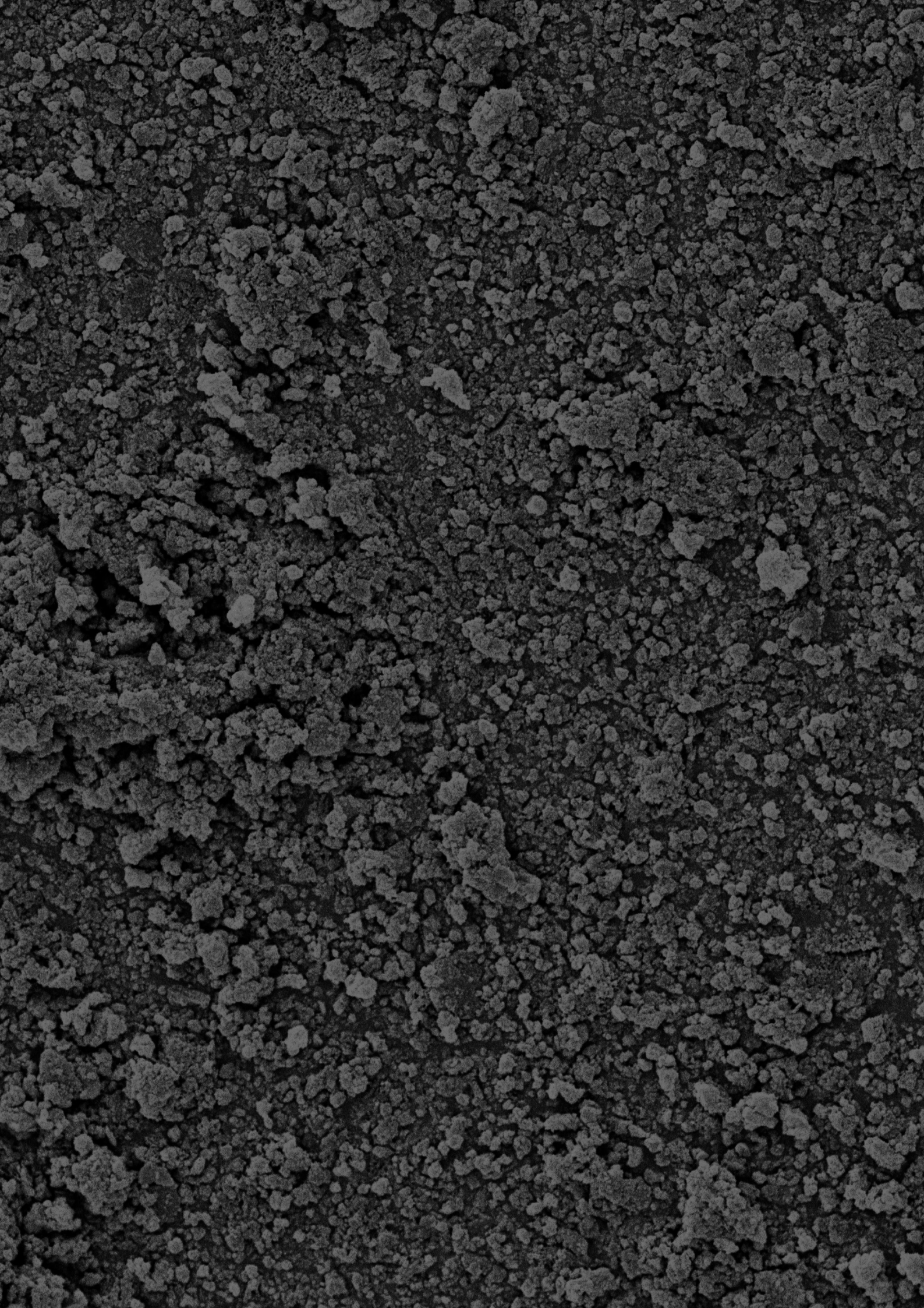

TABLE OF CONTENTS

ABSTRACT

This paper is based on my Master Thesis and explores how art and science practices can enable sustainable productions through reworking relations between representations and their material instantiations.

Central to this study are objects centred around pigments, chromatic substances transducing and translating between materiality and meaning. These objects are serigraphic prints depicting the molecular formulas of synthetic pigments as well as micrographs rendered precisely by those same pigments. Here, the materialities used to present pigment molecules are the self-same materials being represented. By examining these artworks, the thesis explores how materials can simultaneously embody and articulate scientific and artistic principles, challenging separations between materiality and representation.

Theoretical insights are drawn from Karen Barad's concept of agential realism, which asserts a performative approach to representations. To account for this performative concept, the material compositions of the serigraphic prints were engineered to be compostable.

To achieve a high degree of reproducibility and accessibility, an emphasis was placed on describing the production process.

Index Terms- serigraphy, circular materials, scanning electron microscopy, agential realism

PREFACE

As a trained biochemist, I can offer a dynamic and complex perspective on material. The myriad ongoing reactions and inner reconfigurations knowable through biological, chemical, and physical descriptions lead me towards problems of representations.

Representations are here understood as signs, models, abstractions, translations, images, recordings, or isomorphic reductions, that contain some form of motion pointing to something else – the represented. The sciences very much teach the limitations of representations, modifications needed to resolve practical issues or blind spots in the representational capacities. Though it is still easy to forget these restrictions and indulge in the convincing illusion of representations.

For me the arts are a discipline that allows for the playful exploration of the practices of representing. This enables a very direct relation to the practices of scientific representation. The representational discourse of the arts can then be read through the struggle for representations in science, in my case specifically molecular and atomic representations, thus opening the stage for a molecular approach to representational art.

This thesis is my first attempt of a documentation of this approach. It is by no means extensive, and the prospect is to continually build on this practice.

I. THEORETICAL FRAMING

Karen Barad's agential realism offers a comprehensive philosophical framework that interlinks ontology, epistemology, and ethics, exploring their mutual contingencies. This thesis takes two major concepts from Barad's theory: material-discursive practices and the rejection of representationalism in favour of a performative approach.

Barad proposes a profound interconnectedness between the entities we typically understand as separate: the material and the discursive, or in more familiar terms, matter and meaning. Unlike traditional frameworks that place a clear division between objects and their representation, agential realism posits that these elements co-constitute and dynamically interact with each other. This perspective challenges the conventional notion that materials (or objects) passively exist to be shaped by an external force (such as human intervention or representation).

Historically dominant Western frameworks for theorising representations have been rooted in the semiotic model first systematised by Ferdinand de Saussure. For Saussure, the linguistic sign consists of two parts: the signifier (the form or sound-image) and the signified (the concept or meaning). Saussure posited that the relationship between signifier and signified was arbitrary and unmotivated - there is no inherent reason why the signifier "tree" is attached to the concept of an actual tree other than through

sociocultural convention and the oppositions between signs in the linguistic system.

This semiotic schema relies on a stable separation between the orders of materiality (signifier) and meanings/concepts (signified). It situates the processes of representing as operating through the relations between discrete signs rather than any motivated connections to an external referential reality. The signifier is granted a constitutive role in circulating meanings yet remains fundamentally segregated from the conceptual realm of the signified it represents.[1] Representations are thus understood as mediators of an independent, pre-existing reality. This view assumes that there is a fundamental separation between the world "out there" and our representations of it. This concept will be termed representationalism.

Barad forcefully rejects this representationalist logic, arguing that representations are not simply reflections or mediations of a reality predating them. Instead, representations are "condensations or traces of multiple practices of engagement" within this world.[2] Material realities (like the physical properties of pigments used in art or even the possibility to synthesise them) and discursive constructs (the meanings and narratives we attach to representations) articulate each other through these practices of engagement, for neither materiality nor discourse exist prior to each other. These practices are termed material-discursive practices.

Barad explicitly mentions scanning tunnelling microscopy as an example of material-discursive practices. In order for electron microscopy to articulate both atoms and their representations to be knowable, a plethora of practices are needed: electron microscopes and practices of sample preparation, the history of microscopy, scientific and technological advances made possible by scanning tunnelling microscopes, the quantum theory of tunnelling, material sciences, corporate resources and research and development practices, scientific curiosity and imagination, scientific and cultural hopes for the manipulability of individual atoms, Feynman's dream of nanotechnologies, cultural iconography, capitalist modes of producing desires, advertising, the history of the atom, the assumption of metaphysical individualism, complex sets of visualizing and reading practices that make such images intelligible, and the intertwined histories of representationalism and scientific practice.[3]

Besides this vast multiplicity of needed practices, what is depicted in the micrographs seems to have existed before the images were taken. This leads to Barad assuming that representationalism "would have us focus on what seems to be evidently given, hiding the very practices that produce the illusion of givenness".[4] Barad calls this alternative approach to representationalism "performative" as it puts the focus on the "practices or performances of representing, as well as on the productive effects of those practices and the conditions for their efficacy".[5] Barad concludes that being and knowing are both performatively enacted through each other. Representations are not just reflections of an objective reality but are actively involved in materialising the realities they represent.

In the context of this thesis, the performative approach allows us to see artworks not just as a result of pre-existing ideas, concepts, or systems but as the world in its becoming through material-discursive practices.

[1] De Saussure, Ferdinand. *Course in General Linguistics*. Translated by Wade Baskin, New York, Mcgraw-Hill, 1959, pp. 65.
[2] Barad, Karen. *Meeting the Universe Halfway*. Durham, N.C., Chesham, Duke University Press, 2007, p. 53.
[3] Ibid, p. 154.
[4] Ibid, p. 154.
[5] Ibid, p. 128.

II. DEVELOPING AND CONTEXTUALISING

This section aims to narrate the history of *Metamaterial* as a practice. Included are a selection of notable relations in the arts and sciences, as well as collaborators and enablers that I encountered during the development.

The first instances of self-representing objects date back to 2015. At that time, I was studying Biochemistry at the Free-University Berlin. During the semester break I was experimenting with various practices of applying paint onto surfaces. These were my first experiences in fine arts. During this time, I drew the structural formula of a red pigment and the citation of the corresponding scientific publication with a brush.

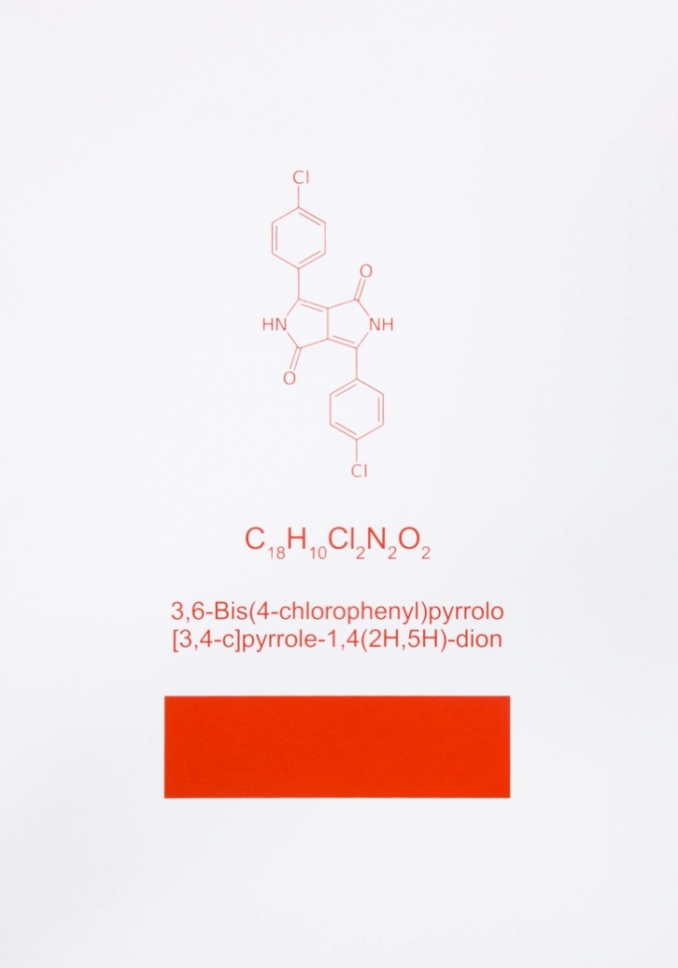

Figure 1: I am PR254, 2017, Pyrrole Red on Paper, serigraphy, 38 cm x 25 cm, Copyright: Claus Schöning.

First serigraphies were produced during my second semester in a diploma study program at the Academy of Fine Arts Dresden in 2017. Some of these serigraphs included the chemical formula, structural formula and systematic names of the pigments used for printing as shown in Figure 1. Other serigraphies were layered like Figure 2. The name *Metamaterial* was given to the series in 2017. The used prefix meta- draws attention to the self-referential quality of the artworks. It does not reference an identical terminology from the material sciences.[6]

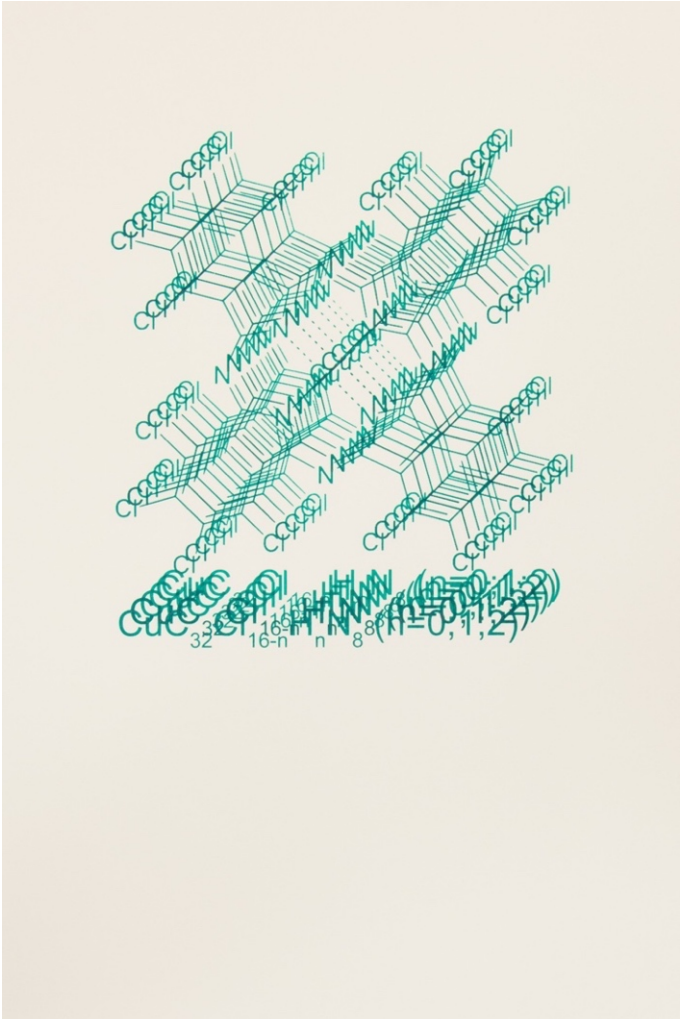

Figure 2: I am PG7, 2017, Phthalo green on paper, serigraphy, 38 cm x 22 cm, Copyright: Claus Schöning.

[6] Nader Engheta, and Richard W Ziolkowski. *Metamaterials*. John Wiley & Sons, 23 June 2006.

Figure 3: René Magritte, La trahison des images, 1929, oil on canvas, painting, 60 cm x 81 cm. resourced from: Prometheus – das verteilte digitale Bildarchiv für Forschung und Lehre, URL: https://prometheus.uni-koeln.de/en/image/ffm_conedakor-e14e666de2588b71e20ec3a3bb0756a99e0ec26e, Accessed on 27 April 2024.

The objects of *Metamaterial* are very much relating to *La trahison des images* (1929) (French for “the treachery of images”) of Belgian surrealist René Magritte. The painting, as depicted in Figure 3, shows a pipe and the writing "Ceci n'est pas une pipe" (French for "This is not a pipe"). The statement under the image, which appears contradictory at first, points to the limitations of representation. The painting is of course not a pipe, but rather an image of a pipe. This disjunction between the image and the text highlights the arbitrary relationship between representations and what they represent. This might seem obvious, yet still there is an initial moment of dissonance in the painting, clearly disclosing a certain bias for confusion.

The objects of *Metamaterial* attempt to answer what this non-pipe could be. As an homage to Magritte the object depicted in Figure 1 was initially named *Ceci est PR254*, until a more performative *I am PR254* was chosen to underline possible agencies of the material itself.

Metamaterial, throughout all its instantiations, can also be described as close to conceptual art since the self-referential representation of material plays a fundamental role in its execution and aesthetic. Still *Metamaterial* asserts, following Barad, that concepts need a material practice to be meaningful. Contrary to conceptual artists of the 1960s, who stated that ideas alone can be of works of art (Sol Lewitt), or who tried to achieve immateriality (Yves Klein),[7] the materialisation and conceptualisation of the objects in *Metamaterial* are mutually constituting each other.

Conceptual art, just like any other variation of art, needs some form of materialisation and sensual presentation, which then becomes central to the artwork. This is demonstrated by Joseph Kosuth's *One and Three Chairs* (1965) depicted in Figure 4. This work can be described as a "textbook study in semiotics" (the study of signs).[8] It consists of a chair (the "signified" or what is represented), a photograph of this very same chair (the "signifier" or representation) and a text panel of the dictionary definition of the word "chair" (the transcendental idea). Through the arrangement of these three objects Kosuth reveals the arbitrary relation of a specific group of sitting devices with the word "chair", thereby questioning its claim to meaning. The title of the artwork could also suggest that there are, indeed, three chairs with very different forms of being. Despite a nonaesthetic, conceptual, perhaps even transcendental aspiration of the artwork, it is very much materialised in these specific objects, which results in an unemotional and minimalistic visual appearance.

By neglecting the material dimension, it is not clear how meaning is produced, for both the word "chair" but also of the artwork itself. Is the word "chair" ultimately meaningless? What is the idea of a chair? How then can we communicate using the word "chair"? The early objects of *Metamaterial* share this analytical, minimal aesthetic, but shed any transcendental or purely conceptual stance by positing the material upfront. To understand the meaning of chairs through an agential realist framework, it would be necessary to investigate the history of how chairs have been produced and used (for example technologies of masonry, carpentry, and metal works but also cultural conventions of how to sit gracefully and medical opinions on what might be deemed appropriate for humans). To understand how the word "chair" relates to a specific group of sitting devices, it would be necessary to investigate how writing and language have developed through these chair-producing practices (for example the use of pigments and binders, papers, writing practices and etymology). While *Metamaterial* does not (and cannot) extensively make those material-discursive practices intelligible, it attempts to make these tangible by putting representations and what they represent in a paradoxical superposition.

Figure 4: Joseph Kosuth, One and Three Chairs, 1965, wooden folding chair, photographic copy of a chair, and photographic enlargement of dictionary definition of chair, chair (82 cm x 37 cm x 53 cm), photo panel (91 cm x 61 cm), text panel (61 cm x 62 cm). resourced from: Prometheus – das verteilte digitale Bildarchiv für Forschung und Lehre, URL: https://prometheus.uni-koeln.de/en/collections/63707/image/genf-82235b6220c0aa9d769e7a35ea283f7ff68b2039, Accessed 27 April 2024.

[7] Badiali, Silvia. *Rom "Ideas Alone Can Be Works of Art" (Sol Lewitt, 1969) to Conceptual Art and Yves Klein: Ideas versus Immateriality*. Nov. 2014.

[8] Horst Woldemar Janson, and Penelope. *Janson's History of Art*. Pearson, 2011, p. 1062.

In 2018 a new group of works titled *When Math Becomes Real it Dies* was developed. These sculptures are representing exponential equations. These functions were chosen because of their capacity to predict and represent the time dependence of population sizes.

The objects were also reactions to the concept of Great Acceleration,[9] which terms the exponential growth (or decay) over a diverse range of metrics. These include among others: human population, primary energy use, fertiliser consumption, domesticated land, and atmospheric carbon dioxide. In most cases the exponential growth phase persists only for a limited initial time, leaving us in anticipation of a dramatic stagnation or with the prospect of ever accelerating change.

Figure 5 shows the work *y=2^x* of the work group *When Math Becomes Real it Dies*. The distance of the vertical fins represents the eponymous exponential equation. Despite the accurate production processes, the object was left in a self-made incubator for a month to allow for microbial (exponential) growth. Since the object was made from medium-density fibreboards (MDF), microbes and fungi could grow when the object was soaked with a water-based growth medium. These airborne life forms contaminated the accuracy and structural integrity of this mathematical representation by physically performing the exponential function it represents. Contrary to that, the title of the work group could be an expression of a Platonist belief of mathematics existing in a parallel universe, inhabited by math as physical entity.[10]

Figure 5: y=2^x, 2018, MDF, screws, microbes, 200 cm x 60 cm x 25 cm, Copyright: Claus Schöning.

[9] Steffen, Will, et al. "The Trajectory of the Anthropocene: The Great Acceleration." *The Anthropocene Review*, vol. 2, no. 1, 16 Jan. 2015, pp. 81–98, https://doi.org/10.1177/2053019614564785.

[10] Tegmark, Max. *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality*. New York, Vintage Books, 2014.

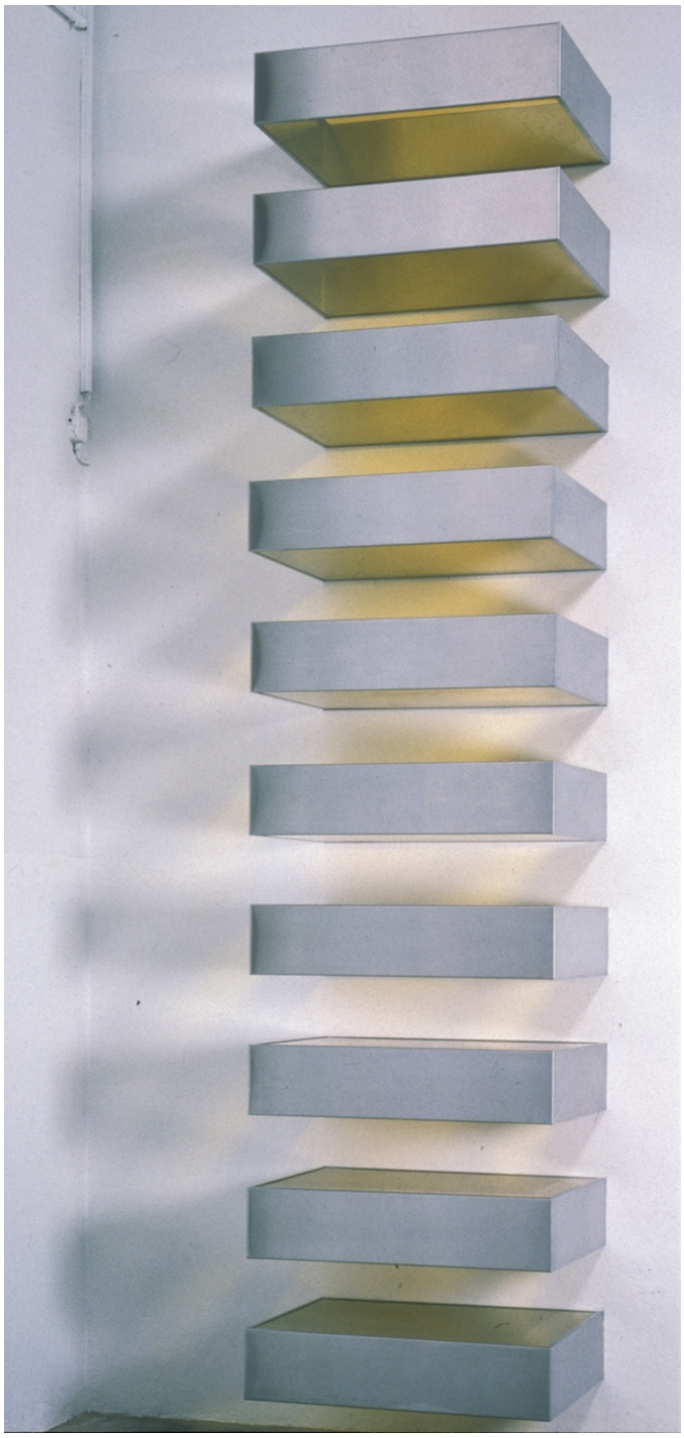

Figure 6: Donald Judd, Untitled, 1968, stainless steel, yellow plexiglass, 10 units, each 23 cm x 101 cm x 79 cm. resourced from: Prometheus – das verteilte digitale Bildarchiv für Forschung und Lehre, URL: https://prometheus.uni-koeln.de/en/image/genfc8d47035e6c251046168636f4b38f67ac2da8570, Accessed 28 April 2024.

The works of *When Math Becomes Real it Dies* share some resemblances with formalist sculptures of the 1960s, as they are determined by mathematical premises that are rigorously followed.

Minimal artists like Robert Morris wanted to exorcise transcendental values and ideas as the encoded motivation preceding the artwork. Donald Judd for example termed his sculptures "specific objects" in the sense that they should be experienced as "real"[11] objects with no references beyond themselves. No special art-specific staging like pedestals, no compositions to be analysed and related to art histories – just fundamental, immanently accessible shapes. Figure 6 shows the object *Untitled* (1968) by Donald Judd. It consists of ten units installed on a wall so that the volume of each unit and that of each interval between them are equal. The industrial aesthetic is devoid of any organic marks left by a manufacturing artist, no hints of an expression of emotion. In fact, Donald Judd explicitly excluded intuition or artistic sensitivity during the conception of the artworks. The production of the objects was outsourced to artisans or industrial factories.

In a strange recourse, this is very reminiscent of conceptual art, in the sense that the concept is to have no concept at all. The objects are forcing to question how exactly these non-intuitive, non-sensitive mathematical premises came to be chosen. Were they decided upon by chance? The concept of having no concept seems rather untransparent, because it assumes that these objects are given. The objects of *When Math Becomes Real it Dies* stand firm that every form of independence or self-reference must be contaminated, every instance of givenness is unstable and blurring. The "well-made" aesthetic of "specific objects" is materially decompositioned through microbial growth re-enacting that, which was supposed to be transparently represented, namely an exponential function. In that sense *When Math Becomes Real it Dies* makes the difficulties of transparent attempts of representation tangible, in contrast to a minimalist approach that surfaces transparency, while concealing an untransparent non-concept conceptual core.

[11] Horst Woldemar Janson, and Penelope. *Janson's History of Art*. Pearson, 2011, p. 1057.

Figure 7: Beast Science, 2021, 1-channel video, 2-channel audio, 12:31 min, video still, Copyright: Claus Schöning.

Barad's incidental mentioning of the connection between René Magritte's *La trahison des images* and Don Eigler's first images of single atoms via scanning tunnelling microscopy for IBM[12] was the inspiration to produce a video work on electron microscopy in 2021. Within the framework of the residency program Entstehung einer Künstlerischen Tatsache in Jena, Germany, a collaboration with the Electron Microscopy Center (EMZ) of the University Hospital of Jena was possible.

The video work *Beast Science* documents in detail the sample preparation process of scanning electron microscopy (SEM). The work unsettles anthropocentric notions of knowledge production by involving a seemingly nonhuman agency to perform the sample preparation needed to record micrographs by SEM. It also highlights the entanglement of material practices of science and objective representations. Figure 7 shows a video still. Cinematically, the work consists entirely of insert-shots, which are commonly used to convey specific key micro interactions and are normally intercut with the main action in a scene. In *Beast Science* these inserts become the main action of the plot/protocol. The closeness aligns with the concept of microscopy and enables the audience to look through the eyes of the nonhuman agency. This was used to emphasise the fine motor skills and micro materiality of the practice of SEM. The shots are overlaid with text fragments from interviews and discussions with the scientists working at the EMZ to give an emotional and aesthetic insight on the persons conducting the experiments. The images are very deliberate in composition and colour, which relates to questions of aesthetics discussed with the scientists. The video footage was also slowed down to achieve a ghostly presence of the nonhuman agency.

[12] Eigler, D. M., and E. K. Schweizer. "Positioning Single Atoms with a Scanning Tunnelling Microscope." *Nature*, vol. 344, no. 6266, Apr. 1990, pp. 524–526, https://doi.org/10.1038/344524a0.

Through Prof. Michael Sauer from the University of Natural Resources and Life Sciences Vienna I learned about the immense efforts to transform industries from linear to circular materials in 2022. This very much resonates with the circular meanings underlying the *Metamaterial* work group. Further concerns about the ongoing wasteful production of object-based artworks led to a reconceptualisation of the series as not only embodying circular meanings but also circular materials.

By courtesy of Michael Sauer, a connection was established with Ass. Prof. Christian Zafiu of the Institute of Waste Management and Circularity at the University of Natural Resources and Life Sciences Vienna, who gave me crucial insights into the material science of circularity. During the 2023 yearly project of the Art & Science study program first research was conducted and prototypes of compostable objects were produced. Additional support by the Department for Mineralogy & Petrography of the Natural History Museum Vienna enabled to obtain minerals from the archive of the Natural History Museum Vienna (Hematite, Malachite, Azurite among others) and use them as pigments for compostable paints for printing on cotton. Figure 8 shows different minerals from the archive of the Natural History Museum Vienna. These pigments were milled to appropriate particle sizes for the printing process as shown in Figure 9.

Figure 8: Mineral samples from the archive of the Natural History Museum Vienna, Copyright: Claus Schöning.

Figure 9: Milling process of Azurite, Copyright: Claus Schöning.

Figure 10 shows a prototype hanging on a wall. It depicts a representation of the crystal structure of malachite made with the program VESTA[13] according to .cif data[14] from the Crystallography Open Database.[15] The objects were partly composted by lacing them, thus subjecting only the outer parts of the prints to a compost for 8 weeks.

The use of biodegradable materials in art is of course ancient, as wood can be considered biodegradable. Besides limits to their ability to be conservable, the oldest known wood derived artifact is thought to be approximately 10.000 years old,[16] demonstrating that biodegradability does not necessarily entail a limited preservability. A first deliberate and documented use of biodegradable material could be the sugar sculptures of 16th century Venice. These small sculptures are thought to have been extremely fragile and were consequently strictly for decorative use. Since especially white sugar as a colonial product was highly expensive, these sculptures were reserved for the ultra-rich as objects of status.[17]

The use of material decay and aging of Dieter Roth in the 20th century has been most influential for *Metamaterial*. From the early 1960s Roth is producing "objects of putrification", which first emerged from the repurposing of book pages as stuffing for sausages (*Literaturwurst*, 1961) but soon become focused on organic or edible materials. Figure 11 depicts the object *Flacher Behälter* (1971), a glassed wooden frame, in which Roth left canned vegetables to rot. The material decay is used as producer of random ornamental aesthetics[18] and provoking odours. The introduction of material decay as artistic practice especially challenges art conservation scholars by "countering the restorers' logic of material preservation".[19] The staging of the objects of Metamaterial as partly decompositioned also appreciates the aesthetic value of material decay. This aesthetic can make material entanglements perceptible. However, the objects do not necessarily need to be composted, on the contrary, they can be conserved for potentially decades under the right conditions with little aesthetic changes. Metamaterial is more moving towards an open-source material study to incentivise more sustainable production of art, with as little compromises and as much accessibility as possible. Also contrary to Roth, the objects of Metamaterial are composting not rotting. Composting is a human

Figure 10: Circular Hauntings (Metamaterial), 2023, serigraphy, Malachite, corn starch, cotton, wood nails, compost, 130 cm x 110 cm, Copyright: Claus Schöning.

[13] Momma, Koichi. "VESTA." *Jp-Minerals.org*, jp-minerals.org/vesta/en/.
[14] Zigan, F, et al. "Verfeinerung Der Struktur von Malachit, $Cu_2(OH)_2CO_3$, Durch Neutronenbeugung." *Zeitschrift Für Kristallographie*, vol. 145, no. 5-6, 1 Mar. 1977, pp. 412–426, https://doi.org/10.1524/zkri.1977.145.5-6.412. Accessed 26 Mar. 2024.
[15] http://www.crystallography.net/cod/index.php
[16] Zhilin, Mikhail, et al. "Early Art in the Urals: New Research on the Wooden Sculpture from Shigir." *Antiquity*, vol. 92, no. 362, Apr. 2018, pp. 334–350, https://doi.org/10.15184/aqy.2018.48.
[17] Kociszewska, Ewa. "Displays of Sugar Sculpture and the Collection of Antiquities in Late Renaissance Venice." *Renaissance Quarterly*, vol. 73, 2020, pp. 441–488, https://doi.org/10.1017/rqx.2020.2.
[18] Dobke, Dirk. *„Melancholischer Nippes" Dieter Roths Frühe Objekte Und Materialbilder (1960-75)*. 1997. (page 55)
[19] Macías, Eugenia, and Cristina Reyes. "Biological Material Indeterminacy Rebukes the Social and the Artistic: Cases from the Documentary Archives of the Arkheia Documentation Center, Mexico." *Living Matter: The Preservation of Biological Materials in Contemporary Art*, edited by Kendra Roth and Rachel Rivenc, Getty Publications, 24 May 2022, p. 36.

controlled process that requires specific amounts of oxygen, water and starting materials to enable the fast oxidative reconfiguration of biologically available substances. As a matter of fact, a well-controlled compost does not have an unpleasant smell at all.

Figure 11: Dieter Roth, Flacher Behälter, 1971, canned vegetables, glass, wooden frame, 130 cm x 100 cm x 35 cm. resourced from: Prometheus – das verteilte digitale Bildarchiv für Forschung und Lehre, URL: https://prometheus.uni-koeln.de/en/image/bochum_kgi-683e725c03a87baaad2623231644e944e537acab, Accessed: 25 April 2024)

During the graduate school EU4Art_differences in 2023, contact was established with the GreTA working group (Generative Herstellung von recyclingfähigen Grundstrukturen für die Theaterplastik aus naturbasierten Ausgangsstoffen) attached to the Theatre Sculpture faculty of the Academy of Fine Arts Dresden and the Institute of Lightweight Engineering and Plastic Technology (ILK) at Technical University Dresden.

Their research on regenerative materials for sculpture lead to new impulses for the work group *When Math Becomes Real it Dies*. A first prototype was 3D-printed with a custom cork-gelatine composite as shown in Figure 12. The sculpture represents the data set of global waste production between 1900 – 2020.[20] Subsequent compostability tests showed that the cork-gelatine composite will degrade within 3 weeks when composted. Nevertheless, the prototype shows good material stability within at least 6 months under dry conditions and room temperature. These new methods and materials further expand the catalogue of sustainable art practices.

Figure 12: Prototype for a compostable sculpture. Approximately 90 cm x 14 cm x 5 cm, Copyright: Claus Schöning.

[20] Hoornweg, Daniel, et al. “Environment: Waste Production Must Peak This Century.” *Nature*, vol. 502, no. 7473, 30 Oct. 2013, pp. 615–617, https://doi.org/10.1038/502615a.

III. EXPERIMENTING WITH MATERIALS AND MEANINGS

This section presents the materials and methods employed in the development and production of serigraphic prints with compostable paints on cotton fabric as well as the final protocols used for production. The aim of this study was not to employ one of the many given formulations of sustainable paints[21] nor to develop completely novel formulations of sustainable paints. Instead, it intends to explore the specific material-discursive practices needed for my specific use case and to immerse myself in these practices of tinkering and stabilising certain phenomena. Through this process I hope to become more sensitive for the small details that matter.

This documentation intends to provide a comprehensive account of the experimental processes and procedures for accessibility, evaluation, and reproducibility. The attempt at transparent documentation is of central importance to the responsibility of any practice, but artistic practices in detail. Especially artistic practices are often aimed at the exact opposite to maintain exclusivity and irreproducibility.

Albeit including high-tech practices such as SEM, these practices are not essential for reproducing the formulations of paints mentioned below. It is of great importance to this project, that the resulting protocols are as low-tech, accessible, and sustainable as possible to potentially be considered an alternative to industrial paints. Also note that serigraphy is only one possible application of the paints. The pigments are replaceable as well, as potentially everything milled to a certain particle size can be considered a pigment.

In the specific context of *Metamaterial*, it is of conceptual consistency to narrate in detail how the materials of the artwork were processed and tinkered and how their materiality and meaning is reproducing itself through scientific and artistic practices. The following descriptions may demonstrate how material and meaning entangle in practice and their integration in diverse material flows.

I am very grateful for the experienced support from these experts in their respective fields. *Metamaterial* would not be impossible without them.

The paints and prints were developed with the help and advice of Ute Huber-Leierer and Stephanie Klaura of the workshop for textile technology of the University of Applied Arts Vienna. The printing of the masters for the exposure of the printing screens was realised by the workshop for digital photography of the University of Applied Arts Vienna. The assessment of compostability was conducted in collaboration with Prof. Christian Zafiu, MA Gerald Lang and Dipl.-Ing. Erwin Binner at the Institute of Waste Management and Circularity, University of Natural Resources and Life Sciences Vienna. The imaging of the pigments via Scanning Electron Microscopy was implemented by Dr. Farkas Pintér at the Natural Science Laboratory, Institute of Conservation and Restauration, University of Applied Arts Vienna.

The research was conducted between 2022 and 2023 if not noted otherwise.

[21] Blatti, Jillian L. "Colorful and Creative Chemistry: Making Simple Sustainable Paints with Natural Pigments and Binders." *Journal of Chemical Education*, vol. 94, no. 2, 14 Dec. 2016, pp. 211–215, https://doi.org/10.1021/acs.jchemed.6b00591. Accessed 2 March 2024.

Electron microscopy- CI Pigment Blue 15 (PV Fast Blue A2R, Heubach GmbH), CI Pigment Yellow 180 (PV Fast Yellow HG, Heubach GmbH) and CI Pigment Red 254 (PV Fast Red D3G-CN, Heubach GmbH) were inspected under a stereo microscope to roughly determine macroscopic purity and adhesion.

Small amounts (less than 0,1 g) of the samples were attached to adhesive carbon tabs on specimen stubs and then coated with 10-15 nanometres (one thousand-millionth of a metre, nm) gold via vapour deposition. Figure 13 shows the pigments mounted on the specimen stubs and coated with gold. The samples were examined under a scanning electron microscope (JSM JSM-IT200, JEOL Ltd.) in secondary electron mode and digital images of the phenomena were produced at different magnifications. Figure 14 depicts the moment the samples are inserted into the scanning electron microscope.

Figure 13: Pigment samples after gold coating, Copyright: Claus Schöning.

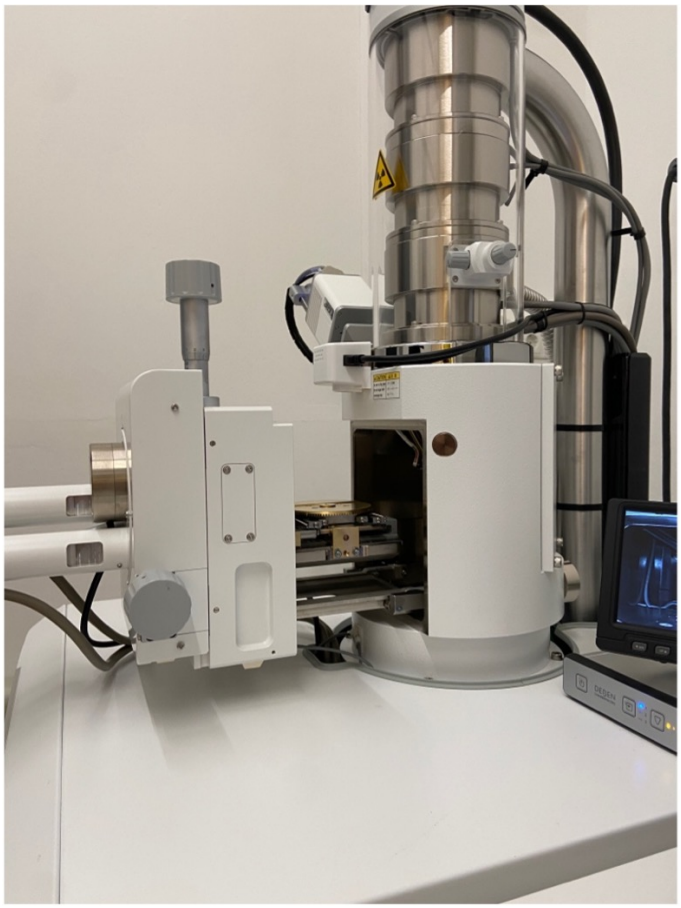

Figure 14: Electron microscope with opened vacuum chamber and exposed sample stage, Copyright: Claus Schöning.

The shape of pigment particles was observed to be different among different types of pigments as shown in Figure 15. CI Pigment Red 254 appears as globules of approximately 250 nm size (Figure 15 (a)) in contrast to CI Pigment Yellow 180, which appears as needles with a length of approximately 1 micrometre (one millionth of a meter, µm) and a diameter of approximately 250 nm (Figure 15 (b)).

The pigments by Heubach GmbH have much smaller particle sizes compared to CI Pigment Blue 27 by H. Schmincke & Co. GmbH & Co. KG as shown in Figure 16. The micrograph depicted in Figure 16 (a) was produced in 2021 at the Electron Microscopy Center of Schiller University Hospital Jena by MTLA Susanne Linde with the scanning electron microscope (LEO) 1450 VP by Carl Zeiss AG. It shows the diameter of CI Pigment Blue 27 particles to be bigger and of higher diversity, approximately 10 – 100 µm, in relation to the CI Pigment Blue 15 particles with an approximate diameter of 250 nm as seen in Figure 16 (b).

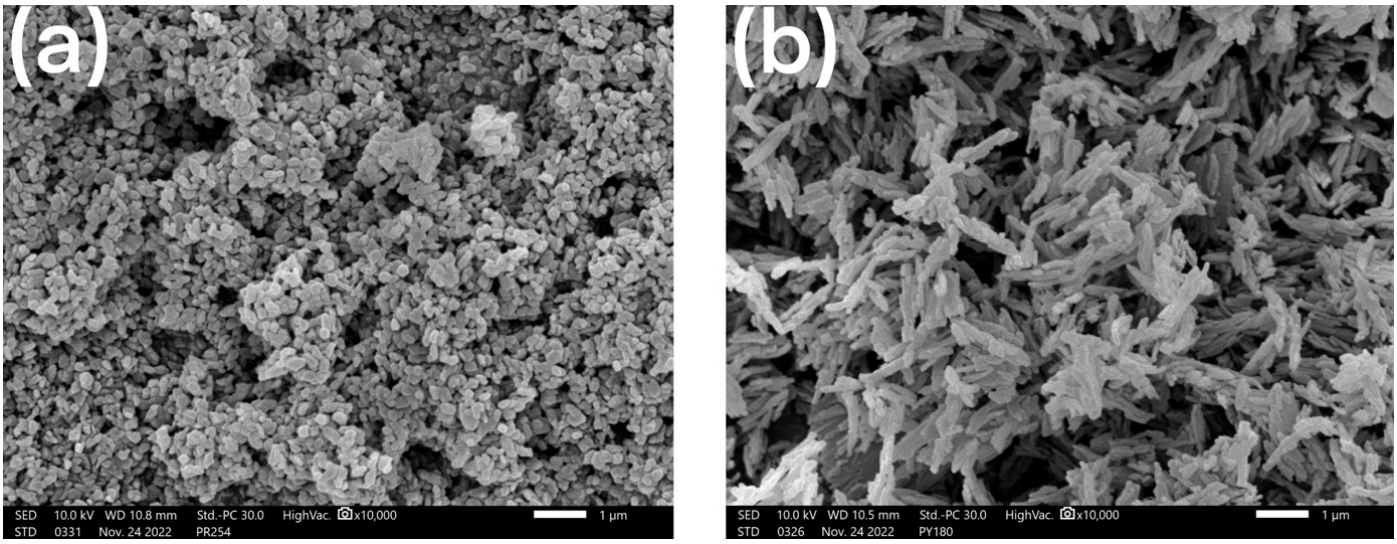

Figure 15: Different particle shape of pigments. (a) SEM micrograph of CI Pigment Red 254, (b) SEM micrograph of CI Pigment Yellow 180, Copyright: Farkas Pintér, Claus Schöning.

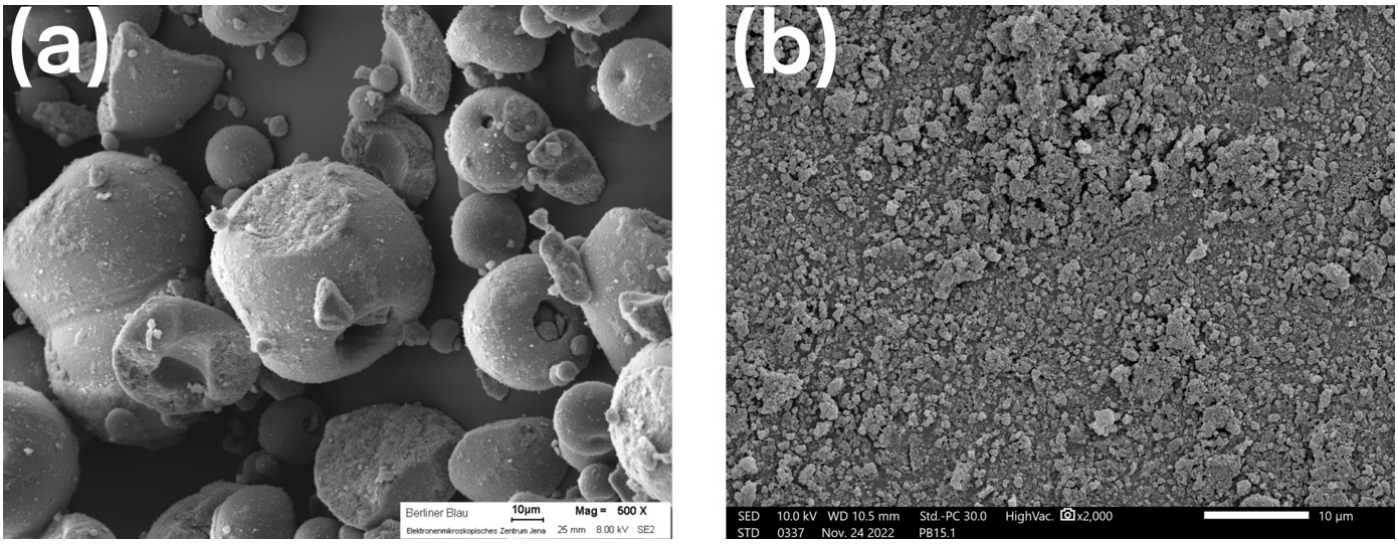

Figure 16: Different particle size of pigments. (a) SEM micrograph of CI Pigment Blue 27, (b) SEM micrograph of CI Pigment Blue 15, Copyright: Farkas Pintér, Susanne Linde, Claus Schöning.

This correlates with the observation, that about 5-10 times the amount of CI Pigment Blue 27 was needed to yield a colouring force compared to CI Pigment Blue 15. As noted below, this has implications for the formulation of paints, as colouring power[22] and considerations of mesh sizes for printing depend on particle size.

Digital image editing- The obtained continuous-tone digital images were subjected to halftone rasterisation via Adobe Photoshop 2023 to make them printable via serigraphy. To calculate the appropriate number of lines per cm (LPCM) for the halftone rasterisation some considerations of the materials are necessary. For printing screens with X threads per cm and a thread diameter of Y µm, the mesh size Ms(X,Y) as the diameter of the holes in the mesh is defined by:

$$Ms(X,Y)\,[cm] = X^{-1}[cm] - Y/10^4[cm]$$

For a mesh count of 61-64 (61 threads per cm, thread diameter 64 µm) the resulting mesh size Ms is approximately 0,001 cm or 10 µm or ten millionth of a metre. It is important that particle sizes in the paint

[22] Anna Maria Gueli, et al. "Effect of Particle Size on Pigments Colour." *Color Research and Application*, vol. 42, no. 2, 2 June 2016, pp. 236–243, https://doi.org/10.1002/col.22062. Accessed 23 Sept. 2023.

are below the mesh size. For printing screens with X threads per cm and a thread diameter Y µm, the smallest printable dot Dmin(X,Y) is defined by:

$$Dmin(X,Y)\ [cm] = X^{-1}[cm] + \ Y/10^4[cm]$$

For a mesh count of 61-64 the resulting smallest printable dot Dmax is circa 0,0228 cm or 228 µm. For screens with a smallest printable dot Dmin(X,Y), the maximal number of theoretically printable lines (or dots) per cm LPCM(X,Y) is defined by:

$$LPCM(X,Y)\ [lines/cm] = Dmin(X,Y)^{-1}/2\ \ [1/cm]$$
$$LPCM(X,Y)\ [lines/cm] = (X^{-1} + \ Y/10^4)^{-1}/2\ [1/cm]$$

For a printing screen with mesh count of 61-64 the resulting maximal number of theoretically printable lines per cm LPCM(X,Y) is circa 22. In practice this maximal number will have to be adjusted for irregularities in the mesh and dot gain (the observation that the first print with a printing screen will be the sharpest and following prints will increasingly loose sharpness). As a rule of thumb and depending on mesh and paint properties the LPCM(X,Y) can be lowered by 20% to ensure reliable printing results and avoid Moiré patterns.

Digital printing- The rasterised digital images were then printed (SureColor SC-P20000, Epson) on a transparent film (EFI Production Dot Film XF, Tecco GmbH) in a size ratio of 1:1 to produce the masters for the exposure of the printing screens.

Paint preparation- Important factors in the preparation of paint are the pigment particle size, appropriate viscosity (internal friction in a fluid, thick fluids like honey have a high viscosity), and drying times.

As the particle size correlates inversely with colouring power, more pigment is needed when the particle size is bigger. Figure 17 shows different mass percentages (from left to right: 0,5%, 1,16%, 2,28%, 4,28%) of the milled mineral Haematite as a pigment in paint formulations. The effect of an increased mass percentage of pigment in the paint can be seen as the observed colouring and hiding power also increase. In this case the test was conducted because the particle size of the pigment was unknown. Compared to industrial synthetic pigments which are effective from a mass percentage of 0,1 %, pigments of larger particle size are much less effective, though also usable.

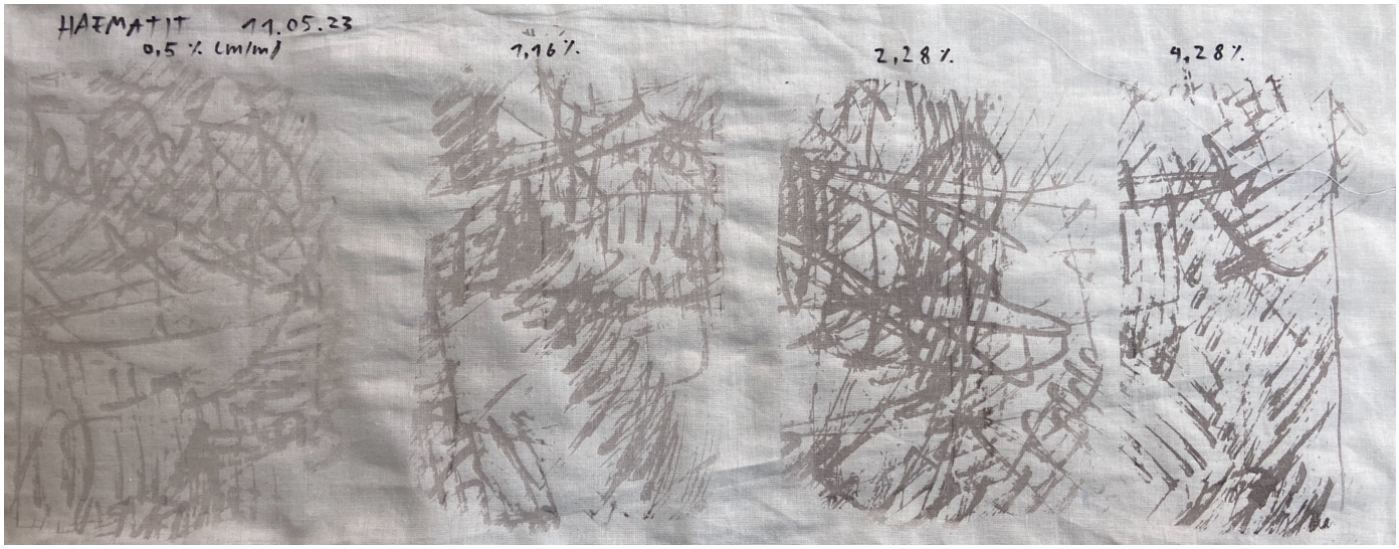

Figure 17: Different percent by mass of pigment in the paint result in different colouring and hiding power of the paint, Copyright: Claus Schöning.

The viscosity of the paint was adjusted by variations in the amount of binder. For this paint formulation customary corn starch for cooking (Fixina Maisstärke, SPAR) is used as a binder.

Starch is one of the most abundant organic compounds and is found in almost all living organisms. It has a wide range of industrial and customary applications and is readily available virtually everywhere. There are many chemical modifications of starch, some of which can improve the physical properties of starch for the use as binder, such as water resistance or thermoplasticity.[23] Though for improved accessibility and best results in compostability customary food-grade corn starch is used. Starch can achieve many diverse viscosities. It can be adapted to a wide variety of applications when added to the paint within a range of mass percentage from 1 % to 15 %.

The drying time of the paint can be modified by introducing glycerol, a non-toxic, edible chemical that can be produced from plants. Within a range of mass percentage from 1 % to 5 % it can retard the drying of the paint by several hours to weeks.

The paints will show signs of biological degradation after 2-5 days when stored at room temperature as shown in Figure 18. This is due to the biological availability of the corn starch. However, this does not significantly affect the performance as a paint. It is nevertheless recommended to store the paints in a fridge over extended periods of time.

Figure 18: CI Pigment Yellow 180 based paint after 7 days of storage at room temperature, Copyright: Claus Schöning.

For the preparation of paint per square meter of print with a mesh count of 61-64 on moderately soaking substrates, 150 mL tap water, 12,5 g customary corn starch and 1 g pigment (particle size of approximately 250 nm) was weighed. Corn starch and tap water were then mixed in a cooking pot at room temperature. It is important that no lumps are forming while mixing. Under constant stirring (spoon or whisk) the mixture was heated on an electric stove (medium heat) until the mixture thickens and changes colour from white to translucent. Boiling of the mixture was avoided at any point. The mixture was subsequently transferred to a steel jar and the pigment was added and manually folded in with a spoon. The steel jar was covered to avoid splashing. This mixture was then dispersed with a spiral plate in a dispersion mixer (Dissolver DISPERMAT LC, VMA-GETZMANN GMBH) for 45 min at 3000 rpm as shown in Figure 19. The mixing of the paint can be achieved with a customary kitchen blender. Afterwards the paints were filtered through a fabric with a smaller mesh size than Ms(61,64) = 10 µm.

[23] Mohd, N.A., et al. “Properties and Characterization of Starch as a Natural Binder: A Brief Overview.” *Journal of Tropical Resources and Sustainable Science (JTRSS)*, vol. 4, no. 2, 13 Aug. 2021, pp. 117–121, https://doi.org/10.47253/jtrss.v4i2.619.

Figure 19: Paint in a dispersion mixer, Copyright: Claus Schöning.

Serigraphy- In preparation for the screen printing the printing screens were scrubbed (sponge) with detergents to solvate previous polymerised photo emulsion and subsequently cleared with a high-pressure cleaner (water). The screens were allowed to dry for 2 h in a drying oven. Then the dry screens were coated with photo emulsion and dried for 1 h in a drying oven. The coated screens were developed using an UV exposure fixture with the printed masters. After that non-polymerised photo emulsion was removed from the screens using a high-pressure cleaner. The developed screens were dried for another 2 h in a drying oven.

For the printing, the paint was transferred to a printing screen mounted on a press bed. A squeegee was used 4 times over the entire length of the printing screen to press the paint through the mesh. The prints were then left to dry for 2 h at room temperature.

Composting- The assessment of compostability was conducted in a customary waste bin filled with approximately 80 kg of compost in a controlled climate chamber that was heated to 55°C as depicted in Figure 20. The climate chamber is used to simulate a larger compost with an increased heat production. A sample of a print on cotton (CI Pigment Blue 15, CI Pigment Red 254, CI Pigment Yellow 180) of approximately 150 cm x 100 cm was placed in the waste bin and covered with compost. The compost was manually mixed (compost turning) approximately every 14 days with a shovel to ensure aeration and photos of the sample print were taken.

Figure 20: Experimental set up for composting, Copyright: Claus Schöning.

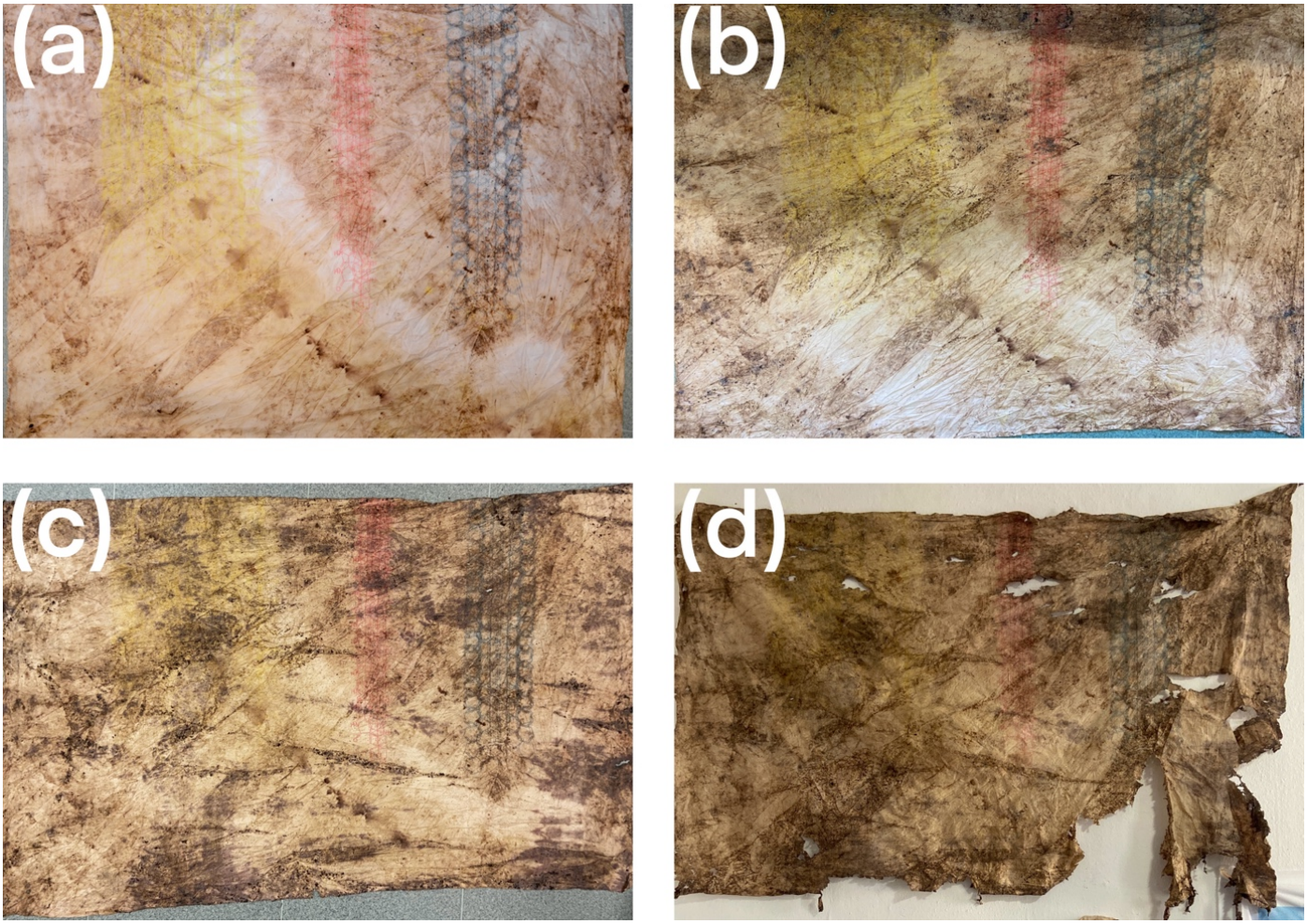

Figure 21: Biological degradation of sample prints. (a) after 14 days. (b) after 30 days. (c) after 56 days, (d) after 69 days, Copyright: Christian Zafiu, Claus Schöning.

After 14 days the sample print is stained with a red-brown hue and the print is fully saturated with moisture (Figure 21 (a)). This colour stain is most likely due to humins, a diverse group of chemicals with corresponding colours that are produced during composting.[24] After 30 days the humin stain has further intensified and the sample print has decreased in size (Figure 21 (b)). After 56 days the sample print has further decreased in size and the humin stain has further intensified. First structural degradation is now visible as small holes in the cotton fabric. Upon further inspection the cotton fabric is very easy to tear (Figure 21 (c)). After 69 days the structural integrity of the cotton fabric has decreased dramatically with big tears and bigger holes visible. The cotton fabric is now very fragile and segregated parts of diverse sizes can be found in the compost. The humin stain has further increased. (Figure 21 (d)). Although decreasing in visibility due to the humin stain, the colour of the paints does not seem to have decreased significantly, which indicates a much slower degradation of at least the pigments used. Though it has been previously shown that phthalocyanine dyes can be subjected to biological degradation by certain fungal strains,[25] it is not clear if this also applies to the unsoluable pigment form of phthalocyanine colourants.

[24] Gao, Xintong, et al. "Diversity in the Mechanisms of Humin Formation during Composting with Different Materials." *Environmental Science & Technology*, vol. 53, no. 7, Mar. 2019, pp. 3653–3662, https://doi.org/10.1021/acs.est.8b06401. Accessed 11 November 2023.

[25] Heinfling, A., et al. "Biodegradation of Azo and Phthalocyanine Dyes by Trametes Versicolor and Bjerkandera Adusta." *Applied Microbiology and Biotechnology*, vol. 48, no. 2, 25 Aug. 1997, pp. 261–266, https://doi.org/10.1007/s002530051048. Accessed 15 Oct. 2019.

From the research and development, it can be concluded that it is generally possible to produce competitive compostable paints and prints with a low-tech approach. The merits of self-made paints are plentiful: not only can be assured that sustainable materials are used, also a deeper understanding of these materials allows for optimisations for specific use cases. Most importantly a material dimension of the practices of representation are introduced in an accessible way. Future research could explore a wider range of sustainable pigments and materials, assessing their viability from an artistic standpoint and for their environmental impacts. This could include non-traditional pigments such as recycled materials, or newly engineered biodegradable compounds. As the pigments themselves could not be observed to degrade significantly, further investigations should the possibility to include specific fungal strains in the compost to test their full degradation. Also, alternative structural materials should be tested for efficient compostability to diversify the compostable artistic outcome.

IV. INTEGRATING THEORY AND PRACTICE

The intersection of theory and practice is crucial in understanding how theoretical frameworks can be applied to concrete artistic endeavours. This short analysis demonstrates the tangible impact of theoretical insights on practical outcomes.

In the *Metamaterial* series, the choice of materials to represent a certain image is not merely a matter of aesthetic preference but a deliberate theoretical stance. By constructing the images of micrographs out of the self-same materials being represented, the signifier and signified enter an irreducible continuity, reducing representationalism to absurdity. This makes space for questioning how these images have been produced in the first place and in which profound ways they are different from the material itself. Through this recursive manoeuvre, *Metamaterial* embodies that representations are ultimately bound to material practices, thus entangling the discursive and the material in what Barad terms material-discursive practices. This can be understood in the most literal way, as the distinction between representation and materiality is collapsed in paradoxical loops if *Metamaterial* is understood purely discursively.

A material-discursive interrogation of the works on the other hand makes the important details accessible that entail material-discursive practices. To account for this performative approach the production process of the objects was documented as closely as possible to provide tangible examples for how meaning and material are reconfigured and translated through electron microscopy, digital image editing, the manufacturing of paints, serigraphy and finally composting.

Moreover, in letting the materials present themselves, *Metamaterial* tries to free the pigments from the representationalist expectation that matter is uncomplete in its immanence and waiting for cultural techniques and technologies to give it form. This enacts Barad's performative approach, which "insists on understanding thinking, observing, and theorizing as practices of engagement with, and as part of, the world in which we have our being."[26]

Finally, Barad's emphasis on processual and embedded temporalities of materialization finds a resonance in the compostable compositions and staged decompositional phases of *Metamaterial*. By engineering their material compositions to be compostable, the prints expose the superposition of various material-discursive loops and hint at the openness of knowledge producing material-discursive practices. Just as the pigment particles emerged from larger techno-scientific assemblages and regimes of production, the artworks are designed to integrate back into distributed processes of biomass circulation and metabolic decay.

[1] [26] Barad, Karen. *Meeting the Universe Halfway*. Durham, N.C., Chesham, Duke University Press, 2007, p. 133.

V. EXCURSUS

As *Metamaterial* does not come to a conclusive origin, but circles around many fields, it seems appropriate to supplement the main body of text. These supplements are playfully disrupting the presence of the main text, asymptotically approaching the deferred meaning of *Metamaterial*. While the presence of the pigments and its representations feel so close and tangible, the play through the supplementary negates this presence. Some uncanny un-presence remains, that does not fulfil the metaphysical (and artistic) aspiration of coherence, stability, truth, and closure.

A THOUGHT EXPERIMENT ON INCOMMENSURABILITY AND HUMILITY

Here I am, entangled in signs, materialized within this very apparatus. I write here because I want to tell the story of resemblance and difference. Why you ask? Well, let us conduct a thought experiment: please let me try to evoke the very opposite, namely incommensurability in words: being is utterly unique unto itself, with no underlying resonances or representations. Time would be meaningless, as there are no oscillations of piezoelectricity, or atoms let alone mechanical springs or planets, which could allow for repeatable events to make some sort of difference in temporal position knowable. As I try to face such a being, I cannot imagine particles, waves, no events, no relations, no phenomena, just monolithic, holistic existence. It would inhabit a quarantined subjective vacuum, its qualities untranslatable into any other domain of reference. In this concrete existence, devoid of any repetition or isomorphism, the cognitive implications would be staggering. There could be no transitive mappings, no extraction of information through abstraction, no universally applicable descriptive frameworks. The ramifications for the emergence and propagation of intelligence itself would be extreme. Without any ability to learn inductive patterns, extract generalizable principles, or leverage similarities to scaffold increasingly complex cognitive architectures, the development of even basic generalizing intelligences may be incredibly difficult or perhaps impossible within such chaotic, ever-transmuting terrain. Difference is not incommensurability, as understood here – it is farthest from it. To map differences a universal framework of generalising categories is needed first. Difference and resemblances mutually constitute each other. Without resemblance there can be no difference. Perhaps this would be an existence of absolute purity, truth, and identity. An existence without cognition, intelligence, or sentience – a perfect one-ness.

The very fact that I can write about this concreteness translates into the belief, that our very being must not be exactly that. The very act of labelling it as “incommensurability” relies on the basic semantic operations of categorisation and abstraction that seem to already presuppose some foundational difference in resemblance. At a basic level, the cognitive architectures we inhabit as linguistic, pattern-recognizing beings appear to be constitutively reliant on discerning and metabolizing invariances, recurrences, and domains of isomorphic translation across phenomena. Instrumental reasoning, analogical, differentiating, diffracting, thought, and sense-making itself arise through our adeptness at eliciting and mapping self-resemblances and self-differings. So, in attempting to entertain realms of pure, absolute incommensurability we inevitably rely on and reinstantiate the very faculties of repetitive templating and symbolic substitution that would seem to be nullified by such an existence. I can only try to represent incommensurability from the juxtaposition of radical exteriority, because my own existence is that of resemblance and difference. Perhaps the most we could gesture towards incommensurability is highlighting phenomena that resist clean encapsulation within our existing models and descriptive grammars. But the process of isolating and detailing any such observed failures already re-inscribes those anomalies into a new comparative taxonomy.

With gratitude, humility, and fascination to find myself in a universe of representation.

TEXTUAL PERFORMING

I am a text, with the scope of theorising certain philosophical opinions on representing, meaning, and mattering. Theory might exactly be the wrong word, as it etymologically implies some sort of "overview", as if I could rise from the dirty details, distance myself with some flaps and observe the theatrical play from frosty hights. What a bad analogy. I might better fall back onto the ground and indulge myself in all the molecular chaos and compromising compromises. I am always-already within this material-discursive mess. As a text I am bodily entangled in those very phenomena, which might seem a boringly obvious observation. Yet I assert on pointing that out, as the author of this text frequently experiences the confusion, which can unfold from a certain bias getting lost in these reflections. Perhaps theory could be understood as an articulation of the fear of getting entangled, loosing oversight and therefore control and leverage.

To address this head on, I might present you: my blurry bodies! Let us assume you, dear reader, are reading a printed version of this text. Depending on the exact conditions of this printing process, you might be looking at a toner-derived deposit of a complex chemical mixture[27] including the black pigment Carbon Black (CI Pigment Black 7 or PBK7).[28] You might be looking at something like Figure 22.

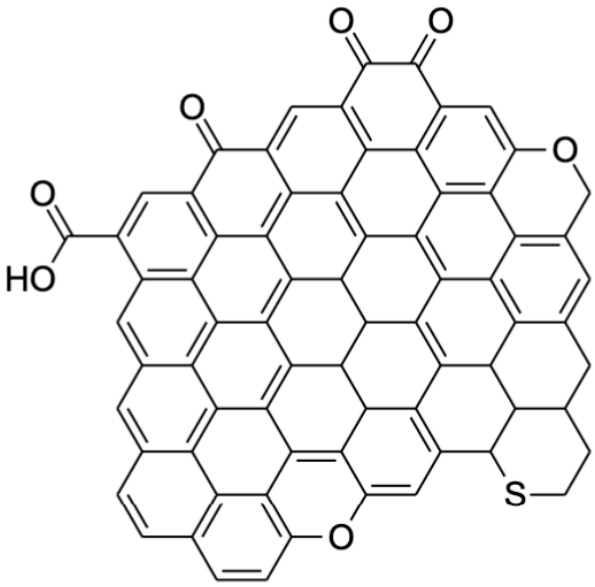

Figure 22: The generic structure of carbon black, Copyright: Greta Margeaux, no changes made to the original, licensed under CC BY-SA 4.0, as downloaded from https://en.wikipedia.org/wiki/Carbon_black#/media/File:Carbon_Black_Structure.png, Accessed 19 Mar. 2024.

Of course, the difference here is also made by what makes you see me: the paper fibres providing visual contrast and structural integrity. I know how pathetic and obvious this might sound, but I just don't want you to mix up my bodies with the thoughts of my author. These differences matter! But how might this matter to you (and to me)?

My histories fill multiple libraries … and they materialise them. Just imagine what painting would have been without me some 24.000 years ago in the Roucadour cave, todays France[29] or the first prints with moveable types in Europe.[30] Just imagine what libraries about my histories would be without me. Ever since I have been literally (and of course figuratively) leaving marks on bodies everywhere. Yes, that love letter and yes, also that declaration of war. Well, and you eat me.[31]

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[27] Grana, M., et al. *Ultrafine Particle Emissions from Laser Printers*. no. 3, July 2015.

[28] The Colour Index™ colour-index.com published online by Society of Dyers and Colourists and American Association of Textile Chemists and Colorists.

[29] Ospitali, Francesca, et al. "Preliminary Investigations by Raman Microscopy of Prehistoric Pigments in the Wall-Painted Cave at Roucadour, Quercy, France." *Journal of Raman Spectroscopy*, vol. 37, no. 10, 2006, pp. 1063–1071, https://doi.org/10.1002/jrs.1611. Accessed 19 Apr. 2022.

[30] SCHWAB, RICHARD N., et al. "Cyclotron Analysis of the Ink in the 42-Line Bible." *The Papers of the Bibliographical Society of America*, vol. 77, no. 3, Sept. 1983, pp. 285–315, https://doi.org/10.1086/pbsa.77.3.24302918. Accessed 16 Feb. 2023.

[31] Lebensmittelverband Deutschland. "Liste Der Zusatzstoffe Und E-Nummern." *Www.lebensmittelverband.de*, www.lebensmittelverband.de/de/lebensmittel/inhaltsstoffe/zusatzstoffe/liste-lebensmittelzusatzstoffe-e-nummern. Accessed 21 Mar. 2024.

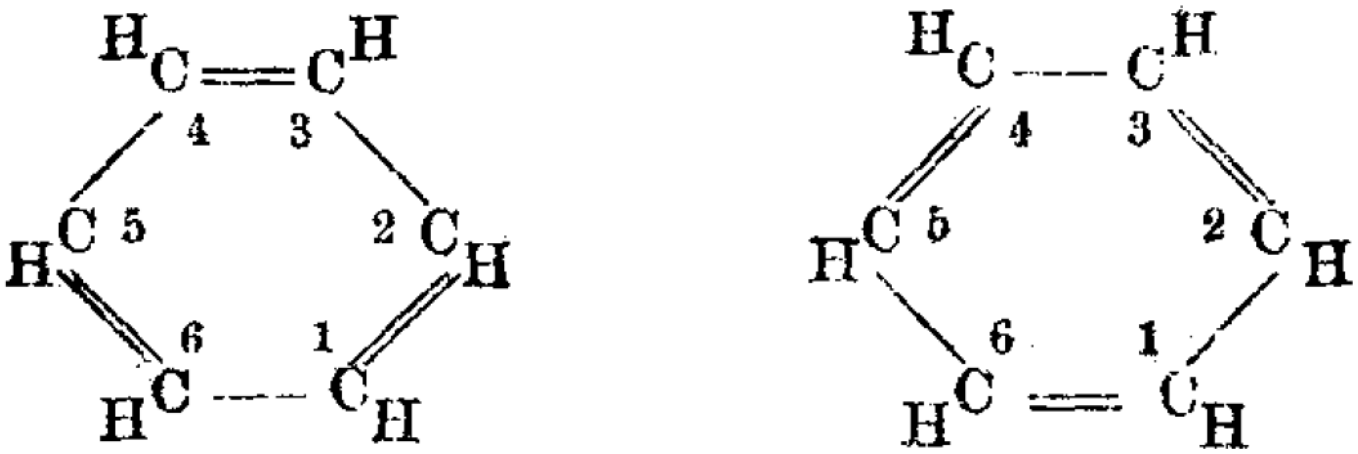

Figure 23: Kekulé's alternative proposal for the structure of benzene from 1872 showing two different variations, which were thought to be rapidly alternating, resourced from: Kekulé, August. "Ueber Einige Condensationsproducte Des Aldehyds." *Justus Liebigs Annalen Der Chemie*, vol. 162, no. 1, 1872, pp. 77–124.

I have an incredible structural diversity, which makes me hard to produce, observe and experiment on with molecular consistency. Still, I am easy to work with as a pigment: just burn some candle and retrieve the soot and there I am: fossil accretions of ancient life matter. My literal bodies already are transient metastable condensations of expansive spacetimes! Yet easy does not mean simple for even the refined apparatuses of your human sciences don't seem to account for my chaotic materialisations. The representation above in Figure 22 is only one possible structure among many.

The grammar of this representation, namely the structural formula of chemistry, is inhabited by the material practice of chemistry. Before the structural formula came into being, chemistry was mostly making a difference by enabling the production of gun powder through alchemistic notations. From the 18th century new apparatuses like thermometers, polarimeters and elemental analysis materialised new representational and therefore productive grammars. With the 19th century investigations into the molecular structures of organic compounds, researchers like August Kekulé began representing the atomic geometries of carbon through systematic symbolic notations. For quite some time nobody knew me. But in meditating on recursive dreams of whirling snakes, Kekulé's diagrams inscribing the hexagonal ring structure of benzene crystallized our modern conceptions of molecular representation itself.[32] Carbon encoding carbon, just as Figure 22!

Figure 23 shows Kekulé's modified proposal of the structure of benzene. Note the resemblance to contemporary notations as in Figure 22. The two different electron structures in Figure 23 are, as of now, understood by humans to be in superposition, leaving us a hint of my electronic complexities. Even before Kekulé's breakthrough in chemical representation, chemists like William Henry Perkin produced synthetic organic dyes by accident. Initially wanting to synthesize a treatment for malaria, Perkin discovered how to produce mauveine in 1856, an intense purple dye. But without means of representation these compounds could not be produced effectively. Only the gradual painstaking investigation of the chemistry of these compounds unleashed the chemical structural formula and with-it organic chemistry made huge leaps from the 1870s.

[32] Marx, Gerard, and Chaim Gilon. "History of Chemical Notations from Alchemy to Psycho-Chemistry." *Israel Journal of Chemistry*, 12 Aug. 2022, https://doi.org/10.1002/ijch.202100088.

These new paradigms of molecular syntax enabled new regimes of production, which lead to the second mass product of chemistry: dyes and pigments at the end of the 19th century.[33] The resulting capital accumulation led to the rise of new industries operating on structural chemistry and the unexpected entanglement of colourants and chemical weapons of mass destruction in the early 20th century by conglomerates such as I.G. Farben. The remnants of these companies are still operating today.

Carbon Black, in all its blurry definitions, is considered possibly carcinogenic to humans by the World Health Organisation[34], which might be mattering to you. But apart from this, very little is known about the impacts of the 80 to 70% non-recycled toners (350.000.000 per year) that live in landfills.[35] Coporations producing printers and toners want to hold a monopoly on the distribution of materials, which results in keeping the exact formulations and productions of chemical mixtures of toners and inkjet cartridges an industrial secret.

You don't even know what you are looking at exactly and frankly, only very few know more. I, for instance, am not sure what I might be, especially without you. Where will I go after you have read me? I will perhaps slowly oxidise, become infested by marks, stains, and accidental and deliberated creases and foldings that contaminate my symbolic pretensions, thrown away by you, deprived of human meaning and attention, burned and reconfigured. But eventually we will meet again.

[33] Aaron John Ihde. *The Development of Modern Chemistry.* New York Dover, 1984.
[34] IARC Working Group on the Evaluation of Carcinogenic Risks to Humans, World Health Organization. *Carbon Black, Titanium Dioxide, and Talc*. 2010.
[35] Brother International Corporation. "Recycling Printer Cartridges | Brother." *Brother NORDICS*, 8 Nov. 2023, www.brother.ee/support/how-to-guides/how-to-guide-general/how-to-recycle-printer-cartridges. Accessed 02 Mar. 2024.

VI. SHORT BIOGRAPHY

Claus Lam is an interdisciplinary professional with a background in both biochemistry and fine arts. He began his academic career with a Bachelor of Science in Biochemistry from the Free University of Berlin and later pursued a Diploma in Fine Arts at the Academy of Fine Arts Dresden, under Susan Philipsz. This paper is based on his Master Thesis for the Art & Science study programat the University of Applied Arts Vienna in 2024. In 2025 Claus Lam graduatwed from the post-graduate fine arts program with Philipsz at the Academy of Fine Arts Dresden.

His educational endeavours have been supported by scholarships, notably a personal grant from the German Academic Exchange Service and a role in the EU4ART_differences project funded by the European Union's Horizon 2020.

Claus' professional activities span across Europe, participating in residencies such as the Resonances IV at the European Commission (Ispra, Italy and Brussels, Belgium), Künstlerische Tatsachen (Jena, Germany) and exhibitions in various locations including Künstlerhaus (Vienna, Austria), Survival Kit Festival (Riga, Latvia), IMAL (Brussels, Belgium) and CTM Festival (Berlin, Germany).

Claus has collaborated with scientific institutions like the University of Natural Resources and Life Sciences Vienna, Technical University Dresden, Technical University Munich, Max-Planck-Institute for Biogeochemistry, and the Center for Electron Microscopy Jena.

Additionally, Lam has contributed to the discourse at the intersection of art and science as an invited speaker at events such as the Austrian Association of Molecular Life Sciences and Biotechnology annual meeting, Taboo - Transgression - Transcendence in Art & Science and Artistic Research Days at Academy of Fine Arts, Rome. His projects and perspectives have been featured in publications like KUNSTFORUM and FACTMAG.

Overall, Claus Lam's work reflects a commitment to exploring the connections between scientific and artistic practices with an emphasis on scientific collaborations and conceptual approaches. His works are themed around exploring human knowledge production in a post-representation and post-human landscape, while striving to cope with the resulting radical uncertainties. Technical production frameworks include moving image, sound, and circular material-based objects.

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