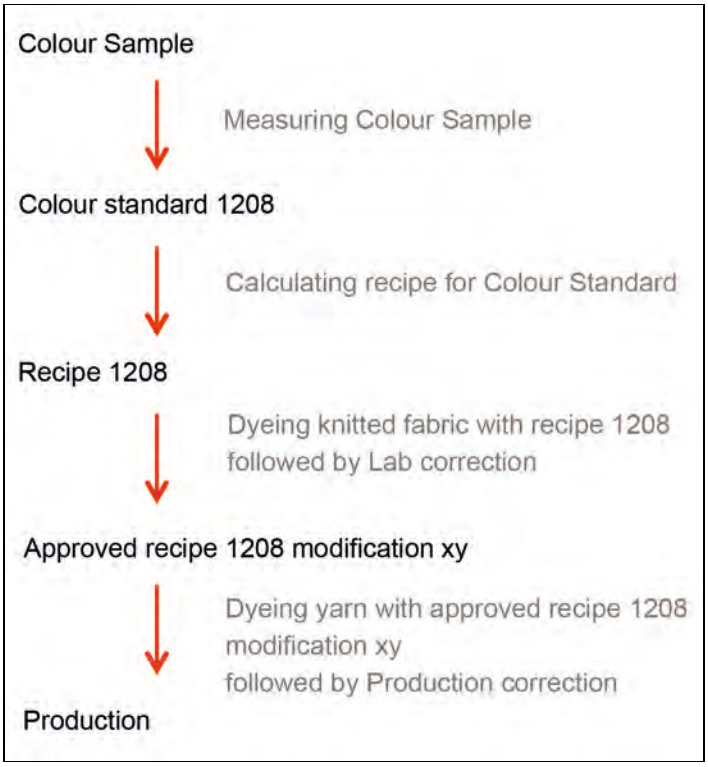


Figure 49 Visualisation of commercial dye process

In commercial dyeing production, all further batches would be dyed with the approved recipe 1208 modification xy. The production batches are measured with the spectrophotometer and the data of these colours are saved in the system. The software compares all the dyed batches to the ‘colour standard’ and each other and calculates their colour deviation (Ch 3.5.2 - 3.5.3), approving or declining the resulting colour shades of the batches by considering the set tolerance of deviation. Essentially all the production batches have to match the standard and each other within the set deviation tolerance (Figure 50).

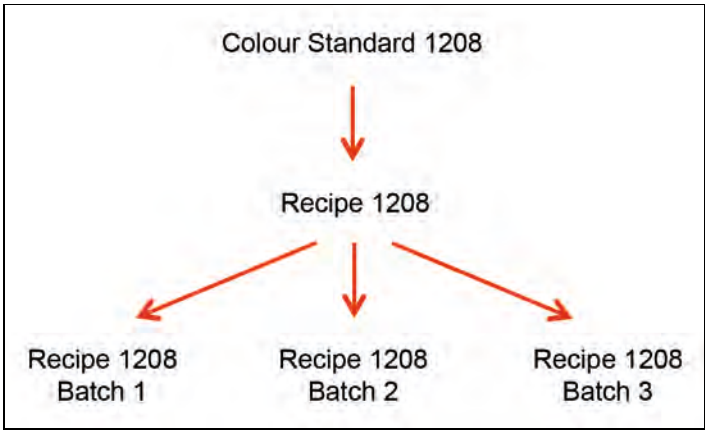


Figure 50 Visualisation of commercial production batch dyeing

5.3 The recipe search for a metameric colour series

The following section explains the procedure in the dye lab with regard to the first successful metameric colour series, which started in December 2013 with an olive green ‘colour standard’ (Figure 51) and led to a dyed series of three metameric colour shades of yarn in April 2014. This was the first moment of the exploration where I achieved clarity from my experimental approach, which informed the further research. Rheinberger acknowledges such actions by ascertaining that ‘clarity in the range of the empiric is ineluctable retrospectively’ (2005, p.77). The lean and rather chaotic period before this pivotal point in the research, including lots of trials, errors and repetition, will be discussed later in this chapter as well as in Chapter 6.

5.3.1 Setting a Colour Standard

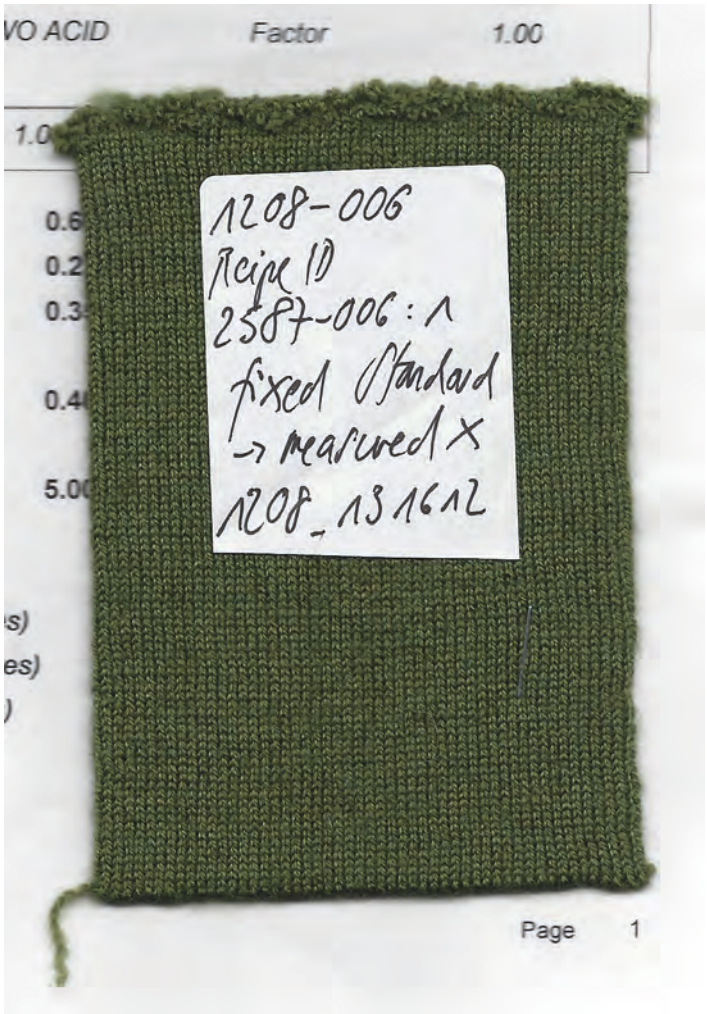


Figure 51 Colour standard for the metameric colour series 1208

Dr. Reidl (2012) confirmed that metamerism could be achieved with achromatic mixed colours such as beige, brown, olive and different shades of grey. These colours would show the phenomenon well and the colour changes could be perceived visually. I therefore started to

explore recipes in this colour range and, after several trials (Ch 6.1.1), I proceeded in December 2013 with an olive green colour (Figure 51), measured with the spectrophotometer and inserted into the software as the standard (1208_131216). The software calculated various recipes (Figure 53 – Figure 55), which should all lead to colours dyed to match the colour standard.

5.3.2 Setting of parameters in the software program

Figure 52 shows the top part of the recipe chart proposed by the software for colour 1208_131216 with the inserted and fixed parameters on which the colour calculations were based.

Standard		1208_131216				
Quality/Style 100.00 [%]		100% Wool Fabric				
Substrate (factor)		100%WoolExtrafine_Cashwool_2_28 (1.00)				
Process (factor)		ACID DYES SALOME (1.00)				
Formula		CieLab Default[D65]				

Quality / Style

100% Wool fabric, the quality / material used.

Substrate

The raw knitted wool fabric was measured with the spectrophotometer and inserted in the software as substrate (100%WoolExtrafine_Cashwool_2_28

Process

The nine available dye colours were inserted in the software system and saved as the standard dye set (ACID DYES SALOME) for all the further recipe calculations.

Formula

CieLab Default [D65]

All the measured colours were placed in the CieLab colour space and compared in the D65 illuminant.

Figure 52 Recipe chart: software parameters

The next three pages, Figure 53 – Figure 55, show the whole chart with all the proposed recipes for colour standard (1208_131216). Further exploratory steps will be explained on the basis of this chart.

Standard		1208_131216														
Quality/Style 100.00 [%]		100% Wool Fabric														
Substrate (factor)		100%WoolExtrafine_Cashwool_2_28 (1.00)														
Process (factor)		ACID DYES SALOME (1.00)														
Formula		CieLab Default[D65]														
dE* D65	1	0.01	0.00	0.01	0.01	0.02	0.02	0.02	0.03	0.03	0.03	0.00	0.00	0.01	0.00	0.09
dL*	0	0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	-0.00	0.00	-0.00	-0.00	0.00	-0.00	0.02
da*	0	0.00	-0.00	-0.01	-0.01	-0.02	-0.02	-0.02	-0.03	-0.03	-0.03	-0.00	-0.00	0.00	0.00	0.08
db*	0	0.01	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	-0.00	0.00	0.00	0.01	0.00	-0.04
Metamerism A	0.7	0.05	0.05	0.15	0.25	0.35	0.36	0.40	0.42	0.46	0.52	0.85	0.99	1.08	1.53	1.93
Metamerism F11	0	0.06	1.67	1.45	2.21	2.85	3.27	3.14	3.33	4.52	3.85	4.12	4.21	0.57	1.09	2.20
Total concentration [%]		1.340	2.441	1.416	1.442	1.317	1.442	1.143	1.427	1.422	1.436	2.245	1.445	2.619	1.496	1.380
Smartmatch infos		L/1														
Trial 1																
Trial 2																
Trial 3																
Trial 4																
Trial 5																
Dyestuff		**1(3)**	**2(4)**	**3(4)**	**4(4)**	**5(4)**	**6(4)**	**7(4)**	**8(4)**	**9(4)**	**10(4)**	**11(3)**	**12(3)**	**13(3)**	**14(3)**	**15(4)**
Ceravon Milling Brilliant Yellow 5GL			1.887									1.444		2.110		
Ceravon Milling Yellow R 300%		0.709		0.903	0.752	0.735	0.732	0.789	0.746	0.805	0.800		0.672		0.895	0.863
Ceravon Milling Orange G 150%			0.087	0.041	0.133	0.148	0.180	0.116	0.193	0.186	0.207	0.258	0.230			0.112
Ceravon Milling Brilliant Red B		0.276	0.169	0.178	0.050									0.234	0.144	
Ceravon Milling Violet BL 200%							0.067			0.218						
Ceravon Milling Blue BL 150%									0.168		0.361					0.366
Ceravon Milling Navy 2RN 200%						0.051		0.114								0.038
Ceravon Brilliant Blue 8G		0.354	0.297	0.292				0.124		0.211	0.066			0.275		
Ceravon Milling Green G 125%					0.504	0.383	0.461		0.319			0.542	0.542		0.456	
Recipe with D65																
Standard with D65																

Figure 53 Recipe chart 1: colour standard 1208_131216

Standard																						
Quality/Style 100.00 [%]																						
Substrate (factor)																						
Process (factor)																						
Formula																						
dE* D65	1	0.01	0.01	0.00	0.01	0.00	0.00	0.00	0.01	0.00	0.83	0.01	0.00	0.00	0.00	0.00						
dL*	0	-0.00	0.01	-0.00	-0.00	0.00	-0.00	-0.00	-0.00	-0.00	0.05	0.00	-0.00	0.00	0.00	-0.00						
da*	0	0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	0.00	0.83	0.00	0.00	-0.00	0.00	0.00						
db*	0	0.01	-0.00	0.00	0.00	-0.00	-0.00	-0.00	0.00	0.00	-0.06	-0.00	0.00	0.00	-0.00	-0.00						
Metamerism A	0.7	2.06	2.08	2.19	2.23	2.30	2.44	2.66	2.74	2.92	2.38	3.61	3.64	3.75	3.86	4.17						
Metamerism F11	0	1.95	3.05	0.21	2.94	0.15	0.12	0.20	0.27	0.67	0.30	0.83	0.73	8.81	8.90	1.70						
Total concentration [%]		2.606	1.497	1.096	2.515	1.104	1.118	1.695	2.167	2.199	1.085	1.557	2.335	2.156	1.442	2.828						
Smartmatch infos																						
Trial 1																						
Trial 2																						
Trial 3															X							
Trial 4													X									
Trial 5														X								
Dyestuff	**16(3)**	**17(3)**	**18(3)**	**19(3)**	**20(3)**	**21(3)**	**22(3)**	**23(3)**	**24(3)**	**25(2)**	**26(3)**	**27(3)**	**28(3)**	**29(3)**	**30(3)**							
Ceravon Milling Brilliant Yellow 5GL	1.990			1.853			1.095	1.960	1.998			2.067	1.299		2.277							
Ceravon Milling Yellow R 300%		0.869	0.901		0.897	0.911	0.405			0.895	1.023			0.611								
Ceravon Milling Orange G 150%		0.152		0.184				0.013					0.451	0.426								
Ceravon Milling Brilliant Red B	0.168								0.009		0.105				0.130							
Ceravon Milling Violet BL 200%												0.110										
Ceravon Milling Blue BL 150%		0.475		0.477		0.033					0.428				0.420							
Ceravon Milling Navy 2RN 200%			0.184		0.179	0.173	0.194	0.194	0.191	0.190		0.157										
Ceravon Brilliant Blue 8G			0.010										0.405	0.405								
Ceravon Milling Green G 125%	0.447				0.028																	
Recipe with D65																						
Standard with D65																						

Figure 54 Recipe chart 2: colour standard 1208_131216

Standard											
Quality/Style 100.00 [%]											
Substrate (factor)											
Process (factor)											
Formula											
dE* D65	1	1.01	0.01	0.00	0.24	0.00	0.00	0.00	0.00	6.98	11.58
dL*	0	-0.11	-0.00	0.00	-0.12	-0.00	0.00	0.00	-0.00	-1.91	-2.65
da*	0	-1.00	-0.01	0.00	-0.20	-0.00	-0.00	-0.00	-0.00	-6.38	-10.56
db*	0	0.04	0.00	0.00	0.01	-0.00	0.00	-0.00	-0.00	2.12	3.94
Metamerism A	0.7	3.04	5.11	5.13	5.03	5.95	6.46	6.49	7.26	4.00	5.34
Metamerism F11	0	0.78	1.41	1.61	1.51	1.86	2.35	2.26	2.56	1.80	2.40
Total concentration [%]		2.245	1.680	1.691	1.690	1.686	3.113	3.052	3.109	2.176	2.650
Smartmatch infos											
Trial 1									**XX**		
Trial 2						**X**					
Trial 3											
Trial 4											
Trial 5											
Dyestuff		**31(2)**	**32(3)**	**33(3)**	**34(4)**	**35(3)**	**36(3)**	**37(3)**	**38(3)**	**39(4)**	**40(2)**
Ceravon Milling Brilliant Yellow 5GL		2.044					2.453	2.376	2.455		
Ceravon Milling Yellow R 300%			1.037	1.075	1.083	1.079				1.440	1.936
Ceravon Milling Orange G 150%											
Ceravon Milling Brilliant Red B											
Ceravon Milling Violet BL 200%			0.479	0.544	0.527	0.397	0.605	0.554	0.491	0.318	
Ceravon Milling Blue BL 150%					0.013	0.209			0.162	0.018	0.713
Ceravon Milling Navy 2RN 200%		0.201									
Ceravon Brilliant Blue 8G				0.072	0.066		0.054				
Ceravon Milling Green G 125%			0.163					0.122		0.399	
Recipe with D65											
Standard with D65											

Figure 55 Recipe chart 3: colour standard 1208_131216

Figure 56 shows a part of the recipe chart with the predicted colour deviation[35], marked in red, regarding the visual appearance in set light sources (D65, A, F11) compared to the colour standard.

dE* D65	1	0.01
dL*	0	0.00
da*	0	0.00
db*	0	0.01
Metamerism A	0.7	0.05
Metamerism F11	0	0.06
Total concentration [%]		1.340
Smartmatch infos		**L/1**
Trial 1		
Trial 2		
Trial 3		
Trial 4		
Trial 5		
Dyestuff		**1(3)**
Ceravon Milling Brilliant Yellow 5GL		
Ceravon Milling Yellow R 300%		0.709
Ceravon Milling Orange G 150%		
Ceravon Milling Brilliant Red B		0.276
Ceravon Milling Violet BL 200%		
Ceravon Milling Blue BL 150%		
Ceravon Milling Navy 2RN 200%		
Ceravon Brilliant Blue 8G		0.354
Ceravon Milling Green G 125%		

Figure 56 Recipe chart 1208_131216: colour deviations

5.3.3 Criteria for developing a metameric colour series

For the creation of a metameric colour series of three yarns dyed with three different recipes I set the criteria illustrated in the following sections.

5.3.3.1 Criterion for all recipes of a metameric colour series

The criterion for the first selection of potential recipes for a metameric colour pair or colour series is a match in daylight, D65, where the whole colour series should appear the same (Figure 24). In Figure 56, for example, marked in red, the software predicts a deviation of 0.01 (dE* D65: 0.01). This minor deviation is not visually perceivable and therefore this recipe could be taken into consideration for the final recipe choice of this metameric colour series.
During the journey, I encountered other recipe proposals (Figure 57), which showed high deviation in D65. Recipe proposals 1 - 4 of this example are all matching the standard in D65, but from recipe 5 onwards, the system predicts a major deviation. Recipes with a major predicted colour deviation in D65 were therefore discarded.

[35] As described in Chapter 3 a deviation higher than DE 1 is visually perceivable, which means a problem for industry. Instead for this research, a deviation over DE 1 starts to be a valid visually perceivable change.

Standard		Texwell_Amos_2007					
Quality/Style 100.00 [%]		100% Wool Fabric					
Substrate (factor)		100%WoolExtrafine_Cashwool_2_28 (1.00)					
Process (factor)		(1.00)					
Formula		CieLab Default[D65]					
dE* D65	1	0.00	0.00	0.00	0.00	9.88	21.76

Figure 57 Visualisation recipe choice

5.3.3.2 Criterion for achieving a 'stable colour' in a metameric colour series

At least one colour of the metameric series should be stable in all three different selected light sources (Figure 24), though the criterion for this recipe, compared to the 'standard', incorporated a minimal deviation in all the light sources.

In Figure 56, marked in red, the deviation of Metamerism A is predicted at 0.05 and of Metamerism F11 is predicted at 0.06. These minor deviations do not have to be considered (Ch 3.5.2) and this recipe was therefore selected as the 'stable colour' for this colour series.

During the dye lab exploration, I encountered recipe proposals of other colour tones, which did not offer a recipe for a stable colour in the set light sources. These recipes could not be taken into consideration for further exploration, as they did not fulfil the set criterion, which is described above.

5.3.3.3 Criterion for achieving a recipe with a colour change in A and/or F11 of the metameric colour series

The criterion for the recipe choice of the second and the third recipe/colour of the series was a predicted minor deviation compared to the colour standard, as all the three recipes/colours (stable, colour A, colour F11) of the series should match each other in D65 (Figure 24). Additionally, compared to the colour standard, the second recipe/colour A of the metameric series should predict a maximal visual strong deviation in illuminant A and the third recipe/colour F11 should predict a maximal visual strong deviation in illuminant F11.

5.3.4 Selection of a recipe range

All the proposed recipes (Figure 53 - Figure 55) and the colour deviation in the set light sources were mathematically calculated. There was not a guarantee that the dyed fabrics would visually deviate as much as the recipe predicted. Therefore I selected six recipes for further exploration, based on the above-mentioned criteria.

In Figure 53 - Figure 55, the recipes chosen for further testing are marked in red: L/1 and Trial 1 to 5. The table (Figure 58) shows the predicted value of colour deviation per recipe. With these selected recipes six knitted fabric samples were dyed in the beaker machine[36] using a wool dye program.

[36] The NTU dye lab has a lab beaker dye machine for small lot dyeing from Mathis AG, which I used for the adjustments of the various recipes. Mathis AG is a Swiss company, providing standard laboratory and production equipment for the coating and dyeing sector.

Illuminant	DE prediction / recipe					
	L/1	Trial 1	Trail 2	Trail 3	Trail 4	Trail 5
D65	0.01	0.00	0.00	0.00	0.00	0.00
A	0.05	7.26	5.95	3.86	3.64	3.75
F11	0.06	2.56	1.86	8.90	0.73	8.81

Figure 58 Overview table of predicted colour deviation

5.3.5 Final selection of metameric colour series

Subsequently the dyed samples were observed in the light box under illuminant D65, A and F11 and analysed regarding a strong visibility of colour change in comparison to the 'stable colour', in this case L/1 (recipe 3412-001). Recipe Trial 1, 4 and 5 were discarded after the first dyeing, as the colour change was visually not strong enough to be perceivable. Instead I carried on with the sample of recipes L/1 (recipe 3412-001) as 'stable colour', with trial 2 (recipe 3412) and trial 3 (recipe 3412), because of a strong visually perceivable colour change in illuminant A or in illuminant F11. These three recipes were brought forward and adjusted until the three colours of this metameric series matched each other visually in D65.

5.4 Dyeing of the metameric colour series

Most of the steps of the commercial process of yarn dyeing, the sample dyeing in the beaker dye machine as well as the production package dyeing, were valid for this research. However, there was one major difference. Within the parameters of this research, I have one colour standard, for example colour 1208, and based on this I have three recipes (Figure 59). The colour output of the dyeing of these three recipes should have the same appearance in D65.

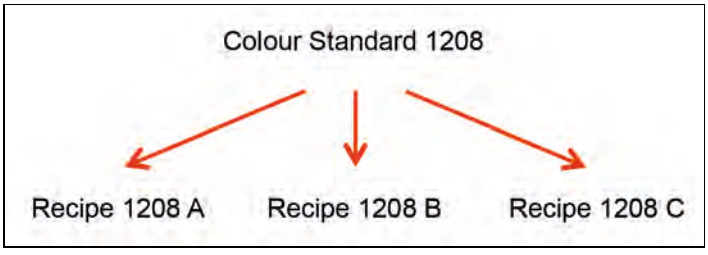


Figure 59 Visualisation of metameric dyeing: 3 recipes

In the commercial dyeing process, a dyed colour is always compared to the colour standard and to existing batches; it's a 'workmanship of certainty' (Pye 2002, p.21). The software is able to propose an adjustment for each recipe in comparison to the colour standard, based on a single recipe, but is not programmed to compare the output of *different* recipes. The goal of this research seeks a match between three different recipes and this was not feasible using the software, as it is a 'workmanship of risk' (Ibid.).

5.4.1 Lab correction of metameric series

The adjustment of the three chosen recipes (Figure 53 - Figure 55): L/1 (recipe 1208_131216-001), Trial 2 (recipe 3412) and Trial 3 (recipe 3412) was executed with quantitative measurements using the spectrophotometer and followed by the lab correction until the approval of the colour by the system (Appendix 1).

5.4.1.1 Colour approval

Stable colour: L/1 (recipe 1208_131216-001) modification 3 (Figure 143)
Colour A: Trial 2 (recipe 3412) modification 5 (Figure 145)
Colour F11: Trial 3 (recipe 3412) modification 2 (Figure 147)

In December 2013, I reached the goal of having a series of three metameric colour recipes approved by the software. But the three colours of the series could only be quantitatively approved when individually compared to the 'colour standard', as the system is not able to compare the colour outcome of different recipes.

Therefore, we assessed them visually in the light box under the set illuminants (Ch 3.4.1) and fortunately, they matched quite well. The visually perceivable colour deviation in D65 was minor (Ch 3.5.4).

However, as these three colours and the corresponding recipes were not quantitatively compared to each other, because of the incompetence of the system, there was already a certain grade of deviation between them, which enhanced further deviations in the following step of the dyeing of production yarn.

5.4.2 Production correction of a metameric series

I quantitatively assessed the three metameric recipes of the colour series in the Lab correction process and these approved recipes were used for production dyeing in the package machine. By contrast, because of the problematic of the present colour deviation as described above, I was not able to undertake the assessment of the production yarn by solely quantitative methods. We still measured the dyed production yarn with the spectrophotometer and we considered this calculated and proposed dye quantity adjustment. But some of the proposed production corrections seemed to increase the deviation compared to the colour standard and to the other shades of the series. Though, for example in April 2014, during the dyeing of trial 3 / colour F11 we followed our perception and added orange, as we saw orange missing, the system proposed the addition of yellow.

We therefore assessed the dyed production yarn visually and decided each time again whether we trust the adjustment of the system or if we prefer to follow our perception and trust the adjustment proposal of the experienced dye technician.

While in the production phase visual assessment determined the decision of colour approval. In April 2014 yarn was dyed (Figure 149) with the approved recipes of the colour series 1208:

08 April 2014: recipe 1208_131216 trial 2: failed
09 April 2014: recipe 1208_131216 trail 3: approved
10 April 2014: recipe 1208_131216-001: approved

14 April 2014: recipe 1208-131216 trial 2: approved

The colour outcome of the yarn dyeing of the 8th April failed to match the colour standard and so the yarn is waste.

5.4.2.1 Production batches

Furthermore, during the production process complexity was additionally increased, as all dyed batches of the three recipes, as shown in Figure 60, should match the standard and should also match each other within the fixed deviation tolerance of DE1 (Ch 3.5.2).

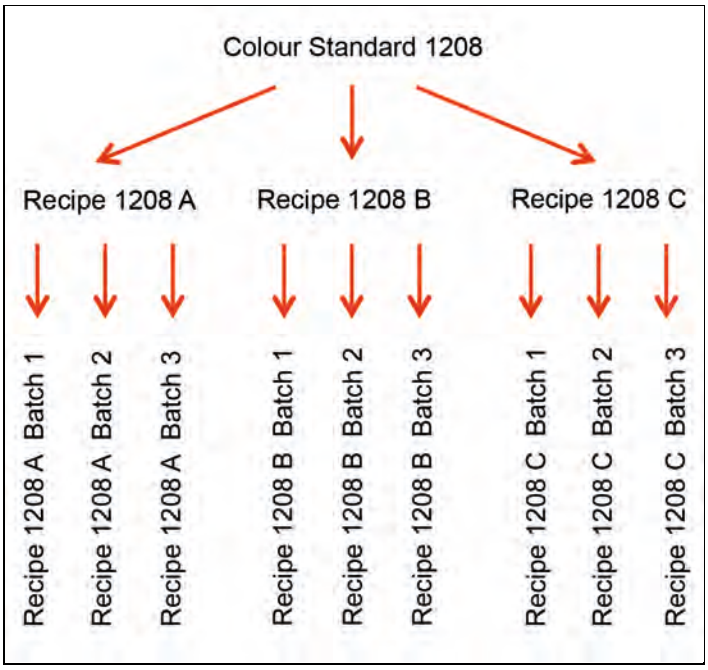


Figure 60 Visualisation of metameric dyeing: 3 recipes & 9 batches

5.5 Limits of software

The Datacolor software for colour management, as well as the software of other companies, is very sophisticated in doing the job it is programmed to do (Ch 5.2.3). The software was not programmed to fulfil my requests of comparing colours dyed with different recipes. In fact, it is designed to achieve consistency in terms of matching colours as far as possible in various lighting conditions. The inversion of producing metameric colours, instead of avoiding them, stretched the technology to its limits.

I was not fully supported by the software to adjust the recipes during the production phase and was not able to execute the whole process with a quantitative method, as I expected. The dye technician and I had to assess the dyed production yarn colour visually in the light cabinet and based on this decided the adjustments and the approval of dyed colours.

5.6 Conclusion

This chapter describes the first part of the research, covering the category ‘research for the arts’ (Ch 1.3.3), executed in the dye as well as in the knit lab. I illustrate the setting of parameters and criteria for this research phase and the exploration of metameric colour recipes. I explain the dyeing process from an olive green colour standard, to the approval of a metameric colour recipe series, to production dyeing of the wool yarn, to repetition of dyeing the same recipe and the dyeing of batches. I describe the procedure in the dye lab on the basis of the first successful process of the production of metameric material.

I compare the dye procedure of this research with the general procedure of commercial dyeing and I demonstrate the differences required to achieve the original goal of this research.

A fundamental difference is that my goal is to dye three different recipes, which should all match the standard, as well as each other, in D65. In contrast, commercial dyeing operates with only one recipe. The software programmed to do this job is not able to fulfil my request of comparing three dyed colours of three different recipes to one standard and to each other.

As a consequence, I could not assess the production yarn quantitatively alone, but had also to assess it visually. During Datacolor Software training Daniel Aitken (2013) confirmed that there was no other solution than to involve a qualitative subjective visual judgement and that the research was executed in the right way.

6 Challenges in the dye lab

Outline

This chapter continues to describe and analyse the various processes in the dye and knit lab and the inherent sources of failures that occurred through experimentation with, and testing of, specific metameric colours. In the following sections I present the empirical structure and discuss the building of the research environment, created in order to reach the goal of the first phase of the research. By listing all the problems (Ch 1.4.7) encountered I intend to map and reflect upon 'the actual experimental' and 'intellectual process at work' (Firestein 2016, p.4). By 'expressing doubt and uncertainty' (Ibid., p.249) I submit an 'accurate record of the way it actually happened' (Ibid., p.4).

6.1 Challenges during the progress in the dye lab

Most of the equipment in the dye and the knit labs at Nottingham Trent University is provided for the students' realisation of prototypes. Prototyping equipment at a university requires a different quality level than production equipment, as repetition and consistency is not a major necessity. Some of the problems I experienced stemmed from the standard of the equipment at Nottingham Trent University, which was not appropriate for my requirements, as shown in the following sections. To reach the goal of my research I coped pragmatically with the existing equipment and I considered '*pragmatism* [as] *the care of the possible*' (Stengers 2011, p.12). I faltered, as the equipment in the dye lab was so new (Ch 5.2.1), nobody was yet experienced enough to support me. The dye technician had limited experience of dyeing yarn; his core practice was fabric dyeing so my requests were a challenge to him. Fortunately, he knew the Datacolor Software and its functions, which were important for the tasks he performed in his former job, but had never been set the task of dyeing metameric fabrics.
When I started the journey, the goal was clear: the creation of knitted material dyed as a metameric colour pair or a metameric colour series; and instructions for this were not available. As I stated in the research journal

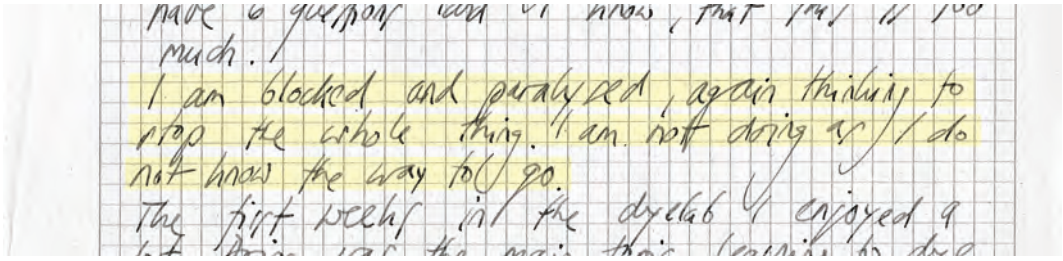


Figure 61 Research Journal, 04 December 2011

Rheinberger (2007, p.86) emphasises that 'what is new is per definition not foreseeable' and that '[t]his is a concise articulation of the nature of research'. Further, he states:

> What is really new has to present itself, and one has to create conditions that allow it to be able to arrive as an event. In the experiment, the researcher creates an empirical structure, an environment, that gives him the ability to act in this state of ignorance about what he does not know (Ibid.).

In the following sections I describe and discuss the environment I built to enable myself to act.

6.1.1 Exploration in the dye lab with various colour standards

With the first two colours, a grey and an olive (Figure 25), defined in September 2011 as my colour standards, I established an understanding of the field of colour calculation and dyeing practice. The process in the dye lab was iterative (Ch 1.4.5) and based on the first problems I encountered. I gained experience, learned, improved and defined the parameters of my exploration in the dye lab. In order to reach the set goal of the creation of a metameric colour pair or colour series, I dyed a great many fabric samples and documented them as rigorously as possible (Ch 5.2).
In December 2011, I broadened the colour range and added the following as colour standards: 2030: dark green, 2024: grey, 2009: brown and 2007: caramel brown (Figure 62: marked with a star).

Figure 62 Colour card Amos from Texwell, for colour reference

In December 2012 I achieved a recipe based on colour standard 2007 (caramel brown), the first milestone, by dyeing in the package machine a metameric yarn pair (recipe 1512-005 modification 1 and recipe 1512-001 modification 2; Appendix 2), which matched in illuminant D65 and differed in illuminant A. The first metameric trial fabrics were knitted with this yarn (Figure 28).

6.1.2 Colour comparison of production dyed yarn using the Datacolor software

In the commercial dyeing process, the data of all dyed batches (Figure 63 black dots), relating to one recipe, is saved in the system and can be compared with each batch and with the colour standard (Figure 63 green dot). The system calculates colour differences within the whole group and assesses them according to the defined tolerance (DE1, Ch 3.5.2).

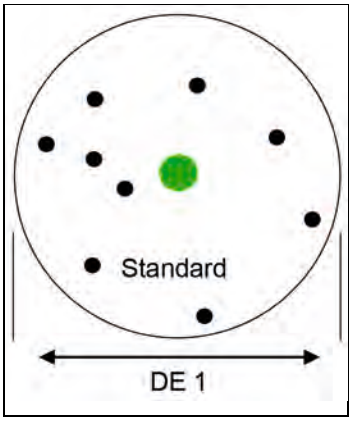


Figure 63 Illustration of a colour standard with all belonging batches

This research also required a comparison of the colour outcome based on a series of three different recipes (Figure 64), as the colour outcome of these three recipes should look unicolor in illuminant D65. Thus, the dyed colour outcome of all the three recipes needed to be compared in illuminant D65 to the same common colour standard (Figure 64, green dot) as well as within the whole group of the three recipes. Hence each colour has to be assessed with regard to matching in illuminant D65 within the whole group.

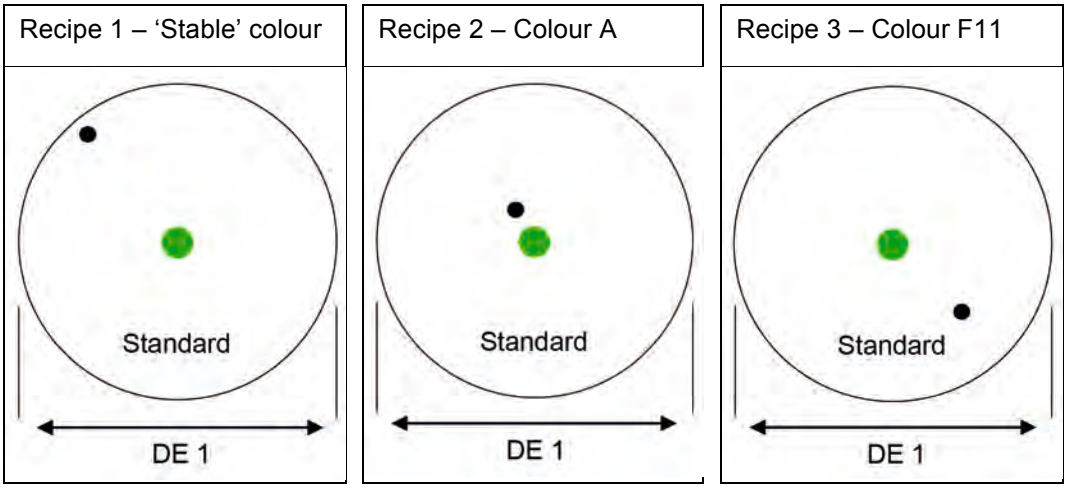


Figure 64 Illustration of a colour standard and the corresponding three recipes

Furthermore, the various dyed batches of these three recipes should also match the colour standard and each other in illuminant D65 (Figure 65).

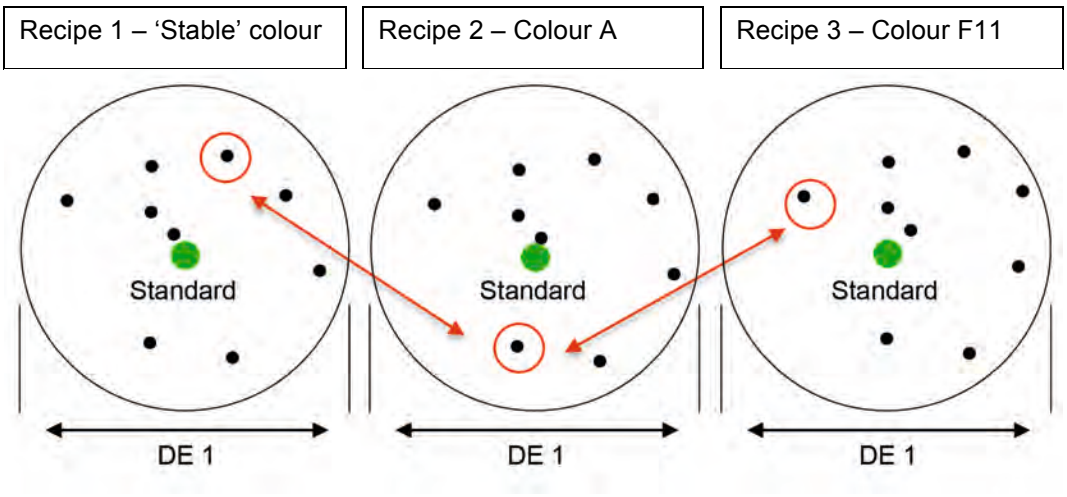


Figure 65 Illustration of a colour standard, the corresponding three recipes and their batches

The assessment of a metameric colour series could not be done directly, as the software does not allow linking of outcomes from different recipes.

Therefore, I had to measure each dyed sample ('stable', colour A, colour F11) with the spectrophotometer and insert this measured data into the system, pretending different dyes belonged to the same recipe. As a consequence of this, data measurements were no longer linked to their original recipes and I was unable to quantitatively adjust, within the system, these colour outcomes as compared to the colour standard and each other. With this additional step, I 'subverted' the software to be able to quantitatively assess the output (Figure 66 - Figure 67) of the three recipes but could not make further use of the result.

CMC Pass Fail

Standard:	140414_STD_1208		
	%R SAV SCI UV Inc 600	14-Apr-14	14:35:36
Batch:	140414 TRIAL2_1208		
	%R SAV SCI UV Inc 600	14-Apr-14	14:36:50

Formula: CMC Tolerance: 1.00

Illuminant	DE	DL	DC	DH	Decision			
D65 10 Deg	0.68	0.40	0.54	-0.02	Pass	thinner	brighter	yellower
A 10 Deg	5.35	0.50	-0.47	-5.30	Fail	thinner	flatter	yellower
F11 10 Deg	0.34	-0.12	-0.19	0.26	Pass	fuller	flatter	bluer

Figure 66 CMC Pass Fail form of approved production yarn colour 1208

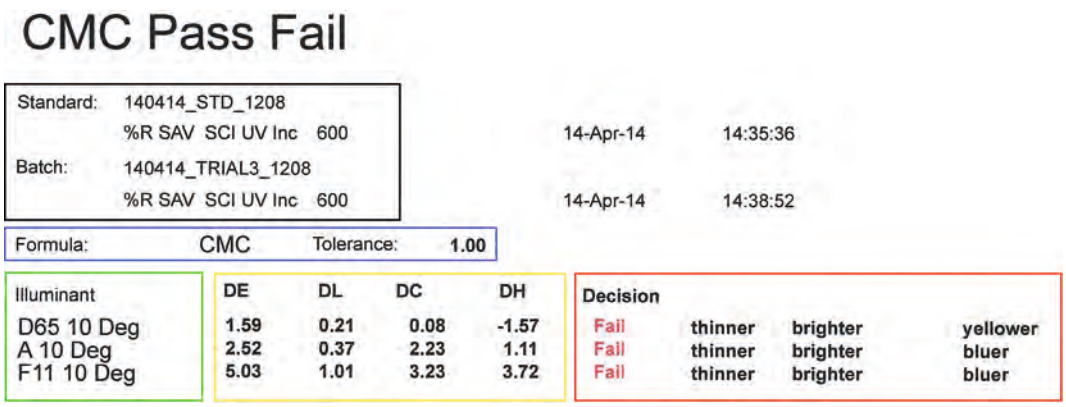


Figure 67 CMC Pass Fail form of approved production yarn colour 1208

Figure 66 and Figure 67 show the CMC Pass Fail (Ch 3.5.2) form, which was established after measuring the metameric colour series 1208 with the fixed tolerance DE 1 (blue frame on both Figures). The illuminant/observer conditions (green frame on both Figures) was set to illuminants D65, A and F11 and the standard observer to 10° (Field size of 10°).
The 'stable colour' was inserted as the 'standard colour' and Trial 2 (colour A) and Trail 3 (colour F11) as 'batches' of the recipe (black square on both Figures).
In Figure 66 Trial 2 (colour A) and in Figure 67 Trial 3 (colour F11) are compared to 1208-131216-001, the 'standard'/stable colour'.
The software calculated the colour difference between standard and batch (yellow square on both Figures) and decided, based on the set tolerance DE1, an approval (Pass) of Trial 2 in illuminant D65 and F11 but a rejection (Fail) in illuminant A (Figure 66). The comparison of Trial 3 (Figure 67) failed when tested in all three illuminants (red square on both Figures).

6.1.3 Difficulty of documentation and naming

The software did not support documentation and tracking of the various undertaken steps, as there was no possibility to save the recipes as files. The only way to include them in this thesis, beside 'print screen' with a poor quality image, was to print them out and scan them.
As described in Ch 6.1.2 in order to execute a quantitative comparison, each shade ('stable', colour A, colour F11) of the series had to be measured once more, pretending it belonged to the same recipe. Each dyed colour shade was already saved in the system with a name, connected to the proper data, but the system did not allow me to reuse their original names for additional measurements. Therefore, I had to give each colour measurement a new unique name.
In Figure 66 & Figure 67, for example the 'stable colour' has been inserted as Standard and named 140414_STD_1208 and Trial 3 ('colour F11') is inserted as Batch and named 140414_TRIAL3_1208.
In the first phase of the research, colour naming of the various dyed samples for tracking and documentation was crucial. I tried to name them systematically using actual dates, but in general this procedure was very confusing, as the same colour sample would have various names. This made it hard to neatly document and keep an overview of 'what is exactly what'

(Ch 5.2). Colour naming per se is an often-discussed subject, as will be illuminated in Chapter 7.3.2.

6.1.4 Testing of repeatability

In April 2012 I was interested in the exploration of repeatability of an ordinary dyeing recipe, by producing a classic dye batch of a pre-adjusted colour recipe. I did this trial with the 'colour standard' Texwell Amos 2007, a caramel brown (Figure 62), on the basis of recipe 1512-005 (Appendix 2). I dyed three fabrics; two fabrics of 8 grams in weight and one fabric of 16 grams in weight in the same dye bath with 'exactly' the same parameters (material, knitting tension, dye temperature and time). I measured the three dyed samples with the spectrophotometer and got three different measurement results and two dyed samples passed: one failed to match the 'colour standard'. On one hand the process was successful, as the 16 gram sample passed, but for the 8 gram sample the software gave me a 'warning' regarding the match to the standard in D65 and so the exploration did not assure the success of further dye lots (Figure 152). Choudhury (2015, pp.61-62) confirms:

> Much of textile fabric production involves coloured fabrics and repeat production that should ideally be of exactly the same colour as the original one. However, this is usually not the case because the manufacture of coloured textiles is subject to many variables, just as any other manufacturing process. Even though computerisation is utilized to minimize and control variability in the process, it will still be present to some degree. Each batch of fabric dyed for a given shade is done the same way but with different batches of textile fibres, dyestuff, chemicals, dye machines, operators, water, etc. We see it is never truly done the same way, and we should not be surprised to see variations in our production.

In the field of dyeing, as described by Choudhury many variables influence the results and it is difficult to work accurately and repeat dyeing results. When I started the research journey, I was not at all aware of the relativity of general dyeing and, with the aim being to create metameric material against the system's defaults, I further increased the complexity of dyeing.

6.1.5 Trial to extend the metameric colour range

Figure 68 Testing of brighter colours

In December 2013 I tried to extend the colour range, which up until then was based on achromatic colours in brownish, greyish and greenish tones. I explored some brighter and colourful colours: four reds, three greens and four blues (Figure 68). However, the outcome of this exploration was unsuccessful, because the colour changes of these dyed fabrics, compared to the 'stable colour', were minimal and visually imperceptible (Ch 3.5.4).

6.1.6 Knit for colour checking

When I started to dye yarn cones in the package machine, I took, after each dye run, some yarn from the cone, dried it and measured the colour of the yarn (Figure 69 left) then, with the spectrophotometer and the software, compared the measured sample to the standard. The colour standard of the various dye recipes was in the form of a knitted fabric (Figure 51) and as 'the visual colour-difference evaluation is strongly influenced by the texture of the sample pair' (Choudhury 2015, p.56) the measurement of the yarn sample differed strongly from the knitted fabric (Figure 69).

Therefore the additional step of knitting the dyed yarn after each dye run was introduced in order to gain a similar texture for all the compared samples to achieve more accurate measurement data and support the results of visual analysis. These fabrics were knitted on the hand operated Dubied machine (Figure 70) in the Fashion Knitwear labs at Nottingham Trent University then visually checked and compared with the other dyed knitted samples in the metameric colour series.

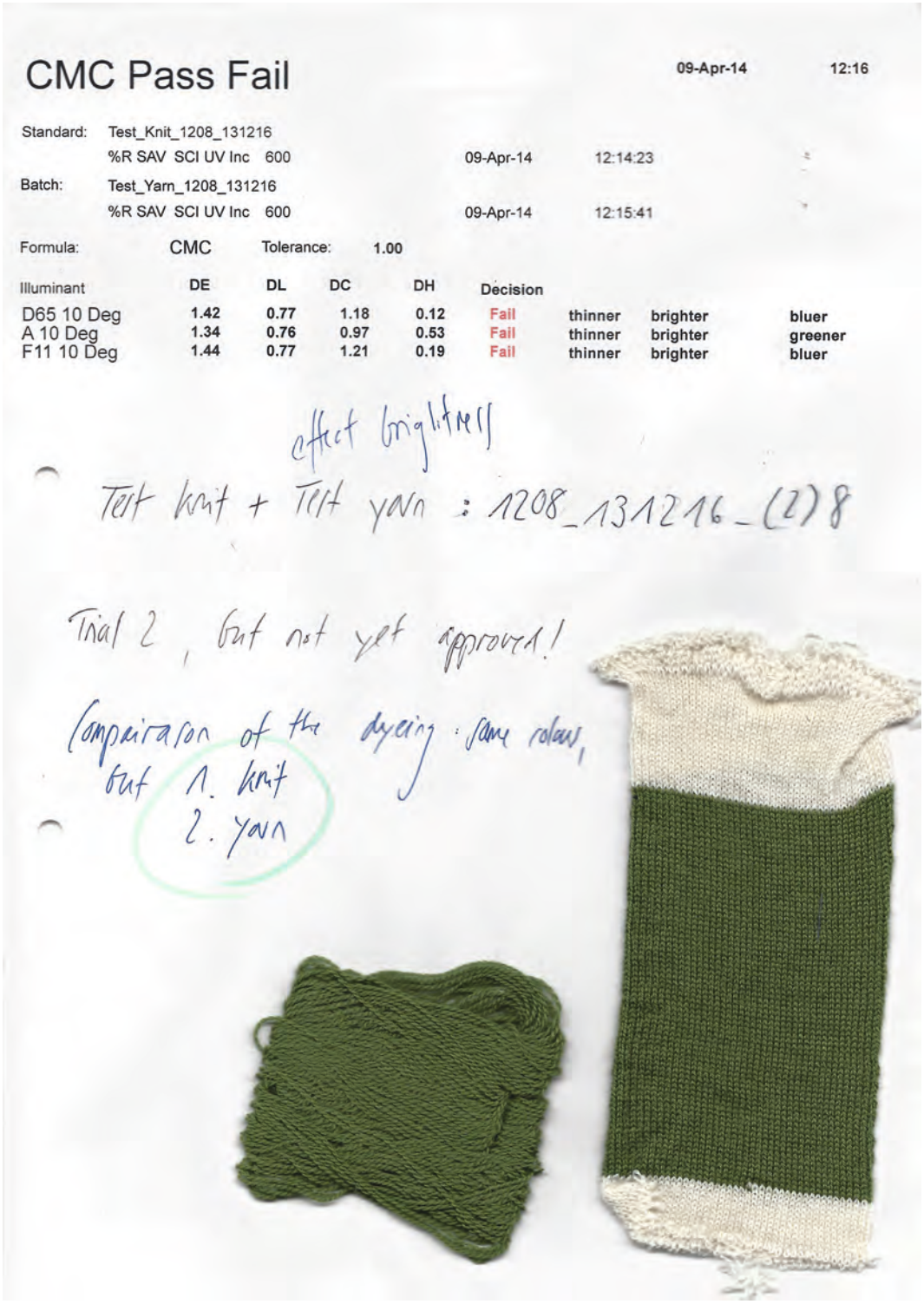


Figure 69 Same dyeing batch: yarn and knitted fabric

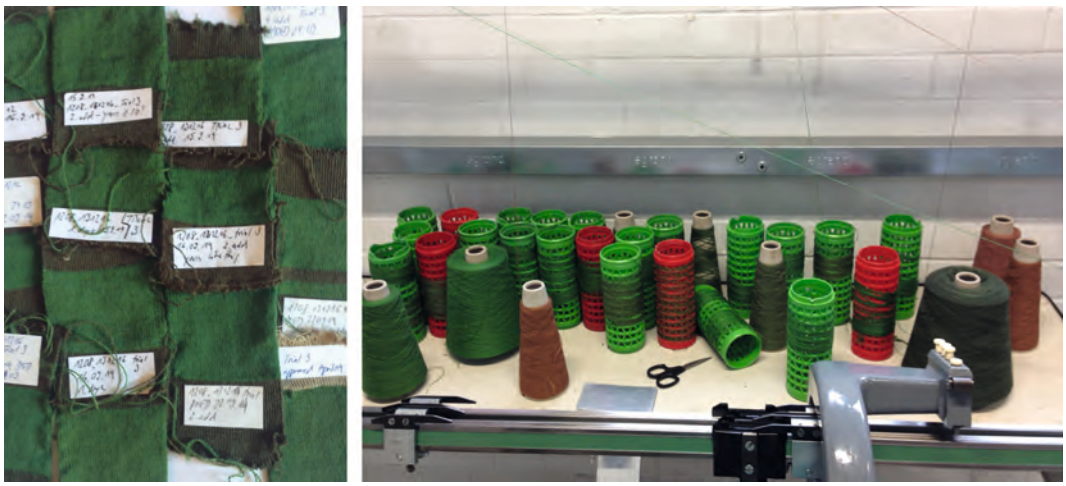


Figure 70 Knitted fabrics and yarn cones on knit machine for colour checking

6.1.7 External yarn dyeing

The package machine available at NTU allowed me to dye approximately two kilos per colour at once and, as the repetition of a matching metameric dye batch, as described in Ch 6.1.4, is tremendously difficult, I looked for possibilities to dye bigger quantities with consistent colour outcome for the production of planned further artworks. Ged Fern, the managing director of Blackburn Yarn Dyers Ltd, agreed to dye some metameric yarn for my research. After receiving an explanation of the research concept and three dyed metameric fabric samples, they prepared three lab colour samples (dyed, but not knitted yarn) for approval. Following the approval of the lab dips they dyed five kilograms of each colour and named the dyed shades:

- Blackburn Standard
- Blackburn Blue (change in F/TL84)
- Blackburn Brown (change in A)

In December 2015 I checked the received yarn shades and realised that the colour change of Blackburn Blue, which should be evident under fluorescent light, was very subtle and visually hard to perceive. However, the colour change of Blackburn Brown under ‘Tungsten’ was clearly perceivable, as requested.

I supposed that in the production phase at Blackburn Dyers Ltd. an error may have occurred and compared the received dyed production yarn with the approved lab colour samples. The production yarn matched the approved samples very well and Blackwell Dyers Ltd had dyed the yarn correctly.

I realised I had deceived myself with my assessment of the lab colour sample. I supposed the colour change to be visually perceivable and could not detect the too minimal colour change by means of the lab colour sample, which was not knitted. This confirmed the importance of the comparison of similar surfaces as described in Ch 6.1.6.

6.2 Remarks on ignorance and failure

> All of old. Nothing else ever. Ever tried. Ever failed. No matter. Try again. Fail again. Fail better. (Beckett 1989, p.6)

The first phase of the research was experimental and comprised the constant failing of the dyeing process, leading to ongoing iterations and detours (Ch 1.4.7). As Beckett wrote, I failed, I tried again, I failed again, but failed better. I gained through each failing an idea of how to improve the experimental setup. I 'directly experienced' (Dewey 1933, p.107) problems and these 'felt difficulties' led 'into a *problem* to be solved'. Firestein (2016 p.146) points out, that failure is an inherent part of research in science. 'Most of the experiments don't work for one reason or another. So most science is negative results'.

I assumed that the part of the research in the dye laboratory, the scientific/technological practice, would be predictable, based on the popularly believed notion of the 'pillars of science': 'KNOWLEDGE and REASON, or FACT and TRUTH, or EXPERIMENT and OBJECTIVITY' (Ibid., p.2). But instead of working within the parameters of 'certainty and risk' (Pye 2002, p.20) mine was a practice of uncertainty and risk where I never knew what the dyeing outcome would be. I needed a 'willingness to fail' (Firestein 2016, p.11).

The time in the dye lab was an 'exploratory movement' (Rheinberger 2005, p.77) and I was confronted by 'non-comprehension' of errors as these happened. The research process was a searching movement, taking place along the boundary between knowledge and ignorance. As for Firestein, Rheinberger disagrees with common conceptions of research in natural science (clear planning, concepts and control) and underlines the importance of accident, chance and improvisation in experimental systems (Ch 1.4.7) and research processes.

6.3 ‘Felt difficulties’ – Dewey in the dye lab

In the following sections I illustrate failures and problems encountered in the dye lab.

6.3.1 Exact measuring

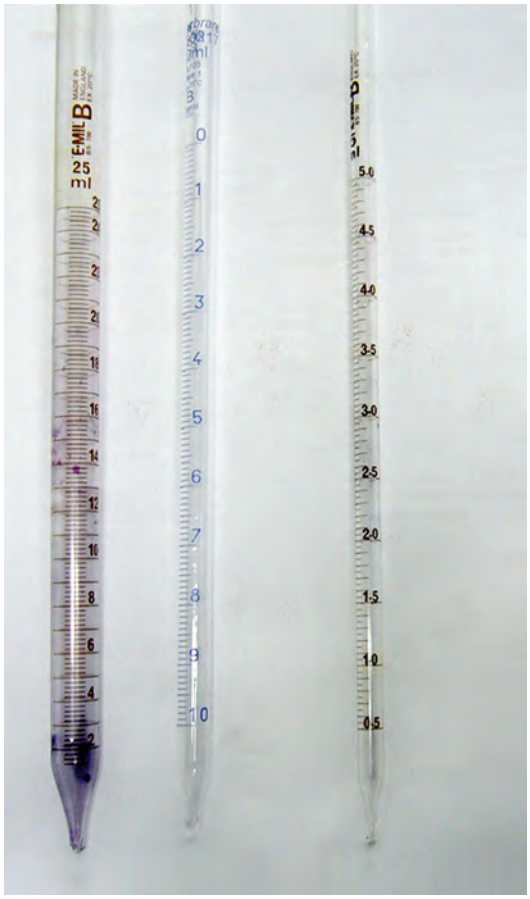


Figure 71 Different pipettes creating errors during the dye solution measurement

The exact measuring of dye solutions as well as keeping an overview, by measuring different recipes at the same time, required a high level of concentration. On more than one occasion I screwed up a dye batch as I simply forgot to add a colour component and the outcome of the colour was incorrect (Figure 85 right).

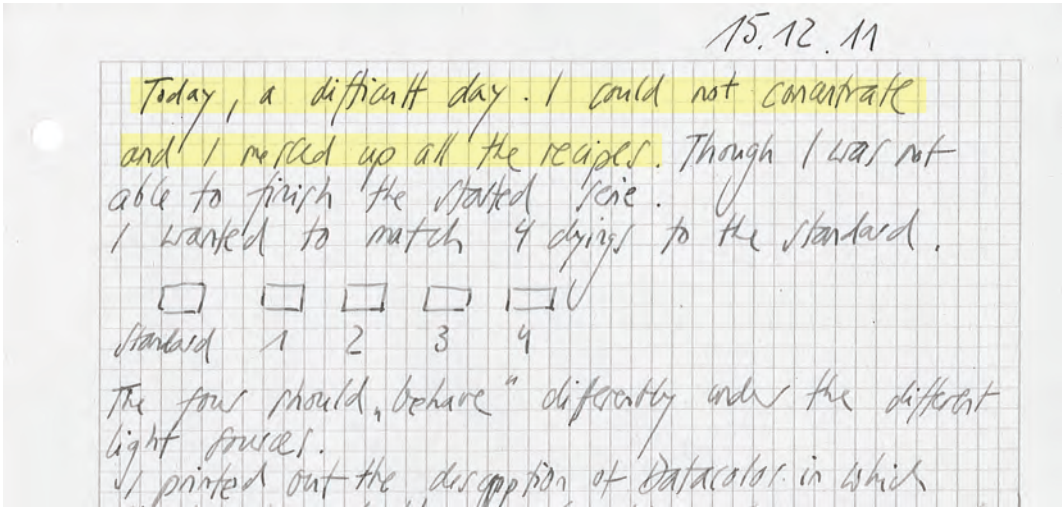


Figure 72 Research journal, 15. December 2011

In the dye lab different pipettes (Figure 71) were available and on some the scale of indications of measurements was inverted. This demanded extra attention during the measuring and lack of attention caused some mistakes because of incorrect measurements. In line with Firestein (2016, p.8) I considered these failures as ‘just mistakes’ and ‘simple lessons’ to learn.

> There is a continuum of failure, not just one narrow kind. Yes, there are failures that are just mistakes or errors, and they may often be no more than an unfortunate waste of time. There are failures from which you learn simple lessons: be more careful, take more time, …

6.3.2 Time – Temperature ratio

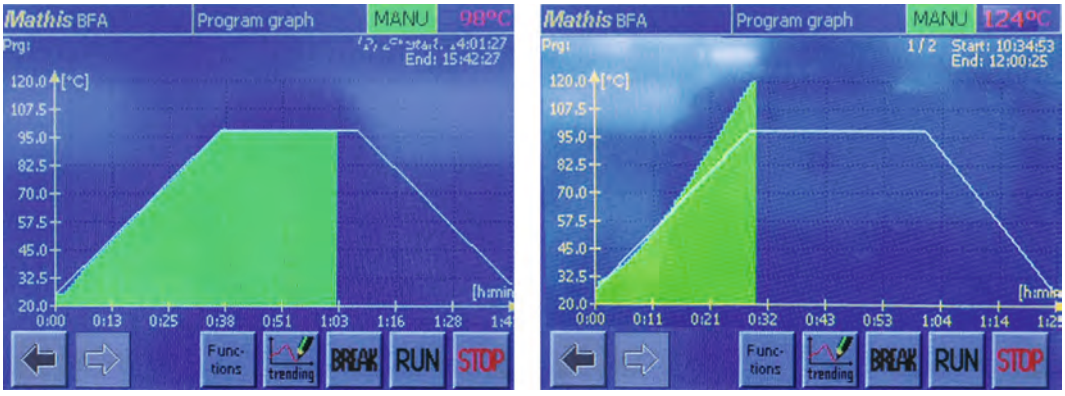


Figure 73 Beaker machine program graph: left side: correct, right side: wrong

Figure 73 shows the program graph of the beaker machine. The white line indicates a specific program for wool dyeing with a fixed time and temperature. The light green colour, filling the white line, shows the actual dyeing procedure. The graph on the left-hand side shows the correct execution. In comparison, the graph on the right-hand side shows a clear deviation. On the 28th of March 2012 the dyeing did not follow the fixed time and temperature of the dyeing process and instead heated up much too much. As a consequence, the wool fabric was totally

burnt and all the dyeing had to be repeated. We did not know the reason for this error at the time but later, with help of the technician from Mathis, we figured out that the reason was an incorrect sequence in programming.

6.3.3 Winding

Shamey and Zhao (2014, p.8) consider that 'the most important parameters affecting levelness of dyeing in a package dyeing operation' are, amongst others, 'density, construction and shape of packaging'. The winding of the packaging is crucial in the dyeing process.

6.3.3.1 Winding for dyeing

For package machine dyeing yarn needs to be wound on appropriate cones (Figure 48) with holes. The available winding machine at NTU is intended for twisting yarn (Figure 48) and so I was not able to adjust the tension properly. As a consequence, I could not keep the consistency of the shape and density of packaging, which influenced the outcome of the dyeing.

6.3.3.2 Winding for knitting

'Knitting on a machine is highly dependent on yarn tension at various points in the process', state Dias and Lanarolle (2002, p.997). They also stress the impact of yarn tension on knitting.

> Delivering an extended yarn (due to yarn tension) to the needles and subsequent relaxation of the yarn in the fabric is another reason for the difference between the apparent delivered yarn length and the true yarn length in the fabric.
> Thus, the tension of the yarn wound on the storage yarn feed wheel is not zero, and the yarn there is already elongated [2]. Consequently, the actual length of the yarn in the fabric is influenced by the extent to which it has been stretched before it is wound on the storage yarn feed wheel. (Dias and Lanarolle 2002, p.997).

The equipment for yarn winding at Nottingham Trent University did not allow for a constant setting for the winding tension. Hence the winding of the various cones of yarn was inconsistent, which may have created various problems that occurred during knitting. The yarn quality did not come into consideration regarding these knitting problems, as I knew this quality performed very well based on my former industrial experience (Ch 5.1.1).
The winding was often very tight and the yarn on the cones extended, losing its inherent elasticity. Hence, it may have broken easily during the knitting (Figure 111).
In addition, the stretched yarn may have influenced the outcome of calculated measurements of the knitted works, as described by Dias and Lanarolle (2002, p.997).
Some of the yarn was not dry (Ch 6.3.5) enough, when I started the winding and so the damp yarn created friction in the winding process leading to elongated yarn, which could also have triggered knitting problems.

6.3.4 Uneven dyeing

In industry, some dyestuff combinations (recipes) are excluded, as they tend to create a ‘skittery’ (Ch 5.2.3), uneven outcome. As my goal is to purposefully dye metameric colour pairs or a series, I could not avoid these problematic dyestuff combinations. I had to accept that some of my dyed fabrics could have an all-over dappled look.

6.3.4.1 Uneven dye distribution

Sometimes the outcome of the dyeing was waste, as dye distribution was uneven, as shown on Figure 74. Yarn colour on the outside of the cone was totally different when compared to the colour on the inside.

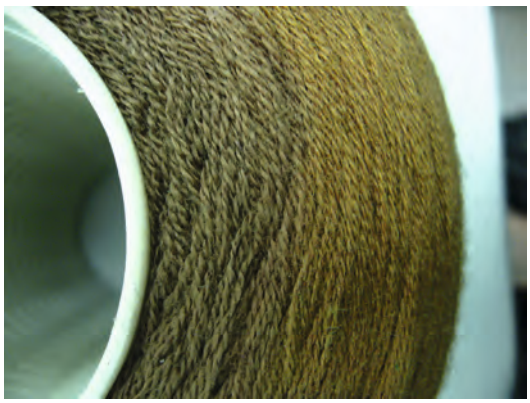


Figure 74 Uneven dyed yarn from the 07 December 2012

We assumed that the temperature rose too quickly and the colour stack concentrated inside, meaning dye did not penetrate the whole cone. As stated in dye handbooks (Heetjans et al. 2005, Lewis 1992, Choudhury 2006) possible sources of errors can be: insufficient wetting of cones, wrong pH value, faulty dissolving of dyestuff, faulty liquor ratio, inapt temperature to time ratio, inappropriate quantity of chemicals.

> Levelness is the uniformity of dye distribution (and hence colour) on textiles. Two fundamental mechanisms contribute to level batch dyeing. One is the initial sorption of dye during the dyeing; the other is the migration of dye after initial sorption on the fibre. An initial level sorption will lead to level dyeing. The mechanisms are controlled by adding dyes and chemicals, textile substrate, and parameters of the dyeing process such as dyebath pH, liquor ratio, flow rate and temperature (Shamey and Zhao 2014, p.6).

6.3.5 Drying

Figure 75 Distorted yarn cone after spinning

After dyeing the yarn needs to be dried before further use. There was no specialist yarn dryer available at NTU and to reduce the drying period, we tried to take out the first amount of water with a spin dryer, appropriate for spinning fabric. But this procedure destroyed the yarn cones (Figure 75) and the risk of trapped yarn increased, which consequently influenced the winding tension of the cones for knitting (Choudhury 2006, p.419).

Figure 76 Burnt yarn after drying

The yarn cone shown in Figure 76 was scoured in the package machine. As we had not dyed the cone we dried it in the fabric drying cabinet in the print lab. The colour of the cone outside became brownish and we guessed that the yarn outside was burnt, as the heat in the drying cabinet was too strong.

These were all informative failures, as Firestein (2016, p.8) noted: ‘There are failures that are informative: it does not work this way: there must be some other way’.

In 2015 Nottingham Trent University acquired appropriate yarn drying equipment.

After drying using this some cones were felted (Figure 77) and unusable, but we could not identify the reason for this failure.

Figure 77 December 2012: Felted yarn cone after drying

6.4 Conclusion: encountering failure and ignorance

This chapter offers an honest presentation of the real journey and, including failures, provides a report of the research process.
I enjoyed the exploratory phases of my research, despite being often deeply disappointed.
A crucial driver throughout was stubbornness, which certainly helped me to not resign in difficult moments and to continue overcoming the various struggles. I was convinced that I would be able to reach my goal and to accomplish what I had set out to do – to produce metameric dyed yarns, metameric knitted materials and metameric artefacts. I never completely lost this hope despite often stating in my research journal that maybe I should just stop (Figure 61).
The process of dyeing, reaching the goal of achieving a series of three metameric yarn colours, was a riddle I wanted to solve. Challenges of problem-solving can be very creative and they have always intrigued and propelled me, as they did during the process in the dye lab. I valued the moments when I discovered how to move on from ignorance, from not knowing how to do something to the moment I finally succeeded in doing it.
Endurance was crucial, as iterations and detours prolonged the process in the dye lab. I never expected that I would spend so much time preparing the material needed to further and fulfil the research journey. Besides the ongoing problem solving, there were plenty of repetitive tasks to undertake, for example the daily calibrating of the spectrophotometer or knitting of small fabric swatches for checking dyed yarn colour. All these steps were time consuming. Firestein describes these tasks of research in a lab:

> As a rule, it takes the shape of instruments, devices, and equipment. These may frequently only be set in motion for the purpose of testing their own operability – the calibration and testing of equipment actually takes up the major portion of the scientific experimenter's working time. The machines that are used are expected to perform their work as noiselessly as possible (2016, p.86).

Some of the problems I encountered were the normal struggles of any craft or technological practice where the parameters have to be developed and adjusted. But often we did not know the reasons for faulty results, which was very frustrating; we padded through the dark and from this position it was often hard to understand how to improve.

At the outset, I never thought that dyeing was as challenging as it is, or that the repeatability, the dyeing of a matching dye batch, is so tremendously difficult to achieve (Ch 6.1.4). I expected to trust the accuracy of the software to reach my required results and did not consider the limitations of the software. To reach my set goal I had to subvert and work against the software.

The first phase of the research was an ongoing experience of approximation where all the recipes and dyed samples, filed in folders, folders full of failures, became an important part of my research ‘data’. Failure became a tool, a key method in this research.

7 Art practice part 1

Outline

This chapter describes and analyses part of the research journey which was not foreseen when the project was designed. During the exploration in the dye laboratory I produced a lot of ‘waste products’ (Ch 6.1.1), which unexpectedly became significant material for artworks. What had been considered a by-product became an essential component of the research. These artworks, as a form of documentation, visually depict the process of knit and dye practice. Through this, I created a unique and distinctive visual methodology, established and discussed in this chapter.
Furthermore, I introduce the technique of knit as an art practice and describe the building-up of aesthetic criteria for this project.
The artworks, discussed in Chapters 8 and 9, touched on several thematic fields: light, colour, perception, everydayness, wonder and the colour green. These different but converging fields and their inherent aspects are identified at the end of this chapter and laid out in order to provide the basis for further analysis.

7.1 Process Artworks - The by-product as Artwork

> Art does not reproduce the visible; it makes visible. (Klee 1987, p.60)

Figure 78 Folders containing dyed fabrics and recipes

In 2011, as described in Chapter 5 and 6, I spent a lot of time in the dye laboratory exploring, developing and realising metameric material as the basis for the creation of artworks. Trying and retrying to reach the set goal of having two samples, which would have the same appearance in daylight but differ under another light source, I produced well-organized folders full of annotated dyed fabric samples accompanied by their recipes (Figure 78).
In this phase of the research I strove for the success of dyed metameric yarn. The scientific and technological practice in the dye laboratory, including the calculation of recipes on the computer, was a long haul during which it seemed that the actual art practice would remain in a waiting state for a long time. When I designed the project, I had thought that the art-making would start as soon as I had the metameric yarn ready, but had never considered starting with the material of the exploration phase, the dyeing 'failures'. Observing the 'failed' dyeing outcomes, I noticed the beauty of the produced colour shades and began to perceive them as visual material. These unobtrusive and unintentional colour differences have magic in their own right. Similarity is present, the same colour again and again, though with slight differences.
As discussed in the following sections, discovering opportunities in this scientific and technological exploration, which I did not expect at the beginning of the research process, my attitude towards these samples changed. I realised I could gather the flowers 'on the brink of the pursued way' (Rheinberger 2005, p.79) rather than only keep to the main goal, neither looking to the left nor the right side. 'There are failures that lead to unexpected and otherwise unavailable discoveries: they often seem like serendipity, an accidental failure that opened a door you did not even know was there' (Firestein 2016, p.8).
As a consequence, I spotlighted the 'failed' dyed material and involved it in my artistic practice, which now went alongside the scientific and technical research.
At this point of the journey I decided to leave aside the aspect of light, as the material had not yet reached the set goal, and I worked instead with the available coloured material without observation under different light sources. The metameric effect is present in these Process Artworks but it was not a criterion in their creation.

7.1.1 Background and concept of the Process Artworks

I documented the process in the dye laboratory; I kept all the recipes and attached the dyed fabrics to them. The documentation followed scientific/technological rules containing data, quantitative facts and figures. Whilst in the process of my experimentation each step undertaken was present, it remained somehow invisible, hidden in the folder with related information. A visualisation of the actual work done, a visual overview of the dyed colour shades, was missing.
Triggered by the beauty of the similarity of the colour palette, I started to explore the content of these folders and discovered the poetic potential of the 'failed' material. As a visual person discovering the beauty of the produced colour palette I considered it important to find a way to visualize the content of the folders and show all the trials, which approximated my final goal.

Hessler and Mersch (2009, pp.9-10) state that it is impossible to make a valid description of a colour shade, as the chromaticity of a field cannot be described precisely. In such cases, visual representation can show things when the descriptiveness of language is limited.
The not yet successful output of the scientific and technological exploration therefore became the material for the creation of a series of artworks, the Process Artworks. Through the 'failed' material, altered into the Process Artworks, I added a new dimension to the phase of repeating errors, as these failures became 'a poetic dimension of art' (Szeemann 2001, p.194).

7.1.2 Production and development of the Process Artworks

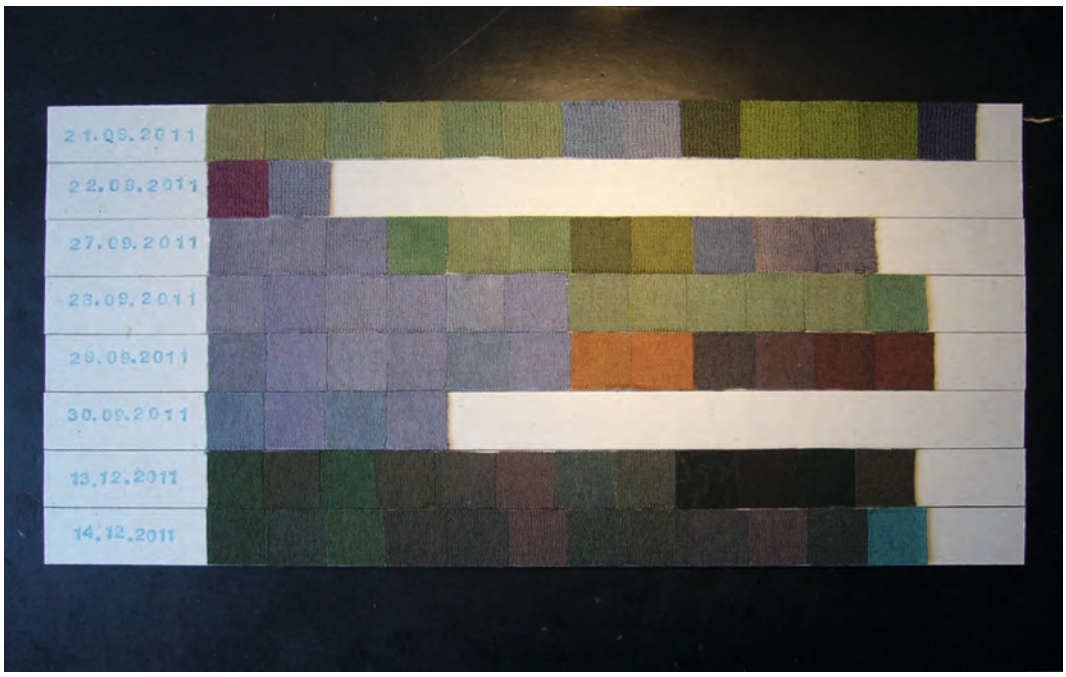


Figure 79 Visual Diary, 2011

The first Process Artwork was the *Visual Diary*. A cut square from each colour trial is glued side by side on two-centimetre wide cardboard strips, each strip equating to one day's dyeing activity. These dated strips of trial colours give an organized visibility to the dyeing output of the exploration phase in the dye lab.
As the exploration in the dye lab got more focused it became evident which dyed fabrics and recipes needed to be kept for further research. I took the redundant dyed fabric leftovers out of the folders and intentionally destroyed the well-organized structure. I selected the small pieces of fabric, the 'failures', and brought them together in order to observe and reflect upon them.
I arranged them, grouped and varied them again and again. I documented the various arrangements during this phase of composing by taking photos (Figure 81) in order to compare the manifold arrangements and forms created.

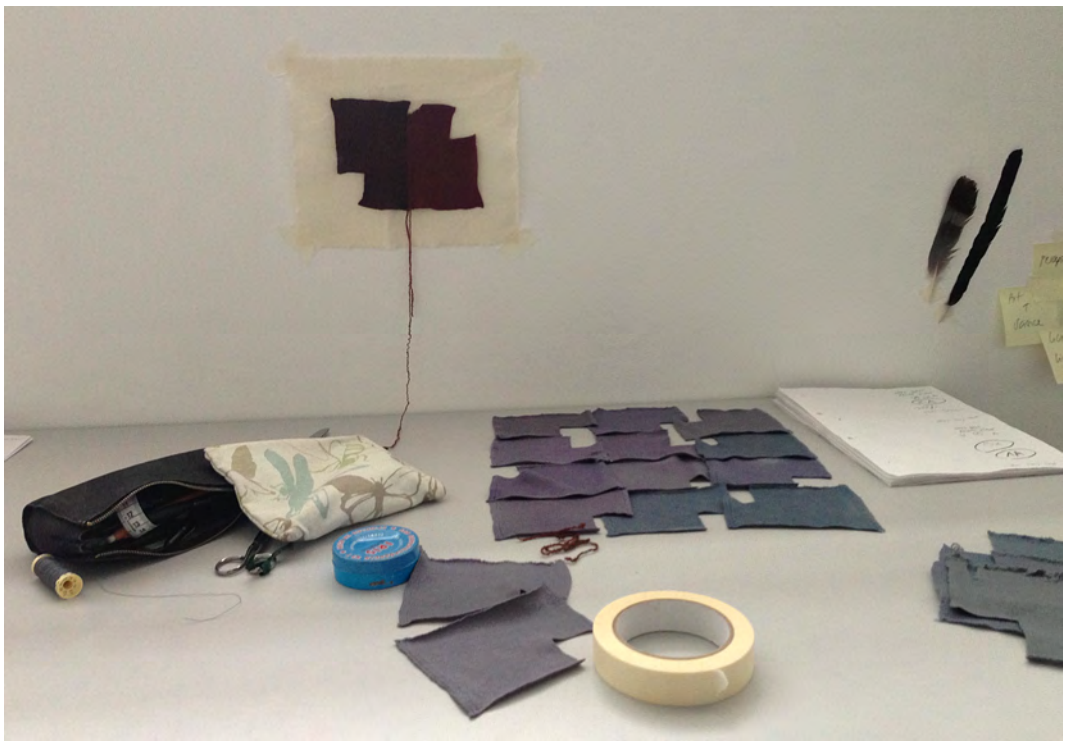
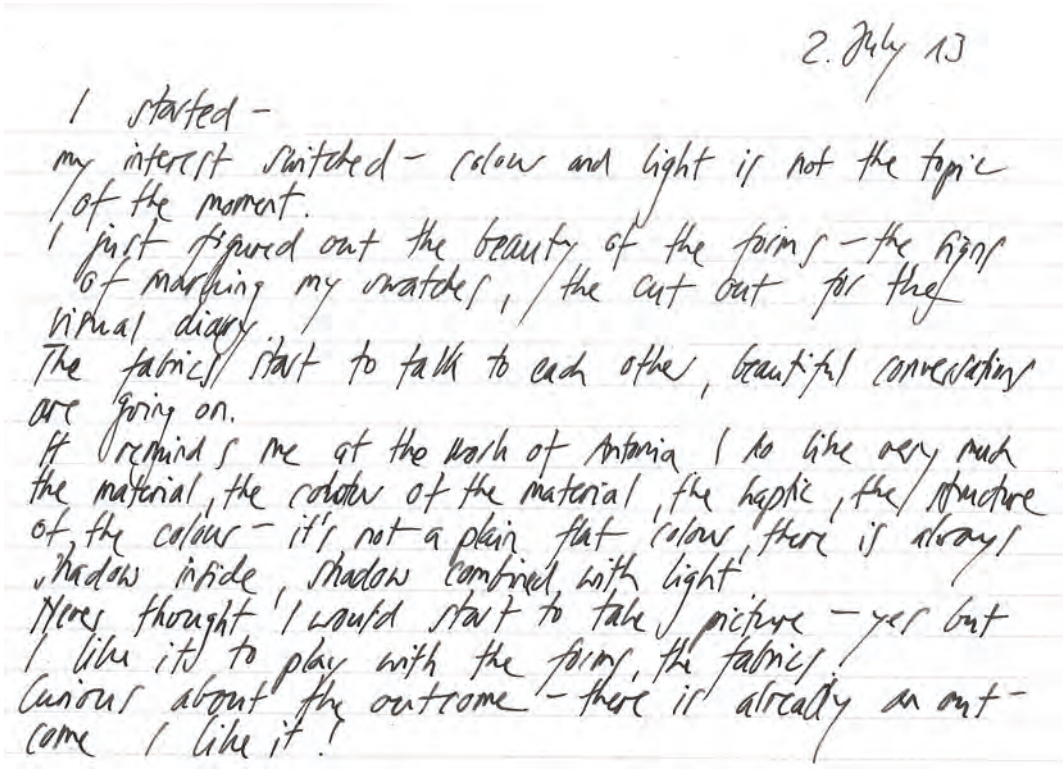


Figure 80 Development of Process Artwork: ‘Shades of Grey’

Figure 81 Documentation of Process Artwork Trials

On the 2 July 2013, in the middle of the process of arranging and observing, I noted in the research journal:


2. July 13

I started -
my interest switched - colour and light is not the topic of the moment.
I just figured out the beauty of the forms - the right of marking my swatches, / the cut out for the virtual diary.
The fabrics start to talk to each other, beautiful conversations are going on.
It reminds me of the work of Antonia I do like very much the material, the colours of the material, the haptic, the structure of the colour - it's not a plain flat colour, there is always shadow inside, shadow combined with light.
Never thought I would start to take picture - yes but I like it to play with the forms, the fabrics.
Curious about the outcome - there is already an outcome I like it!

Figure 82 Research journal, 02 July 2013

At this point I focused on the form and shape of the fabric arrangements and, as a method, to increase understanding, sketched the outlines of each displayed variation (Figure 83).

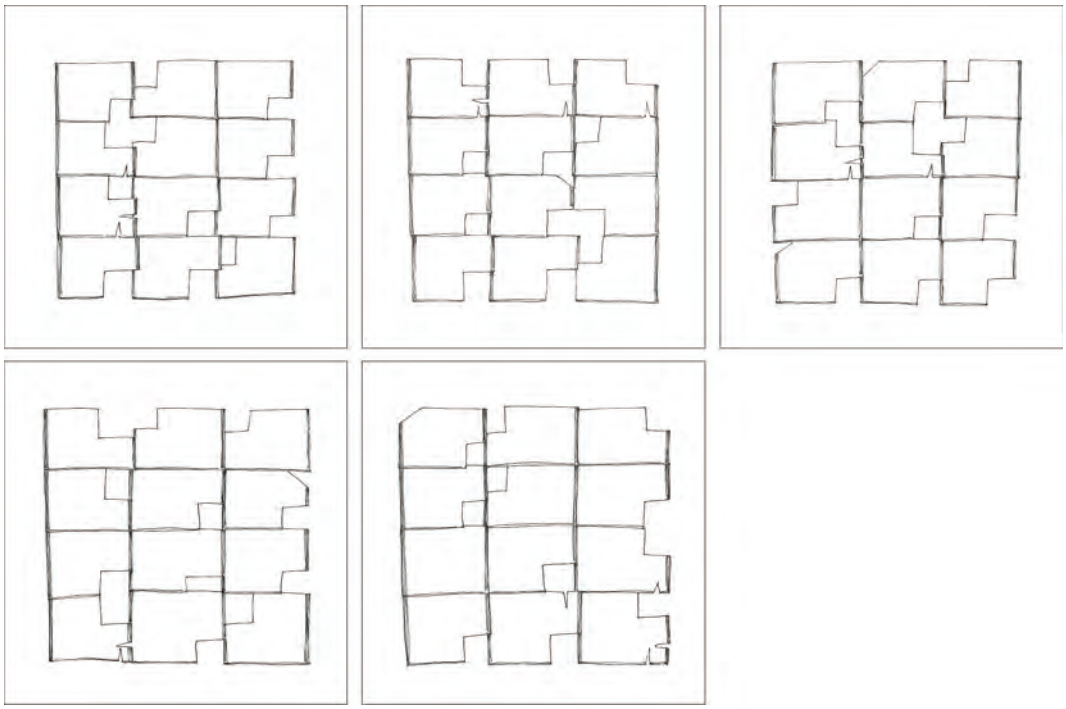


Figure 83 Sketches of shape and form of arrangement possibilities

I built concepts and consistently rejected them until I reached what I considered an arrangement with visually strong impact whose aesthetic look satisfied me. For this, my composition criteria were balance, form and colour placement: criteria, which emerged during the phase of the experimental lay out of the fabrics and their scrutiny. In this phase of the research my former trainings, my competence in aesthetic matters, supported me. The working method of creating and selecting fabrics, shaped by the research process, and the search for a meaningful concept for their grouping was driven by tacit knowledge (Ch 1.5.2).

As soon as the final composition was finalized as an artwork, the small dyed fabrics were patched together and sewn by hand on a substrate/backing material. The dyed fabrics were treated as colour areas and the material paintings created on neutral off-white backing fabrics with raw cut edges. I did not neaten the edges of the knitted fabrics, leaving loose hanging threads to underline the 'inbetweeness' of the Process Artworks, which were no longer mere colour samples even though they had not yet become the planned metameric artworks.

The group of grey fabrics found their final composition in the artwork *Shades of Grey*[37] (Figure 81).

[37] I am well aware, that this title recalls the book Fifty Shades of Grey (James 2011). Since the colour standard for this group of dyeing trials was a grey (Figure 25) and all the trials were shades of this colour standard, the title is appropriate.

Figure 84 Shades of Grey

7.1.3 Information contained in the Process Artworks

Besides being aesthetic in terms of my personal sensation of beauty, this material incorporates information on the process of making, as the fabrics give visibility to the various exploratory steps. As described in Chapter 6, during the exploration phase in the knit and dye lab many problems were encountered and steps undertaken to address these. The Process Artworks show information about the research procedure and the decisions I took; but the information is

deliberately not made explicit. Through the Process Artworks I offered a visual experience that reflects the process of problem-solving without verbal explanation.
The titles of these artworks are descriptive and hint, without being explicit, at issues encountered during the production, for example:
Knitting structure and form (rolling edges, tubular, full needle); ironed flat or just left as they were; dyeing failures; approximation and harmonization; general failure (obvious and unobtrusive); colour range.
In what follows below, I will reflect on these issues via two artworks, *rolling spine* (Figure 85) and *missing orange* (Figure 86).

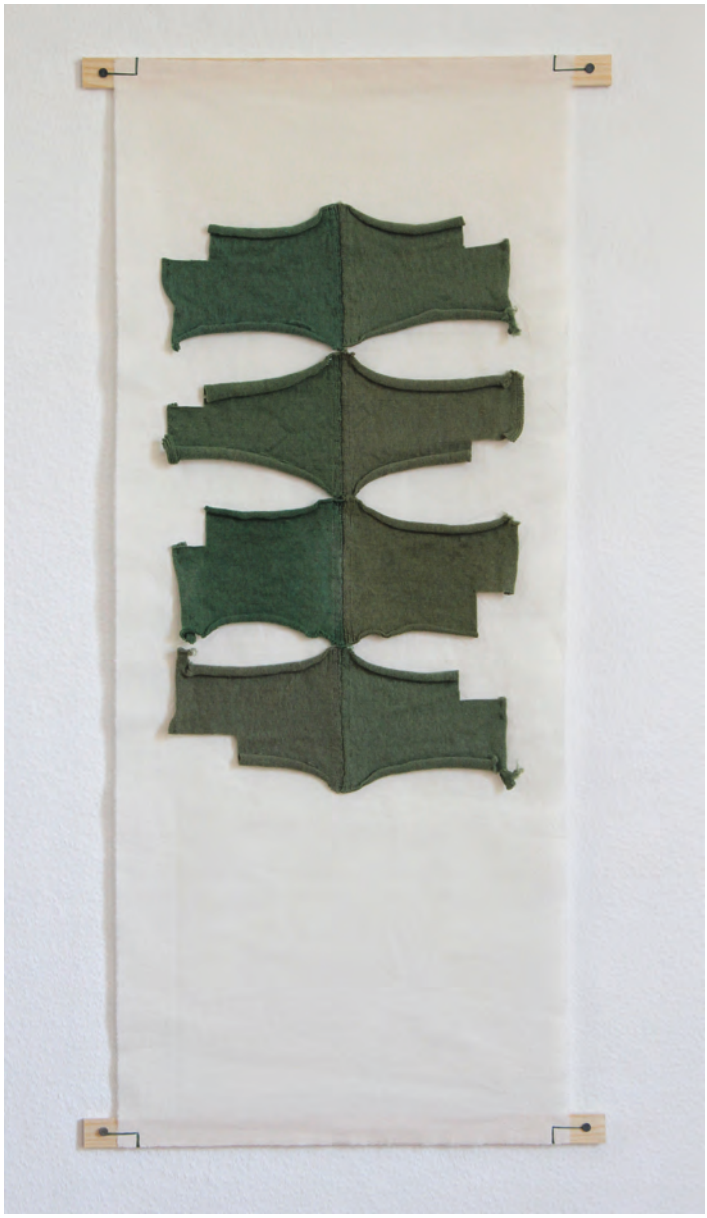


Figure 85 Process Artwork *rolling spine*

Figure 86 Process Artwork *missing orange*

7.1.3.1 Knitting structure and form

In September 2011, at the beginning of the research, my first trials were plain knitted fabrics cut into four gram pieces (Ch 5.1.3). This failed because it led to rolling edges, which did not allow an even dyeing of the fabric. The artwork *rolling spine* was realised with fabrics from this initial exploration phase, hence with rolling edges. The arrangement of *rolling spine*, with a straight middle line connecting four fabrics with rolling edges on each side, awakens the visual association of a spine with attached ribs. This visual impression gave the artwork its title.
The dyed fabrics composing *missing orange* were made with tubular knitted fabrics, the knitting structure finally decided upon for the project, which avoided rolling and guaranteed even dyeing.

7.1.3.2 Dyeing failure

The artwork *missing orange* was executed with dyeing variations of a brown colour (Ch 6.1.1; Amos Texwell nr. 2009). One fabric sample breaks the ranks of this brownish colour series, as in preparing the dyeing I forgot to add the orange component to the dyestuff and consequently the colour output failed. The Persian green colour thus produced steers the focus and draws the audience's attention. The artwork's title points to the error, which occurred in the dye lab.

7.1.3.3 Square cut for Visual Diary and Marking for differentiation

For the first realised artwork, the *Visual Diary*, squares of two centimetres of each dyed colour shade had been cut out. Thus most of the fabrics had this cut out square missing, indicating that a part of this fabric was already involved in another artwork (Figure 87).

Figure 87 Marking for square cut and differentiation

During the exploration phase in the dye lab I selected several recipes from the chart (Ch 5.3.2), which I assumed would fulfil my metameric criteria for a metameric colour series. I prepared the dye for these recipes, put each fabric into the dye baths in a metal tube and inserted all the metal tubes at the same time in the beaker machine.

Figure 88 Visualisation of the different markings for the assignment of recipe and dyed fabric

As all the recipes were intended to be the same colour under D65, I invented a system in order to be able to differentiate the differently dyed fabrics and assigned each fabric to one recipe. Hence the tubular knitted fabrics, before being dyed, were all marked with cuts positioned at different points (Figure 88, red signs) and on each recipe a small sketch of the assigned cut fabric was drawn (Figure 89).

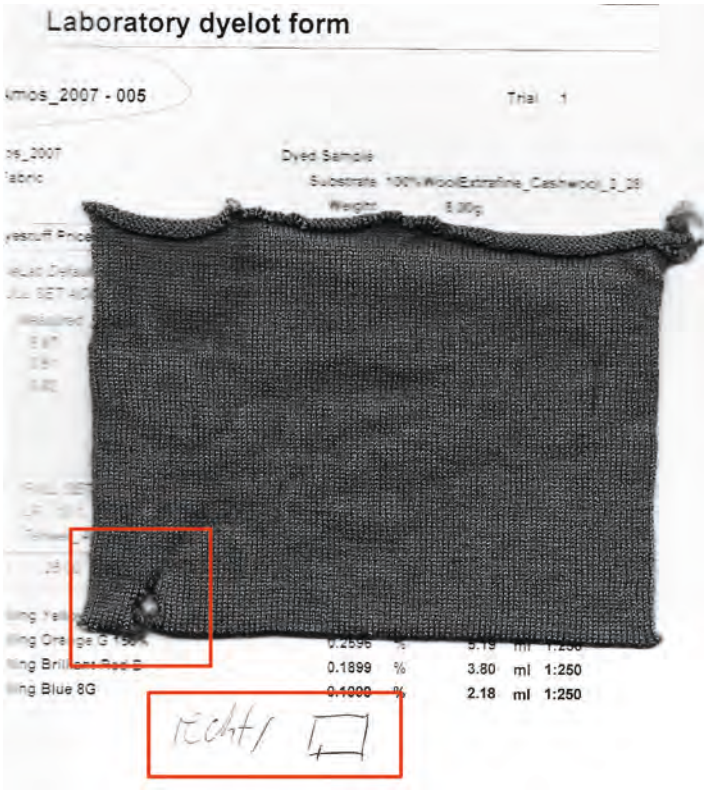


Figure 89 Recipe with attached fabric and sketch of cut.

7.1.4 Analysis

The Process Artworks reveal the colourfulness of one colour, a fine gradation of green, grey and brown; and their different variations circling around. The first phase of the research, approached with a physical and chemical attitude, studied the unique chroma of colour (Itten 1973, p.11, called it agent). In contrast, I created the Process Artworks as an artist and hence the visual colour effect, the 'psychophysiological color reality' (Ibid., p.19), was decisive.
The concept of the artwork *Visual Diary* was developed as a means to show all the dyed colours ordered by date to 'spatialize the chronological developments' (Hessler and Mersch 2009, p.17). Gray and Malins (2004, p.107) emphasise the advantage of visualization to make the steps of research clear. The Process Artworks fulfil exactly this function as they document and represent daily exploration in the dye lab. These clusters of colours, dyed with the various recipes for one colour, tell something about sameness, similarity and the processes of research: a tool or method for understanding and visually representing a crucial part of the research process.
'The eye and the mind achieve distinct perception through comparison and contrast. The value of a chromatic colour may be determined by relation to [ ] one or more other chromatic colors' (Itten 1973, p.19). As Itten writes, colour perception is influenced by comparison and contrasts. The colours of the Process Artworks are arranged and each colour has an effect on the neighbouring one.

Albers (2006, p.5) stated:

> We are able to hear a single tone.
> But we almost never (that is, without special devices) see a single color unconnected and unrelated to other colors.
> Colors present themselves in continuous flux, constantly related to changing neighbours and changing conditions.

Colour areas, which produce intense colour effects, compose the Process Artworks, and colour is 'the chief vehicle of expression' (Itten 1973, p.20). The simultaneous contrast (Itten 1987, p.52) triggers changeful, lively vibrations that elude conceptual verbalisation. Exploration of this idea will be resumed in later chapters (Ch 8 - 9).
The aesthetic impact of the play of colour shades completes the quantitative documentation and information in the folder. It is an artistic form of process communication picturing the daily work in the dye laboratory. The Process Artworks 'show that art and method can connect in a novel and constructive way' (Slager 2009, p.49). They offer a hybrid of artistic practice as research method and at the same time become artworks in their own right. The 'emphasis [is] shift[ed] from an art practice focused on final products to a practice directed towards an experimental, laboratory-style environment, exploring novel forms of knowledge and experience' (Ibid., p.49-50).

I presented and debated the *Visual Diary* (19 December 2011) and the artwork *missing orange* (01 August 2013) as an artistic practice as research method at the colloquia of the Thinking Through Practice (TTP) group (Ch 2.3.4) and gathered their feedback (Ch 1.5.4.1). In line with Gray and Malins (2004, p.21) I consider reflection on action and in action and discussions in peer groups as valid methods for ensuring research rigour.
This group asserted that this product of the process, assembled from different elements, was a statement of that process. They saw repetition and rhythm, differences beside similarities. The support fabric annoyed one group member, Rhiannon Pinchbeck (2013), who considered the woollen artworks as soothing and calming. The unfinished aspects, the unravelling of the fabrics, which indicated the topic of error and failure, intrigued Belen Cerezo (2013) and she liked the 'mess'. The artist group largely confirmed my statement, which I made above. They saw the Process Artworks as works with their own aesthetic value and confirmed that they considered these works to offer a valid visual art research method.

7.2 Knit as art practice

The creation of the knitted artworks was based on a conceptual, aesthetic approach, bringing together 'technique and expression' (Sennett 2008, p.65). The general knit development correlated with my experience as knit designer. However, the use of knit as a medium for art was new for me. In contrast to my former work experience there was no clear briefing so I had to approach knit in a new way. I remarked on the 17 September 2013 in the research journal

(Figure 90) that it is difficult to plan and presented, on the 25 September 2013, my doubts and my thinking to the Thinking Through Practice (TTP) group (excerpt: Figure 91 and Appendix 3).

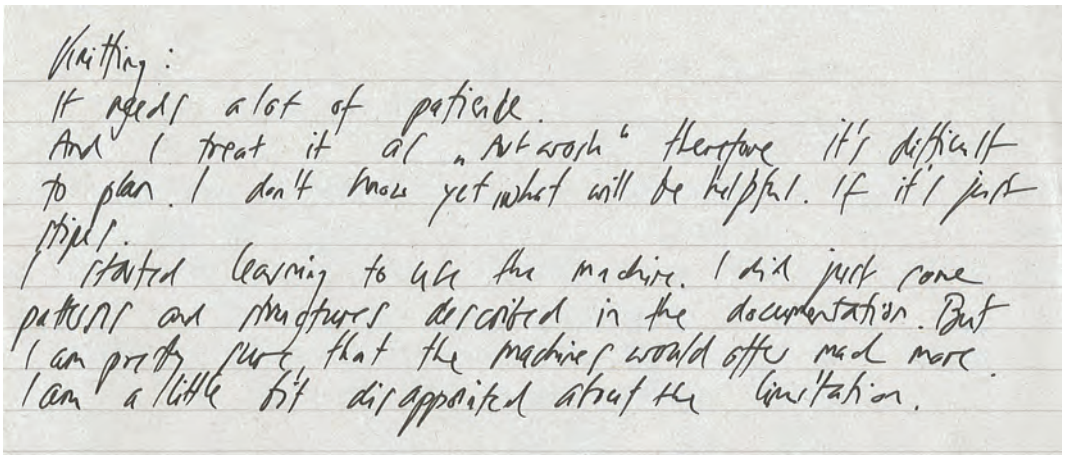

Knitting:
It needs a lot of patience.
And I treat it as „Artwork" therefore it's difficult to plan. I don't know yet what will be helpful. If it's just trial.
I started learning to use the machine. I did just some patterns and structures described in the documentation. But I am pretty sure, that the machine would offer much more.
I am a little bit disappointed about the limitation.

Figure 90 Research journal, 17 September 2013

> *I am just trying out, exploring. But what does it mean to explore knitting? How do I proceed? Do I have a plan? What shall I do in the meantime, waiting for the moment, when my ideas for the installation getting clearer.*
> *How do I observe my knitted fabrics, how do I reflect and document this process? This process of as well sitting around not knowing, what could be the next step.*

Figure 91 Presentation to Thinking Through Practice group, 25 September 2013

The process of the creation of an artwork involved various steps and decisions, often based on my former training and education where I had learned a 'vocabulary' of form and colour. The exploration and observation of knitted metameric fabrics was fundamental for the creation of artistic concepts and their realisation.
In the phase of the development of knitted artworks I collaborated closely with the knit technician Simon Johnson (Ch 5.1). We discussed my ideas, the technical possibilities and we searched for the best way to achieve their realisation.

7.2.1 Knit for observation to build up aesthetic criteria

From my industry experience as a knit designer I knew how difficult it is to envisage knitted structures and even knitted stripes. But, in industry, to save time and cost, we were asked to avoid the realisation in material of design ideas and visualized them with computer software (Adobe Photoshop, Adobe Illustrator, Shima Seiki, Stoll and Koppermann). The capability of this software has tremendously improved in recent years and some of these programs visualize knit structures as well as the quality of applied yarn[38]. These visualisations came close to the real but we designers, who were trained, had collected a lot of design experience over the years

[38] Several researches were done in the field of computer visualisation. Professor Magneat Thalmann is one of the pioneers in this field. She is founder of the interdisciplinary research group, miralab at the university of Geneva, CH. Yuksel et al. (2012) proposed an improved model for knit visualisation.

and hence had a good level of imagination, so we did not like to take decisions based only on visualisations. We preferred to judge the real materials and base our decisions on these. We preferred the real: the real material, the real combinations of colour, and the real material's haptic qualities. Before starting this research project, I observed metameric colour changes in industry, where it was judged problematic. Back then, I did not consider metamerism a poetic effect and therefore did not observe metameric colour changes from this perspective. I had never before worked consciously with metameric yarns and hence lacked a visual understanding, a 'vocabulary' for observing metameric colours and their colour changes under set light sources.

Figure 92 First knit observation in light box: left: D65, middle: A, right: F11

In September 2011 I started observations of metameric colour changes in the light box under the fixed illuminants (D65, A and TL84) (Figure 92[39]) with the dyed four-gram fabrics (Ch 5.1.3). In September 2013 I knitted the first metameric dyed yarns (Ch 6.1.1) and these knitted fabrics allowed the observation and exploration of metameric colour changes and a first assessment of their effects. As an initial step, I combined the yarns of the metameric colour series by plain knitting of various stripes with different heights (Figure 93).

Figure 93 Observation of striped metameric fabrics in illuminant D65, F11, A

Moreover, in September 2013, I knitted some smaller fancy structures (Figure 94) to observe whether the colour change is still visible/perceivable or if the structure is too fine and the effect gets lost.

[39] As already explained in Chapter 3.5.4, Figure 28 pictures just an approximation, as it's hard to capture the real colour of metameric material.

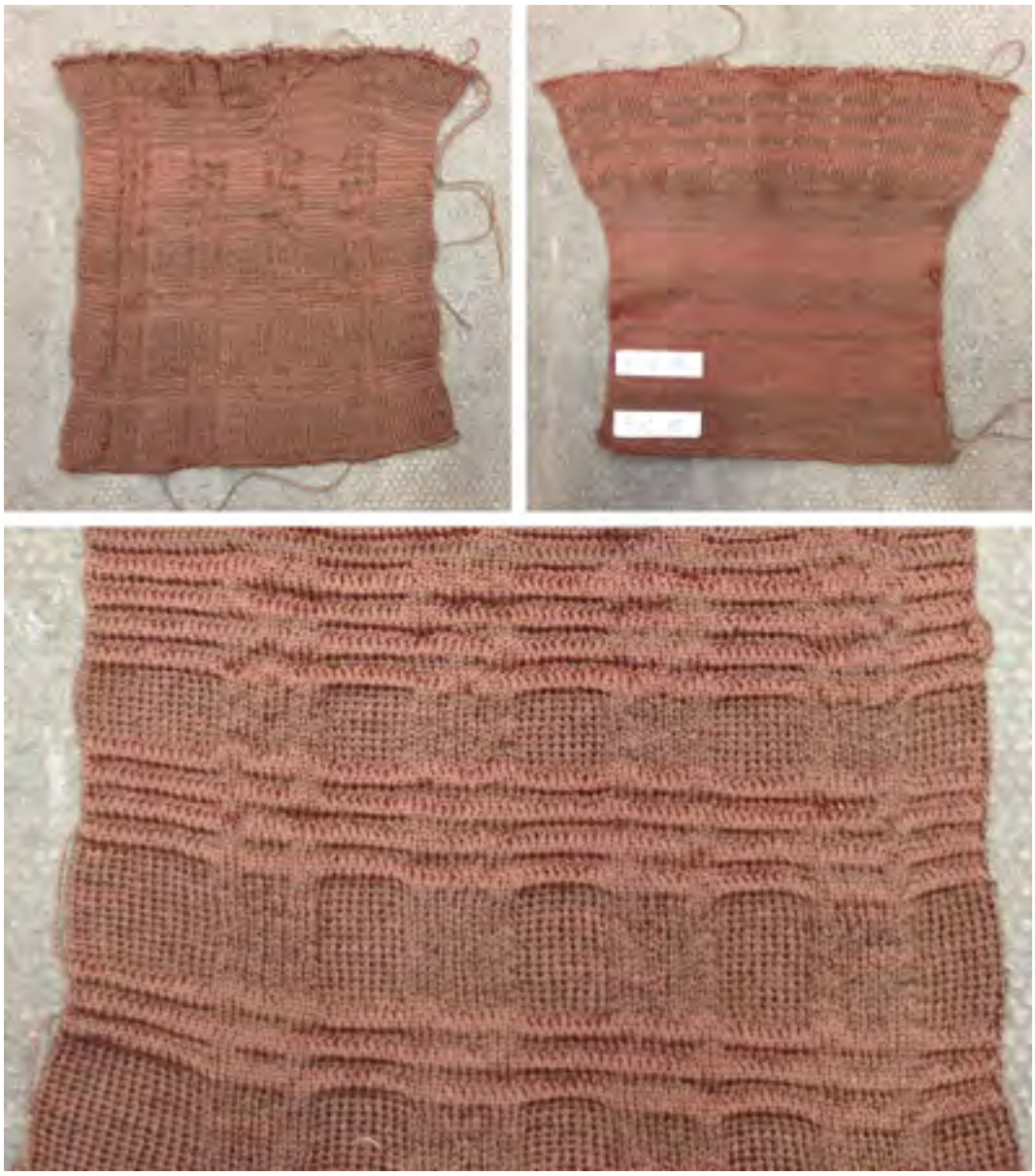


Figure 94 Various knit structures in metameric material

To build an understanding of metameric material, I needed to visually explore, observe and experience the real material made in the metameric colours with a new intention: to see possibilities for creation. Through the exploration of the effects of various structures and metameric colour combinations I increased my ability to imagine the potential impact of metameric effects, which enabled me to build concepts for artworks.

7.3 Remarks

The artworks, discussed in Chapters 8 and 9, addressed several subjects, which I introduce in the following sections. The remarks are underpinned by a multi-disciplinary literature review, which will later support my analysis of the artworks.

7.3.1 Remarks on colours

'Color is essentially an [...] interdisciplinary area' (Pastoureau 2014, p.9) and as Le Rider (2000, p.13) states: 'if we want to talk about colours, we need to consider the fields of philosophy, general linguistics, cognitive psychology, as well as culture, science and art history.' The focus of the previous chapters was on colour perception (Ch 3.2); connections between a light source, an object and an observer. This involved physics, physiology and psychology, and colour management, which were all needed for the creation of metameric material. Colour as a research field, with its inherent disciplines, is extraordinary fruitful and offers a broad palette of possible readings of fundamental problems and questions. Some of these (colour meaning, colour naming, colour perception) were explored in performances and installations (Ch 8 – 9). Wyler (1992, p.9) states that 'discussions of colour rarely distinguish between the various phenomenal areas' and 'often move between these'. In line with Wyler, in the performances and installations I did not demarcate singular areas, but let them fluidly merge.
Gage recapitulates the involved fields, stressing that visual art alone is able to integrate all of them by stating:

> Colour is implicated in physics, in chemistry, in physiology and psychology, as well as in language and philosophy; yet it is visual art alone that has engaged simultaneously with most of all of these branches of knowledge and experience. Thus, to know art goes a long way towards knowing colours… (2006, p.7)

7.3.2 Remarks on colour naming

> ... colour as a phenomenon exists in human awareness in its full complexity. That is to say colour is, as it is well known, a phenomenon of light and darkness, a phenomenon of vision and perception, a phenomenon of the segmentation or ordering of wave-lengths or frequencies, a phenomenon of ordering the visible environment, a phenomenon with semiotic and symbolic power, a phenomenon of emotion or human reaction, etc. Also colour is a linguistic phenomenon. (Wyler 1992, p.9)

One of the linguistic issues is the colour naming debate, which involves anthropology, linguistics and cognitive science and is discussed by several scientists and writers (among others: Berlin and Kay 1991, Wyler 1992, Zwimpfer 2012, Le Rider 2000, Choudhury 2015)

> There seems to be no end to the questions that can be asked in the context of colour terms. This complexity and its inherent drive to always beg more and newer questions, is, it seems to me, the cause of the almost irrational fascination that springs from speaking about colours. (Wyler 1992, p.11)

When we learn our mother tongue, we learn the names of colours; it is learned knowledge from the everyday. We link the names of colours to objects, as described in the children's book (Lionni 1997) mentioned in Chapter 8.1.2): Elephants are grey. Pigs are pink. Frogs are green. Apples are red.
But what does red look like?

> If one says "Red" (the name of a color) and there are 50 people listening, it can be expected that there will be 50 reds in their minds. And one can be sure that all these reds will be very different. (Albers 2006, p.3)

The perception and imagination of colours is subjective (Ch 3.4), which makes it difficult to talk about the specificity of a single colour. Each colour can be described by words, but as Albers wrote, the verbal description of colours is not distinct. Thus systems were invented to allow a smoother communication in the field of colour, as with Pantone[40], linking a colour sample to a specified number. Colour management software, crucial for the development of the metameric material, solves this problem with quantitative colour description, assigning each colour shade a physically defined profile (Ch 3.4), which enables consistent communication.
Colour names are descriptive, operating often in combination with basic colour terms: 'white, black, red, green, yellow, blue, brown, purple, pink, orange, and grey' (Berlin and Kay 1991, p.2). As this research is mainly working with an olive green colour, the category 'green' and its inherent colour terms were of particular interest and are listed (Appendix 3).
In the past, pigments from various materials were the basis for colour manufacture and the material determined colour names (among others malachite, celadon green, emerald green). 'Green is the color of the vegetable kingdom, the mysterious chlorophyll involved in photosynthesis' (Itten 1973, p. 136). By association with objects in nature various green colour terms were given (among others moss green, fern green, pine green). A further possibility in colour description is the lightness and darkness of a colour (dark green, light green).
Myriad colour names already exist and the colour industry, incessantly creating new fashionable colours, invents new names.

7.3.3 Remarks on colour meaning, focus on green

The historian Michel Pastoureau specialised in the history of colour. He recounts in his book 'green' 'the long social, cultural, and symbolic history of green in European societies, from Greek antiquity to the present' (Ibid. 2014, p.7). He shows how the perception and meaning

[40] 15-0343, 'Greenery' is the Colour of the Year 2017, fixed by Pantone.

(psychological, symbolic, traditional, cultural and political) of the colour green is changed and shaped through culture and history.
A high percentage of participants in Eva Heller's (2013, p.81) survey consider green a soothing colour and link words such as 'ease, calm, pleasant, security and tolerance' to green.
Pastoureau notes that green, following blue, takes second place in rankings of favourite colours.

> For more than a century in Western Europe, all the opinion polls very consistently show that green comes in second after blue when people are asked to name their favourite color. The results are identical in all countries, from Italy to Norway, from Finland to Portugal. (Pastoureau 2014, p.219)

These results are astonishing, as Pastoureau (Ibid., p.7) further remarks on the apparent ambivalence and ambiguity of this colour: 'a symbol of life, luck, and hope on the one hand, an attribute of disorder, poison, the devil and all his creatures on the other.'
Part of the bad reputation of green goes back to former methods of colour production, which included toxic substances. But association also influences colour effects. Mould on food looks generally greenish and, as mould can be toxic, green is considered poisonous.
Green was for a long time 'difficult to produce and even more difficult to fix' (Ibid.), hence green dyed or painted material had bad colourfastness, changed and faded over time. This influenced the meaning of green fundamentally.

> Chemically unstable, as much in painting as in in dyeing, through the centuries it has been associated with all that was changing, changeable, and fleeting: childhood, love, hope, luck, pay, chance, money. (Pastoureau 2014, p.7)

As described by Pastoureau, green 'has been associated with all that was changing', hence this project, having at its core metameric colour changes, uses a symbolically loaded colour to show colour changes, creating a doubling of this effect.

7.3.4 Remarks on light and ecology

In 2012 the traditional light bulb, once a great development that illuminated houses for around 130 years, was banned by the European Union (Willenbrock 2009). From this date, artificial light is required to be energy saving and efficient (e.g. halogen, neon or energy saving bulbs).
Willenbrock states that these light sources, according to manufacturers' data, consume only a fifth of the energy of 'old' incandescent light bulbs and have a much longer life span. Wolfgang Herter, as described in the article, tested various lamps and his results show that energy saving lamps do not deliver the expected fundamental improvements and neither are they a real alternative to the 'old' light bulb. These results, published in the journal 'Öko Text' sparked a huge uproar, yet even climate scientist Ottmar Edenhofer, cited in the same article, finds this ban to be a 'nuisance and blind actionism'.
The commission of the European Union defended their decision by stating that climate protection is a serious issue. Light planner Katja Winkelmann, also cited in the article,

elucidates emotional aspects of the light bulb ban. She suggests that halogen and the 'old' incandescent light bulb offer the closest colour spectrum to daylight. Energy saving bulbs and LEDs, by contrast, cancel some colour nuances found in the daylight spectrum. The hormone serotonin is affected by daylight. Light designer Ingo Maurer takes a critical stance towards current innovation in the field by predicting a 'boom for psychiatrists' because of this loss of nuance. As with examples given earlier (Ch 4.1.2) innovations in the field of light have long provoked fear and controversy and continue to do so.

7.3.5 Remarks on light in everyday life

Light is an everyday occurrence, a medium of the everyday. We are aware how natural light is on a sunny day and how different the light is on a foggy day. But I doubt that we have a conscious perception of the different qualities of natural light during the day[41]. We think we know light; we think we know the differences between different light sources, as this belongs to our everyday experience and knowledge (Heller 1984, p.185). But do we realise consciously that evening light has a reddish touch? Do we consciously experience the light qualities of different ambiences as we sojourn? We are daily in the ambiences of various artificial lights, which we cannot choose. I am pretty sure we do not realise how or what the light quality is; we just accept it.
Is it a warm or a cold light, and which light would we prefer?
Light has a strong influence on how we perceive colours but we are often aware of its effect[42]. As Pastoureau (2014, p.8) writes: 'who among us remembers it when visiting a museum or exhibition?'

> Furthermore, we see these colors in lighting conditions very different from those of the societies preceding ours. The torch, oil lamp, candle, and gaslight produce different illumination than electricity provides. (Ibid.)

As further elucidated in Chapters 8 and 9, I offered to audiences an experience of everyday light and invited them, through performances and installations, to explore the colour effects triggered by different kinds of natural or artificial light, heightening this awareness.

7.3.6 Remarks on everyday life

The decision to work with common light sources (Ch 4.1.3) led one focus of the research to the philosophical notion of 'everydayness', as discussed in the fields of philosophy, sociology and art history (by, among others, Lefebvre 1977, Heller 1984, de Certeau 1984, Felski 1999, Johnstone 2008, Perec 2008, Sheringham 2009, Highmore 2012). Felski (1999, p.15) defines the everyday life:

[41] Glasauer and Kracher (2007, p.323) state that 'our perception of colours of light sources is remarkably bad' and they add, that 'we perceive the colour of a traditional light bulb in day light as yellow, but by night, we perceive it as white.'
[42] Some people are aware of colour inconsistency triggered by light. In fact, quite often customers in clothing stores ask to see clothing additionally in daylight.

> After all, everyday life simply *is*, indisputably: the essential, taken-for-granted continuum of mundane activities that frames our forays into more esoteric or exotic worlds.

The everyday is the time we live in daily. It is the repeating of practices and tasks, a term 'synonymous with the habitual, the ordinary, the mundane' (Felski 1999, p.15); 'we are all ultimately anchored' there (Ibid., p.16). How often in the evening do we not know how the weather was during the day, just because we were not aware of our surroundings?
The association of the everyday is as something opposite to the exceptional. We do not expect surprises in the everyday. Daily life can be seen 'as the realm of monotony, emptiness and dull compulsion' (Ibid., p.17). However, some people value the qualities of daily routines; the everyday offers order and stability.
Is our daily life humdrum, day in day out? Or could there be surprises, little wonders, if we would only slow down our pace and look to our right and left? Mostly 'we look but we are unable to see' (Lefebvre 1991, p.132). In the daily rush we are not in the mood for sensing, for stopping, for slowing down and we miss all the small and subtle wonders happening at the edges. 'If the everyday is the realm of the unnoticed and the overlooked, however, it might be asked just how we can attend to it? How do we drag the everyday into view' (Johnstone 2008, p.13)?
With my research, I intend to 'drag the everyday into view' and to take the audience by the hand, guiding them to experience the impact of light and colour consciously.

7.3.7 Remarks on affective and aesthetic experience provoked by art

In 2012 I visited the Sean Scully retrospective exhibition 'Grey Wolf' at the Kunstmuseum Bern, Switzerland and was touched by the artworks, I even had tears in my eyes. Generally, strangers do not talk to each other in exhibitions, but this time, an unknown elderly couple approached me and asked why these different grey-coloured spaces, side by side, excited emotions. It does not happen to me often, that I am moved to tears by an exhibition and it was the first time that I got approached by unknown people having a similar experience. The curator Frehner (2012, p.12) was also emotionally touched and stated that 'the painting radiated an energy that assailed [him] like gusts of wind'. But how is this quality/this effect created?
Peter De Bolla (2001) in his book 'Art Matters' sets himself the 'task to arrive at a better understanding of what it is to be moved profoundly by a work of art' (Ibid., p.3) and he calls such encounters '"affective" or "aesthetic"' experiences (Ch 1.5.3). Noël Carroll (1999, p.160) describes the encounter with an artwork in the following:

> ... our attention is engaged by its sensuous forms, its aesthetic properties, including expressive ones, and its design. We peruse the object, we let our attention roam, but not aimlessly, since what we see and hear has been structured to guide our attention along certain pathways, rather than others. (Carroll 1999, p.160)

As an artist working with a physical colour phenomenon, which vexes perception, my intention was to guide the attention of audiences, through my artworks, along a pathway towards the

fields of colour, light and perception. In addition, this written thesis is, as De Bolla's book, an attempt to overcome the 'inarticulacy' often ascribed to aesthetic experiences (2001, p.4). I am well aware of the inherent difficulty described by Itten: 'Yet the deepest and truest secrets of color effect are, I know, invisible even to the eye, and are beheld by the heart alone. The essential eludes conceptual formulation' (1973, p.11).
Generally, De Bolla (2001) attributes to the aesthetic an experience of radical singularity, and asserts:

> However, and here is the sting in the tail of the radical singularity of *aesthetic* experience, these themes and approaches appear to me as attributes of the works themselves. In other words, they tell me something not only about how I tend to approach these specific works but also about those qualities I perceive to be internal to them. Given the latter perception, I believe these qualities to be perceptible to others as well. (De Bolla 2001, p.131)

In line with De Bolla, I believe that affective qualities can be internal to artworks and Scully's artworks are an example, as their grey colour areas, related to each other side by side, appear to vibrate and to trigger emotional effects.
My aim was to create such qualities, perceptible to a broad audience. I am aware that experience is 'contaminated by the myriad filters through which we perceive and come to understand both the world and ourselves' (Ibid. 2001, p.14) and that 'the aesthetic dimension is qualitative' (Carroll 1999, p.190). This must be taken into account with regard to the responses of audiences.

7.3.8 Remarks on wonder

Lorraine Daston and Katherine Park (1998, p.18) wrote a history of wonder covering the period from 1150 -1750 and, in their book 'Wonders and the Order of Nature', they foreground the alternating prestige of wonder from reputable to disreputable. Descartes described wonder as the first of all passions:

> When the first encounter with some objects surprises us, and we judge it to be new, or very different from what we knew in the past or what we supposed it was going to be, this makes us wonder and be astonished at it. And since this can happen before we know it the least whether this object is suitable to us or not, it seems to me that Wonder is the first of all the passions. (Descartes 1989, p.52)

A wonder is an incident whose derivation, on the first impact, we are not able to explain or grasp totally. It is a feeling that emerges when we see or experience something unexpected, triggering astonishment. De Bolla describes such encounters in the context of art as follows:

> The physical encounter rapidly mutates into a jumble of thoughts, as if an impulse – call it a spark of affect –sets in motion a series of reactions that leave their trace in whatever permeable surface they encounter. For some viewers that surface is identifiable as "emotion," for others it is more like "ratiocination." (De Bolla 2001, p.2)

He (Ibid., p.3) considers 'this state of "in-between-ness," as it were, part physical and part mental' as 'one way of describing wonder'. Descartes stated: 'And it can be said in particular of Wonder that it is useful in making us learn and retain in our memory things we have previously been ignorant of. For we wonder only at what appears rare and extraordinary to us' (1989, p.59) and Francis Bacon considered wonder the seed of knowledge (1998, p.11).
As introduced in Chapter 1.5.3, I disagree with the claim that 'affective experiences do not lie within the realm of the cognitive' (De Bolla 2001, p.4) and in line with the thinkers mentioned above, I consider wonder as an important impulse for learning. Mysterious artworks may 'make visible what is unknown or unknowable' (Ibid, p.12) but we 'sense the artwork as containing something [we] strive to uncover or appropriate (Ibid., p.13). De Bolla prefers to 'call that state of "wonder"' 'a knowing rather than knowledge since it is more like a state of mind than an item of knowledge' (Ibid., p.135). This knowing 'does not lead to certainties or truths about the world or the way things are' (Lee 2007).
Wonders are subtle instances, needing contemplation to be perceived. An experience of wonder can be a genuine access to the world. Wonder affects us and the emotion sparks long-lasting sensation and sustained impressions: it 'is an impression of pleasure in itself' (Bacon 1998, p.11). With my artworks, I was keen to share the pleasure of the experience of the marvellous metameric phenomenon.

7.4 Conclusion

As introduced in Chapter 1 (Ch 1.4.3.2) visual methods were fundamental for the documentation of this research. In this chapter I presented an original artistic form of this. I visualised the first phase of the research, the creation of metameric material, through artworks 'tied to the process of producing' (Leavy 2015, p.30). For a long time, the dyeing experiments resulted in the production of coloured swatches illustrating subtle colour differences.
Yet what had been well documented and sorted into folders felt hidden. Thus, the created artworks, as a form of an aesthetic visualization of this first phase of the research, made the process visible and traceable in an artistic way. I transformed the 'data' (Ch 6.4) filed in folders into artworks and thereby gave artistic value to this fundamental part of the research.
These clusters of similar colours contain the different steps and decisions taken during the project development. The artworks visually communicate the process of the explorative practice in a subtle but concise form.
The Process Artworks stand autonomously and are not intended to need explicit explanation: they are an artistic form of communication, which does not depend on the functional information of data, instead taking on the expressive role of a creative process. 'Visual representations arrange, connect, form and integrate knowledge and create thereby coherence, where possibly

a merely discontinuous order of results is available' (Hessler and Mersch 2009, p.17). In line with this, I revealed the coherence of the research process through these artworks.
For a long time I dealt with the delusion of not yet having reached the final target. The outcome of my dyeing, the multiplicity of the dyed fabrics made as I sought 'success', taught me the difficulties of accurate dyeing. I had to accept these 'felt difficulties' (Dewey 1933, p.107), these constant failures. By integrating them into the research process they became a method. The resulting visual artworks embody and reflect upon the artistic process of documentation, which in turn informed the distinct methodology of this artistic investigation.

Hessler and Mersch (2009, p.11) reproach 'humanities, as they still doubt the power of insight of images and are reluctant to concede them their own logic'. They argue, 'that images in natural and engineering science have, for a long time, been a constituent part of the process of cognition.'
In line with Hessler and Mersch I argue that these artworks (considering them as images, as visual material) have their own logic and are a valid tool in tracing the lab process. By knitting together the thread of meaning with the thread of practice they contain insights into the process.

Through the processing of colour samples and their transformation, a 'problem' created by unexpected surplus material and through embracing failure, the act of incorporating this failed material into artworks gave the research a very important input. The Process Artworks are a crucial method in this process, and the concepts for further installations and performances were strongly nurtured by the exploration and experiences gathered in this way. The development of further concepts has been based on the outcome of these subordinate targets.
Before I was able to build concepts for artworks I needed to gain a visual understanding of metameric materials and their effects. Hence, through various knitted variations I explored the metameric material and, through observation under set illuminants, built up a visual metameric 'vocabulary'. This learned 'vocabulary' enabled me to imagine concepts for artworks.
In this research, knit is the medium for the realisation of artworks. Through trying out structures and colour arrangements, I had to build up the aesthetic criteria for these artworks.
Remarks on manifold issues (colour, colour naming, colour meaning, the colour green, light and ecology, light in the everyday, everyday life, wonder and emotions provoked by art) are outlined, building a context where the artworks following could be discussed (Ch 8 - 9) and embedded. These sections establish a basis for analysis of the artworks and offer a preparation for the chapters that follow.

8 Art practice part 2

Outline

This chapter illustrates a part of the art practice of the second phase of this research: the conceptualisation, production and presentation of performances and installations. Here, the metameric material, the development of which was discussed in previous chapters (Ch 5 - 6), was essential. In contrast to the first phase, strongly based on science and technology, this second phase was approached with an Art Research (Ch 1.3) attitude requiring artistic modes of investigation (Figure 3).
Based on the metameric 'vocabulary', described in Chapter 7, I built concepts for artworks, as described and discussed in this chapter. These artworks, shown and tested in various contexts, are analysed on the basis of the remarks introduced in Chapter 7.3, within analysis informed by informally gathered feedback from audiences (Ch 1.5.4.1) alongside personal reflection (Ch 1.4.5).

8.1 Performance *green-green-green*

Presentation performance *green-green-green*

Location	Nottingham Trent University, Nottingham, UK During Summer Lodge[43] 2014
Date	10 July 2014
Duration	Approximately fifteen minutes
Documentation	https://www.researchcatalogue.net/profile/show-work?work=397531

Presentation performance *green-green-green*

Location	Progr[44], Berne, CH
Date	07 September 2014
Duration	Approximately fifteen minutes

8.1.1 Background and concept of the performance *green-green-green*

When I planned the research journey I did not expect the metameric phenomenon would be as remarkable as it is in 'uncontrolled' light situations or that the colour change would happen with

[43] Summer Lodge is an annual two-weeks residency at Nottingham Trent University, UK, offering space for practice, discussion and exchange to Fine Art staff, PhD students and invited artists. Participants are working over the period of two weeks alongside one another on their own art practice in the studio spaces of the University.
[44] Progr is an artistic centre and cultural hub in Berne, CH, offering various studio spaces for artists and creative businesses and as well for cultural institutions and galleries.

a broad palette of non-defined fluorescent and incandescent light sources. I intended to realise the installations with purposefully built light boxes using intentionally set illuminants. In 2013 (Ch 4.1.3) I discovered that my metameric samples changed colour constantly in ordinary light situations, as found in the University building. This discovery brought me to consider different ways I could move my artworks around buildings so that normally present light sources would trigger colour changes. As I wrote on 12 December 2013 in my research journal:

> *I would like to do a performance during Summer Lodge 2014. In a green dress, just walking around and talking – performance lecture – the script about light, about colours. A green dress, red cheeks and the performance would be called 'Bonington'.*

Figure 95 Research journal 12th December 2013

Following this note[45], I abandoned the anticipated light boxes and adopted performance[46] as an appropriate medium and method to explore and disseminate this research. As described and discussed in the following sections, as well as in Chapter 9, with myself as performer[47] I used the 'permissive, open-ended medium with endless variables' (Goldberg 2014, p.9) and took the knitted metameric dress 'directly to the public' (Ibid.).

[45] Bonington is the name of the building where the Fine Art department and the dye and knit lab of the Nottingham Trent University, UK, are situated.

[46] 'Performance became accepted as a medium of artistic expression in its own right in the 1970s' (Goldberg 2014, p.7). I use the term performance, as defined by Schechner (2006, p.2): 'any action that is framed, presented, highlighted, or displayed is a performance.'

[47] As described in Chapter 1.2. I am a trained performer with performance experience.

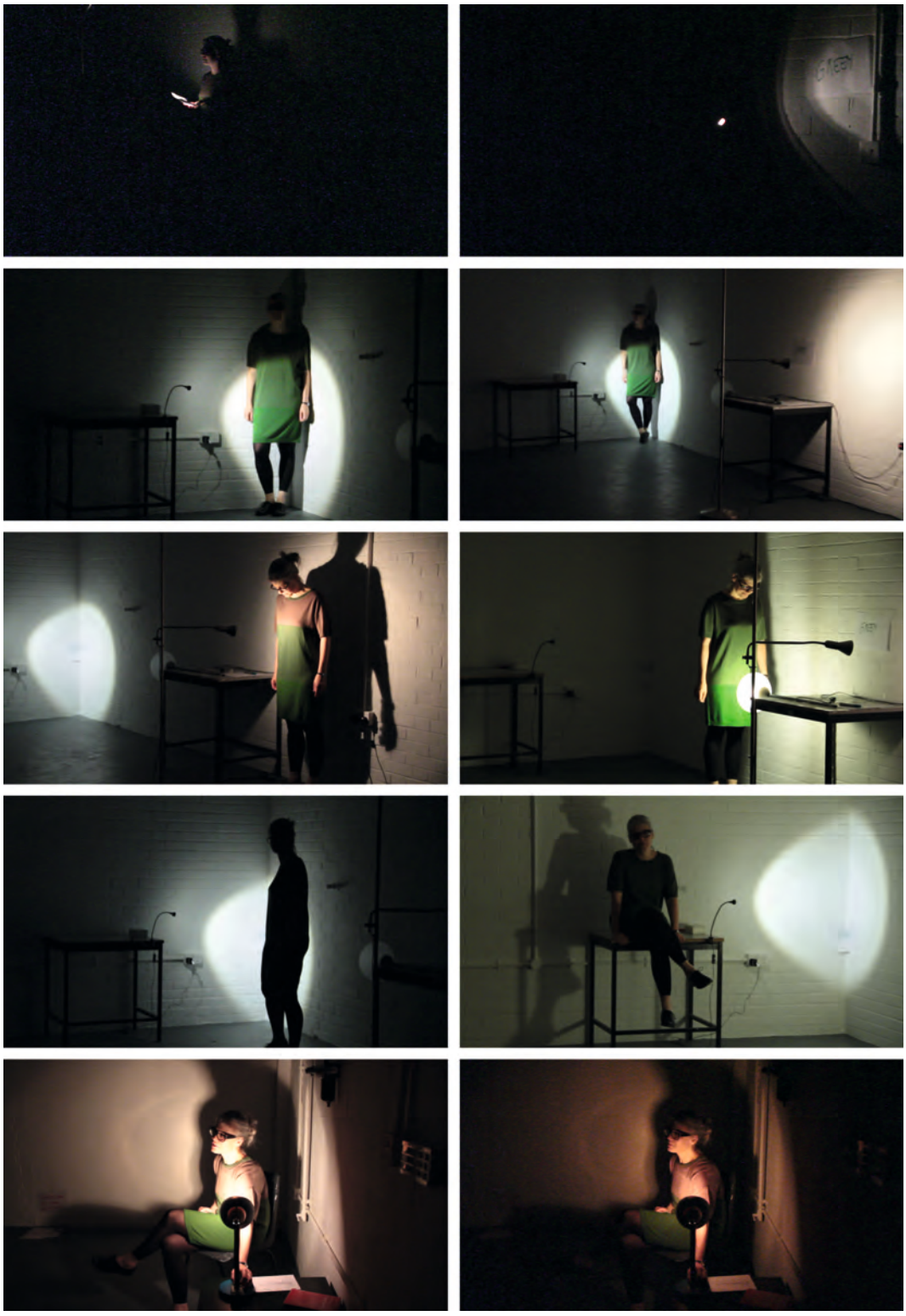


Figure 96 Still images of performance green-green-green, NTU, 2014

8.1.2 Production of the performance *green-green-green*

The production of the performance required as a first step, the creation of a metameric costume. For this I used the three olive yarn shades, the three-part metameric colour series, which I dyed in April 2014 (Ch 5.3). The knitted metameric dress, holding and revealing the potentiality of colour changes, is the performative headliner; the resulting performance is in a medium of colour and expression, a 'form of visual art', as Hollander (1993, p.311) stated.
For the creation and development of the dress I benefited from my design experience and knit knowledge. The main goal for the dress was to act during performances as carrier material showing the subtle metameric colour changes, and thus raised questions: How should the dress be designed and shaped to act as a support for metameric colour change? How should the three metameric colours be arranged within the form of the dress?
The dress had to be very basic without specific details or references to any particular era or fashion period, since its form should not attract major interest from audiences.
I sketched different options for shape, details and arrangement of colours as a basis for decision-making. Initial ideas circled around a striped dress with optional horizontal or vertical alignment, and a final decision on the colour arrangement was taken after discovering Blinky Palermo's (1989, p.100) Stoffbilder (fabric pictures), in particular the Stoffbild *green-green-green*. 'The *Stoffbilder* are fabricated, quite literally, from commercially available bolts of cloth purchased from department stores in the desired colors' (Rorimer 2003, p. 65). *green-green-green* is composed of three 'broad bands' of different green shades 'horizontally placed one above the other' and sewn neatly together 'in order to create smooth, separate fields of solid color' 'attached tightly to a stretcher' (Ibid.). Rorimer adds that 'the *Stoffbilder* are made with a matte cotton yardage whose surface texture and weave do not distract from their communication of color.'
In my own case, it was important that neither texture nor the form of the dress would distract from the communication of colour, and in particular the metameric colour changes. In contrast to Palermo's work my dress is knitted, in order to hide the transition between the three horizontal colour blocks, meaning seams could be eliminated and the effect of wonder increased. My three green shades are also not at all ready-made; I developed and created my olive metameric colour series over a long period in the dye lab (Ch 5 - 6). The three green shades are principal performers[48]: hence the name of the performance, *green-green-green*, adopted from Palermo's work. Beside the name I adopted the arrangement of colours from Palermo's work, using three colour blocks for the creation of the dress.
After sketching, reflecting and evaluating, the shape and details of the dress were fixed in May 2014 and the producer, Point Tricot in Italy, realized the dress following my instructions (Appendix 4). To avoid confusion in the production process, knowing that the apparently unicolor looking yarn could easily be mixed, I marked yarn cones carefully and called the

[48] There were other performances, which had a specific colour at their core, among others: Yves Klein showed *The Anthropometries of the Blue Period* in 1960 in Paris (Goldberg 2014, p. 145-146) and Gilbert and George performed in 1975 in Tokyo *The Red Sculpture* (Goldberg 2014, p. 168 -169).

producer's attention to the particularity of the yarn colours and the vital importance of correct placement for the three shades of olive.

I prepared and showed the first performance of *green-green-green* during the two-week residency, Summer Lodge 2014 (Ch 8.1). For a venue, I chose a room[49] without windows in order to be able to create a distinct light setting without other interferences.

During the first week of Summer Lodge I investigated literature from various fields (light, colour, colour naming, perception), which I considered helpful for the creation of this performance. 'Remarks on Colour' from Wittgenstein (Wittgenstein 2007) intrigued and inspired me. I also found philosophical approaches to colour in various children's books[50]. I reviewed material, which I had collected since the beginning of the research, and wrote texts about personal experiences and memories of light and colour.

I already knew how my fabrics looked under the set defined illuminants (Ch 7.2.1), as during the first phase I constantly observed and compared the colours in these lighting conditions. But I had not yet consciously and systematically explored my fabrics under commercially available everyday light sources. In order to decide the light setting of performances, I first observed my fabrics in the light of various lamps with different light bulbs. I observed the shape of the light shades (Figure 97) and the triggered colour changes in the three green shades (Figure 98).

[49] Room BON 018, Bonington Building, Nottingham Trent University, UK.

[50] Lionni 1997, A color of his own; Lionni 1995, Little Blue and Little Yellow; Galler 1970, Nimmerfroh und Immerfroh; Daywalt and Jeffers 2013, The day the crayon quit.

Figure 97 Light sources and shades

Figure 98 Testing light sources: left under fluorescent light, right under incandescent light

To observe the impression of the light of different bulbs I directed their lights onto a white wall and compared the colour of these ‘white’ lights. Generally halogen light is accounted to be warm light, and fluorescent light (energy-saving) accounted as cold light. This assumption goes back to the time when neither halogen nor fluorescent bulbs were very sophisticated. Today energy-

saving bulbs, whose product specification attributes them as warm light, are available. This was clearly visible in my explorations, as the energy-saving bulb light on the wall seemed warm with a yellowish touch while the halogen bulb light was rather a cold white. Although the different energy-saving bulbs appeared very different, they all worked with my metameric fabrics as intended. All incandescent bulbs changed the olive green into a strong yellowish green (Figure 98 left, bottom colour) and halogen bulbs also triggered a reddish green (Figure 98 right, upper colour).

I built different lamp/light settings in the room, checked options and started to plan different courses of movement. Beside the on and off options of incandescent and fluorescent light, I had one dimmable lamp, which offered an additional variation. In this experimental phase I played with the effects of standing, walking and sitting and combined movement with text. I switched lights on and off or dimmed light. All these experiments and experiences, alongside the collected text material, built a foundation for the final performance.
On Friday afternoon during the first week of Summer Lodge 2014 we discussed our art practices in smaller groups. My group strongly doubted that my performance could be a poetic artwork and not just a demonstration of technological research (Ch 3 - 6). I failed to convince my group verbally of the poetic qualities inherent in this physical colour phenomenon and I was not able to effectively convey my idea that the creation of an ambiance, where the metameric colour change could be perceived as a wonder, would be at the core of my performance.
At the beginning of the second week Dorit Ehlers[51] joined me and I gave her an overview of all my collected and prepared material so far. On the basis of the presented material we started to discuss the performance and Ehlers, acting as an external eye, gave me feedback on where she felt the focus was, what she felt was important, and which aspects should be expanded. In addition, she took over my role of wearing the dress, which gave me the opportunity to see the various settings as an external eye, to give her instructions for moving around in the different light sources and to judge for myself the various movements and ambiances created. This helped to decide the final look and aesthetic of the performance.
After several trials and discussions, we figured out, what the key moments of the performance could be. As Goldberg (2014, p.8) stated: ‘the content [of performances] rarely follows a traditional plot or narrative.’ We created the performance on the model of a knitted jacquard fabric (Ch 2.2), bringing the various coloured threads (light, colour, green, perception, colour naming and meaning) together. We constructed the sequence of actions, decided on the texts to be involved and finalised their order.

The documentation of the performance *green-green-green* is on:
https://www.researchcatalogue.net/profile/show-work?work=397531

[51] Dorit Ehlers is an actress and theatre maker, based in Salzburg, A. She is part of the network ‘ohne titel’, a platform for multidisciplinary theatre and art projects.

The performance started in the dark. I read, illuminated just with a torch, the following text:

I can't remember colours. Why?
I remember smells; I remember flavours.
My sister has got the furniture of my grandmother and when I open the drawer I still smell the smell of my grandmother's furniture.
I remember the smell of the clothes of my grandmother; I remember music; I remember songs.
But I can't remember colours. Why?
I remember, that I wanted the walls of my room painted red. But my parents didn't agree. I didn't get the red walls in my room. Why?
I had an orange raincoat, I had an orange satchel, I had an orange alarm clock, but I didn't get my red walls. Why?
If I would have asked for green ones?
Would this have been different?
Indeed, they say, that green coloured walls do have a good impact on people and therefore often in hospitals the walls are green.
But I didn't want my walls in green.

Figure 99 Performance text, Salome Egger, July 2014

After this reading I switched on the first light source and I stood in the light, so that the first variation of the colour arrangement of the dress became visible. I switched on another light in order that the second colour variation became visible. Moving between these cones of light, I mentioned different green colour-names, some that exist, some invented: unfriendly green, sweet green, hopeful green.
Later on, I hummed the song 'It's not easy being green' by the children's puppet character Kermit the Frog, approaching a fluorescent spotlight, which 'coloured' the lower part of my dress. Then I turned off all the lights, except the dimmable light on a table. I sat down in front of this lamp and while I slowly dimmed the light, I narrated the adapted children's colour story of Lionni (1997), which ended in the dark.

Elephants are grey.
Pigs are pink.
Frogs are green.
Only the chameleon has no colour of its own.
One day a chameleon decides to remain one colour forever by staying on the greenest leaf he can find. But in the autumn, the leaf changes from green to yellow to red . . .

Figure 100 Adaption of the text of Leo Lionni by Salome Egger

8.1.3 Analysis of the performances green-green-green

Performances are ephemeral. They remain as memories for the performer and viewer and in documented material (texts, audio recordings and films). After performances or during exhibitions I informally collected feedback (Ch 1.5.4.1) from audiences, some poetical, some critical, some enquiring and others wondering. The following analyses are based on this

feedback, documented in my research journal (Ch 2.3.1). Moreover the analysis is linked to my remarks of Chapter 7.3 and underpinned by personal reflections.
In the first text (Figure 99) I narrated personal memories of colour, among other things, dealing with sense memory. I asserted, that I cannot remember colours, but I easily remember melodies, smells and flavours. It is said that we can distinguish ten million different colours (Hunt and Pointer 2011, p.1) and hence it is 'no wonder that we cannot remember colours well enough to identify a particular shade' (Ibid.). Albers confirms my claim as follows:

> First, it is hard, if not impossible, to remember distinct colors. This underscores the important fact that the visual memory is very poor in comparison with our auditory memory. Often the latter is able to repeat a melody heard only once or twice. (2006, p.3)

This effect is complicated by the impact of light, as stated by Aspland and Shanbhag:

> Interestingly, one reason many objects are referred to as color constant is the human failing of being unable to precisely remember the original color of the object once the light source is changed. (2006, p. 36)

I add that my parents' denial of red walls had a psychological reasoning. Red is a vivid colour; green is considered a soothing colour (Ch 7.3.3) and stands for the meaning of calm, ease and comfort (Heller 2013, p. 81).
As described in Chapter 6, to reach the goal of dyeing a metameric colour series, I dyed a considerable amount of colour shades. The variety of olive-green shades produced triggered my interest in colour naming (Ch 7.3.2).
Would there be a name for each of my manifold dyed shades? And if so, how would these be created? As metameric colours were generally considered problematic, and to be avoided, there was little need to name any single shade of a metameric colour series. Metameric colours are nameless and their namelessness emphasizes the difficulty of grasping them. But my interest in perceiving metameric colours as an opportunity for creation could open up discussions around their naming and possibly add new aspects to an on-going colour naming debate.
How could the colour vocabulary of metameric colour names look? How can I think of a colour name, when two or even more colours 'belong' to one and the same material?
All three colour shades are present, but absent; unrepresentable at the same time, as the polychromatism of the material is easily revealed through changes in light quality.
Should the colour names of metameric material be composed as a description of each variation? Should the colour names include the light source, which influences their perception?
In fact, as I explained in Chapter 3.2.2.3:
Stable colour: which indicates that the colour is stable in all the light sources.
Colour A: indicates that this colour changes under illuminant A.
Colour F11: indicates that this colour changes under illuminant F11.
But even this is not a distinct approach to naming metameric colours, as light sources are not constant over time (Ch 4.1.3).

I resolved the naming issue for the technical part of this research by adding the illuminant to the colour name (for example: olive A) but deliberately left the issue of metameric colour naming in any more descriptive poetic way unresolved. In the performances, I specified various green colour names (Ch 7.3.2) inviting the audience to think about metameric colours and their naming. Moreover, in listing invented colour names, combining them with such descriptive adjectives as unfriendly, sweet and hopeful, I addressed and questioned the more specific meaning of green colours (Ch 7.3.3).
Most of the audience, daily surrounded by light, colour and textile, did not know about the metameric colour phenomenon. They marvelled at the magical colour changes of the dress, which were triggered by everyday light sources and were surprised by the unexpected.
After performances, audiences began to tell stories related to their own experiences of colour inconstancy (Ch 3.1). The performances awakened memories of colour, light and colour changes. The performances also aroused curiosity and raised questions. Audiences wanted to know more about this phenomenon and understand it. One spectator commented that he went home to 'google' the effect. Presenting the metameric wonder had opened a line for further investigation and stimulated 'loquaciousness', 'g[iving] rise to an astonishing amount of talk' (Daston 2004, p.11). This issue will be further elucidated in Chapter 9.

One observer saw the dress in daylight before the performance and perceived it as unicolor. After the performance the same observer told me about her changed perception. Knowing now that the dress is not unicolour, she could no longer revert to seeing the dress as unicolor. She now perceived the subtle colour differences of the dress in daylight.

During Summer Lodge 2014 I did my performance in the Bonington Building of Nottingham Trent University, where I had limited room options. One received feedback noted that the chosen room was a little 'cell like' and 'oppressive' (Lee 2014).
There is probably no ideal venue for this performance. I intend to take the performance to different sites and find out how the concept works in different settings. I consider this aspect linked to the notion of everydayness. I like to situate the metameric poetry in less convenient rooms, which adds a political dimension. The poetic can unfold everywhere. The poetic does not need a specific surrounding; it needs the right light.
During the first performance, visible in the documentation video, it was also problematic that people came and went, disturbing the light setting and creating noise[52] through the opening and shutting of the door, which disturbed the metameric magic in the room. This issue needed to be considered in further performances.

[52] In the video documentation the ringing of a mobile phone is also in evidence.

8.2 Performance *green – green – green,* SARN conference

Presentation performance *green-green-green* at SARN conference

Location	Various spaces of the University of Applied Sciences and Arts (HEAD) Geneva, CH During the 'unconference' of the Swiss Artistic Research Network (SARN)
Date	From the 6th to the 7th November 2014
Duration	Twenty-four hours
Documentation	Videoclip online: https://vimeo.com/122789999; 5.33 – 5.45min.

Figure 101 Visualisation of the performance green-green-green for application

8.2.1 Background and concept of the SARN performance *green-green-green*

In February 2014, before the first *green-green-green* performance became reality, I described the performance in the abstract for the conference of the Swiss Artistic Research Net, SARN. SARN invited me for 'Parenthesis ()', an 'unconference', and their aim was 'to create a space' where 'the relationship between format and project in the process of practising artistic research' can be explored (SARN 2014). Following their call, I applied with a twenty-four hour performance and set myself the task of performing in various slots during the event. I proposed to explore light situations in various spaces and find out how they interacted with my olive dress. I brought material (paper, file cards, colours, brushes, adhesive tape, various texts) and prepared some actions. I did not know the spatial possibilities and light situations and did not fix any action in advance.

I was the performer, exploring the spatial situation and the possibilities of my actions, but was also a participant in the 'unconference', taking part in presentations and discussions. I had

different roles and was not sure I would be able to switch fluently from presenter to participant. I planned to improvise on the spot which role or action to take.

8.2.2 Description of the SARN performance *green-green-green*

I expected the conference to be loosely planned with lots of open spaces and time. But when I arrived it became clear that the twenty-four hours were meticulously planned and most of the places booked. It was difficult in these conditions to perform as I planned. I realised also that the light setting of the building was limited and did not trigger many colour variations in my dress. I started to make notes about these light settings and my emotions and stuck my comments on walls. (Figure 102)

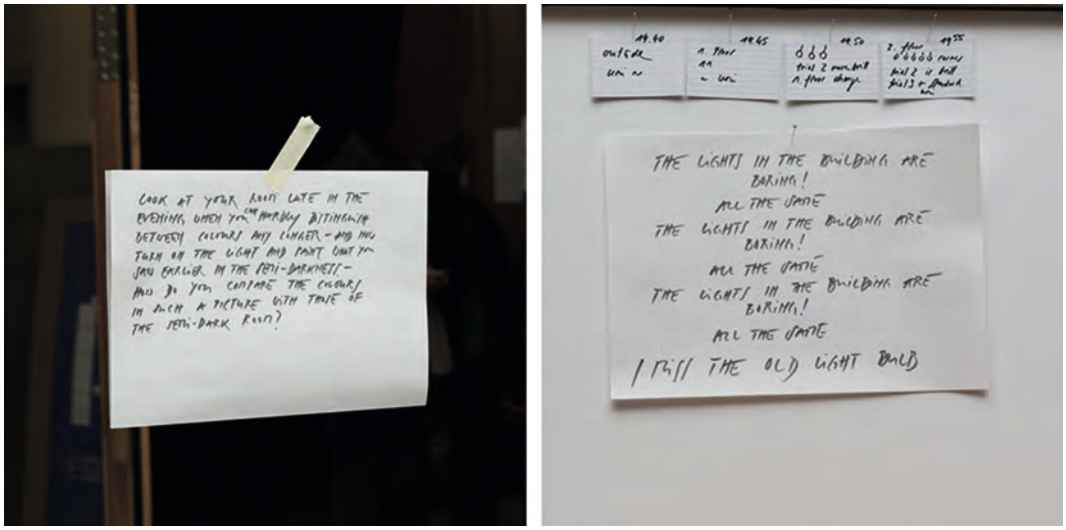


Figure 102 Text written and posted during performance

I had the impression that I did not really get started. I agonized and hesitated. And I wrote:

> *I feel introverted, I am introverted! It's showing, but not performing. I need to do something still tomorrow or tonight. (16pm)*
> *I cannot enter, find space, find room. Difficult, very difficult! (17.30pm)*

Figure 103 Research journal, 6th November 2014

I read some of my texts in front of the camera of Italian researchers, who were working on a project in the field of art criticism, and got feedback from an observer, who appreciated my reading. I took part in the discussion of another research group, hoping this would support me to get into the mood to start my performance properly.

But it did not help:

> *I am tired, not in the mood. I would like to go home, I feel lonely, it's not yet working, perhaps it fails – okay!*
> *Still difficult, very difficult. I just should stop – or what should I do. I don't know. Do I share my knowledge – how – why – where?*
> *Stupid setting. I couldn't handle it, okay – I failed.*

Figure 104 Research journal, 21pm, 6th November 2014

I was desperate and retired in my sleeping bag. In the morning I got up early, sat down, started to mix various green colour shades and paint them onto file cards (Figure 105) as a re-enactment of the practice and lengthy process in the dye lab.

Figure 105 Performance in the early morning

> *Got up in the morning early. It was calm.*
> *And there, for a short time, was a place for me.*
> *Later on, my work got moved. Ronny had to cut wood on the same table and Julie started to place her computer on the table, moving my work to the other side, than Ronny did.*

Figure 106 TTP text 26 November 2014

But even this action got disturbed, as I wrote in the text (Figure 106), which I presented the 26 November 2014 to the Thinking Through Practice (TTP) group (Ch 2.3.4).

8.2.3 Analysis of the SARN performance *green-green*-green

I was disappointed during and after this performance, as in my opinion this failed. In my presentation (Appendix 4) I set out my experience, expressed my thinking and reflected, disclosing a description of the situation and my feelings concerning it (Figure 107).

The performance didn't take place.
But perhaps, the performance did take place.
It just wasn't like I imagined it.
It was not loud enough.
There was no calm place.
I thought, that I would be able in an open setting to take my place.
What does it mean to fail?
Isn't it just an important step on a learning journey?

Figure 107 TTP text 26 November 2014

The group appreciated my presentation and considered the performing of this text an artwork in itself. They remarked that the text could be all made up. It was not clear if what I wrote is true. There was a fictional element (Ch 2.3.2), a friction. The method of 'performerly' writing (Ch 2.3.4), presenting my thinking and reflections, proved successful. It was a valid research strategy of my journey and the feedback gathered within this group was crucial.
'Performerly' writing is a poetic and speculative way of narrating, written for oral presentation. These texts are crafted and written with an art approach. They are useful to gain feedback and, at the same time, including the way I presented them, were themselves a body of work.
After the discussion with the TTP group, I could see my experience in another light. I realized that I couldn't accomplish what I intended but was not able to recognize and value the unexpected incidents. In my perception the performance wasn't successful, as it did not fulfil my expectations. But my personal perception does not have to conform to the perception of the public, as Schechner states:

> Not all performances are successful. A performance can fail in two ways: if it does not please its public or if it does not accomplish most of what those making the performance intend. But even these indications of success and failure can be mistaken. Some artists are never satisfied – even with works that the public loves. (Schechner 2006, p.242)

8.3 Installation green-green-green_1_03:11

Presentation of installation *green-green-green_1_03:11*

Location	'Knitting Nottingham' exhibition, Bonington Gallery, Nottingham Trent University, UK.
Date	From the 6th to the 28 November 2014
Documentation	https://www.pinterest.com/pin/334814553521931945/

8.3.1 Background and concepts of the installation *green-green-green_1_03:11*

In 2014 I applied to participate in the exhibition 'Knitting Nottingham' and proposed to show the performance *green-green-green*. The performance was approved but an additional artwork representing the performance, preferably a video was requested for inclusion in the exhibition. As Anderson stated: 'Life art is especially ephemeral. Once performed, it tends to become myth and a few photos and tapes' (2004, p.6). I documented my performances through film to provide evidence (Ch 1.4.3.2) but do not consider this material as artwork to be exhibited in an exhibition. Performances need to be experienced live and should stay as 'memories of the viewers – with all the inevitable distortions, associations and elaborations' (Ibid.). I am sceptical about video's ability to document live performances.

> When live art is documented through film or audio recordings it immediately becomes another art form – a film or a record – another rectangle or disk. It's in the can. But live art is continually elusive. (Anderson 2004, p.7)

Documentation (Ch 1.4.3.2) is a representation of the live act and narrates only part of the performance. It can give an idea of the ambience and actions as 'the work resonates through its images' (Ibid., p.7). In order that a performance can resonate, the film material needs to be edited thoroughly[53]. I do not have the skills for editing and when I got the feedback regarding the exhibition 'Knitting Nottingham' there was not enough time to find a film-maker to support me in editing the material[54]. In addition, the metameric effect cannot be fully captured by photo or video (Ch 4.1.3), so the effect of the phenomenon, the visual impact, which can be perceived in live performances, cannot be fully represented on video. I searched for another form of representation of the performance in the Gallery space. I was keen to show the real material (knitted yarn) and the real colour changes, and represented the performance, underlining the

[53] I consider the representation of the performance *The artist is present* in the film of the same title (Akres and Dupre 2012) as a very good and successful example of a documented performance. The film follows Marina Ambramovic during the preparation of her retrospective at The Museum of Modern Art, New York, as well as during her long-lasting performance.

[54] In summer 2016 I edited three different performances with filmmaker Annemarie Haller, CH (Ch1.3.3.) and the documentation is online (links on p.15).

‘act of imagination’ (Anderson 2004, p.6), through an installation. I extracted a still image from my video documentation and transformed this image into a knitted artwork.

8.3.2 Production and development of the installation *green-green-green_1_03:11*

In September 2014 I extracted and saved several still images (Figure 108 left) from the raw video documentation, which might resonate and represent the performance. It was vital that myself illuminated by one of the lamps, would be visible. In order to translate the image into a knitted jacquard fabric, I reduced the selected images to three colours (black, grey, white; Figure 108 right) and adjusted them as described in Chapter 5.1.2.5.
I observed these colour-reduced images and imagined the metameric effect. I estimated if the colour changes would be perceivable and selected the images I assumed best suited to translation into knit. This was an approximation, as I could not digitally imitate metameric colours.

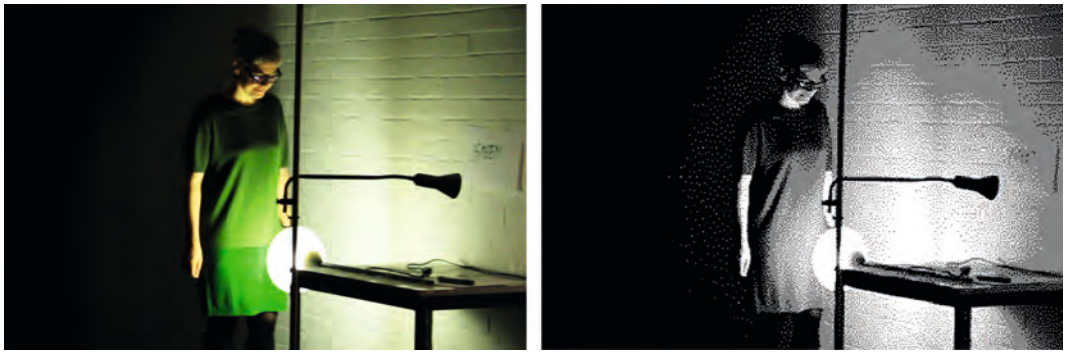


Figure 108 Left: still image and right: colour-reduced image of performance green-green-green

The first knitted work did not convince me, as the image (Figure 108 right) was too ‘pixelated’ and the colour changes could hardly be perceived. The outcome was that the image needed to be defined, in the sense that bolder colour parts would compose it in order for the knitted image to be perceived in fluorescent or halogen light.
Figure 109 shows the finally chosen image, where the body of the performer is unicolor surrounded by fluid light shadows with smooth colour transitions.

Figure 109 Snapshot of video from performance green-green-green, 2014

Figure 110 Final image prepared for three colours jacquard knitting

8.3.2.1 Encountered problems

I encountered knit problems (Figure 111) as the ‘stable’ yarn was constantly breaking. In order to avoid breakage, we had to slow down the knit speed. This problem could have been caused because of inconstant winding, as described previously (Ch 6.3.3.2).

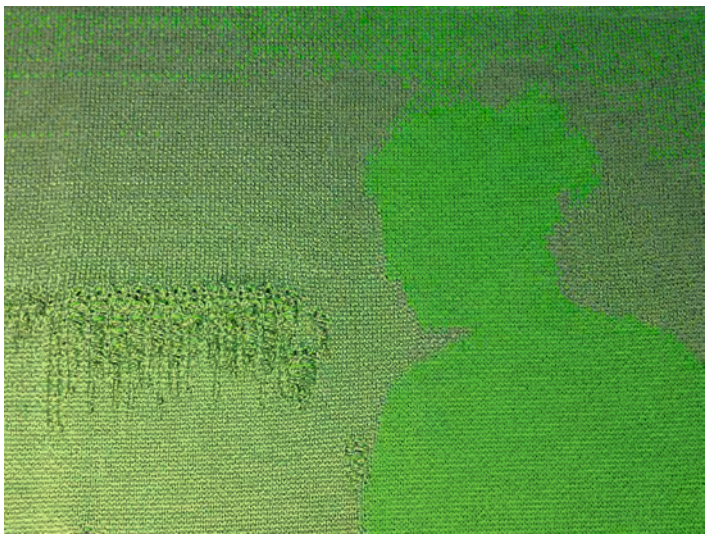


Figure 111 Image of work with dropped needles

8.3.2.2 Colour placement of the three shades

Figure 112 (above) shows a first knitted colour variation. This placement of the three colour shades created a strong visible contrast and formed a ring around the performer, which I did not like. To create a smoother colour transition I changed the colour arrangement, as shown in Figure 112 below.

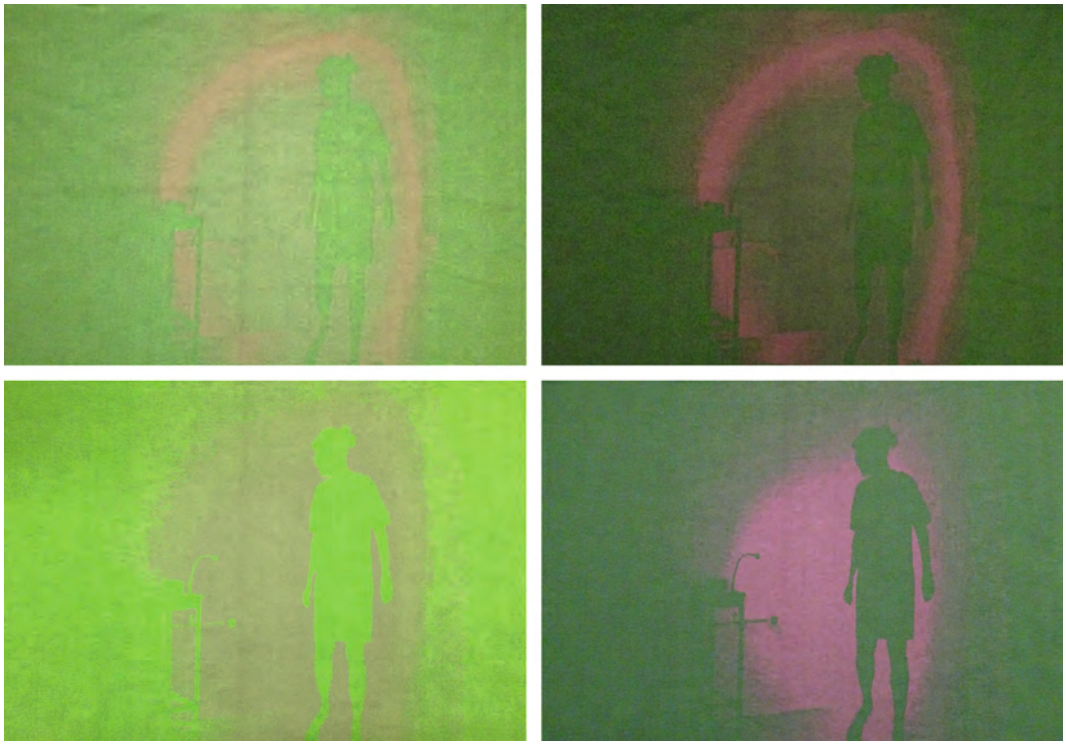


Figure 112 Trials for colour arrangement

8.3.3 Analysis of the installation *green-green-green_1_03:11*

By way of the installation, myself as well as the performance were present in the exhibition. Highlighted by two alternating light sources, the artwork performed a metameric effect, changing colour during the exhibition. It thus became a performative installation.

I prepared and discussed light settings for the installation with technicians at Nottingham Trent University (Theatre department as well as Gallery technicians). We fixed two light sources, an incandescent and a fluorescent lamp, which would illuminate the work alternately. The light settings of other exhibits were not fixed and it was not clear what other light qualities would be around my work. This fact complicated the planning. I was not able to join the setup of the exhibition; I carefully explained the important points for the setup to the Gallery technicians. Unfortunately, they placed the fluorescent tube on the floor (Figure 113 right side), which was too far away from the work and, as a consequence, the work was not sufficiently illuminated and the colours remained dark and their effects yet not visible. The installation, as presented, did not convince; the artwork did not show colour changes triggered by the two present light sources. The installation could not be seen as I had planned and the wonder of the colour change was lost.

Figure 113 The two light situations in the exhibition: right: fluorescent light, left: incandescent light

This incident underlined the importance of a thorough evaluation of light settings in further exhibitions. This fact also made clear that participation in group exhibitions is problematic: when space is shared with other illuminated artworks with unpredictable effects. Installations of metameric artworks require a lighting concept not influenced by other light sources.

In January 2016 the same work was part of the exhibition grün!? (Ch 9.3.2), where the installation worked well and visitors confirmed that the work by itself was convincing and offered a vivid snapshot of the effect, even if they had not see the original performance.

8.4 Lecture Performance *green-green-green*

Presentation performance *green-green-green* at SARN conference

Location	Symposium within the framework of the Knitting Nottingham exhibition, Bonington Gallery, Nottingham Trent University, UK
Date	28 November 2014
Duration	Twenty minutes
Documentation	Performance texts in Appendix 4

8.4.1 Background and concepts of the lecture performance *green-green-green*

For this Symposium, I opted for a Lecture Performance, a hybrid format, situated between art and science (Peters 2011, p.36), lecture and performance. This form of showing and telling has particular relevance in the context of Art Research (Ibid.).
I combined Performance settings with a classic Lecture setting involving equipment. The performance started in daylight, allowing me to demonstrate the dress in a ‘unicolor’ state. This lecture performance, being part of a *green-green-green* series, explored the same topics described above. Additionally, the ecological, political and psychological aspects, which I had introduced previously (Ch 7.3.4), inspired the conceptualization of this lecture performance.

Figure 114 Lecture Performance green-green-green

8.4.2 Description of the lecture performance *green-green-green*

I started the performances in daylight in my olive green 'unicolour' dress, sitting at a table in the middle of the Atrium of the Bonington Building at the Nottingham Trent University, playing Memory[55]. In front of me, on the table were covered Memory cards (Figure 114 above). The covered side of the cards showed various green colour shades and, within the deck, two cards always showed the same shade. I tried to find the matching pair, by turning two cards, trying to remember the green colour shade and its location in the deck. If two turned cards did not match, I turned them back again. Normally the game is played with different players and the winner would be the person with most pairs at the end of the game.
While I was playing, the audience arrived, spread around the table watching me. After several trials, I was able to match and pair some of the cards. I stopped playing, took out a small black booklet and read a text, written by Kandinsky, offering his opinion about the colour green:

> Absolute green is the most anesthetizing color possible. It moves in no direction at all and has not the least consonance of joy, sadness or passion; it demands nothing, attracts nothing. This permanent absence of movement is certainly a beneficial property for tired men and souls, but becomes very tiresome after a certain amount of rest… Passivity is the characteristic property of pure green, a property that gives it a kind of unctuous air of self-satisfaction, however. That is why, in the area of colors, green corresponds to what represents, in human society, the bourgeoisie; it is an immobile element, self-satisfied, limited in all directions. This green is similar to a fat cow full of good health, lying down, rooted, capable only of ruminating and contemplating the world through its stupid, inexpressive eyes. (Kandinsky 2014, p.202)

This text was followed by my own text, whose purpose was to lead the focus of the audience to the actual light situation, daylight, and my green dress. The text introduced the notion of everyday life and wonder (Ch 7.3.5 & 7.3.8).

I am green.
I wear a green dress.
I like green.
I love green.
I like changes.
I like, when the same is not the same.
I like the every day.
I like the subtle wonders of the every day.
What do you see in daylight?
Green?

Figure 115 Performance text, November 2014

After this reading, I invited the audience to move back in the Lecture Theatre, where I marked a square on the floor with white tape (Figure 114, second row left).

[55] This game is also known by the name Concentration or Match Match.

In this square, representing a boxing ring, I started to perform a ‘boxing game’. The contestants were various lights and light sources. Every light battled with its strength and suffered its weaknesses related to light quality and energy consumption. The conclusion was that the winner is the climate, as the European Union banned the traditional light bulb and the history of banned light sources continues (Ch 4.1).

As in other performances, I started to turn on different lamps and these illuminated my dress showing the inherent colour variations. I embedded these actions with text, citing different light expressions (for example: It dawns on me, I saw daylight and so on, full list in Appendix 4).
I introduced the colour naming debate by using the light projector, which allowed me to throw green names on the wall (Figure 114, fourth row). I finished the lecture performance, like other *green-green-green* performances (Ch 8.1.2), with the adapted children’s story about a chameleon, which wanted its own colour (Lionni 1997).

8.4.3 Analysis of lecture performance *green-green-green*

The memory game was a good tool to illustrate the long-standing matching process in the dye lab and I consider this a kind of re-enactment (Ch 4 - 6).
It was hard to find, or better to match, the various green shades on the cards or remember where each shade was or if it was the right shade of green. Through this game the difficulty of colour matching and the topic of colour memory were explored.
I touched on psychological aspects of light and on the field of ecology, as previously introduced (Ch 7.3.4): What impacts do artificial lights have on our well-being? How do we respond psychologically to various light situations? Which light source is ecologically sustainable?
The psychological, ecological and political aspects of light are highly controversial. Do we consciously miss the light quality of the banned incandescent light? Which light source will be banned next because of energy inefficiency – perhaps tungsten lamps, which are currently considered to be ‘inexpensive, compact’ and ‘flattering to the human complexion’ (Hunt and Pointer 2011, p.91)? All these questions were swirling around in my performance.
I take no position nor do I create a hierarchy of discourses involved. I am keen to offer moments for reflection on the effect of light and to initiate discussion through my work.

8.5 Q & I – Questions & Installation

Presentation performance *Q & I – Questions & Installation*

Location	Nottingham Trent University, Nottingham, UK During Summer Lodge 2015
Date	09 July 2015
Duration	One hour
Documentation	https://www.researchcatalogue.net/profile/show-work?work=397528

Presentation performance *Q & I – Questions & Installation*

Location	Schneller Wohnkunstraum, Berne, CH, during exhibition 'grün!?'
Date	23 & 24 January 2016
Duration	Four times a day, hourly repeated, duration approximately fifteen minutes

8.5.1 Background and concepts of the performance *Q & I*

In April 2015, I worked again with Dorit Ehlers, who had already supported *green-green-green* (Ch 8.1). The aim of this collaboration was to prepare a combination of performance and installation (a performative installation, or installative performance). I had a clear impulse to link these two art forms, bringing together text and textile (Ch 2), action and object.
Based on an overview of my ideas and thinking so far, we started to discuss possibilities. During these discussions, we found parallels between the metameric effect and the self. In a figurative sense, we change colour depending on whether we stand in a spotlight or shadow. Sayings composed in a vocabulary of colour and light often describe human beings and actions.
The question of who and what I am has bothered me for a long time. The topic of the self was already present in a former performance (2010), where I sung a Swiss folk song:

> You ask me who I am,
> You ask me, what I can,
> You would like to know,
> Why I never lose sight of you.
>
> I do not know, who I am,
> I do not know, what I can,
> I just know, you attract me,
> I cannot let you go. (Zulliger n.d.)

In 2013 the Fine Art Team at Nottingham Trent University gave PhD students the opportunity to present our research and ourselves. As a distance learner, I prepared an Audio, which they could listen to without me being there. In the Audio I explain my research work, but also who and what I am. In trying to describe this I point out that I have various facets depending on

phase of life, where I am, in what context. I mention various diplomas and I describe how the different versions of 'me' work together. As described in preceding chapters, I have used these different facets to execute this research.
A key phrase in the Audio from 2013 was: *'My PhD is about myself'*.
I have therefore already addressed this personal issue of the different versions of 'me' involved in this thesis in the Audio from 2013. This transdisciplinary PhD research can be seen as a playground to deploy my various facets and, driven by curiosity, I discovered and developed even more. 'I do not feel that it is necessary to know exactly what I am. The main interest in life and work is to become someone else that you were not in the beginning' (Foucault 1988, p.9). I still do not know who and what I am but, in line with Foucault, I do not need to know exactly who I am. I am, however, still keen to learn more about myself.
Bringing together all these threads, it became clear that this performance would draw parallels between colour perception and perception of the self; between the self and metamerism. Pastoureau (2014, p.9) asserts that 'for the historian – as for the sociologist or the anthropologist – color is defined first as a social phenomenon'; 'it is the society that "makes" the color, that gives its definitions and meaning, that constructs its codes and values, that organizes its uses and determines its stakes'. Is society also 'making' our colours and defining us?
This performance would illuminate social and psychological aspects of the research; the self with its changes would be set, figuratively speaking, in the context of metameric colours.

8.5.2 Development and production of the performance *Q & I*

We started the preparation for the performance with an autobiographical approach and explored the topic of the self and the different 'me', assuming that depending on which light I stand in, a different 'me' becomes visible. As a medium we chose to perform question-and-answer sessions. Ehlers asked questions covering the full spectrum of my character, skills, hobbies and so on. We collected material. We integrated light and colour expressions (Appendix 4) to highlight the parallel universe of the self and the knitted artworks/installations.
The question-and-answer sessions were fruitful in creating texts; it turned out to be the most appropriate form for the performance as we could present various facets of myself, linking them directly to the iridescent installation.
Out of the collected text material we created a dialogue, translating various topics, including metamerism, light and colour, metaphorically and figuratively, into the context of human life. We tested dialogue, rewrote and adjusted it, until we considered the wording concise and the dialogue fluent and expressive. We rehearsed the performance with a particular focus on timing and voice leading.

The text of the performance is in Appendix 4, the documentation of the performance *Q & I on*: https://www.researchcatalogue.net/profile/show-work?work=397528

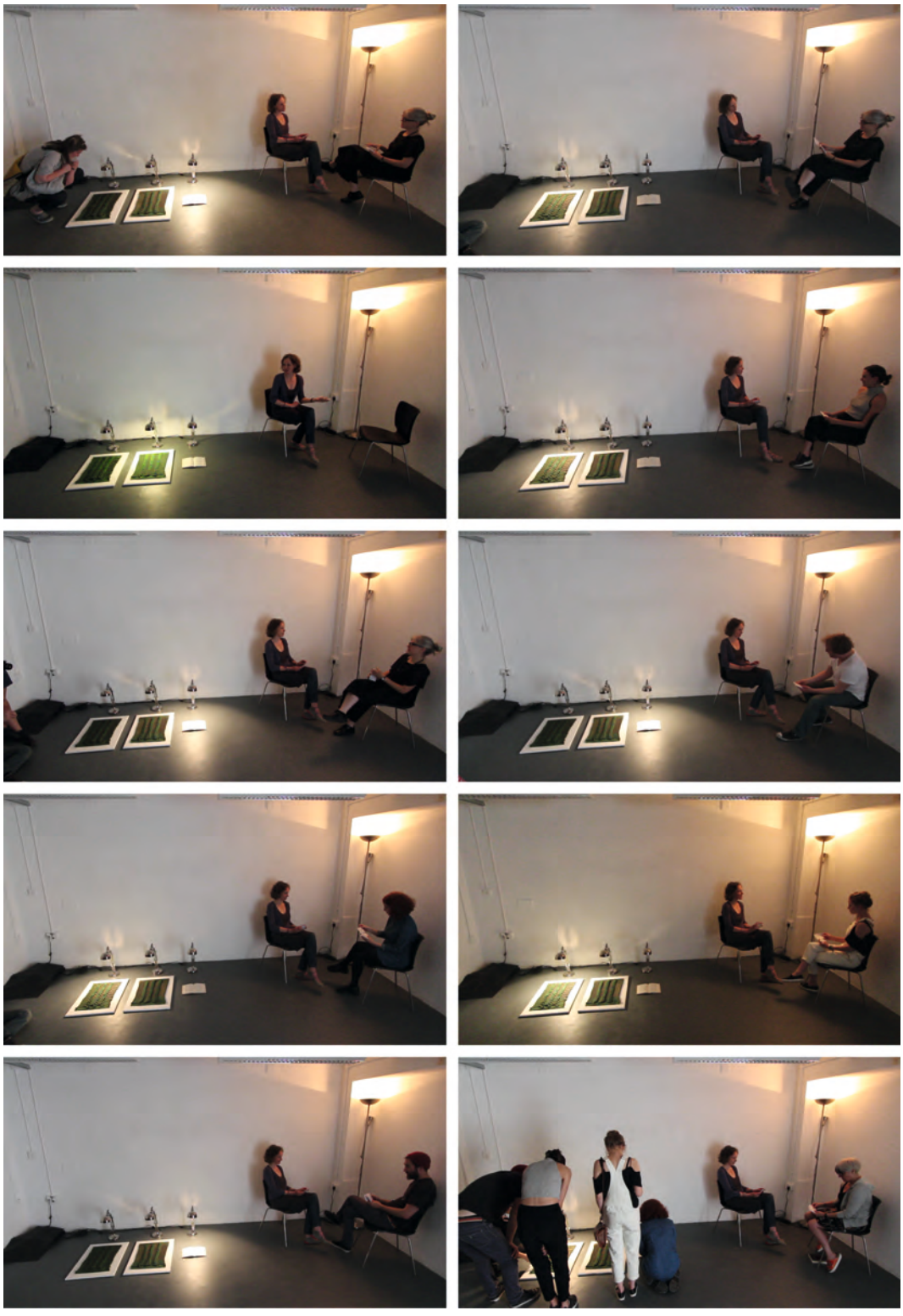


Figure 116 Q & I NTU, July 2015

The first *Q & I* performance took place in the Bonington Building at Nottingham Trent University (Figure 116). Three lamps standing on the floor alternately illuminated two artworks, *I lead you down the garden path I* and *II,* and Wittgenstein's book 'Remarks on Colour' (2007) (Figure 116, above).
Ehlers and myself were sitting beside this installation, each with a pile of cards. Ehlers asked and I answered questions, card by card. When we finished our round of questions and answers, I handed my cards to Ehlers and left. Ehlers started to invite people from the audience to take my place, sit down and do a question-and-answer session by reading appropriate answers silently on the cards (Figure 116). Only the questions were spoken aloud.
From this moment, we created a parallel situation in the room. On one side was the small stage, where Ehlers was sitting and the questions-and-answer sessions took place, and on the other side, where the installation was placed, I debated with the audience on topics such as light, colour, metamerism and 'metamerising'[56].
It took a while until my answers seemed to 'evaporate' in the room and at this point I sat down again on the chair in front of Ehlers, filling the space once more with my vocal answers.

8.5.3 Analysis of the performance *Q & I*

After these performances, we took the opportunity to talk with audiences and received valuable feedback[57]. The feedback surprised us, as we learned from the audience about new aspects of our work. When I left the question-and-answer session, my answers seemed to stay in the room, as though the reverberant sound of my voice was still present when people from the audience took my place and replaced my answers with their own silent thoughts.
The empty space of this silence created a situation where people could think about themselves, about who they were, and why. Everyone brought his or her own style when sitting on 'my' chair. The answers seemed to appear on the faces of people and it was interesting to study expressions. I had the impression I could read their thoughts on their foreheads as though they were written on a billboard.

At the core of this performance was the question: Who am I? What colours do I have? When do I show which colour, which personal aspect? The constructed dialogue appeared natural and authentic and my answers were genuine and personal but left space for generalisation and appropriation. These autobiographical aspects of the performance 'set up a particular empathy between performer and audience' (Goldberg 2014, p.174). Several participants identified with the content of my answers, as written on the cards.
Different participants addressed in their feedback the moment of the audience taking my place. Some of them appreciated that they did not have to speak; others would have preferred to answer the questions for themselves. All invited participants became part of the performance

[56] The created term ‚metamerising' stands for the fact that human beings are constantly seen in 'different lights' and therefore perceived differently.
[57] The 23 and the 24 January 2014 I filmed the whole day, hence I have also documented the discussions afterwards, which supported the analysis of the work.

and some enjoyed the focus while others found it uncomfortable, although no demand was made for personal revelation. Several participants confirmed that they were touched by the performance and felt emotionally involved (Ch 7.3.7).
Feedback suggests the audience felt invited to think about their own situation and filled silent moments, where my answers were in the air, with their own answers. One participant had the impression that two personalities, hers and mine, were melting, becoming an alter ego, a shadow to one-another. Another described the experience as two rivers coming together and running side-by-side but not mixing.
The audience was fascinated by the 3D effect of the knitted artworks installed and the colour changes these demonstrated. Those who knew about my metameric work could easily identify a strong link between the iridescent quality of the artworks and personality. They linked the installation and the performance and confirmed, that they often share this sense of different 'me's' and roles in life (mother, lecturer, partner, friend...). They daily 'metamerise'.
People, who did not know about this work, found it harder to make a link. One viewer admitted that this link only seemed obvious to him retrospectively, following an explanation.

8.6 Conclusion

The intention of the performances and installations described in this chapter was to offer audiences an affective and aesthetic experience. Artworks were designed to make the phenomenon of metamerism experienceable in a sensual way as moments of magic, staging everyday matters of light and colour to create manifold ambiances where audiences could perceive unexpected metameric colour changes as a wonder. Metameric colour changes are subtle but instantaneously experienced effects, which viewers can clearly perceive.

As performer, I embodied my research; I was the enquirer**,** exploring perception, light and colour, and also, wearing the metameric phenomenon as a costume, the enquiry. Through live acts I tested my ideas in the public domain (Ch 1.5.4) and created platforms to show various facets of metamerism.

Artists working in the field of Art and Science are usually using up-to-date knowledge and emerging technologies, as do artists working with light. The work of James Turrell (Peschke 2011, p.63) is strongly influenced by scientific findings and innovative technology (Ch 4.2.1).
In the first phase of my research I created cutting-edge knowledge through the dyeing of purposefully metameric materials (Ch 5 - 6) but deliberately excluded cutting-edge light sources in the second phase. In this second phase of the research philosophical questions regarding 'the everyday' and 'wonder' emerged; familiar light sources seemed more suited to an exploration of these philosophical and cultural questions.

Using various texts the wider context of light, colour and perception was highlighted and explored. I drew pertinent and original connections between these contextual fields and the phenomenon where philosophical language met the physical. I investigated cultural questions

by means of a physical colour phenomenon. I spotlighted the cultural context of colour green, and explored colour memory, colour naming and colour meaning. I drew on psychological, ecological and political aspects related to light and light sources.

In the performance *Q & I*, I also drew a metaphorical parallel between the self and metamerism, setting a focus on social aspects. 'Who we are is a story of our self – a constructed narrative that our brain creates' (Hood 2011, p.XI). *Q & I* played with the 'story of our self' and highlighted this social and psychological aspect. The self **'**is continuously shifting and reshaping as the contexts change. We are so willing to accommodate others that we adapt to each role in a continuous, dynamic, shape-shifting ballet' (Hood 2011, pp.215 - 216).

Audiences appreciated the poetic qualities, 'poetic subtleties of the text and the gentleness of the actions/movements' (Lee 2014). The *green-green-green* performances convinced the critical voices of Summer Lodge, 2014, who found the performance realised a distinct artwork and not a technical demonstration of a process in the dye lab.
The core of all my presentations 'consist[ed] in getting the investigated phenomena to talk' (Rheinberger 2007, p.86) and fostering platforms where the research could be tested and debated. Audiences were invited to comment or ask questions and these opportunities produced lively discussions and dialogues. 'The continuous transgression of boundaries' (physics, chemistry, philosophy, art) 'generated novel, reflexive zones' (Slager 2009, p.51). Slager considers this 'the most intrinsic characteristic of artistic research'. This research, by making visible the invisible, provoked curiosity, reflexivity and wonder and supports the transdisciplinary as a fruitful research approach.

Installations and performances alter colour perception. The experience of this wondrous phenomenon raised questions such as: Is our sight reliable? Which is the true colour? Why does the colour change, and why only some colours and not others? I offered encounters of a phenomenon and let each viewer perceive the installations and performances in their own way. As an artist, I do not consider it my duty to 'convince' viewers. I am rather looking to 'move' audiences through 'aesthetic power' (Leavy 2015, p.294).

I am convinced that my 'commitment to an open-endedness of interpretations is vital to creative thought' (Becker 2013, p.48). Slager (2009, p.53) states that 'the most important methodological paradigm of artistic research could be described as an awareness of divergence without a hierarchy of discourses'. In line with this statement, I intentionally avoid the 'hierarchy of discourse' as well as hierarchies of interpretation. I attribute to colours and colour changes 'a subliminal communication' (Bourgeois 1998, p.222), which I consider, with Bourgeois, 'stronger than language'. I point to the complexity of colour, light and perception itself:

> After all, through merely visual means, the artist succeeds in making visible what ordinary vision fails to see. Everyday categories of perception can be dislocated in a flash. The artist compels us to see the world in a different way, according to different norms and habits. Images do not replace reality, but reveal novel visibilities, and art proposes polymorphic kinds of observation. The artistic image provides an open view while liberating the spectator from a frozen perspective. (Slager 2009, p.54)

Slager's description of the visual work of artists can be applied to the artworks described here. By presenting metamerism as a wondrous phenomenon, I 'compel' audiences to see colour phenomena in a different way and dissolved the frozen perspective of seeing metamerism only as a problem. I turn the 'problematic' phenomenon into a wonder and I embed this 'problematic' phenomenon in a new context. The artworks allow a new and different view by knitting together magic and meaning (Ch 2.2) and thereby generated a new perception of metamerism.

9 Art practice part 3

Outline

This chapter illustrates the third part of the art practice, a fundamental method of this thesis. I describe the conceptualisation, production and presentation of performances and installations embedding metameric material. The core of this chapter is the art exhibition ‘grün!?’, which took place in January 2016. The exhibition showed an overview of metameric outcomes alongside the process by which the material was created. This made the research experienceable. The exhibition, exposing the enquiry and the main findings, fostered audience interaction with artworks and served as a platform for questions relating to light, colour and perception triggered through experience of the exhibition. The presentation of artworks, produced over a period of three years, allowed for further exploration of particular issues such as, metamerism as wonder, the beauty of the phenomenon, visible-invisible, as already touched on in former chapters (Ch 7 - 8). In this chapter these ideas will be further elucidated and deepened.

9.1 Exhibition ‘grün!?’

Exhibition ‘grün!?’

Location	Schneller Wohnkunstraum, Berne, CH
Date	03 to 30th January 2016

Figure 117 Invitation card for the exhibition

Figure 118 Art space viewed from outside

9.1.1 Background and concept of the exhibition grün!?

From the beginning of 2015 I planned to curate an exhibition in January 2016 where the whole research process and its resulting artworks could be shown and the perceptual phenomenon of metamerism explored and experienced as a wonder. Through this endeavour the PhD research and the artworks gained visibility through a live transfer of the metameric phenomenon in the public domain (Ch 1.5.4). In line with the Swiss Science National Foundation[58] I advocate the importance of broad dissemination of research findings; research should not be something that takes place only in universities. It was my intention to reach a general public.
One aim of the exhibition was to facilitate new links between the artworks and their philosophical aspects, metaphorically knitting the technical and practical with the poetic.
The intention was also to encourage the audience to interact with the artworks by experiencing the impact of light on metameric material, leading to a new perception of colour and light. This would enable a new understanding and appreciation of metamerism. The exhibition was crafted as a platform for interaction and dialogue; artworks were displayed to facilitate inquiry and, in addition to performances, the inquiry was staged. Feedback to support the research hypothesis and inform analysis was gathered in an informal way (Ch 1.5.4.1).

9.1.2 Production and description of the exhibition

In November 2015, I received a plan of the art space, but was not able to design the exhibition on paper. To imagine the setting of the exhibition I needed to be in the room, surrounded by my work. At the end of December 2015, I displayed all my artworks in the exhibition room and playfully tried out variations and possible layouts. Friends[59] supported me in planning the

[58] The Swiss government promotes and funds research and offers specific subsidies for formats which enhance the dissemination of knowledge and open dialogue between researchers and the general public: http://www.snf.ch/de/foerderung/wissenschaftskommunikation/agora/Seiten/default.aspx

[59] Antonia Erni, Anet Rhiner, Dr. Rachel Mader, Sibylle Stamm, Emanuel Morgenthaler.

curating of the space and their external views, inputs and discussions were crucial to the process of making the exhibition.
It was important to perceive the space as an empty canvas and to consider the setting of the exhibition as an artwork in itself. The creation of the exhibition had to take into account all elements within the space. The art space was equipped with moveable spotlights mounted in the ceiling, some with halogen bulbs, others energy-saving bulbs. Both lighting options were incorporated into the exhibition design. Lamps of simple and classic design, with neutral character and colour, were also subtly integrated into the setting.

9.1.2.1 Background and concept of the installation *Trilogy of Light*

Trilogy of Light was first presented with accompanying visualisations (Figure 119 & Figure 120) at the conference AIC 2015 (International Association of Colour) which took place from the 19 to the 22 May, in Tokyo, Japan.

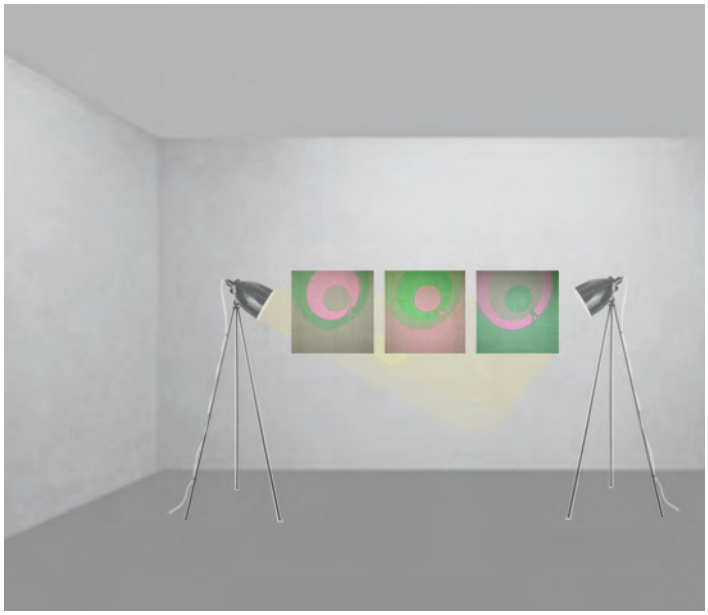


Figure 119 Visualisation of installation in an art space

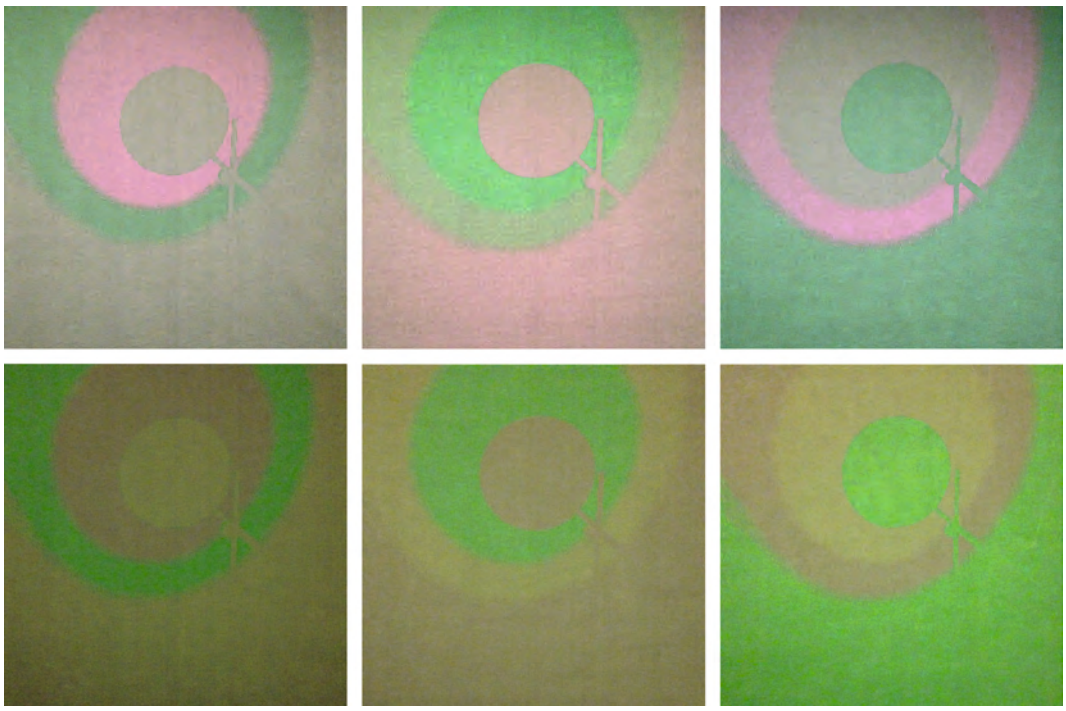


Figure 120 Trilogy of light above in Tungsten, below in Fluorescent light

The conference theme was ‘Color and Image’ and following the title of the conference I wrote a paper, ‘The hidden image – a strategy to put an unwanted phenomenon in its true light’ (Egger 2015) based on the artwork *Trilogy of light* (Figure 119). In this paper I highlighted key aspects of my research, drawing a connection to the everyday (Ch 7.3.6) and playing with ideas of the visible and invisible. I discussed the artwork as a strategy to show metamerism as a wonderful colour phenomenon.

Everyday we are surrounded by images: the plethora of visual material is overwhelming and we no longer look at images properly, assuming that what we see is ‘correct’. We do not generally doubt our sight or expect that the same image could appear in different colours under different light sources (Ch 7.3.5).

9.1.2.2 Production and development of *Trilogy of light*

In order to consider the specific types of light to be used within the research (Ch 8.1.2), it was necessary to explore a range of different light sources, and as a by-product of this an archive of images of lamps and light was created (Figure 121).

Figure 121 Various photos of lamps and light

At a certain point, these images of lamps and their corresponding light effects became interesting in themselves and I chose one image to repeat for the creation of the three squares, which form *Trilogy of light* (Figure 119). I reworked the image in Photoshop, reduced it to three colours (Figure 122) and prepared it for realisation as a jacquard knit (Ch 5.1.2.5) using the metameric olive green three colour series.

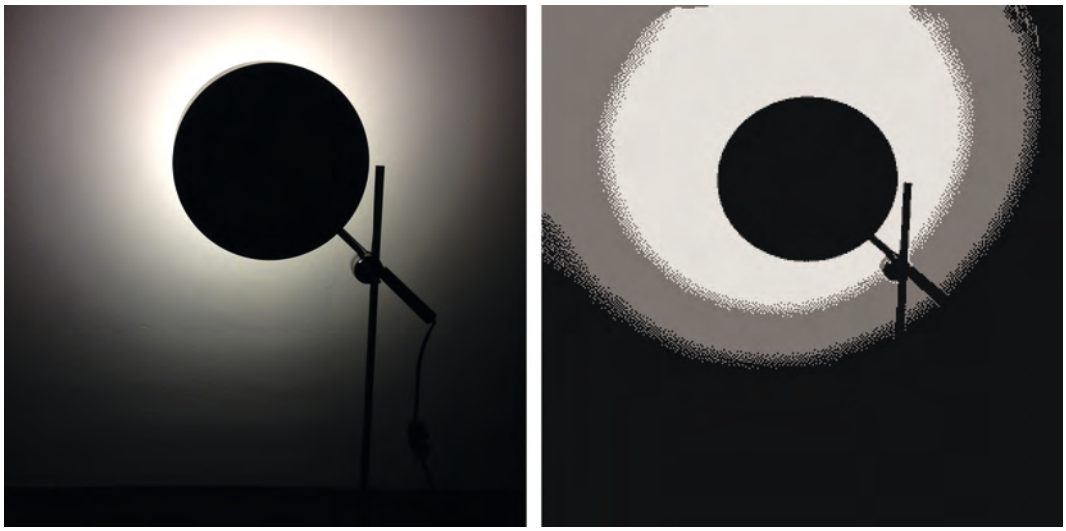


Figure 122 Left: chosen lamp, right: prepared image of 'Trilogy of light' for knit realisation

Trilogy of light is a performative installation with three wall-mounted knitted 'canvases' showing the same image of a shining lamp three times using different arrangements of colours (Figure 119).

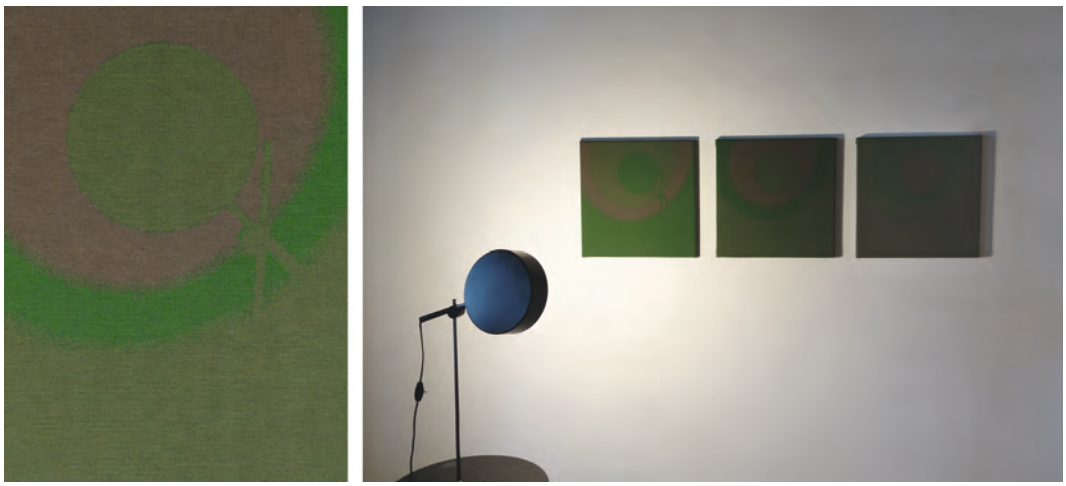


Figure 123 Trilogy of light in the exhibition grün!

In daylight, the human eye is hardly capable of perceiving differences between the three metameric colour shades used and the image is hidden; inherent colour variations only appear when artificial lights are used. In contrast to the visualisation (Figure 119) I also presented *Trilogy of light* in January 2016 illuminated by just one lamp, the 'same lamp' depicted in the artwork. The 'real' lamp was mirrored in the artworks (Figure 123).

9.1.2.3 Analysis of the installation *Trilogy of light*

This installation juxtaposed what appeared to be three identical knitted images, which differed only in regard to their metameric colour arrangement. In daylight, colour differences dissolve and changes in the colour arrangements are hardly perceivable; the three 'canvases' seem the same. The installation is performed with the play of artificial lights to which each canvas reacts differently, uncovering the metameric phenomenon in real time.

In this work, we need artificial light to 'see' the image, as in daylight the canvases appear as unicolor.

It is a double-cross: the real light source triggers the colour changes of the metameric knitted images of the light source. Thus, the real encounters the unreal increasing the effect to the maximum and carrying the surrealistic touch of this work to extremes.

Böhme (2006, p.117) stated 'that light requires a medium in which it can be seen if it is to be visible.' The artwork is the medium where light manifests the metameric phenomenon and the light quality itself becomes visible. Miller asserted: 'The play between the visible and the invisible has always been at the heart of Western art and scientific thought' (2014, p.3). This installation illustrates again the strong linkage of art and science (Ch 1.3.1) in this project.

The title of the paper, 'The hidden image – a strategy to put an unwanted phenomenon in its true light', indicated that to see metamerism just as a problem (Ch 3.1.1) hides the potential opportunities represented by this phenomenon. This research suggests a strategy to reveal metamerism as an aesthetic experience and source of wonder (Ch 7.3.7 – 7.3.8).

Trilogy of light offered an experience, which rendered metamerism visible and suggested things are not always as they appear or as we first perceive them; aspects may remain hidden. We cannot take for granted what we see and a first impression is not the whole truth. We need to

see and consider all the inherent aspects; we have to illuminate with different lights and observe from different perspectives before we judge. Figuratively, this aspect is political.
Natascha Moschini (2016) commented on *Trilogy of light,* saying that the image on the right-hand side (Figure 123) triggered the effect 'as if you had looked too long in sunlight and afterwards your eyes try to adapt again by blinking'. The vibrancy of the colours affected her and her observation suggests the liveliness of the phenomenon and successfully performative nature of the installation. Joëlle Valterio (2016) observed that the artworks were 'charged' and remarked that in her opinion the invisible colours were perceivable as they resonated.

9.1.3 Visual Diary and Process Artworks

Figure 124 Installation of dyed samples and the Process Artwork 'rolling spine', 2013

The *Process Artworks* (Ch 7.1) are an important artistic part of this research and hence were also presented in the exhibition *grün!?*. I displayed some parts of the *Visual Diary*, showing all colours involved in the process, with *rolling spine* (Figure 124 right) selected from the Process Artwork series of works. In addition, I placed a raw form of dyed and labelled colour samples from the initial research phase, pinned onto file cards, in the map stand (Figure 124 left). The important first part of the research process, the development and production of the metameric

material was in this way visualized and made present in the exhibition meaning that the first steps of the research journey could be traced.

9.1.4 ‘Work in progress’ wall

Figure 125 ‘Work in progress’ wall

The conceptualisation and development of knitted artworks was highlighted through a ‘work in progress’ wall (Figure 125). Various artworks, which I did not consider finished yet, were presented and illuminated with two lamps, one with an energy-saving, the other a halogen bulb. The lighting was programmed using a digital-mix DMX system so these two different lights alternated to illuminate the wall for fixed intervals of 30 seconds each.
These works still had raw edges; threads hung down. Most were part of a group related to the same in-progress artwork, which I had started to develop in April 2015. The concept was to combine manifold image material related to the research, such as visualisations and graphics of light, light sources, perception, lamps and textile patterns, then realise these image materials in Jacquard knit (Ch 5.1.2.5). These pieces featured concept ideas, which were not yet finalised.

9.1.4.1 Illuminants: D65 – F11 –A

Light, as one of the crucial topics of this research, led to another group of three knitted artworks. These images show the reflectance curves of the three illuminants (D65, F11, A; Ch 3.2.1.1), which were fundamental during the creation of the metameric material. These graphic curves intrigued me and I considered them shapely and beautiful. Hence, I used them as visual material (Figure 126) for this group and after preparing and transforming source images (Figure 127; Ch 5.1.2.5) in Adobe Photoshop, I realized them in knit.

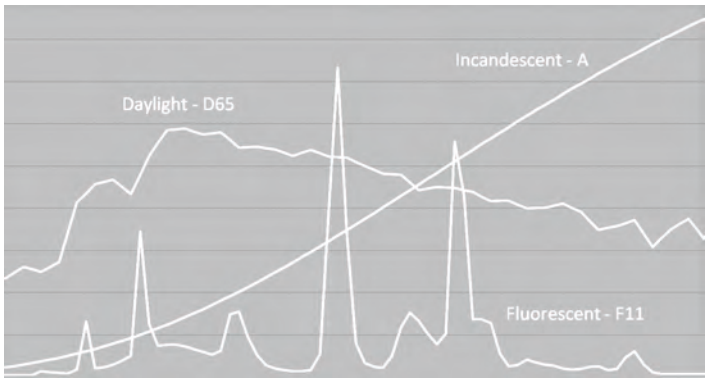


Figure 126 Graphics of illuminants

Figure 127 Prepared two colour images for knit

Figure 128 Workgroup reflectance curves of illuminants F11, A, D65, above in Tungsten, below in Fluorescent light.

Once more I played with a doubling effect as the artworks, each depicting the specific reflectance curve of an illuminant, were then illuminated by the ‘depicted’ light sources. This in turn triggered colour changes in the images representing the properties of each illuminant.

9.1.4.2 Textile pattern

The whole research project is based on a physical colour phenomenon and, as discussed elsewhere; the realisation of metameric material was a highly technical process (Ch 3 - 6). This research made the phenomenon visible through a textile technique, knitted artworks. In order to underline the use of the textile medium, I implemented textile patterns (Figure 129) as visual material.

Figure 129 Textile pattern houndstooth, left in Tungsten, right in Fluorescent light

9.1.4.3 Brain

The sensation of colour and vision (Ch 3.2) ‘depends on the physical quality of light, and physiological and psychological processes occurring in the eye and brain’ (Choudhury 2014, p.159). The brain is a contributing factor of vision and hence a visualisation of a brain was part of the concept (Figure 130).

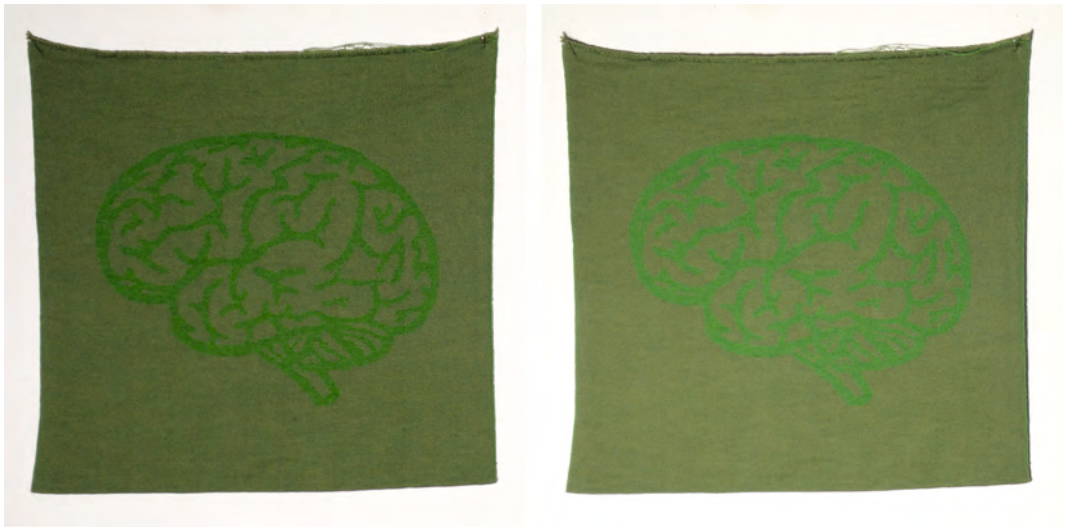


Figure 130 Brain, left in Tungsten, right in Fluorescent light

The presentation of these ‘unfinished’ artworks, as units within the exhibition was successful, as the gathered feedback confirmed. The ‘wild’ wall was considered very beautiful by several visitors, among them an unknown visitor (n.n. 2016).

9.1.5 I lead you down the garden path I and I lead you down the garden path II

I lead you down the garden path I and *I lead you down the garden path II* were placed on a black table with a very simple classic design; one was illuminated with a halogen light and the other with a LED light (Figure 131). These artworks were knitted in purl and plated (Ch 5.1.2.4), hence depending on the structure one or the other yarn/colour shade was visible at the front. In addition, the knitting structure created a three-dimensional play (Figure 132).

Figure 131 View of installations on tables

Figure 132 Close up of I lead your down the garden path

Despite negative experience with LED in 2014 (Ch 4.1.4) in January 2016 I tested a commercially available LED bulb, which, operated with a remote control (Figure 133), offered different kinds of light.

Figure 133 Remote control of LED-bulb

As I restricted this research to ‘white’ light, I used only four buttons labelled: candle, light bulb, sunlight and snowflake. The effect was unexpectedly convincing and the various options showed the colour changes very well and played beautifully with the artworks, triggering various green shades. Hence this LED bulb was integrated into the exhibition. This added another possibility for interaction as the audience could manipulate the light quality themselves and observe the changed colours of the artworks.

9.1.6 Blurred crest

The artwork *blurred crest* (Figure 131 right) was illuminated on one side with a halogen light and on the other with an energy-saving light. This knitted artwork is purl knitted all-over and plated with two metameric coloured yarns (Ch 5.1.2.4). Triggered by the two different light sources the artwork, being the same all-over, changed colour from the left to the right side with a subtle transition in the middle (Figure 134).

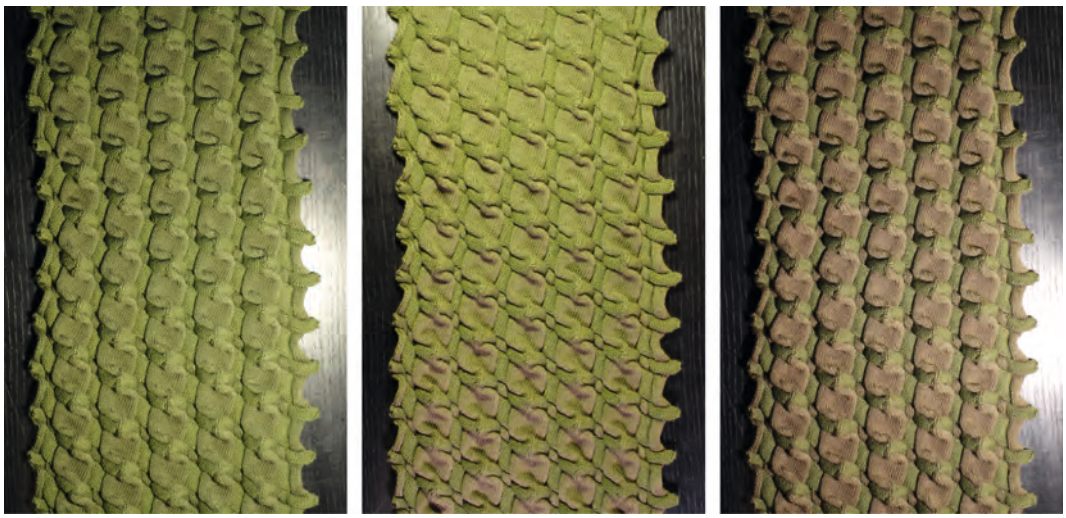


Figure 134 blurred crest: left side under fluorescent light, right side under incandescent light and middle with subtle transition.

Figure 135 Close up blurred crest under incandescent light

This simple and static setting was visually effective and convincing as it showed the colour change permanently. It also gave the spectator the option to touch and move the artwork from the right to the left side and to realise instantly that the colour change is dependent on the light shining on it. I invited the audience to interact with the artworks and allowed them to bring artworks out of the room to observe them in ‘natural’ daylight.

9.1.7 Remnants of SARN performance green-green-green

Figure 136 Memory of performance green-green-green, SARN conference 2014

Performances (Ch 7 - 8) were a crucial thread in the research fabric and some left remnants, traces, which allowed the performances to resonate. I displayed the remnants, the green painted file cards of the SARN performance *green-green-green* (Ch 8.2), on a small table mounted on the wall (Figure 136). These green shades, presented side-by-side, constituted a visualisation of the lengthy process in the dye lab, become an artwork in itself and a visible reminder of an essential but ephemeral performance.

9.2 Analysis of exhibition grün!?

Several works had already been displayed in various venues, but the salient threads of the research were still not knitted together. I consider *grün!?* a research exhibition, entwining the multifarious threads involved in the fabric of this thesis, bringing to light the enquiry and its main findings. This recapitulation was coherent in its comprehensive depiction of the various dimensions and showed the depth of the research. Furthermore, it was crucial in gathering informal feedback, which confirmed the originality and the significance of this research.
As intended, a diverse group of people visited the exhibition and joined the performances: all ages were represented, from children and teenagers to retired people, with various educational backgrounds, including artists, academics, teachers and social workers.

Several visitors confirmed that they experienced the exhibition as a platform for debate, for exchanging and developing ideas. They felt welcome to think, reflect upon and debate their own perceptions of colour and light in the setting of the art space. They often got involved in interesting discussions triggered by the artwork and many of these discussions took place among and were inspired by the artworks.
The possibility of interaction was used and enjoyed in lively ways. Again and again visitors were surprised and astonished as their phone cameras captured the seemingly unicolor artwork, placed in the display-window in daylight, revealing it as two-coloured (Egger 2016).

Several feedback comments, mostly from architects, remarked that it would be great to blow up the size of the works and realise them in large-scale as wallpapers, playing with the possibility of room changing perception. At the beginning of the research I considered this option but did not pursue the idea of knitted wallpapers. I plan to take up this idea again (Ch 10.3).

Most of the visitors confirmed that they had never seen anything similar before. They contemplated and observed the artworks attentively, intensely and accurately. (Figure 137)

Figure 137 Visitors of exhibition grün!?

Joëlle Valterio (2016) told me that the artworks spurred her imagination and inspired her to invent stories. Others said that they perceived the borders on some artworks as blurred, as the colours coalesced and colour shades engaged with each other.
In a longer discussion, artist Ka Moser[60] (2016) stated that the colours of the artworks are oscillating as they all have the same chromaticity. She drew comparisons to her own work and stressed the importance of nuance. She considered my work meticulous and complimented me for sparing no effort. In her opinion, the installation of works on the black tables was very convincing, as the direct basis for the artwork, the texture of the visible wood fibres, played very well with the textile textures. She appreciated the distinctiveness and clarity of the exhibition.

[60] Colour is the core topic of Ka Moser's artwork.

9.3 unravel wittgenstein

Presentation performance *unravel wittgenstein*

Location	Schneller Wohnkunstraum, Berne, CH in the context of the exhibition 'grün!?'
Date	15 January 2016
Duration	One hour
Documentation	https://www.researchcatalogue.net/profile/show-work?work=397532

Presentation performance *unravel wittgenstein*

Location	Progr, Berne, CH, in the context of the performance platform, UTP (unwrap the present)[61], title of the evening 'true colours'
Date	31 January 2016
Duration	Twenty minutes

Figure 138 Invitation card for performance

9.3.1 Background and concept of the performance *unravel wittgenstein*

In December 2015, I thought for the first time about this performance. Back then it was just a vague notion. An early aim of the performance was to reveal the relation between text and textile (Ch 2) through the action of 'unravelling' both.

One imagined action was to unravel a knitted artwork titled *unravel wittgenstein*[62]. This artwork, developed for the performance, combined two metameric yarn plies; one ply stable yarn and

[61] The monthly performance platform UTP is curated by performance artist Joëlle Valterio

one ply changing colour under Tungsten light[63]. Under a specific lighting condition[64] the artwork would firstly appear unicoloured and after the unravelling of the unicoloured artwork the two yarn plies would be separated and the formed ravels mounted on the wall. The two ravels, seen under Tungsten light would appear bicoloured and reveal the hidden phenomenon.
The other planned action was the performing of the fascinating philosophical treatise 'Remarks on Colour' (2007) by Wittgenstein. This particular text has a 'descriptive and exploratory style' (Mc Ginn 1991, p.436) and comprises fragments circling the phenomena of colour, approaching it from different perspectives. The various threads combined in the complex fabric of the text would also be 'unravelled' during the performance.

The documentation of the performance *unravel wittgenstein* is on https://www.researchcatalogue.net/profile/show-work?work=397532.

[62] In 1986 the artist Rosmarie Trockel (Trockel et al. 2012) realised a similar artwork. 'Untitled' is knitted with three different acrylic yarn plies, red, blue and white. The artwork is hung on the wall and the three loose and unravelled (obvious because of the curliness) yarn plies hang down, with three ravels on the floor.

[63] For this work I used the yarn, which was dyed by Blackburn (Chapter 6.1.7).

[64] Illuminated with the LED bulb (Müller Licht, I Dual, 470lm, 40W, E14), by selecting the 'snow star' setting, the Blackwell Standard and Blackwell Brown yarn looked unicolor.

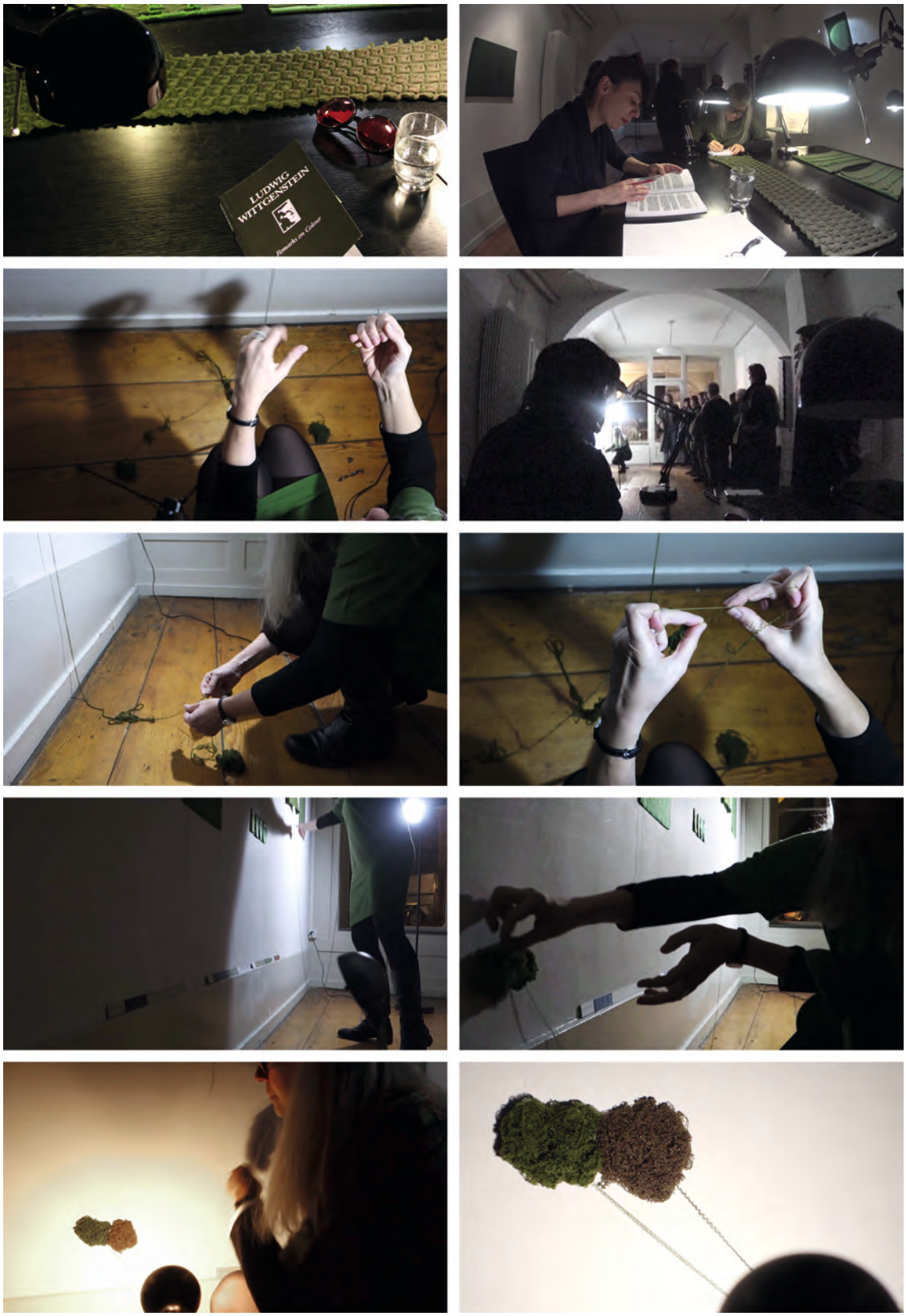


Figure 139 Performance *unravel wittgenstein*, January 15th 2016

9.3.2 Production of the performance *unravel wittgenstein*

I realized this performance in collaboration with the performance artist Joëlle Valterio[65]. We settled on our roles and a musical score. We agreed to improvise the performance but set 'clear markers signalling the start and finish' (Schechner 2006, p.240) as well as fixed points for major changes in the course of the actions performed.

The performance started before the first spectators came into the space. Wearing my metameric green dress, I received visitors as they arrived. Valterio, holding a red pencil in her fingers and sitting at a black table, performed the text 'Remarks on Colour'. She performed the text as though trying to understand the content by reading it out loud. She did not recite; her approach was more a search for meaning. As a native French speaker, Valterio was not familiar with all the English words. Having a different language and vocabulary, she sometimes had to search for the right pronunciation. At other times, she knew the sound of a word but did not understand the meaning. She repeated phrases and parts of phrases. Using a bilingual text, she switched back and forth between English and German.
Concurrently I introduced people to my work in the exhibition until the performance officially began. At the announced starting time of the performance I withdrew from personal contact in order to concentrate fully on the actions I planned to carry out during the performance.
I moved in the space while playing with the remote control of the LED bulb (Figure 133), changing the light and in doing so activating colour change in the installation on the table. I also exposed the dress in the various light situations present in the art space, revealing a further colour change. Occasionally I sat down beside Valterio and wrote different terms on white cards, placing them in the map stand. These consisted of a series of green colour names, pointing to the difficulty of colour naming (Ch 7.3.2), and terms captured from Valterio's reading such as: Transparent green, sameness, refined notion of green, blend of blue and yellow, shade of colour, same, colour concept, and so on.
I moved from the table, making my way through the audience, which stood around the room, and inserted the newly written cards in the map stand. Now and then I responded to Valerio's reading, taking it as an input for my next action. When she spoke about a reddish-green, for example, I exposed my dress under halogen light to show the 'reddish-green' in my dress.
Valterio's voice had a steady sound, which every now and then changed to murmuring.
It was a tentative reading using different qualities of voice, at times slow or hesitant. She thumbed through the book, turned pages back or skimmed forward before stopping and starting the reading again. There was a consciously chosen randomness, a play with rhythm, a combination of short rests and longer breaks. She supported her head with her hands, taking a thinker's pose, alternated silence with loud reading, stopped in the middle of a phrase.
In the meantime, I directed the light of one lamp on the artwork *green-green-green_1_03:11* (Figure 140 above), the knitted still image of a former *green-green-green* performance (Figure

[65] Joëlle Valterio is a performer, curating monthly a performance platform: http://unwrapthepresent.blogspot.ch

140 below). By placing myself in front of this artwork, my alter ego confronted me and I was doubly present in the room. The 2D knitted panel and the 3D knitted dress were visually communicating across the space, both depicting the colour change.

Figure 140 Above: Still image of the performance *unravel wittgenstein*, myself in front of the artwork green-green-green_1_03:11 and below the artwork

The audience sometimes stood still, sometimes moved around following the actions taking place and taking different perspectives from which to observe the performance.
After the agreed time-frame of twenty minutes, Valterio stopped her reading, her ‘unravelling’ of the text, and the simultaneousness of text and textile was suspended.
This cue triggered my next action. I turned off all lights in the room apart from the light in front of *unravel wittgenstein* (Figure 141), which was placed in the middle of the ‘work in progress’ wall.

Figure 141 *unravel wittgenstein*

I started to unravel the knitted artwork by pulling the loose yarn. I did not rehearse the unravelling and kept the tension and curiosity of the lived moment in real time. The action was a new experience for both the audience and myself. The loose hanging thread was also still straight; unravelled yarn is curly, as the yarn is formed by the loop of the knitting. By not rehearsing I could emphasize the change in the hanging thread from straight to curly.
As the plan was to divide the two yarn plies, I paid close attention to the way the material fell, so that the unravelled yarn building up in a heap on the floor did not become a tangled mess. From time to time I split the yarn plies and created ravels. Sometimes the unravelling stopped, as there was tension because of the twisting of the two different plies. After loosening the tension, the unravelling proceeded. I varied the moves, making them smaller and bigger, and played with the rhythm. Once the ravels were compact and the yarn interlaced enough to show the colour, I stopped the unravelling and pinned the ravels separately to the wall, highlighting them with a halogen light to show their true colours (Figure 142).

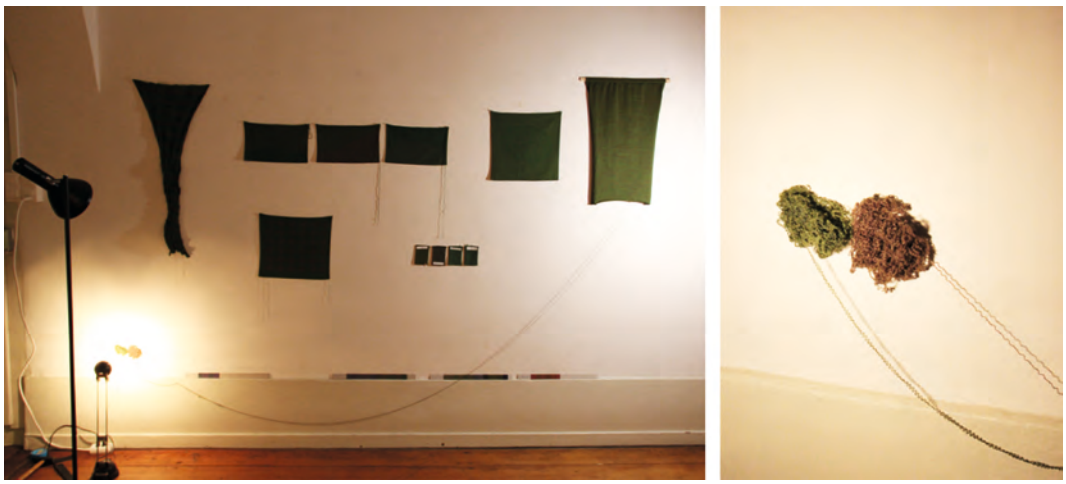


Figure 142 Left ‘work in progress’ wall after performance, right the two illuminated ravels

9.3.3 Analysis of performance *unravel wittgenstein*

Lugg (2014, p.2) stated that ‘Remarks on Colour is a significant document, actually a profound and challenging work of philosophy’; ‘there is plenty here for philosophers to get their teeth into’ (Ibid., p.1). As described in Chapter 1.4.1, even though I am not a ‘Wittgensteinian’ I used this text ‘unashamedly’ (Nevanlinna 2011, p.29) for the purposes of this research.

The text ‘represents Wittgenstein’s considered opinion’ (Lugg 2014. p.2) and alludes to various facets of the mystery of colour. He asks puzzling questions but rarely gives answers; he describes but does not go into detail. He invites readers to look closer at daily colour phenomena, to observe more carefully their own experiences and question preconceptions. ‘Rather than offering a solution Wittgenstein involves himself in pointed dialogues, switching sides more than once’ (Hrachovec 2014, p.85). The performance of Wittgenstein’s text set the context in which the mysterious metameric colour change was embedded. In this research, metamerism has served as a means to expose the complexity of the phenomena of colour and light.

The text, using language to think about colour, suited this research very well and further underlined the complexity of colour phenomena**,** a core interest of this research.

‘Philosophers are often concerned to describe the nature of things, and in particular the nature of colour’ (Kemp 2014, p.57). They ‘attempt to answer the philosophical question: “What is colour?” (Ibid., p.58). Wittgenstein attempted ‘to elucidate the *nature* of colour, its *essence’* (Ibid.). He scrutinised colour concepts, terms and terminology and acted out a colour language game[66], drawing attention to the multifarious facets of colour (Ch 7.3.1). He illuminates the topic of colour from different perspectives and addresses linguistics, phenomenology, physics, physiology, mathematics, psychology and anthropology. He did not want ‘to establish a theory of colour’; he was more interested in ‘the logic of colour concepts’ (Wittgenstein 2007, 22. p.5e).

[66] Wittgenstein consistently uses the term ‘language-game’ with manifold meanings. Language-games can be simple, ‘description of simple patterns of linguistic behaviour’ (Black 1987, p.75) or ‘*sophisticated*’, requiring ‘background and skills’.

The textuality of 'Remarks on Colour' is clearly not offering itself for an oral presentation. The built phrases, comments and remarks are not easy to understand on first reading and it is certain that Wittgenstein did not intend or anticipate the staging of his remarks. But, as I realised after the performance *unravel wittgenstein*, his textual material has inspired other artists' performative works. Video artist Gary Hill, among others[67], is interested in perception and the relation of image, sound and text. He worked in 1994 with the Wittgenstein text and realised a video in which his eight-year-old daughter, Victoria Hill, reads the philosophical text. She is 'struggling with pronouncing the words of a text she can't possibly understand' (Hill 2009, p.467). In contrast to Hill's work, Valterio did not recite the text. She performed the text, explored the text and treated it in various manners: repetition, translation, musicality, multifarious voice leading and rhythm. Trying to understand the complex content she unravelled the text and in this way the text is remade, as Schechner (2006, p.227) states:

> Understood performatively, texts are transformable and pliable sign and / or symbol systems. Every text invites being remade into new texts. This proves to be the case, especially with regard to texts used in or as performances.

This kind of reading embraces the particularity of the text and reconciles its content with the rest of the performance. Pronunciation errors evidenced the difficulty of the content. Several spectators struggled to understand the text or found it tedious. Brigitte Roth (2016) reported that the 'incompetent' reading of the text initially irritated her and then her effort to understand the 'why' of this incompetence held her attention; at a certain point, she let go of her question and got into the performance. She entered the flow and shifted to just experiencing the moment. Discussing the performance afterwards with another spectator, she discovered that this happened for both at a similar point. From then on they enjoyed the performance and at the end had come to consider the manner of reading coherent.

This performance set the focus on undoing, the unravelling and deconstruction of the constructed. The act of undoing became the craft of the lived moment. The undoing of the knitted fabric; the act of pulling the yarn, the movement of fingers and arms, dividing the two plies, creating ravels on the floor, was a poetic composition. I developed a technique for unravelling; played with various rhythms and movements. I enjoyed the discoveries in the moment. From time to time the twisting gave resistance, linking the unravelling of the fabric to the text's intrinsic friction. There was a musicality in the unravelling of the artwork as there was in the reading of the text; both represented a gesture of storytelling and played with rhythm, repetition and stops so that a comparison of text and textile (Ch 2) occurred.
The moment of unravelling held magic, the deconstruction created poetry. In the moment, surrounded by the audience, I felt increased concentration in the room. It was very silent.

[67] Portuguese multimedia artist Julião Sarmento, realised a video: R.O.C. (40 Plus One) in 2011 (https://www.youtube.com/watch?v=NhFJMkID4Lg) and artist and writer Kristina Lee Podesva realised a video '(r.e.) remarks on colour' in 2006. Her work is a remake of Gary Hill's video, but differentiated as she herself is reading the text, showing the viewer just her back and a little bit of her face in silhouette. (http://www.kristinaleepodesva.com/videos-200614/)

Nobody moved and everyone watched me perform my own movements and the movements of the yarn. I enjoyed this bodily movement in the unravelling, the actions of the fingers and arms. This subtle moment was poetic and touching, as the audience confirmed afterwards.
Brigitte Roth (2016) noticed that she does not normally observe someone practising a craft and realised how much she enjoyed the beauty in this careful observation of a simple task. She told me that after the performance she discussed it with her partner for quite a long time, reflecting on the experience of watching the meditative slow movement of unravelling; appreciating the craft, the moves of the yarn, my hands and arms. This response confirmed that the performance 'abets a peculiar – that is to say, *distinctive* – type of contemplative state (Carroll 1999, p.160).

Generally, knit is undone when the knitted piece has failed so unravelling can be considered problematic. But in this performance, the audience perceived unravelling as a positive act.
The performance made visible two generally negatively perceived acts: the act of the metameric colour change interlaced with the act of unravelling and undoing.

9.3.3.1 Facets of the remarks

In this performance, I also approached the topic of colour naming (Ch 7.3.2) through the action of writing green colour names on cards, exposing them in the room and underlining the variety of green shades present in the exhibition.

Wittgenstein addressed the language-game of colour meaning (Ch 7.3.3) and naming, among others, in the following remarks:

> We must always bear in mind the question: How do people learn the meaning of colour names? (Wittgenstein 2007, III 61. p.25e)

> What is there in favour of saying that green is a primary colour, not a blend of blue and yellow? Would it be right to say: "You can only know it directly by looking at the colours"? But how do I know that I mean the same by the words "primary colours" as some other person who is also inclined to call green a primary colour? No, - here language-games decide. (Wittgenstein 2007, I 6. p.2e)

Following the subtractive principle (Ch 3.2.2.2), the blend of blue and yellow creates a green, which in this case is considered a secondary colour. On the other physical principle, the additive principle, green is a primary colour. These remarks point to the sophisticated language-games of the various fields puzzling over colours. In the course of time some pure chromatic colours were granted priority in meaning and the 'search for a method, which illustrates the mutual relations of *all* colours in the context' (Zwimpfer 2012, Nr.362-365), led to the creation of the colour wheel, a uniform and symmetrical arrangement of colours. But as Zwimpfer stated:

> Depending, if such primary colours are determined out of a philosophical, physical, technical, optical or psychological point of view, the arrangement of the colours in the circle change. (Ibid.)

These different points of view are based on contradictory principles and cannot be integrated in one universal colour wheel. This remark indicates the 'differing assessments and interpretations of the phenomenon of colour and manifested thereby the different Weltanschauungen' (Ibid.).

It's rather difficult to describe normal vision, as 'normal viewers' perceive colour very subjectively and we are all unable to articulate these differences in seeing (Ch 3.2.2 & 3.4).

> The description of the phenomena of colour-blindness is part of psychology: and therefore the description of the phenomena of normal vision too? Psychology only describes the deviation of colour-blindness from normal vision. (Wittgenstein 2007, I 16. P.4e)

Each audience perceived the performance differently, as each comes with a certain knowledge and set of physiological capacities (Choudhury 2014, p. 201). Moreover, in the audience there were spectators with colour vision deficiency[68]. 'Colour vision deficiency is the inability, or decreased ability, to see colour or to perceive colour differences, under lighting conditions when colour vision is not normally impaired'. People who 'cannot distinguish between reds and greens' (Mather 2016, p.260) are commonly called red-green blind.

[68] In the current language people with defective colour vision are often called colour blind. 'The term 'colour blind' is misleading, as more than 99% of colour-blind people *can* see colours' (Choudhury 2014, p.201).

Colour vision deficient people surely saw the performance and the inherent colour changes it involved differently. In their case the difference in perception of the performance is obvious and so can easily be described. A 'colour-blind' viewer, being aware of having different perception compared to people with 'normal' colour vision, mentioned after the performance a children's game: I see something, which you do not see[69]. A 'normal viewer' saw colours, which he couldn't perceive, as he missed some colour changes. The 'colour-blind' viewers, considering themselves red-green blind, could detect colour change in the incandescent light, but could not see the strong green in fluorescent light. In the following remark, beside colour-blindness, Wittgenstein adds the topic of language translation and the learning of colour names.

> Imagine a tribe of colour-blind people, and there could easily be one. They would not have the same colour concepts as we do. For even assuming they speak, e.g. English, and thus have all the English colour words, they would still use them differently than we do and would learn their use differently. Or if they have a foreign language, it would be difficult for us to translate their colour words into ours. (2007, I 13. 4e)

9.4 Conclusion

The exhibition *grün!?* enabled further encounters with the colour phenomenon of metamerism and presented, in a concentrated form, the enquiry and the main findings of my research. Gage (2006, p.7) asserted that 'Albers's book [Interaction of Color] is largely concerned with demonstrating the relativity of colour perceptions'. In line with Albers, I identified the relativity of colour perception and disclosed the complexity of the phenomenon of colour and light. The exhibition was created as an aesthetic experience and the audience was invited to interact with the artworks and to observe 'in order to see' (Wittgenstein 2007, 326. P.61e).

> To observe is not the same thing as to look at or to view. "Look at this colour and say what it reminds you of". If the colour changes you are no longer looking at the one I meant. One observes in order to see what one would not see if one did not observe. (Wittgenstein 2007, 326. P.61e)

On the basis of my knitted artworks I narrated a story of colour and light and by mooting a colour phenomenon, metamerism, inviting audiences to contemplate their perception. With my work, I confirmed Checinska and Watson's (2015, p.279) opinion:

> Likewise, cloth and fibre are being rediscovered by a new generation of creative practitioners: visual artists re-interpreting textile craft practices, curators and cultural critics using textiles as a route towards contemplation, as a way of opening up an argument or narrative.

The colour changes in the textile artworks piqued the curiosity of audiences and triggered questions, and the exhibition was lively and often used as a platform for debate. The exhibition,

[69] This game is in English called: I spy with my little eye.

showing artworks that play with a colour phenomenon triggered by ordinary everyday light, was accessible to a broad audience, from children to elderly people, and from academics, artists, and others from a variety of backgrounds. Independent of age and background, people were fascinated by the experience of the artworks and their unexpected colour changes and effects.

The performance *unravel wittgenstein*, a sophisticated colour and language game, knitted together text and textile, including both literal and topical threads. Two continuous yarn plies built the fabric of the artwork. In contrast to these threads, the texture of Wittgenstein's remarks is not ongoing; the fragmentary text is not linear. The performance juxtaposed the fragmented threads of the text with the continuity of the threads comprising the artwork. The performance combined the performative unravelling of the text with the unravelling of the artwork through an act of deconstructive 'craft'. By deconstructing this particular text as well as the artwork, the performance also deconstructed the phenomenon of metamerism. The performance, after unravelling the unicolour artwork, highlighted the two threads, revealing them in two colours. This is a strategy to put an unwanted phenomenon in its true light, allowing this negatively perceived physical colour phenomenon to offer an aesthetically beautiful experience.
The audience confirmed this perception of the experienced phenomenon as a wonder. Many were touched by the performance and the audience reports suggest that it was considered to show something previously unseen, supporting the originality of this research.

> Like all good artists, Wittgenstein is selling us less a set of doctrines than a style of seeing; and that style cannot be abstracted from the feints and ruses of his language, the rhetorical questioning and homely exemplifying, the sense of a mind in ceasing ironic dialogue with itself. (Eagleton 1993, p.9)

In line with Wittgenstein, the performance invited a certain 'style of seeing', a conscious seeing of the subtle colour phenomenon. The exhibition, and also the performances, foregrounded the impossibility of truly grasping the complexity of colour phenomena. It addressed several aspects of colour, allowing for their indefiniteness without presenting doctrines. Wittgenstein's remarks address the topic of 'colour blindness', and audience members with colour vision deficiency were present to discuss and cast light on this fundamental issue in colour perception. These informal comments add further emphasis to the awareness of the complexity of colour perception addressed by this research.

10 Final junction of the threads – Conclusion

Outline

In this chapter I recapitulate the journey of this research and summarise the findings, insights and reflections, which emerged from this project. In the previous chapters I critically analysed and discussed the various threads of my work, while in the following sections I draw together these manifold threads of my argument using, as 'appropriate evaluative standards', 'vigor instead of the positivist-based rigor' (Leavy 2009, p.257). The aims and objectives defined in Chapter 1 will be revisited and I will consider whether I succeeded in implementing them.

My hypothesis was that whilst metamerism is a major 'problem' in the commercial textile industry, it could potentially generate previously unconsidered opportunities for creation. Thus, the main aim of this investigation was to re-think and culturally relocate this physical colour phenomenon. This study originated findings, as discussed in previous chapters, and in this chapter I set out to highlight and finalise these, bringing this thesis to a close. Open questions remain and my curiosity regarding this phenomenon is not yet satisfied; before going on to conclude this text, I introduce plans for further research and potential new work.

10.1 Aims and objectives revisited

The following sections are a summary of my research approach and my intentions. In Chapters 1 and 2 I located the territory of this research. I set out my background, which strongly influenced this project; I introduced the applied methodology and corresponding methods; and I presented the various fields involved in my study (physics, chemistry, physiology, psychology and colour management) and explained how I used methods from the fields of science, technology and art in this transdisciplinary investigation. Furthermore, I outlined how I would knit together these research threads; the methods, practice and tools used in this research.
The project, a hybrid of research for the arts and research in the arts (Ch 1.3.3), was executed mainly in two phases:
Phase 1: Chapters 3 – 6: research for the arts.
Phase 2: Chapters 7 – 9: research in the arts.

10.1.1 Phase 1: research for the arts

First, I had to create the metameric material, which was later needed as the medium for the creation of artworks (Ch 7 -9). Thus, I researched for the arts (Ch 1.5.2). The preparation of the metameric textile material was the preparation of the main threads of this research in the truest sense of the word.

The first phase of the research took place mainly in the dye and knit lab, alongside the reading of supporting literature to build up the knowledge and technical know-how needed for the execution of this project.
I researched the various topics involved in light and colour perception, introduced the terms needed for the understanding of the research journey and defined the research parameters for the development of metameric material.
I created a unique methodology and corresponding methods suitable for realising the objectives of this phase. This part of the research was conducted mainly with quantitative methods (technical actions, lab work: measuring, calculating and assessing), combining methods from different fields and disciplines (science and technology). I identified and explored dye recipes in order to be able to produce metameric material and finally produced a metameric colour series of three olive shades.
I expected to execute the journey in the dye lab using quantitative methods only but encountered unanticipated problems. For this reason, I adapted the procedure and introduced qualitative methods into the assessment of the dyed colours.
In line with Leavy (2015, p.294), I regard truthfulness as a main tenet of art research, an opinion shared by scientists (Ch 1.4.7). I honestly documented the whole journey in the dye and knit lab and analysed and drew conclusions from the outcomes. These personal experiences included emotions, triggered by the research process, which were not always as smooth as I hoped or anticipated. My descriptions of failures and detours, which triggered these frustrations, are part of the documentation.
In the dye lab, I was confronted with problems because I asked the system to do something it is neither designed for nor normally asked to do. There was no defined procedure for achieving purposefully metameric material and I had to invent new methods, combining quantitative with qualitative methods, to achieve this final goal. I had creatively to figure out how to get my desired results using industrial dye software against its own standard programming.
I implemented all the aims and objectives set in Chapter 1 to reach the set goal and finally succeeded in producing metameric yarn in a colour series of three olive shades.

10.1.2 Phase 2: research in the arts

I did not expect to make artworks before the metameric material was ready. But the research in the dye lab was a long haul and this produced a lot of by-products, which were re-purposed as artworks (Ch 7.1). Hence, I started the research in the arts (Ch 1.5.3) earlier than anticipated, during the first phase, when I discovered the failed material could be used in artworks, and as an artistic form of process documentation, which led me to regard these early failures as an opportunity to extend the scope of my research in an unexpected way.

With the first successful metameric dyed material, I started to explore the possibilities and effects I had hoped the colour phenomenon of metamerism would offer. As a next step, as soon as the metameric yarn was ready, I created various knitted structures and experimented with colour combinations. I investigated the visual possibilities in order to build up my visual

understanding and a visual vocabulary. This step, involving the conscious experience of metameric material, increased my ability to imagine further possible effects, looks and designs, which proved fundamental to the creation of artworks.
I observed how the colours of my knitted metameric works (in trials as well as finalised artworks) interacted with the agency of the defined illuminants, as this allowed a certain consistency in my approach to realising effects. I also examined the colour effects triggered by various light sources, including ordinary light (daylight) and common commercial lighting (fluorescent and incandescent light). I manipulated and influenced the effect of colour metamerism under these different light sources and studied how these varied the colours within purposeful colour arrangements and manifold knitted structures. I analysed these studies and drew conclusions from their outcomes. These researches allowed for optimum display of my artworks. I candidly documented the journey of this artistic research phase in my research journals, with photographs and sketches, and included personal experiences and emotions.

As discussed and analysed in Chapters 8 and 9, based on the outcome of the executed studies, I created knitted metameric artworks and presented the results in the form of performances and installations in the public domain. I employed art practice to test, to communicate and to disseminate the research process as well as the findings of this research.
The transfer of my work in the public domain (Ch 1.5.4) was a goal of this research and I chose a variety of strategies for the mediation. Through presentations at conferences, performances and installations, I made my research accessible to a broad academic and non-academic audience (including artists, designers, people working with light or/and colour, people with diverse backgrounds and of different ages).
I invited audiences to encounter the physical colour phenomenon of metamerism and offered an aesthetic experience of its colour changing effects. Through the embedding of metameric material in artworks, I generated possibilities to experience sensuously the powerful agency of light and its effect on colour, and thereby allowed audiences to explore and revisit their understanding of these phenomena. In staging my findings, demonstrating the ephemeral character and remarkable power of light, I revealed metamerism as an opportunity and not merely a problem. In this way, I relocated the optical colour phenomenon of metamerism and led audiences to a new appreciation of its possibilities.
Through my artworks I explored this specific phenomenon in all its inherent aspects and contextualised it in a broad spectrum of theories surrounding questions of colour, light and perception. Through performances, I addressed several subjects (including colour; colour naming; colour meaning; the colour green; light and ecology; light in the everyday; everyday life and wonder) as introduced in Chapter 7.3. I combined the non-verbal experience of colour changing textile artworks with spoken text, highlighting multiple facets of manifold fields while consciously shaping each artwork to fulfil my intention of relocating the ‘problematic’ phenomenon of metamerism as a sensual and poetic experience, giving a different focus to each work in the various series produced.
I created a group of *green-green-green* performances, where a metameric dress was the main feature. These performances laid out a first selection of topics from the fields of philosophy,

psychology, linguistics and ecology. In addition, during the twenty-four hours *green-green-green* performance at SARN, I re-enacted my lengthy process in the dye lab by mixing and painting live in public, green shades on a series of file cards.
The performance *Q & I* introduced the term 'metamerising', a powerful metaphor for the connections between the different metameric shades in my artworks and the different shades of personality, offering the idea of a metameric self, which adapts to changing circumstances and contexts. This performance was especially interested in evoking emotional responses, by triggering reflections on the metameric and 'metamerising' self in the audience.
The performance *unravel wittgenstein* combined a performative deconstruction of Wittgenstein's (2007) remarks on colour with the physical deconstruction of a metameric artwork. The deconstruction of the text revealed the complexity of colour, light and perception while the deconstruction of the artwork revealed its previously hidden metameric poetry.
To finalize the art practice phase of my research, I curated an art exhibition, *grün!?*, where I installed a selection drawn from the full range of artworks produced during all stages of the project. I included early process artworks, unfinished and envisaged artworks in partially realised forms, alongside the remnants of performances and a body of completed artworks. This was a 'research exhibition', exhibiting the process as embodied in the artworks, which for this purpose I consider as findings. Audiences could experience the exhibition without explanation and were allowed to interact directly with the artworks, for example by changing the light situations to study the changes for themselves. This exhibition proved to be a useful platform for questions, reflections and discussions to take place and the research benefited greatly from the opportunity it provided to communicate my research and process to a broad public and consider the questions raised by audiences on all aspects of my research.

For the execution of the second phase of my research I created a unique and appropriate research methodology and correspondingly suitable methods. I used 'practice as research' and, taking a transdisciplinary approach, applied methods from different fields and disciplines (art and science). I studied selected literature and underpinned this reading with further insights and remarks drawn from different subject fields (philosophy, linguistics, social science), incorporating these into my own reflections and subsequent analysis. As summarised in this section, the actions undertaken in the second phase tally with my set aims and objectives.

10.2 Main findings

I was interested in the moment when the unexceptional can be seen as exceptional. I was interested to see something different through the same eyes. I was keen to undercut the standard perception, to offer a new experience of the 'well known', or at least, of something we thought we knew well.

10.2.1 What is artistic research all about?

> What is artistic research all about? It is about cutting-edge developments in the discipline that we may broadly refer to as 'art'. It is about the development of talent and expertise in that area. It is about articulating knowledge and understandings as embodied in artworks and creative processes. It is about searching, exploring and mobilising – sometimes drifting, sometimes driven – in the artistic domain. It is about creating new images, narratives, sound worlds, experiences. It is about broadening and shifting our perspectives, our horizons. It is about constituting and accessing uncharted territories. It is about organised curiosity, about reflexivity and engagement. It is about connecting knowledge, morality, beauty and everyday life in making and playing, creating and performing. It is about 'disposing the spirit to Ideas' through artistic practices and products. This is what we mean when we use the term 'artistic research'. (Borgdorff 2006, p.21)

Borgdorff's description of art research is fully applicable to this project. With this doctoral dissertation, I have presented a coherent research project with internal consistency, as specified by Leavy (2015, p.268), as criteria for art research assessment. I was wholeheartedly engaged in this research project and I believe I have thoroughly and consistently reflected the process as well as the outcome of my research.
I regard the instrumentalisation of art and art research critically, as I advocate for the autonomy of art, and as a consequence, I consider uselessness a fundamental condition for the creation thereof. Thus, I developed this project without any particular educational intent and explored the colour phenomenon of metamerism following my own curiosity and this has shaped my journey. Further, I was keen to share the newly discovered beauty of metameric artworks with a broad audience. However, retrospectively I see value in this phenomenon as an aesthetic rather than instrumentalised experience.

10.2.2 Creating catalytic conditions

> Ultimately, it is a matter of acquiring *new* insights, and what is new is per definition not foreseeable, thus it can also only be brought about within bounds. What is really new has to present itself, and one has to create conditions that allow it to be able to arrive as an event. (Rheinberger 2007, p.86)

To reach the final goal of my research, certain conditions had to be created, as the final artworks and their reception could only succeed if these conditions were in place. Therefore, as preparation, and as described in previous chapters, I created and identified a great variety of threads, which contributed in diverse ways to the realisation of the dense and complex cloth of this research.
The topic is not just illuminated from one or two different perspectives or specific disciplines; instead, this transdisciplinary research (Ch 1.4.2) is knitted together from various threads drawn from various perspectives, integrating different disciplines (science of textile chemistry and physics, humanities, design and visual art) and their methods: through a process of knitting these together, I created new threads and fabrics. In this way, I 'continuously thwart[ed]

academically defined disciplines', which is 'the most intrinsic characteristic of artistic research' (Slager 2009, p.51). The threads of various fields (physics, chemistry, physiology, psychology and colour management, anthropology, linguistics, cognitive science, philosophy, sociology, art history, ecology) and their appertaining topics were interconnected and, through their differing combinations, secondary findings emerged (technical as well as philosophical, practical as well as conceptual insight), all leading towards the final aim: the creation of a fabric of wonder (Ch 7.3.8).

10.2.3 The cloth methodology and its threads

I am a textile artist and artisan, and so approached the research by creating a textile methodology and corresponding methodological threads, which I adapted where changes in the course of the project required it. This research used the practice of knitting as an innovative means of thinking. I proposed in this dissertation to think through knit, and to pursue thinking through knitting. Metaphors belong to the territory of art, and I believe to have presented with this research a powerful metaphor of knit as medium, technique and material. Threads were raw material in the making and thinking, and the aim of this holistic approach was to reach a personified unity of the intellectual and practical frameworks.
The various skills and expertise I brought with me (Ch 1.2), supported the execution of this personal research at a fundamental level and are a significant condition for the success of this project. I created my own field of meaning by knitting the various threads of personal skill and expertise together and playfully combining these in a unique way.
The physical colour phenomenon of metamerism runs like a golden thread through the whole research jacquard and remains always visible. Other threads were taken up on the journey; sometimes visible and foregrounded, sometimes hidden, running on the reverse side of the jacquard fabric and, while not visible, essential to the appearance of the whole cloth. These invisible threads were not lost and their invisible presence lets the artworks vibrate.

Through the Process Artworks (Ch 7.1) I contributed to the formation of a new visual methodology and method; in creating a unique form of research documentation, documenting the research process through repurposed, dropped off and failed by-products turned into artworks. The act of incorporating these failures created an unexpected surplus and by embracing these the research gained an important input. The installation *green-green-green_1_03:11* can also be considered as a form of documentation since it depicts a still image from an earlier *green-green-green* performance.

I used the presentations to the Thinking Through Practice (TTP) (Ch 2.3.4) peer group as an artistic strategy; a form of thinking, reflecting and presenting by which I garnered feedback that, in turn, strongly influenced further steps.
I described the general difficulty of performance documentation (Ch 8.3.1), in which something always gets lost. Wherever live events are translated into another medium the resulting documentation can only offer an approximation. This was further compounded by the

impossibility of capturing the 'live' experience of a visual manifestation of metamerism. To document this colour phenomenon, when photographs and cameras represent colours in a form analogous to visual translation (Ch 4.1.3), means that the image is not equivalent to what is visually perceived by the naked eye.

In line with Leavy (2015, p.276) I consider audience responses an 'important marker of success' for an art research project and thus I garnered these responses, scrutinized the feedbacks and documented them in my research journal. I consider this collection of eclectic informal feedback as research evidence. Audiences witnessed that this research revealed a so far unknown creative and aesthetic possibility for this colour phenomenon, supporting the contention that this research is original.
Audiences were highly engaged by the performances and exhibitions and comment on the sensual nature of their experiences as well as the form, look and design of individual artworks. Informal feedback acknowledged that the magical colour changes made audiences curious and many reported feelings of astonishment. Audiences also acknowledged and valued the emotive quality of my artworks and marvelled at the poetic aspects inherent in the metameric colour changes embedded in my installations and performances. Numerous responses were convergent, suggesting that audiences found my artworks affective, appealing and beautiful.

This investigation asserts that these performances, installations and the exhibition *'grün!?'* are valid 'art practice as research' methods. In line with Badura (2013) I claimed 'art as a knowledge production practice' (Ch 1.5.4.) and argued for my art practice as findings, expressed as aesthetic experiences. I let the metameric material speak (Albers 1961, p.45) and thereby 'generated novel, reflexive zones' (Slager 2009, p.51). I employed my art practice to provoke discussion regarding the perceptions and sensations triggered by my artworks, and in touching on diverse issues within manifold fields I encouraged reflection and critical thinking while offering places for debate. The unexpected and inexplicable colour changes astonished audiences and the mystery of light and colour was the starting point for many discussions after performances or during the exhibition, leading to a greater awareness of how much we do not fully understand about our perception of colour more generally.

> Our reaction, explicit or tacit, to any completely novel or unexpected perception is to say: 'What is this?' The question itself expresses the desire to integrate the new experience, the new sensation into the category of everyday knowledge. The concept of 'wonder' plays, accordingly, a very big part in everyday thinking: being simply the means whereby we subsume whatever we may have experienced [...] though we have not yet been able to fit it into the structure of everyday knowledge. (Heller 1984, p.196)

Lee (2007) citing De Bolla (2001, pp.12 – 13) states

> ... that wonder requires us to acknowledge what we do not know or may never know, to acknowledge the limits of knowledge. It is, then, a different species of knowledge, a way of knowing that does not lead to certainties or truths about the world or the way things are. (Lee 2007)

Through the wonder of metamerism I make a contribution to the understanding of the complexities of colour and light and broaden horizons, as audiences gain knowing through the experience of the phenomenon. Even so, I am well aware that this kind of knowing 'does not lead to certainties or truths about the world or the way things are' (Lee 2007).

10.2.4 The 'metamerising' self as an artistic research strategy

I claimed my 'metamerising' self as an artistic research strategy while, as an art researcher, I twisted threads back and forth to create a research cloth with oscillating background and foreground. I thereby drew a parallel between the self and my oscillating artworks.
My particular strength lies in the knitting together of various threads, different approaches and different perspectives. I described in previous chapters how I built new connections between fields and individuals as the *'grün!?'* exhibition and its diverse audience demonstrated.
This research is an in-depth study, with the proviso that by 'in-depth' it is not meant that the research is dug in only one field: instead, it achieves depth in the research analysis through its combination of many fields and topics. This approach contributed to the richness of this research.

10.2.5 Multiple languages and metameric namelessness

I succeeded in translating the outcome of the technological work in the dye lab, the metameric material itself, into unfathomable artworks. I combined the development of the metameric material, where a scientific language with defined parameters is used alongside the language of emotion and affect, as triggered through the wonder of metameric colour change.
In the first phase of the research (unexpectedly, as I used the industrial dye software against its standard programming) the naming of my dyed samples was complex. For this reason, I had to invent consistent ways of naming my samples in order to be able to track my process in the dye lab.
In the second phase of the research I discussed the issue of colour naming more thoroughly, a subject, on which several thinkers have been engaged for a long time (Ch 7.3.2). In doing so I raised the issue of metameric colour naming, involving the naming of colours, which embody various colour shades in one and the same material, and spotlighted the namelessness of metameric colours and the difficulties involved in their naming.

10.2.6 Metamerism as a metaphor

Metameric colours show differing colours depending on their illumination, with all the inherent shades the true colours of one and the same material. Thus, multiple true colours and states of being are held simultaneously in one and the same material. This is exactly, how things are! Through my artworks, I showed that the same material could appear to be different, depending on how it is lit. This fact can be transferred into daily life and points out how important it is to illuminate topics from different perspectives, observe issues from different angles and under different lights and consider all inherent aspects. I consider this to offer a parallel for political situations, in which attempts are made to split left and right axes into left or right binaries and eradicate all other shades. Metamerism stands for plurality, complexity and versatility.
The artworks stimulated different interpretations and multiple meanings, which is, according to Leavy (2015, p.276), 'one of the unique strength of ABR [art based research] practices'. Thereby I created a parallel between the multiplicity of approaches of art research interpretation and analysis and the phenomenon of metamerism itself. For this reason, I claim metamerism as a mechanism and metaphor for artistic knowing.

10.2.7 Problem or magical opportunity?

All these different perspectives contributed to the ultimate impact and value of this project. Moreover, the realisation of what we do not know raises questions, a fact, which also occurs in science, as Firestein states: 'answers beget questions, always more questions than answers' (2016, p. 247). This is another common strength of art and science research.
De Bolla describes the physical encounter with an artwork as follows:

> The physical encounter rapidly mutates into a jumble of thoughts, as if an impulse – call it a spark of affect –sets in motion a series of reactions that leave their trace in whatever permeable surface they encounter. For some viewers that surface is identifiable as "emotion," for others it is more like "ratiocination." (De Bolla 2001, p.2)

One audience member giving feedback on their physical encounter with the performance *unravel wittgenstein* combined "emotion" and "ratiocination" by writing:

> The performance was beautiful, meditative and informative. (Witzig 2016)

I regard this feedback as a confirming response to the whole research process, as this response touches on three different levels of experience: aesthetic, in the sense of personal artistic preferences; contemplative, as in the state evoked through an aesthetic experience; and the seeking of knowing which, through debates and discussions following this performance, led to understanding and appreciation, and yielded information: thus, artistic data was turned into epistemic claims.

De Bolla (2001, p.3) considers ‘this state of “in-between-ness,” as it were, part physical and part mental, in the orbit of the emotive yet also clearly articulated or potentially articulatable within the higher order of mental activity’ as ‘one way of describing wonder’.
By presenting the phenomenon of metamerism in a new context, the context of art, I changed the usual and established way of seeing metamerism. I offered a new perspective, allowing broad audiences to see this ‘problematic’ colour phenomenon in a new way, and consider seeing something differently as offering new insight. By embedding the usually unwanted phenomenon of metamerism into installations and performances, I revealed it as a wonder, reversing the general view of this ‘problem’ by approaching it as a miraculous opportunity.

> Colour is a good topic to understand the limits of traditional scientific approach because: what can be a necessary and sufficient scientific approach to grasp such a rebellious, ever changing, seemingly-unscientific phenomenon? (Soeire 2011)

Colours as well as light are rebellious and therefore hard to grasp. The character of light is highly elusive and within my artworks I demonstrated the powerful impact of ordinary lighting on colour perception. I created awareness of how hard it is to talk about colour and light, since colour and light perception is highly subjective. Thus, this project is also an attempt to map the indefinable; the elusive character of the phenomenon of light and colour.

In this research wonder occurred where art, technology and science met and created this state of ‘in-between-ness’. The state of metamerism as a state of wonder is my area of expertise.
I still delight in these small wonders, in the play of colour and light, and I strongly advocate the reconnection of the miraculous and the magical within our daily lives. Artworks as devices can facilitate poetic lived moments and magical sensations, which can stop people in their normal tracks and can lead them to calm down and to take the time to observe and marvel, to see something different. In line with Turrell (1971, p.121), ‘I believe in the need and thought of spiritual sensibilities or dimensions beyond us’ and I am convinced that in this day and age, as the world gets louder, brighter and faster, we need the sense of wonder in our daily life.

In short, my metameric self was crucial for the realisation of this research and I was thinking through knitting, as knit was technique, material and medium. Through a textile methodology and an alternating combination of methodological threads, this research revealed through performances and installations the phenomenon of metamerism as a wonder. Thereby diverse verbal and visual languages were combined, pointing to the namelessness of metameric colours. Metamerism was recognized as a mechanism and metaphor for artistic knowing. Finally, metamerism was discovered as metaphor standing for plurality, complexity and versatility, and thus a hint for the actual political situation.

10.3 Further work – further jacquards

> …that's exactly what happens in science – answers beget questions, always more questions than answers. And so there are still lots of questions. But you have to end somewhere. It's the only way to get on with it (Firestein 2016, p. 247).

I fully agree with Firestein on this point, which evidences another strong relation between art and science. Indeed, I am very much looking forward to proceeding with my research, as there remain many exciting areas, which I could not fully exhaust in the course of this research as they fell outside of the scope of this particular investigation. I believe, that a great deal of untapped potential remains to be explored in both the possibilities opened by my art research and the colour phenomenon of metamerism itself.
My personal intention was to do an art research project and I omitted metameric options in the field of design, but I am well aware that metamerism could offer innovative applications and, I can very well imagine myself, after the completion of this dissertation, going ahead to discover such opportunities.

The colour palette for this kind of metameric art is restricted, however in the beginning of my research I tested many different colours. In 2013, I deliberately limited the colour range explored in this research to one colour series, an olive. There remains a whole range of additional brownish, greyish and different greenish colours to be explored in further research. This study was also limited to 'white' light with coloured light sources still to be studied in addition.

As described in Chapter 4.1.2, innovations in the field of electric lighting are still ongoing but this investigation did not scrutinize the full available ranges of these new light sources in depth. However, I experienced in the exhibition *'grün!?'* (Ch 9.1.5) a freely programmable LED bulb, which suggested that new lighting solutions could offer a huge field to explore further in considering new possibilities for creating metameric artworks.
Moreover, the industry struggles with LED lighting to get acceptable colour rendering properties (Roth 2017). As a consequence the Colour Rendering Index ($R_{a)}$ (CRI) of LED lighting is still rather low. Thus it could be interesting to look for collaboration with a lighting company or a post-doctoral position at an university doing research in the field of colour rendering of newer light sources. With my artworks, which are playing with visual colour perception, making obvious the colour rendering of light, I could somehow or other contribute to the improvement of the actual technical situation of newer light innovations.

During my research journey, I realised, how little I had learned in my former design education about colour and light and the appertaining problematic, including metamerism. Now I am well aware of the gap between designer and colour technicians in industry and the communication problems generated by this, as there is not done enough regarding colour knowledge in education. By presenting my artworks in the context of design education, I could rise the

awareness and understanding of the complexity of colour and light and thereby fill the knowledge gap in an artistic way. Furthermore, I have already received requests from people working in the field of education for metameric demonstration material, so that students can experience with their own eyes the phenomenon of metamerism and the agency of light.

As described in Chapter 9.2, there is an interest, confirmed by architects, in working to scale up this phenomenon. I see the potential for space-filling metameric artworks, perhaps including wall coverings, influencing colour perception in rooms and raising new issues regarding spatial and architectural perception.
An artist expressed her interest in metamerism as a design opportunity and I will be happy to take this request up looking for a collaboration to share my gained insights.
Finally, I am looking forward to opportunities to continue to disseminate the already executed transdisciplinary work in various contexts, be it galleries, exhibitions or conferences. I am also keen to develop new artworks, exploring other colours and / or other light sources in order to exploit the full technical and aesthetic potential of this phenomena, in keeping with the broad scope of my research, encompassing art, science and technology.

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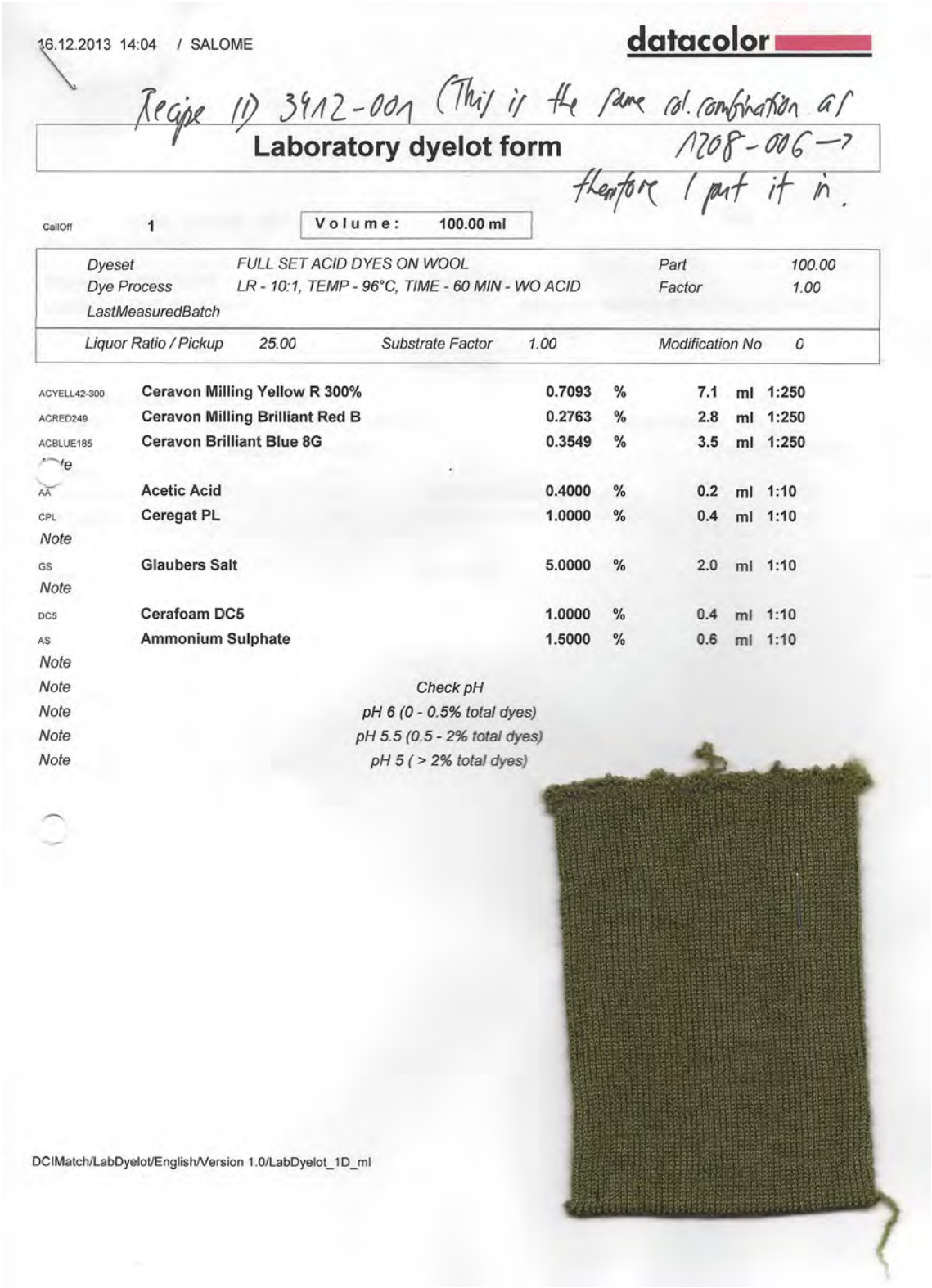
Appendix 1 Chapter 5

Adjustment of metameric colour series 1208

L/1 (recipe 1208_131216-001), Trial 2 (recipe 3412) and Trial 3 (recipe 3412) Ch 5.4.1



16.12.2013 14:04 / SALOME

datacolor

Recipe ID 3412-001 (This is the same col. combination as 1208-006 → therefore I put it in.

Laboratory dyelot form

CallOff 1 Volume: 100.00 ml

Dyeset	FULL SET ACID DYES ON WOOL	Part	100.00
Dye Process	LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID	Factor	1.00
LastMeasuredBatch			
Liquor Ratio / Pickup	25.00	Substrate Factor 1.00	Modification No 0

ACYELL42-300	Ceravon Milling Yellow R 300%	0.7093	%	7.1 ml	1:250
ACRED249	Ceravon Milling Brilliant Red B	0.2763	%	2.8 ml	1:250
ACBLUE185	Ceravon Brilliant Blue 8G	0.3549	%	3.5 ml	1:250
AA	Acetic Acid	0.4000	%	0.2 ml	1:10
CPL	Ceregat PL	1.0000	%	0.4 ml	1:10
GS	Glaubers Salt	5.0000	%	2.0 ml	1:10
DC5	Cerafoam DC5	1.0000	%	0.4 ml	1:10
AS	Ammonium Sulphate	1.5000	%	0.6 ml	1:10

Note

Note

Note

Note

Note

Note

Check pH
pH 6 (0 - 0.5% total dyes)
pH 5.5 (0.5 - 2% total dyes)
pH 5 (> 2% total dyes)

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

Figure 143 Recipe ID 3412-001, ‘stable colour’ 1208, modification 0 - 3

16.12.2013 16:40 / SALOME

datacolor

RECIPE ID 5412-001

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 - 001 (1)/1*		

Liquor Ratio / Pickup 25.00 *Substrate Factor* 1.00 *Modification No* 1

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.6394**	**%**	**6.4 ml**	**1:250**
ACRED249	**Ceravon Milling Brilliant Red B**	**0.2012**	**%**	**2.0 ml**	**1:250**
ACBLUE185	**Ceravon Brilliant Blue 8G**	**0.3764**	**%**	**3.8 ml**	**1:250**
Note					
AC	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
Note					
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
Note					
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
Note					
Note	*Check pH*				
Note	*pH 6 (0 - 0.5% total dyes)*				
Note	*pH 5.5 (0.5 - 2% total dyes)*				
Note	*pH 5 (> 2% total dyes)*				

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

17.12.2013 11:32 / SALOME

datacolor

RECIPE ID 3412-001

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 - 001 (1)/2*		

Liquor Ratio / Pickup *25.00* *Substrate Factor* *1.00* *Modification No* *2*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.6876**	**%**	**6.9 ml**	**1:250**
ACRED249	**Ceravon Milling Brilliant Red B**	**0.2290**	**%**	**2.3 ml**	**1:250**
ACBLUE185	**Ceravon Brilliant Blue 8G**	**0.3623**	**%**	**3.6 ml**	**1:250**
Note					
AA	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
Note					
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
Note					
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
Note					
Note					
Note					
Note					
Note					

Check pH

pH 6 (0 - 0.5% total dyes)

pH 5.5 (0.5 - 2% total dyes)

pH 5 (> 2% total dyes)

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

17.12.2013 16:45 / SALOME

datacolor

RECIPE ID 3412-001

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 - 001 (1)/3*		

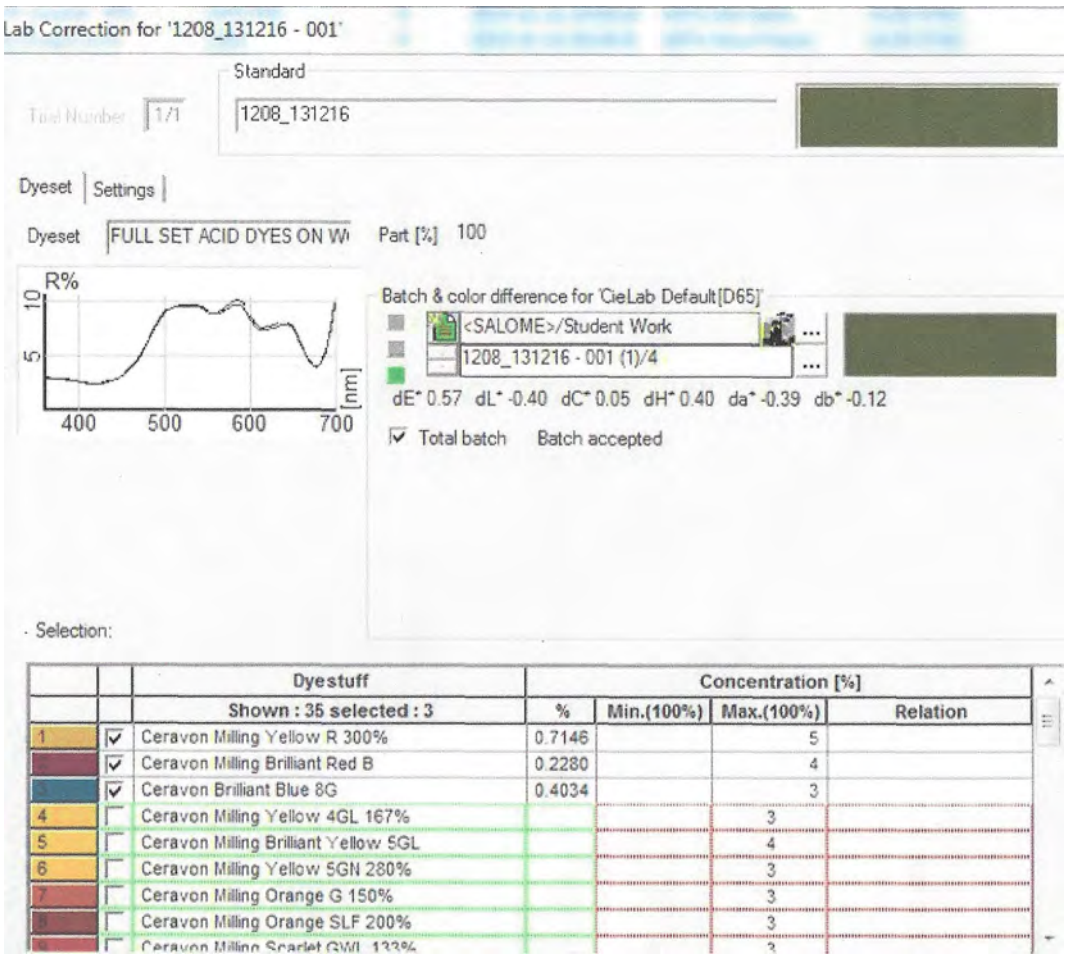
Liquor Ratio / Pickup 25.00 *Substrate Factor* 1.00 *Modification No* 3

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.7146**	**%**	**7.1 ml**	**1:250**
ACRED249	**Ceravon Milling Brilliant Red B**	**0.2280**	**%**	**2.3 ml**	**1:250**
ACBLUE185	**Ceravon Brilliant Blue 8G**	**0.4034**	**%**	**4.0 ml**	**1:250**
	Note				
AA	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
	Note				
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
	Note				
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
	Note				
	Note				
	Note				
	Note				
	Note				

Check pH
pH 6 (0 - 0.5% total dyes)
pH 5.5 (0.5 - 2% total dyes)
pH 5 (> 2% total dyes)

This is the ~~Same dye conti of~~ stable recipe!

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml



		Dyestuff	Concentration [%]			
		Shown : 35 selected : 3	%	Min.(100%)	Max.(100%)	Relation
1	☑	Ceravon Milling Yellow R 300%	0.7146		5	
	☑	Ceravon Milling Brilliant Red B	0.2280		4	
	☑	Ceravon Brilliant Blue 8G	0.4034		3	
4	☐	Ceravon Milling Yellow 4GL 167%			3	
5	☐	Ceravon Milling Brilliant Yellow 5GL			4	
6	☐	Ceravon Milling Yellow 5GN 280%			3	
7	☐	Ceravon Milling Orange G 150%			3	
8	☐	Ceravon Milling Orange SLF 200%			3	
	☐	Ceravon Milling Scarlet GWL 133%			3	

CMC Pass Fail

09-Apr-14

Standard: 1208_131216
%R SAV SCI UV Inc 600 16-Dec-13 13:31:35

Batch: 1208_131216 - 001 (1)/4
%R SAV SCI UV Inc 600 18-Dec-13 11:24:25

Formula: CMC Tolerance: 1.00

Illuminant	DE	DL	DC	DH	Decision			
D65 10 Deg	0.40	-0.22	0.03	0.33	Pass	fuller	brighter	bluer
A 10 Deg	0.44	-0.25	-0.06	0.36	Pass	fuller	flatter	bluer
F11 10 Deg	0.41	-0.23	-0.02	0.34	Pass	fuller	flatter	bluer

Figure 144 Colour approval and CMC Pass Fail of recipe ID 3412-001, ‘stable colour’ 1208, modification 3

16.12.2013 13:46 / SALOME

datacolor

Recipe ID 3412 trial 2

Laboratory dyelot form

CallOff	1	Volume:	100.00 ml

Dyeset	FULL SET ACID DYES ON WOOL	Part	100.00
Dye Process	LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID	Factor	1.00
LastMeasuredBatch			

Liquor Ratio / Pickup	25.00	Substrate Factor	1.00	Modification No 0

ACYELL42-300	Ceravon Milling Yellow R 300%	1.0796	%	10.8	ml	1:250
ACVIO48-200	Ceravon Milling Violet BL 200%	0.3971	%	4.0	ml	1:250
ACBLUE80-150	Ceravon Milling Blue BL 150%	0.2098	%	2.1	ml	1:250
Note						
AA	Acetic Acid	0.4000	%	0.2	ml	1:10
CPL	Ceregat PL	1.0000	%	0.4	ml	1:10
Note						
GS	Glaubers Salt	5.0000	%	2.0	ml	1:10
Note						
DC5	Cerafoam DC5	1.0000	%	0.4	ml	1:10
AS	Ammonium Sulphate	1.5000	%	0.6	ml	1:10
Note						
Note						
Note						
Note						
Note						

Check pH
pH 6 (0 - 0.5% total dyes)
pH 5.5 (0.5 - 2% total dyes)
pH 5 (> 2% total dyes)

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

Figure 145 Recipe ID 3412, trial 2 colour 1208, modification 0 - 5

16.12.2013 16:37 / SALOME

datacolor

RECIPE ID 3412 Trial 2

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 (2)/1*		

Liquor Ratio / Pickup *25.00* *Substrate Factor* *1.00* *Modification No* *1*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.6824**	**%**	**6.8**	**ml**	**1:250**
ACVIO48-200	**Ceravon Milling Violet BL 200%**	**0.3614**	**%**	**3.6**	**ml**	**1:250**
ACBLUE80-150	**Ceravon Milling Blue BL 150%**	**0.2833**	**%**	**2.8**	**ml**	**1:250**
Note						
AA	**Acetic Acid**	**0.4000**	**%**	**0.2**	**ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4**	**ml**	**1:10**
Note						
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0**	**ml**	**1:10**
Note						
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4**	**ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6**	**ml**	**1:10**
Note						
Note						
Note						
Note						
Note						

Check pH
pH 6 (0 - 0.5% total dyes)
pH 5.5 (0.5 - 2% total dyes)
pH 5 (> 2% total dyes)

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

17.12.2013 11:41 / SALOME

datacolor

RECIPE ID 3412 Trial 2

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 (2)/2*		

Liquor Ratio / Pickup	*25.00*	*Substrate Factor*	*1.00*	*Modification No*	*2*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.7821**	**%**	**7.8**	**ml**	**1:250**
ACVIO48-200	**Ceravon Milling Violet BL 200%**	**0.4184**	**%**	**4.2**	**ml**	**1:250**
ACBLUE80-150	**Ceravon Milling Blue BL 150%**	**0.2525**	**%**	**2.5**	**ml**	**1:250**
Note						
AA	**Acetic Acid**	**0.4000**	**%**	**0.2**	**ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4**	**ml**	**1:10**
Note						
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0**	**ml**	**1:10**
Note						
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4**	**ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6**	**ml**	**1:10**
Note						
Note	*Check pH*					
Note	*pH 6 (0 - 0.5% total dyes)*					
Note	*pH 5.5 (0.5 - 2% total dyes)*					
Note	*pH 5 (> 2% total dyes)*					

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

17.12.2013 16:48 / SALOME

datacolor

RECIPE ID 3412 Trial 2

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*			*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*			*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 (2)/3*				
Liquor Ratio / Pickup	*25.00*	*Substrate Factor*	*1.00*	*Modification No*	*3*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.7565**	**%**	**7.6 ml**	**1:250**
ACVIO48-200	**Ceravon Milling Violet BL 200%**	**0.3893**	**%**	**3.9 ml**	**1:250**
ACBLUE80-150	**Ceravon Milling Blue BL 150%**	**0.3025**	**%**	**3.0 ml**	**1:250**
	Note				
AA	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
	Note				
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
	Note				
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
	Note				
	Note	*Check pH*			
	Note	*pH 6 (0 - 0.5% total dyes)*			
	Note	*pH 5.5 (0.5 - 2% total dyes)*			
	Note	*pH 5 (> 2% total dyes)*			

Modification No 3
approved!
was matching -> see Striping

18.12.2013 11:29 / SALOME

datacolor

Recipe ID 342 Trial 2

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 (2)/4*		

Liquor Ratio / Pickup 25.00 *Substrate Factor* 1.00 *Modification No* 4

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.7485**	**%**	**7.5 ml**	**1:250**
ACVIO48-200	**Ceravon Milling Violet BL 200%**	**0.4320**	**%**	**4.3 ml**	**1:250**
ACBLUE80-150	**Ceravon Milling Blue BL 150%**	**0.2639**	**%**	**2.6 ml**	**1:250**
Note					
AA	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
Note					
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
Note					
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
Note					
Note	*Check pH*				
Note	*pH 6 (0 - 0.5% total dyes)*				
Note	*pH 5.5 (0.5 - 2% total dyes)*				
Note	*pH 5 (> 2% total dyes)*				

18.12.2013 13:40 / SALOME

datacolor

Recipe ID 3412 Trial 2

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 (2)/5*		
Liquor Ratio / Pickup	*25.00*	*Substrate Factor*	*1.00*
		Modification No	*5*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.7317**	**%**	**7.3 ml**	**1:250**
ACVIO48-200	**Ceravon Milling Violet BL 200%**	**0.4179**	**%**	**4.2 ml**	**1:250**
ACBLUE80-150	**Ceravon Milling Blue BL 150%**	**0.2935**	**%**	**2.9 ml**	**1:250**
Note					
AA	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
Note					
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
Note					
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
Note					
Note	*Check pH*				
Note	*pH 6 (0 - 0.5% total dyes)*				
Note	*pH 5.5 (0.5 - 2% total dyes)*				
Note	*pH 5 (> 2% total dyes)*				

Trial 2
Mod 5
approved!

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

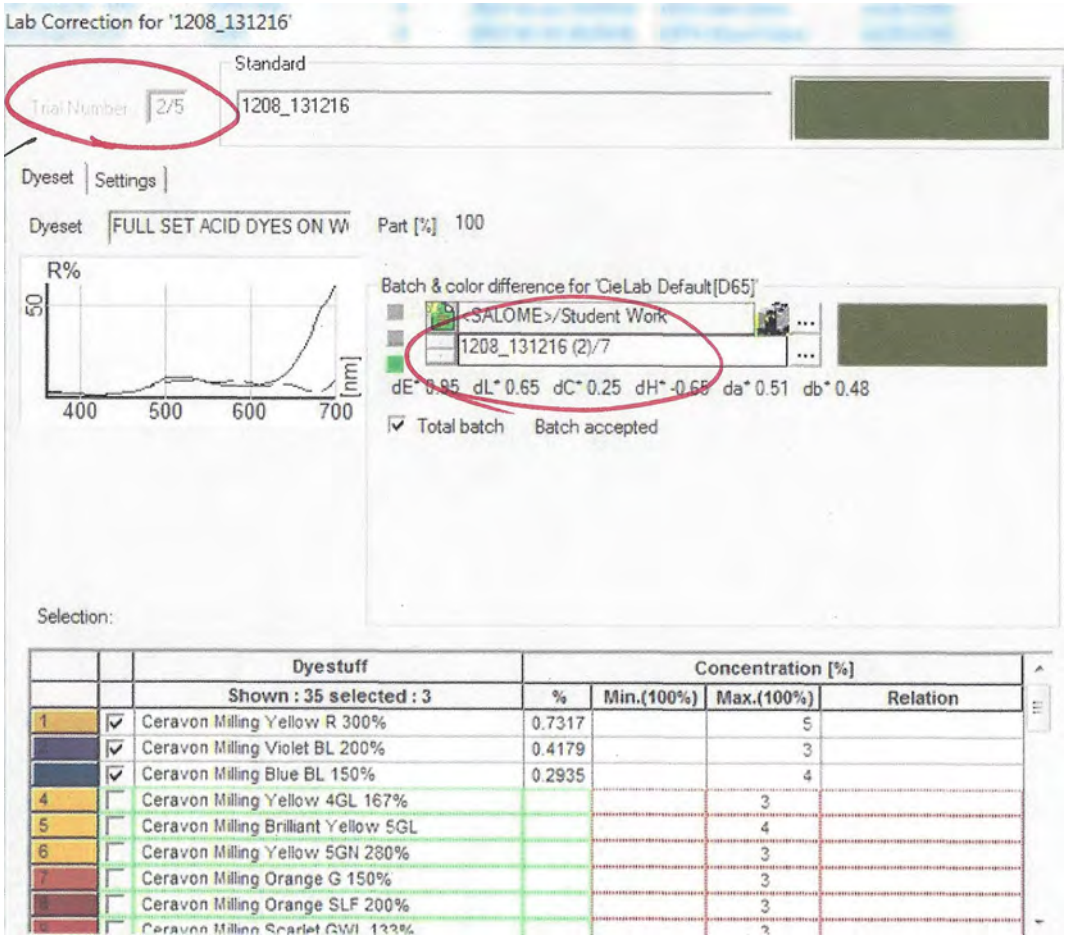


Figure 146 Colour approval of recipe ID 3412, trial 2 colour 1208, modification 5

16.12.2013 13:46 / SALOME

datacolor

Recipe ID 3412 Trial 3

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	FULL SET ACID DYES ON WOOL	Part	100.00
Dye Process	LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID	Factor	1.00
LastMeasuredBatch			
Liquor Ratio / Pickup	25.00	Substrate Factor	1.00
		Modification No	0

ACYELL42-300	Ceravon Milling Yellow R 300%	0.6110	%	6.1 ml	1:250
ACORG33-150	Ceravon Milling Orange G 150%	0.4265	%	4.3 ml	1:250
ACBLUE185	Ceravon Brilliant Blue 8G	0.4052	%	4.1 ml	1:250
Note					
AA	Acetic Acid	0.4000	%	0.2 ml	1:10
CPL	Ceregat PL	1.0000	%	0.4 ml	1:10
Note					
GS	Glaubers Salt	5.0000	%	2.0 ml	1:10
Note					
DC5	Cerafoam DC5	1.0000	%	0.4 ml	1:10
AS	Ammonium Sulphate	1.5000	%	0.6 ml	1:10
Note					
Note	Check pH				
Note	pH 6 (0 - 0.5% total dyes)				
Note	pH 5.5 (0.5 - 2% total dyes)				
Note	pH 5 (> 2% total dyes)				

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

Figure 147 Recipe ID 3412, trial 3 colour 1208, modification 0 - 2

16.12.2013 16:33 / SALOME

datacolor

RECIPE ID 3412 Trial 3

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	FULL SET ACID DYES ON WOOL	Part	100.00
Dye Process	LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID	Factor	1.00
LastMeasuredBatch	1208_131216 (3)/2		
Liquor Ratio / Pickup	25.00	Substrate Factor	1.00
		Modification No	1

ACYELL42-300	Ceravon Milling Yellow R 300%	0.4090	%	4.1 ml	1:250
ACORG33-150	Ceravon Milling Orange G 150%	0.4778	%	4.8 ml	1:250
ACBLUE185	Ceravon Brilliant Blue 8G	0.4804	%	4.8 ml	1:250
Note					
	Acetic Acid	0.4000	%	0.2 ml	1:10
CPL	Ceregat PL	1.0000	%	0.4 ml	1:10
Note					
GS	Glaubers Salt	5.0000	%	2.0 ml	1:10
Note					
DC5	Cerafoam DC5	1.0000	%	0.4 ml	1:10
AS	Ammonium Sulphate	1.5000	%	0.6 ml	1:10
Note					
Note	Check pH				
Note	pH 6 (0 - 0.5% total dyes)				
Note	pH 5.5 (0.5 - 2% total dyes)				
Note	pH 5 (> 2% total dyes)				

DCIMatch/LabDyelot/English/Version 1.0/LabDyelot_1D_ml

17.12.2013 11:38 / SALOME

datacolor

RECIPE ID 3412 Trial 3

Laboratory dyelot form

CallOff 1

Volume: 100.00 ml

Dyeset	*FULL SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*1208_131216 (3)/3*		

Liquor Ratio / Pickup *25.00* *Substrate Factor* *1.00* *Modification No* *2*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.4491**	**%**	**4.5 ml**	**1:250**
ACORG33-150	**Ceravon Milling Orange G 150%**	**0.5345**	**%**	**5.3 ml**	**1:250**
ACBLUE185	**Ceravon Brilliant Blue 8G**	**0.5875**	**%**	**5.9 ml**	**1:250**
Note					
AA	**Acetic Acid**	**0.4000**	**%**	**0.2 ml**	**1:10**
CPL	**Ceregat PL**	**1.0000**	**%**	**0.4 ml**	**1:10**
Note					
GS	**Glaubers Salt**	**5.0000**	**%**	**2.0 ml**	**1:10**
Note					
DC5	**Cerafoam DC5**	**1.0000**	**%**	**0.4 ml**	**1:10**
AS	**Ammonium Sulphate**	**1.5000**	**%**	**0.6 ml**	**1:10**
Note					
Note	*Check pH*				
Note	*pH 6 (0 - 0.5% total dyes)*				
Note	*pH 5.5 (0.5 - 2% total dyes)*				
Note	*pH 5 (> 2% total dyes)*				

Approved Modification No 2
I saved this recipe
see shipping!

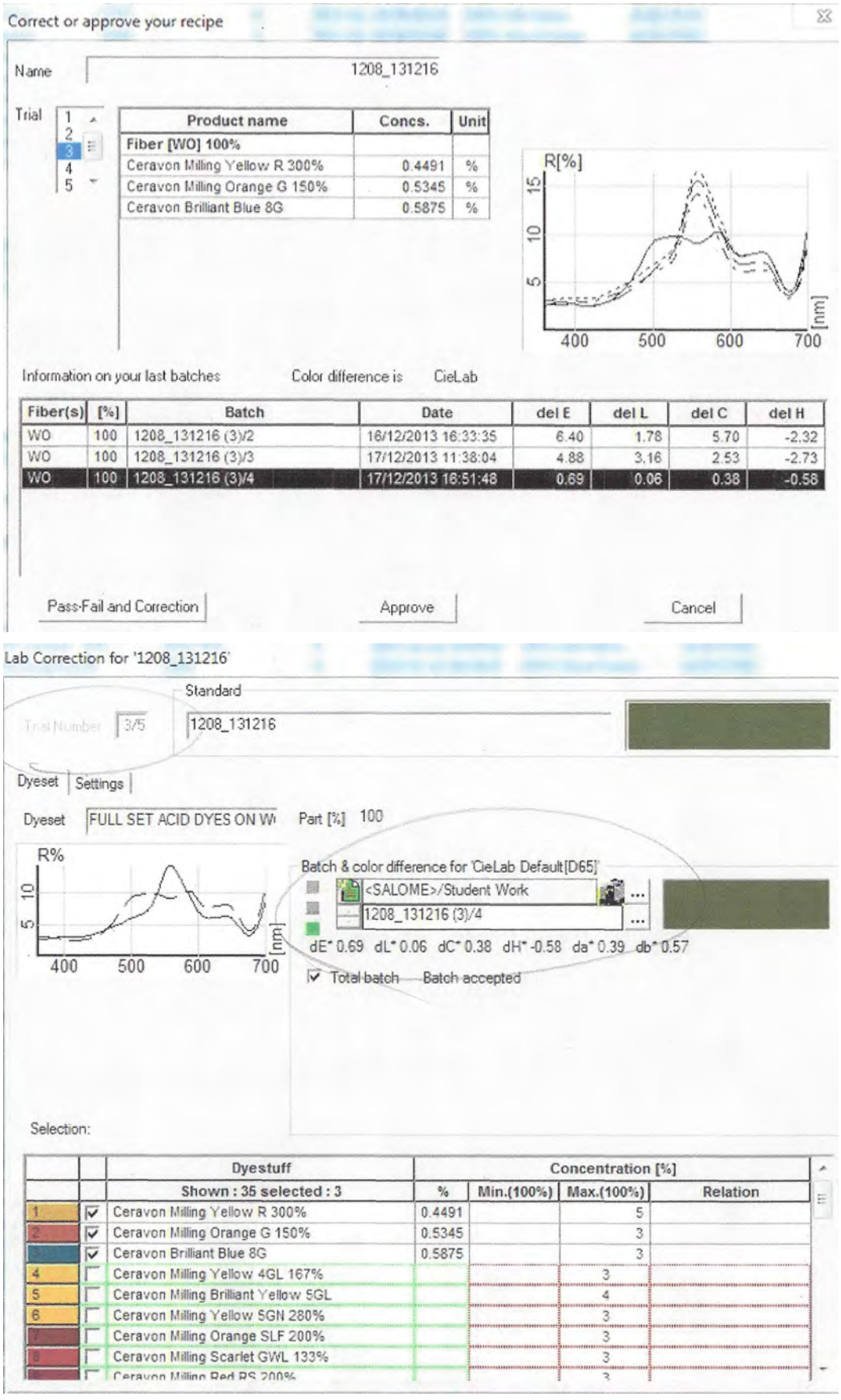
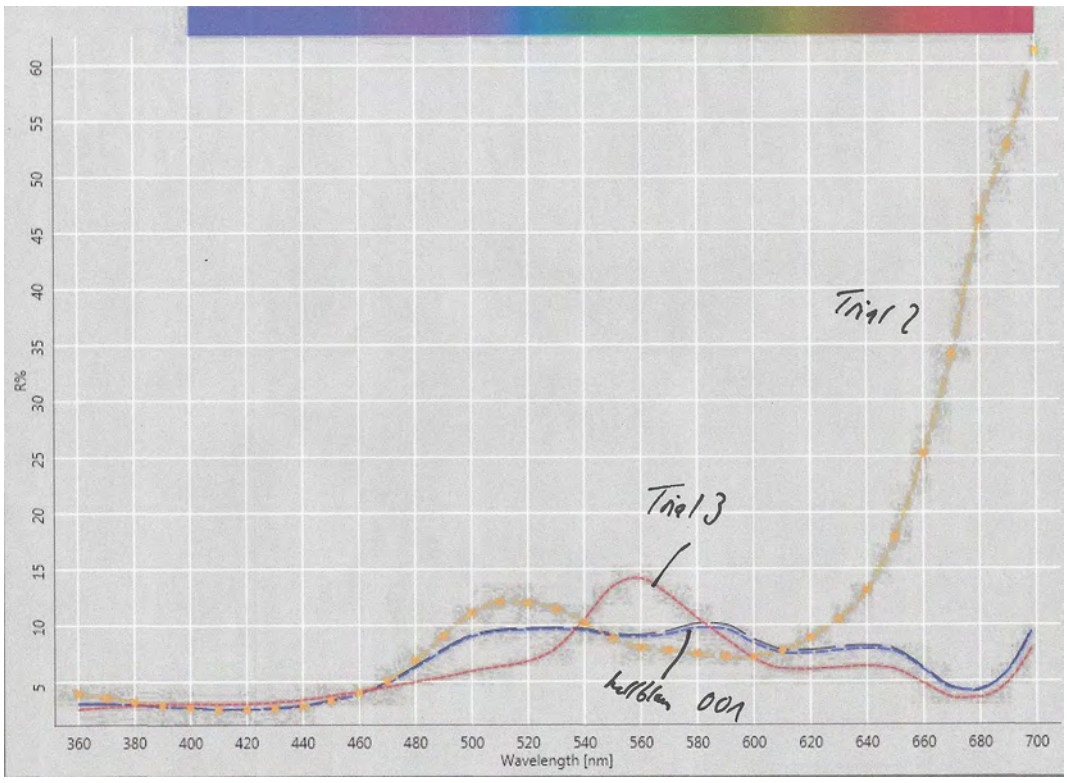
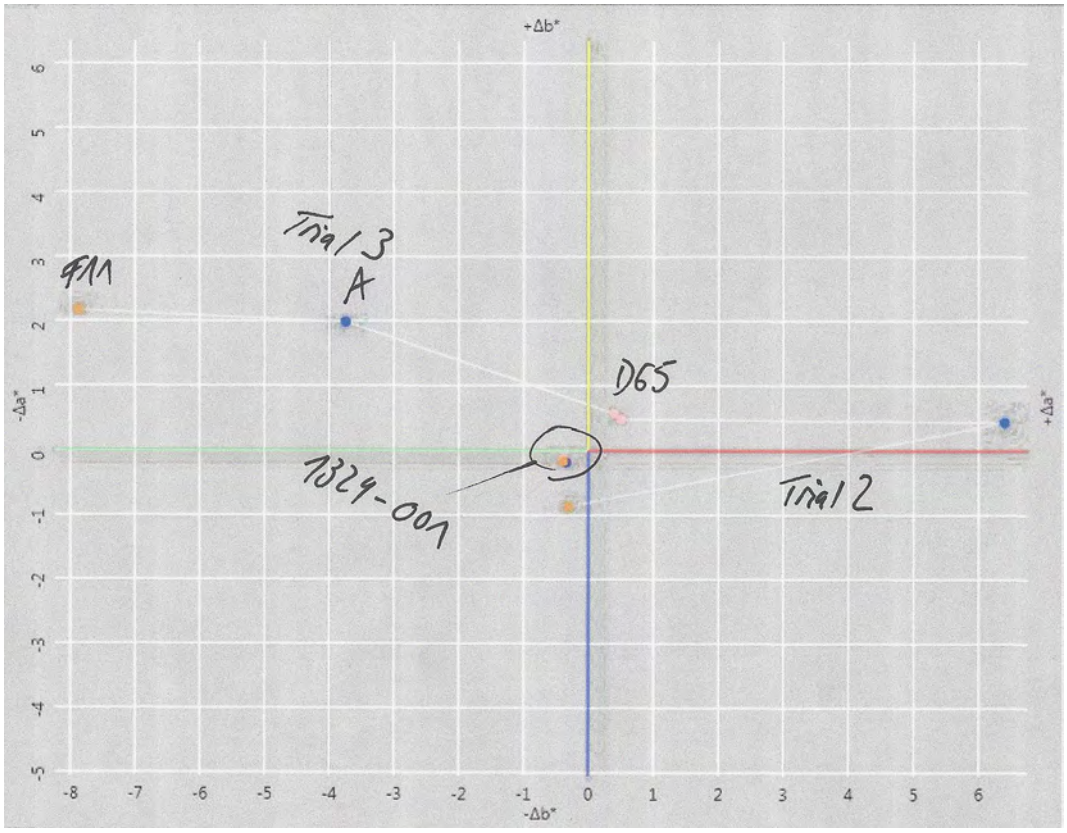


Figure 148 Colour approval of recipe ID 3412, trial 3 colour 1208, modification 2


R%
Wavelength [nm]
Trial 2
Trial 3
7324-001


+Δb*
-Δb*
-Δa*
+Δa*
F11
Trial 3
A
D65
7324-001
Trial 2

CMC Pass Fail: metameric colour series 1208, production yarn

CMC Pass Fail

14-Apr-14

Standard: 140414_STD_1208
%R SAV SCI UV Inc 600 14-Apr-14 14:35:36

Batch: 140414 TRIAL2_1208
%R SAV SCI UV Inc 600 14-Apr-14 14:36:50

Formula: CMC Tolerance: 1.00

Illuminant	DE	DL	DC	DH	Decision			
D65 10 Deg	0.68	0.40	0.54	-0.02	Pass	thinner	brighter	yellower
A 10 Deg	5.35	0.50	-0.47	-5.30	Fail	thinner	flatter	yellower
F11 10 Deg	0.34	-0.12	-0.19	0.26	Pass	fuller	flatter	bluer

Standard approved 10. April + dyed
Trial 3 approved 9. April + dyed
Trial 2 approved 14. April + dyed

CMC Pass Fail

14-Apr-14

Standard: 140414_STD_1208
%R SAV SCI UV Inc 600 14-Apr-14 14:35:36

Batch: 140414_TRIAL3_1208
%R SAV SCI UV Inc 600 14-Apr-14 14:38:52

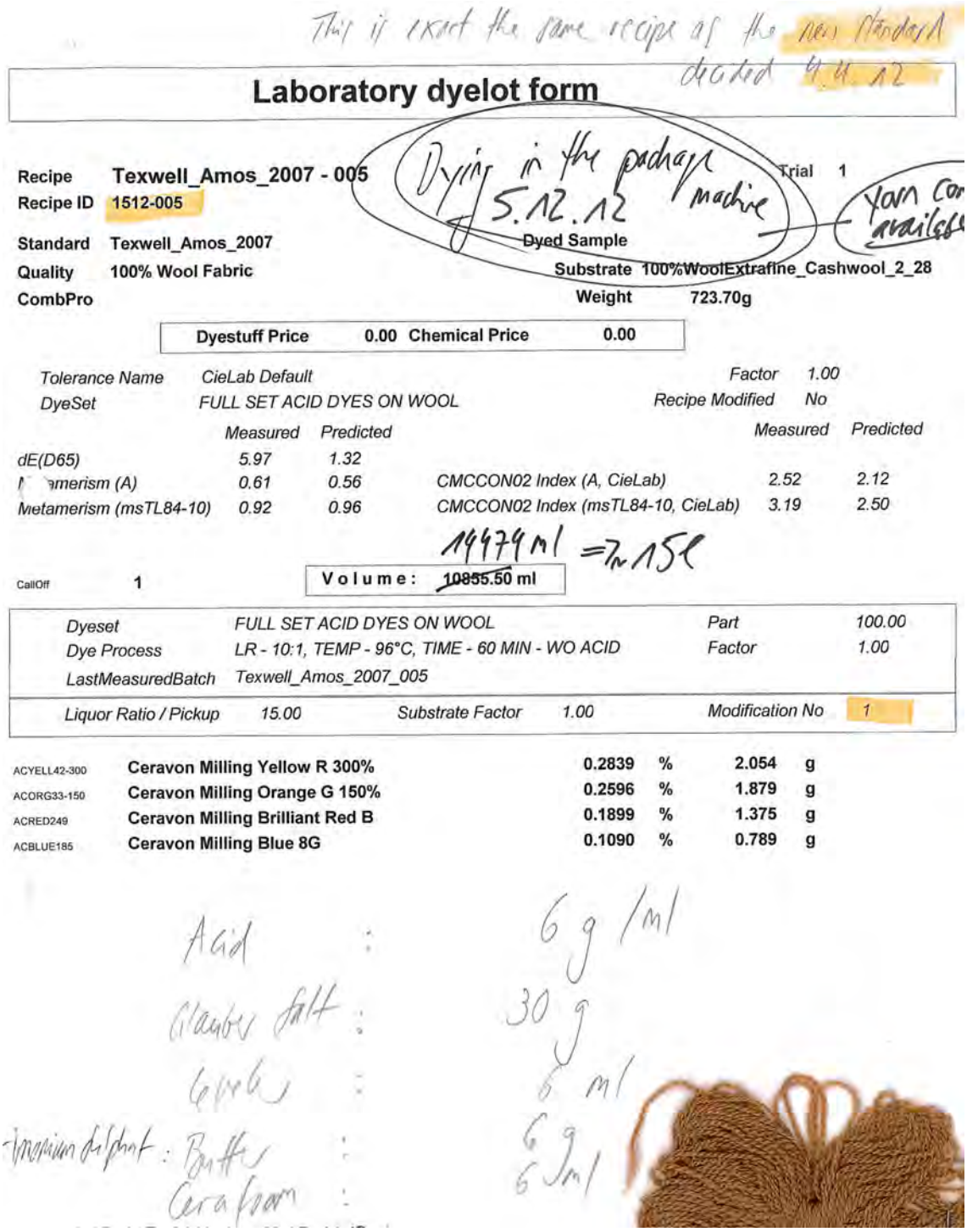
Formula: CMC Tolerance: 1.00

Illuminant	DE	DL	DC	DH	Decision			
D65 10 Deg	1.59	0.21	0.08	-1.57	Fail	thinner	brighter	yellower
A 10 Deg	2.52	0.37	2.23	1.11	Fail	thinner	brighter	bluer
F11 10 Deg	5.03	1.01	3.23	3.72	Fail	thinner	brighter	bluer

Figure 149 CMC Pass Fail, metameric colour series 1208, production yarn, April 2014

Appendix 2 Chapter 6

Metameric yarn pair (recipe 1512-005 modification 1 and recipe 1512-001 modification 2, Ch 6.1.1



This is exact the same recipe as the new standard decided 4.12.12

Laboratory dyelot form

Dying in the package machine 5.12.12

Yarn Co available

Recipe Texwell_Amos_2007 - 005 Trial 1
Recipe ID 1512-005
Standard Texwell_Amos_2007
Quality 100% Wool Fabric
CombPro
Dyed Sample
Substrate 100%WoolExtrafine_Cashwool_2_28
Weight 723.70g

Dyestuff Price	0.00	Chemical Price	0.00

Tolerance Name	CieLab Default			Factor	1.00
DyeSet	FULL SET ACID DYES ON WOOL			Recipe Modified	No
	Measured	Predicted		Measured	Predicted
dE(D65)	5.97	1.32			
Metamerism (A)	0.61	0.56	CMCCON02 Index (A, CieLab)	2.52	2.12
Metamerism (msTL84-10)	0.92	0.96	CMCCON02 Index (msTL84-10, CieLab)	3.19	2.50

14479 ml = 14.5 l

CallOff 1 Volume: ~~10855.50~~ ml

Dyeset	FULL SET ACID DYES ON WOOL	Part	100.00
Dye Process	LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID	Factor	1.00
LastMeasuredBatch	Texwell_Amos_2007_005		
Liquor Ratio / Pickup	15.00	Substrate Factor 1.00	Modification No 1

ACYELL42-300	Ceravon Milling Yellow R 300%	0.2839	%	2.054	g
ACORG33-150	Ceravon Milling Orange G 150%	0.2596	%	1.879	g
ACRED249	Ceravon Milling Brilliant Red B	0.1899	%	1.375	g
ACBLUE185	Ceravon Milling Blue 8G	0.1090	%	0.789	g

Acid : 6 g/ml
Glauber salt : 30 g
Leveler : 6 ml
Ammonium sulphate : Buffer : 6 g/ml
Ceraclean :

Figure 150 Production yarn dyeing, recipe ID 1512-005, colour 2007-005

Production Correction form

Recipe Texwell_Amos_2007 - 005 **Date** 03.04.2012
Recipe ID 1512-005

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 005 (1)/2
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

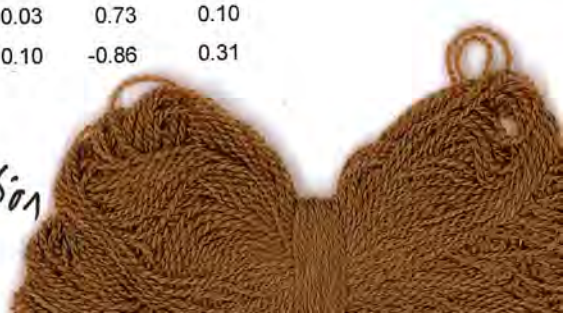
Dyeset	*FULL SET ACID DYES ON WOOL*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACI*		*Process Factor*	*1.00*

Weight of goods **723.70 gr** Bath **00000000.00 l** LR 1 : **000.00**

		Amount	**Add Amount**	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	2.054 g	**0.687 g**	33.44 %
ACORG33-150	**Ceravon Milling Orange G 150%**	1.879 g	**0.838 g**	44.58 %
ACRED249	**Ceravon Milling Brilliant Red B**	1.375 g	**0.353 g**	25.68 %
ACBLUE185	**Ceravon Milling Blue 8G**	0.789 g	**0.293 g**	37.17 %
	Total	6.097 g	**2.171 g**	35.61 %

CieLab Default[D65]	*dE*	*new dE*	*dL*	*dC*	*dH*
D65	5.83	0.04	0.00	0.02	-0.03
	MI	*new MI*	*ML*	*MC*	*MH*
A	0.49	0.74	0.03	0.73	0.10
msTL84-10	1.62	0.92	0.10	-0.86	0.31

1. production correction
1. adding colours



Production Correction form

Recipe Texwell_Amos_2007 - 005 **Date** 03.04.2012
Recipe ID 1512-005

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 005 (1)/3
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

Dyeset	*FULL SET ACID DYES ON WOOL*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACI*		*Process Factor*	*1.00*

Weight of goods **723.70 gr** Bath **00000000.00 l** LR 1 : **000.00**

• can't take away!

		Amount	Add Amount	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	2.054 g	**-0.274 g**	-13.35 %
ACORG33-150	**Ceravon Milling Orange G 150%**	1.879 g	**-0.284 g**	-15.11 %
ACRED249	**Ceravon Milling Brilliant Red B**	1.375 g	**0.067 g**	4.89 %
ACBLUE185	**Ceravon Milling Blue 8G**	0.789 g	**0.074 g**	9.37 %
	Total	6.097 g	**-0.417 g**	-6.84 %

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	3.09	0.04	-0.00	0.03	-0.03

	MI	new MI	ML	MC	MH
A	0.64	0.85	0.04	0.84	0.12
msTL84-10	1.48	1.43	0.10	-1.21	0.76

2. production correction!
Approved color → dyed yarn cone

Laboratory dyelot form

Recipe Texwell_Amos_2007 - 001 **Trial** 1
Recipe ID 1512-001

Standard Texwell_Amos_2007 **Dyed Sample**
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro **Weight** 740.00g

Dyestuff Price 0.00 **Chemical Price** 0.00

Tolerance Name CieLab Default *Factor* 1.00
DyeSet PURCHASED SET ACID DYES ON WOOL *Recipe Modified* No

	Measured	Predicted		Measured	Predicted
)65)	2.31	0.00			
merism (msTL84-10)	3.11	2.96	CMCCON02 Index (msTL84-10, CieLab)	4.48	4.64
Metamerism (F11)	4.67	4.51	CMCCON02 Index (F11, CieLab)	6.07	6.22

CallOff 1 **Volume: 11100.00 ml**

Dyeset	*PURCHASED SET ACID DYES ON WOOL*	*Part*	*100.00*
Dye Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACID*	*Factor*	*1.00*
LastMeasuredBatch	*Amos_2007_001_mod_1*		
Liquor Ratio / Pickup	*15.00*	*Substrate Factor*	*1.00*
		Modification No	*2*

ACYELL42-300	**Ceravon Milling Yellow R 300%**	**0.4923**	**%**	**3.643** **g**
ACRED249	**Ceravon Milling Brilliant Red B**	**0.1340**	**%**	**0.992** **g**
ACVIO48-200	**Ceravon Milling Violet BL 200%**	**0.3446**	**%**	**2.550** **g**

Acid : 6g
Glauber Salt : 36g
Level 6 ml
Buffer / Ammonium Sulphat : 6g
Ceratan 6ml

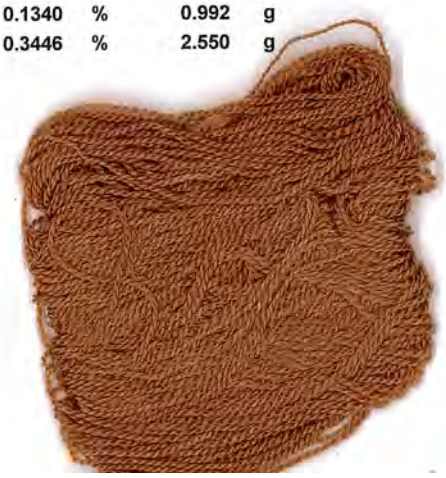


Figure 151 Production yarn dyeing, recipe ID 1512-001, colour 2007-001

Production Correction form

Recipe Texwell_Amos_2007 - 001 **Date** 05.04.2012
Recipe ID 1512-001

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 001 (1)/3
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

Dyeset	*PURCHASED SET ACID DYES O.*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACIL*		*Process Factor*	*1.00*

Weight of goods ~~723.70~~ 740 g Bath 00000000.00 l LR 1 : 000.00

		Amount	Add Amount	Relative
ACYELL42-300	Ceravon Milling Yellow R 300%	3.563 g	0.615 g	17.27 %
ACRED249	Ceravon Milling Brilliant Red B	0.970 g	0.047 g	4.81 %
ACVIO48-200	Ceravon Milling Violet BL 200%	2.494 g	1.093 g	43.84 %
	Total	7.026 g	1.755 g	24.98 %

1. production correction

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	5.99	0.00	0.00	-0.00	-0.00

	MI	new MI	ML	MC	MH
msTL84-10	1.94	3.32	2.04	2.58	-0.49
F11	3.50	5.16	2.44	4.05	-2.07

6 %
3 %
20 %

These are the percentages David proposed! See page attached

7.12.12

Texwell Amol_2007-001
Recipe ID 1512-001
production correction see Datacolor
We decide to not use the recipe of the Datacolor system, as we do match it to the recipe 1512-005 yarn for a metameric pair:

	Add Amount Datacolor		Add Amount Decided		
Yellow	0,615 g	17.27 %	6 %	0.21 g	0.2 g
Red	0047 g	4.81 %	3 %	0.029 g	0.03 g
Violet	1.093 g	43.89 %	20 %	0.498	0.5 g

Production Correction form

Recipe Texwell_Amos_2007 - 001 **Date** 05.04.2012
Recipe ID 1512-001

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 001 (1)/4
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

Dyeset	*PURCHASED SET ACID DYES O.*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACI*		*Process Factor*	*1.00*

Weight of goods ~~723.70~~ 740g gr Bath 00000000.00 l LR 1 : 000.00

		Amount	Add Amount	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	3.563 g	**0.383 g**	10.76 %
ACRED249	**Ceravon Milling Brilliant Red B**	0.970 g	**-0.084 g**	-8.63 %
ACVIO48-200	**Ceravon Milling Violet BL 200%**	2.494 g	**0.707 g**	28.35 %
	Total	7.026 g	**1.007 g**	14.33 %

2. production correction

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	3.33	0.01	-0.00	-0.01	0.00
	MI	new MI	ML	MC	MH
msTL84-10	2.57	3.36	2.03	2.61	-0.56
F11	4.27	5.15	2.45	4.05	-2.04

Yellw: 0.28
+
Violett: 0.3

Virtually adjusted in D65!
Not followed Datacolor correction.

Production Correction form

Recipe Texwell_Amos_2007 - 001 **Date** 05.04.2012
Recipe ID 1512-001

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 001 (1)/6
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

Dyeset	*PURCHASED SET ACID DYES O*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACI*		*Process Factor*	*1.00*

Weight of goods ~~723.70~~ 740 g gr Bath **7237000.00** l LR 1 : **999.00**

		Amount	Add Amount	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	3.563 g	**0.130 g**	3.66 %
ACRED249	**Ceravon Milling Brilliant Red B**	0.970 g	**-0.124 g**	-12.77 %
ACVIO48-200	**Ceravon Milling Violet BL 200%**	2.494 g	**0.543 g**	21.77 %
	Total	7.026 g	**0.550 g**	7.82 %

3. production correction

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	2.90	0.01	-0.00	-0.01	-0.00

	MI	new MI	ML	MC	MH
msTL84-10	2.86	3.42	2.05	2.67	-0.60
F11	4.63	5.23	2.48	4.12	-2.05

Y 0.05
R —
V 0.38

Virtually adjusted!
Not followed Datacolor corr

7.12.12

decision why I match the following two cobs

(1.)
Recipe Texwell_Amol_2007_005
Recipe ID 1512-005
Standard Texwell_Amol_2007

→ I take the yarn after the second production correction!

(2.)
Recipe Texwell_Amol_2007_001
Recipe ID 1512-001
Standard Texwell_Amol_2007

Visually taken decision, checking in lightbox

D65 they look pretty similar
(1.) looks slightly darker, redder
(2.) looks slightly yellower, greener (more olive)

TL 84 darkness quite the same
(1.) more orange
(2.) more olive
• slightes difference

F (1.) yellowish
(2.) strongly redish
• big difference

Production Correction form

Recipe Texwell_Amos_2007 - 001 **Date** 05.04.2012
Recipe ID 1512-001

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 001 (1)/7
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

Dyeset	*PURCHASED SET ACID DYES O.*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACI*		*Process Factor*	*1.00*

Weight of goods **740.00 gr** Bath **43999488.00 l** LR 1 : **224.00**

		Amount	Add Amount	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	3.643 g	**0.001 g**	0.02 %
ACRED249	**Ceravon Milling Brilliant Red B**	0.992 g	**0.000 g**	0.00 %
ACVIO48-200	**Ceravon Milling Violet BL 200%**	2.550 g	**0.000 g**	0.00 %
ACBLUE185	**Ceravon Milling Blue 8G**	0.000 g	**0.021 g**	0.00 %
	Total	7.184 g	**0.022 g**	0.30 %

4. production correction

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	2.20	0.43	-0.43	-0.03	0.04

Blue 8G : 0.

	MI	new MI	ML	MC	MH
msTL84-10	3.26	2.38	1.72	1.64	0.12
F11	5.11	3.92	2.14	3.05	-1.22

For this correction we pressed the button: Best Datacolor correction added Blue 8G.

DCIMatch/ProdCorr/English/Version 1.0/Production Correction Form

We checked the last „batch" and decided Blue 8G 0.05g

Production Correction form

Recipe **Texwell_Amos_2007 - 001** **Date** **05.04.2012**
Recipe ID **1512-001**

Standard **Texwell_Amos_2007** **Dyed Sample**
Batch **Texwell_Amos_2007 - 001 (1)/7**
Quality **100% Wool Fabric** **Substrate** **100%WoolExtrafine_Cashwool_2_28**
CombPro
Tolerance **CieLab Default** **Factor** **1.00**

Dyeset	*PURCHASED SET ACID DYES O.*	*100.00*	*% Process Type*	*Exhausl*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACI*		*Process Factor*	*1.00*

Weight of goods **740.00 gr** Bath **43999488.00 l** LR 1 : **400.00**

		Amount	Add Amount	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	3.643 g	**-0.085 g**	-2.34 %
ACRED249	**Ceravon Milling Brilliant Red B**	0.992 g	**-0.190 g**	-19.15 %
ACVIO48-200	**Ceravon Milling Violet BL 200%**	2.550 g	**0.257 g**	10.10 %
	Total	7.184 g	**-0.018 g**	-0.25 %

This would be the 4. production correction

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	2.20	0.01	-0.00	-0.00	-0.01

	MI	new MI	ML	MC	MH
msTL84-10	3.26	3.45	2.06	2.70	-0.59
F11	5.11	5.27	2.50	4.18	-2.03

Production Correction form

Recipe Texwell_Amos_2007 - 001 **Date** 05.04.2012
Recipe ID 1512-001

Standard Texwell_Amos_2007 **Dyed Sample**
Batch Texwell_Amos_2007 - 001 (1)/8
Quality 100% Wool Fabric **Substrate** 100%WoolExtrafine_Cashwool_2_28
CombPro
Tolerance CieLab Default **Factor** 1.00

Dyeset	*PURCHASED SET ACID DYES O.*	*100.00 %*	*Process Type*	*Exhaust*
			Substrate Factor	*1.00*
Process	*LR - 10:1, TEMP - 96°C, TIME - 60 MIN - WO ACIL*		*Process Factor*	*1.00*

Weight of goods **740.00 gr** Bath **36500000.00 l** LR 1 : **000.00**

		Amount	Add Amount	Relative
ACYELL42-300	**Ceravon Milling Yellow R 300%**	3.643 g	**0.023 g**	0.64 %
ACRED249	**Ceravon Milling Brilliant Red B**	0.992 g	**0.000 g**	0.00 %
ACVIO48-200	**Ceravon Milling Violet BL 200%**	2.550 g	**0.000 g**	0.00 %
ACBLUE185	**Ceravon Milling Blue 8G**	0.000 g	**0.012 g**	0.00 %
	Total	7.184 g	**0.036 g**	0.50 %

5. production correction

CieLab Default[D65]	dE	new dE	dL	dC	dH
D65	1.13	0.39	-0.38	-0.03	0.07

	MI	new MI	ML	MC	MH
msTL84-10	2.82	2.40	1.74	1.66	0.10
F11	4.56	3.95	2.16	3.07	-1.25

Blue 0.1
Yell ~~0.10~~ 0.12

this we added after checking finally ! D65

Recipe ID 1512-001 10.12.12

after all the production correction:

Total (last yarn rane weight) 645g

yellow 4.293g : 740g → (×100) 0.58% - 5% = 0.55% = 3.55g

red 1.022g : 740g → 0,138% - 7% = 0.128% = 0.83g

violet 3.73g : 740g → 0.5% - 5% = 0.478% = 3.03g

Blu 0.15g → X looking at the color, it seemed very violet, that's why we adjusted it

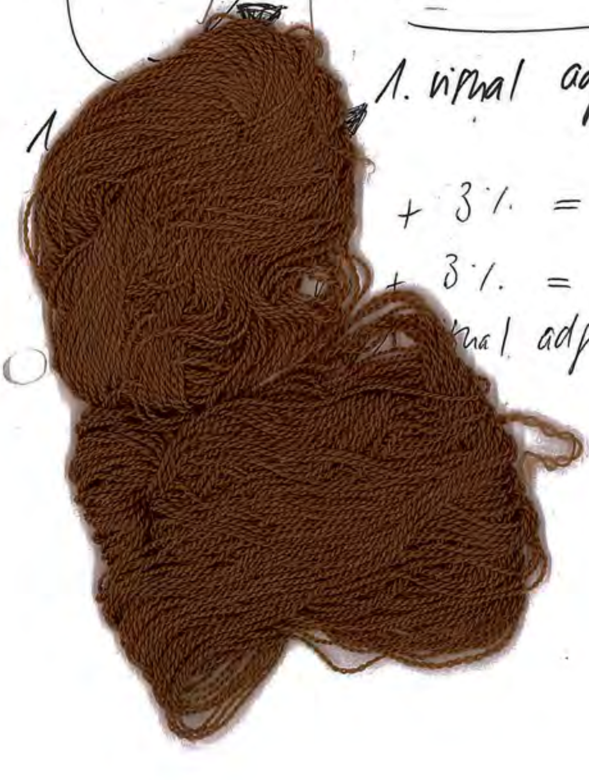
Y : 3.55 g

r : 0.83g

violet : 2.8 g

r +2% = 0.016g = 4ml (1/1250ml) 3%

vio +4% = 0.11 g 3%



1. visual adjustment - production correction

+ 3% = 0.0249g = 6.2ml of solution 1/1250ml

+ 3% = = 21ml "

...ual adjustment - production correction

on „Karton" approved color

Dying packaging machine 12.12.12

909 g Material

1. Adjustment

Yellow 4.84 g + 0.1 g (25 ml diluted)

red 1.21 g + 0.1 g (25 ml diluted)

violet

This recipe is adjusted following the batch dyed the 10.12.12

Recipe ID: 1512-001

2. Adjustment

Y	0.15	(37.5
R	0.15	(37.5
V	—	

We do assume, that we put too much violet!
We try to take it a little bit off with the bottle (honestly I doubt, that this is possible!!!

Next time in 2013!

- Recipe to take over! For 900g

Yellow 4.8

R 1.26

V 85

7.12.12

. count together all dyes used for yarn

⊛ Recipe ID 1512-001

weight of yarn 740g

Yellow 3.643g + 0,2g + 0.28g + 0.05g + ~~0.645~~ 0.12

~~0.645~~
0.2

Red 0.992g + 0,03g + ~~0.047~~

~~0.047~~
0.003

Violet 2.55g + 0,5g + 0,3g + 0.38 + ~~0.893~~

~~1.093~~

Blue + 0.05 + 0.1

⊛

Total					
Yellow	: 4.293g	:740	= -5% =		for
Red	: 1.022g	:740	= -7% =		740g
Violet	: ~~4.823~~ 3.73g	:740	= -5% =		material
Blue	: 0.15g	:740	= X =		

⊛ After the dying of the 7.12.12 we calculated the new recipe ⇒ original + all the production corrections. We cancelled color blue. And we reduced as above ⊛

Testing of repeatability: recipe 1512-005, Ch 6.1.4

Figure 152 Sample analysis: 16 gram sample, yarn of 16 gram sample and 8 gram sample

datacolor
Because Color Matters

Sample Analysis

05-Apr-12

Standard: 1 of 2

Texwell_Amos_2007_005_mod_1

Instrument Conditions: %R LAV SCI UV Inc
600 S/N 8801430

Submit/Sample #: 11 of 11

2007_Yarn

Instrument Conditions: %R LAV SCI UV Inc
600 S/N 8801430

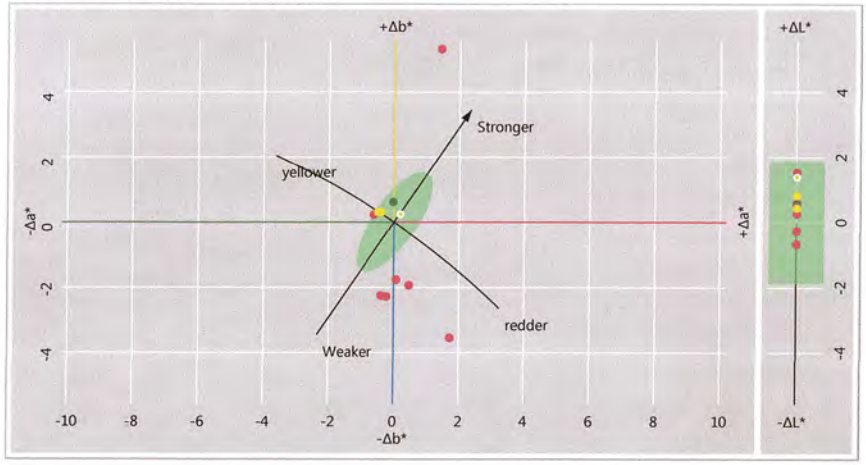
Illum/Obs	DL*/lSL	Da*	Db*	DC*/cSC	DH*/SH	DEcmc	Decision
D65 10 Deg	0.75	0.19	0.24	0.17	-0.04	**0.77**	Warn
A 10 Deg	0.74	0.42	0.28	0.24	-0.29	**0.83**	Warn
msTL84-10	0.74	0.10	0.28	0.15	0.07	**0.76**	Warn

Sample is:
thinner
brighter
redder

DEcmc Tolerance: 1.00
(l:c) Ratio: (2.00 1.00)

Comments:

Delta CMC | D65 / 10 | A / 10 | msTL84-10 /



Customer:
Customer Attn:
Supplier:
Supplier Attn:
Fabric Supplier:
Fabric Supplier Attn:
Country of Origin:
Brand:
Brand Manager:
Buyer:
Department:
Season:
Item Description:
Style Number:
Fiber Content:

Start Date:
Due Date:
Submit Date:
Type:

Decision:

Yarn from the 16g fabric
2007_Standard_dyerepeat_1

datacolor
Because Color Matters

Sample Analysis

05-Apr-12

Standard: 1 of 2

Texwell_Amos_2007_005_mod_1

Instrument Conditions: %R LAV SCI UV Inc
600 S/N 8801430

Illum/Obs	DL*/lSL	Da*	Db*	DC*/cSC	DH*/SH	DEcmc	Decision
D65 10 Deg	0.44	-0.39	0.31	0.02	0.74	**0.87**	Warn
A 10 Deg	0.41	-0.33	0.20	0.00	0.50	**0.65**	Pass
msTL84-10	0.44	-0.37	0.37	0.07	0.68	**0.81**	Warn

Submit/Sample #: 8 of 8

2007_Standard_dyerepeat_2

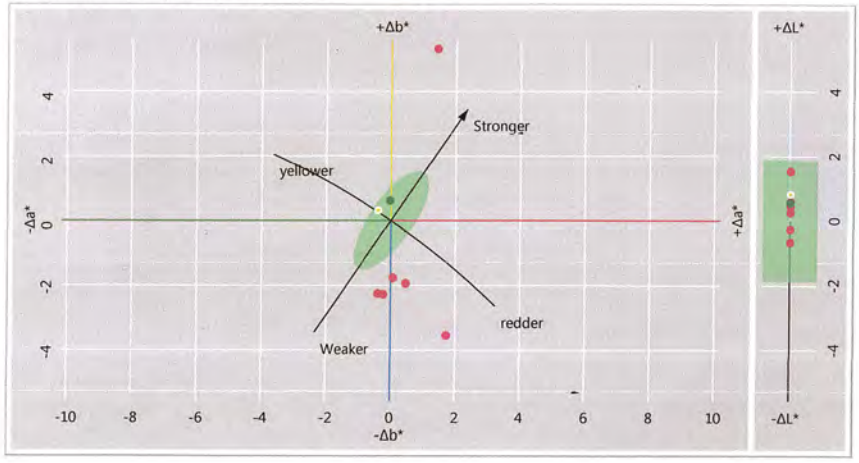
Instrument Conditions: %R LAV SCI UV Inc
600 S/N 8801430

Sample is:
thinner
brighter
yellower

DEcmc Tolerance: 1.00
(l:c) Ratio: (2.00 1.00)

Comments:

Delta CMC | D65 / 10 | A / 10 | msTL84-10 /



Customer:
Customer Attn:
Supplier:
Supplier Attn:
Fabric Supplier:
Fabric Supplier Attn:
Country of Origin:
Brand:
Brand Manager:
Buyer:
Department:
Season:
Item Description:
Style Number:
Fiber Content:

Start Date:
Due Date:
Submit Date:

Appendix 3 Chapter 7

Presentation to the Thinking Through Practice (TTP) group, Nottingham Trent University, September 2013 (Ch 7.2)

Ourselves and Others / The I and the We

The researcher

The researcher has different roles to perform, to realise, and to make her project. The project is allocated in the field of Technology and Art. Hence the researcher needs to adapt to the methods and methodologies of the different fields.

In the starting phase of the project the researcher has to learn all the needed skills and to prepare the material, which will be later on the basis for the artwork.
The researcher has to affront differently, …
The researcher has to perform as an artist, whatever that means and to progress as an artist.
The researcher needs technological skills; yes skills, knowledge, yes she has to perform.
The work process consists in intertwining methods.
Some of the research is well planned.

The enabling technology, which the university is offering unfortunately, does not facilitate a smooth progress. The researcher is confronted with a lack of knowledge of the staff and a lack of appropriate technical equipment, which she did not expect to affront and she still does not know, how to solve it.
The researcher has to develop further craft skills for bringing together the yarn enabling the creation of an experience of the phenomenon called Metamerism.
The researcher flicked through the book, "The art of not making, the new artist/ artisan relationship" written by Michael Petry (2011).
But she assumes both roles, the one of the artist and as well the one of the artisan. Furthermore, she is the technician and scientist in the dye lab calculating recipes, outsmarting the colour management software and dyeing the material, the basis for the artwork.

The academic world is asking for a certain standard of research. But what about the standard of the artisan skills, what about the standard of the practice? And what about the judging of the artwork?

And the big question: who will be the audience, who should be the audience?
Which criteria does the audience have, which criteria are appropriate?
And doesn't each research project ask for his own criteria?

Me, the researcher

I am sitting in front of my computer and I should prepare the presentation for the 2. PhD seminar.
I am suffering in the knit lab. Everything takes too much time. There are always stitches falling down, and the knit is not yet as perfect as I do expect it to be.

I thought, that I am pretty patient doing crafty works- at least when I was a kid I remember, that I did a lot of handcraft, I was doing hand crochet for hours, sitting in my room, in my refuge.
I am just trying out, exploring. But what does it mean to explore knitting? How do I proceed? Do I have a plan? What shall I do in the meantime, waiting for the moment, when my ideas for the installation getting clearer.
How do I observe my knitted fabrics, how to I reflect and document this process? This process of as well sitting around not knowing, what could be the next step.
I am suffering in the dye lab and the results of the dyed yarns still do not convince me, as I still cannot reach even dyed yarns, which are perfectly matching in daylight.

I am disappointed, I did expect, that I could reach much more this summer. I hoped to proceed well and to bring my research a big step forward- but no! It seems that the end move back and back again. I hoped to have passed the middle of my PhD time; I still hope to finish in 2015, but I am not sure, if that is possible.

I still did not present at conferences. I know exactly, that I should. I am confused, as my DOS is asking me to clarify the topic of IP. I should fear the "Others", stealing my idea, being quicker in getting results, and this is easy, with more time and better equipment. I am not really interested in IP, however I am questioning, if I should present my research in a Design context. I am pretty sure; that my topic is relevant in a Design Context and that my DOS basically is right. But…

I am the author of my ambition and I am suffering.

Yesterday I heard a TED talk by Alain de Botton (2009), a philosopher and he talked about the difference of a loser and a failure. In his opinion it is much more self-destructive to be a loser than a failure.
Being a loser, you lost- you lost forever.
Being a failure, you just get up again and you retry.
Do I dare to fail or am I afraid of being a loser?
I have been already working three years on my PhD. I cannot stop anymore. If I would stop now, nobody would understand that, nobody. Stopping would be a huge loss, a waste of time, and even more a missed opportunity to learn something for my life.

And yes, I could fail!

List of green terms (Ch 7.3.2)

- Artichoke
- Asparagus
- Army green
- Avocado
- Bottle green (Bangladesh green)
- Bright green
- Brunswick green
- Cal Poly Pomona green
- Castleton green
- Celadon
- Celadon green
- Dark green
- Dark pastel green
- Dartmouth green
- Emerald
- Feldgrau
- Fern green
- Forest green
- Hooker's green
- Football field green
- GO Transit green
- Harlequin
- Hunter green
- India green
- Islamic green
- Jade
- Jungle green
- Kelly green
- Laurel green
- Light green
- Mantis
- Moss green
- Dark moss green
- Malachite
- Midnight green
- Mint green
- Myrtle green
- Neon green
- North Texas green
- Office green
- Olive
- Pakistan green
- Paris green
- Persian green
- Pine green
- Rifle green
- Russian green
- Sacramento State green
- Sap green
- Screamin' Green
- Sea green
- Shamrock green (Irish green)
- Spanish green
- Tea green
- Teal
- UP Forest Green
- Yellow-green

(Anon 2017)

Appendix 4 Chapter 8

Technical instructions for *green-green-green* dress, Ch 8.1.2

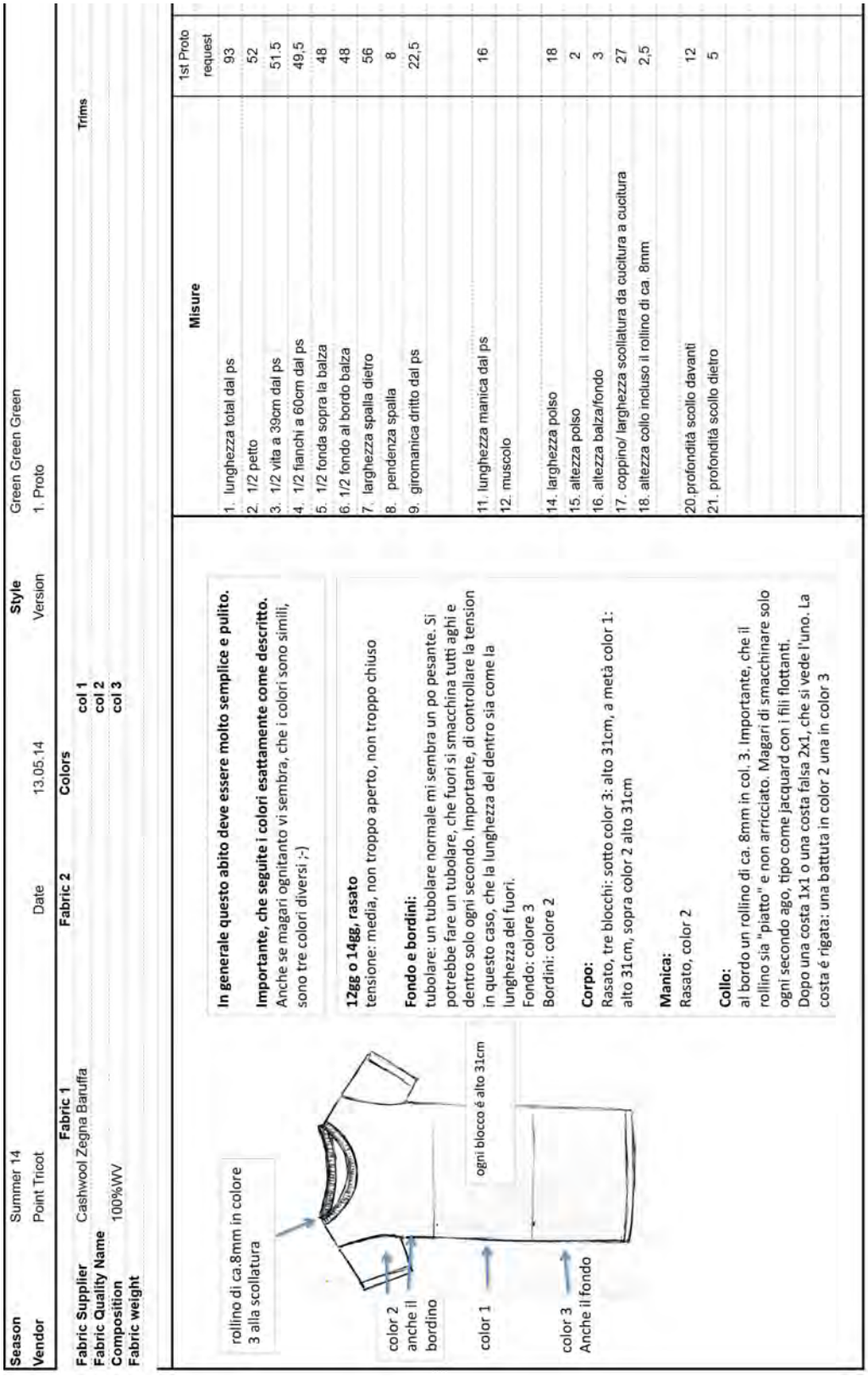


Figure 153 Technical instructions for *green-green-green* dress


Esempio di collo
Forma della manica
Forma della scollatura

Text lecture performance *green-green-green,* Symposium Knitting Nottingham, 2015, Ch 8.2.3

In the ring
In the ring, face to face:
Tungsten light, LED, candlelight, Halogen light, Low energy light.
They are all engaged in a contest of strength, reflexes, quality and endurance.
Each of them battles with their own strength.
The candlelight fights for romantic light.
The strength of the LED is his endurance and his low power consumption.
The traditional light bulb advocates for a warm ambience.
The low energy bulb needs some time to get in form, to get his intensity, but then…

The first one, which got blown out was the candlelight.

The referee, called European Union supervised the contest and after different rounds they decided to expel the traditional light bulb from the match.

The winner is the climate, they say.

The obituary
We miss the incandescent light, 'the most profound invention since man-made fire' (Whelan 2010).
The incandescent light bulb, even called Tungsten light or traditional light bulb, was resident in private houses, offices and industries all over the world.
It was made out of a steel sheet thread, a bulb, copper, a little bit of solder and tungsten filament.
It was a real symbol of innovation.

This cordial light source had to disappear, because of his energy inefficiency. His disadvantage is, that just 10% of the consumed energy generates visible light, 90% of the energy goes to heat. The European Union calculated savings of five millions of Euro of power costs and 15 tons of carbon dioxide each year.

This extinction is good news for the climate and the economy.
Others forecast more work for psychiatrist, new toxic waste and a loss of a whole colour range, a loss of a colour experience.

The history goes back to 1802. In 1802 Humphrey Davy created the first incandescent light by passing current through a platinum strip. It caused a glow and did not last long, but marked the beginning of the development of an unforgettable history, the history of the incandescent lights.
However, Edison is often credited with the invention because his version was able to outstrip the earlier ones.

And as there are no descendants, the family of the Tungsten bulbs will die out.
The very close Halogen lights, which radiate nearly the same warmth as the traditional light bulbs, are in danger of extinction. And if this happens, we will totally loose the warm lights in

the world and our nights will be darker and colder. And there will come the day, when nobody will remember, that the world once was much more colourful.

One day, we will realise the loss and perhaps, then we will celebrate a commemoration day of the incandescent light.

The Incandescent bulb
Lights up rooms
Heats our hearts and bodies
Treats our brain
Tickles our perception
Touches our sensation

And we stand now at the beginning of a completely new way to see the world.
Are you aware of this?

(Whelan 2010), (Anon n.d.), (Martin 2012)

Collection of light expression (Ch 8.4.2 & 8.5.2)

- Light source
- Photosynthesis
- Ray of hope
- Enlightenment
- It dawns on me
- Turn on the light
- I saw daylight
- The light at the end of the tunnel
- To see the light of the day
- In the cold light of day
- Out of sight, out of mind
- Let there be light
- To bring something to light
- To give somebody the green light
- To switch on the light
- To obstruct the light
- Clear as daylight
- To reflect light
- I light you the way

Text performance *Q & I*, Summer Lodge 2015, (Ch 8.5.2)

Dialogue Dorit / Salome:

d: *Sitting here with you reminds me of that song line:*
"That's me in the corner - that's me in the spot"
Let's find out about the 'ME' ...
Who are you?

s: *I'm Salome Egger, born etc*

d: *no, who are you as a personality*

s: *... uff ...*

d: *How would you describe yourself?*

s: *It depends ...*

d: *On what?*

s: *It depends on who looks at me*
how they look at me
if I feel secure - because either I shine or I don't

d: *So you are what people see in you?*

s: *No! ... yes ... maybe*

d: *What do you mean?*

s: *I am what people see in me - but there are so many people and each of them sees a different ME.*

d: *Like what?*

s: *ME as a performer. ME as a PhD student*
ME as ... neighbour / no mother- but mother / lover / friend / costume designer / talented cook / daughter / traveller / host / listener / cyclist / organizer / thinker & writer

d: *Do you have a favourite ME?*

s: *No, they are all favourites if it's the right situation.*

d: *What is the right situation?*

s: *When I'm seen in the right light.*

d: *So we've passed on to the second part of the line "that's me in the spot" ...*
Do you like light?

s: *I like to be seen.*

d: *Is there also a ME in the dark?*

s: *Oh yes, I have a lot of dark moments.*

d: *So let there be light!*
Which light is your favourite one?

s: *It depends.*
In summer, I really like lightning, in spring I love glow-worms, in winter candlelight...
and the old-fashioned light bulb, twilight / dusk, ...