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Points in Making

Introduction

> Humankind, in order to fully develop human capacities, had first to tear apart these capacities (i. e., engineering, art, philosophy), separate them, isolate them and thereby go for an insane sanity. Renaissance man set out to do so. C. P. Snow formulated the clash, or rather the split. . . . But he went on, in an addendum (1963), to again look at modernity and modernization, the beautiful world of design and the terrifying world of rationalization, and to foreshadow the coming of a Third Culture.[1]

Following these thoughts from an obituary for Romanian pioneer of HCI (Human–Computer Interaction), Mihai Nadin, one may render "points in making" as the making of a scientific method that is all-too-often presented as a given. Written by Frieder Nake, a mathematician on rather extraordinary pathways, his 1960s augmentation of computing from scientific to creative purposes in fact anticipated many questions on transdisciplinary takes on technology we are posing today. At the same time, they show how matters of methodology are inherently conditioned through epistemological turns—in other words, a "new culture of the material world"[2] the current Cluster of Excellence "Matters of Activity" (MoA) is investigating.

The present article highlights and discusses some of its current PhD cohort's "points in making," which is highly interdisciplinary from its conception.[3] Rather than an abstract theory, the intention of this piece is in an explicit account on the actual lived practice of interdisciplinarity. MoA's structured doctoral program hosts researchers from various disciplines including natural and engineering sciences, humanities, and design. Integrating both theoretical analysis and experimental approaches, the program supports intensive interdisciplinary exchange through embedding predoctoral researchers within research projects composed of diverse branches of knowledge. Employing more informal, open, and encouraging meetings within the PhD cohort, we —the two authors of this paper—attempted to give an account of how researchers adapt and adopt different kinds of collaborative practice.

Relating ourselves to such differing disciplinary constellations, we will introduce current methodological frameworks focusing on stabilization versus continuity, and

1 Frieder Nake, "Third Culture Man," in *A Mind at Work: We Are Our Questions,* ed. Mercedes Vilanova and Frederic Chordá (Heidelberg: Synchron, 2003), 27.

2 Wolfgang Schäffner, "Matter and Information," in *Materials Research: Inspired by Nature—Innovation Potential of Biologically Inspired Materials* (acatech DISCUSSION), ed. Peter Fratzl, Karin Jacobs, Martin Möller, Thomas Scheibel, and Katrin Sternberg (Munich: acatech, 2020), 79.

3 In this paper, we employ the term "interdisciplinary" in its broadest sense, involving multiple fields of knowledge. The term "transdisciplinary" is utilized in specific instances where collaborations across different disciplines result in moving beyond discipline-specific approaches.

 https://doi.org/10.1515/9783110714883-008

the discursive space that emerges along with their juxtaposition. On the one hand, we will draw on Andrew Pickering's argument of how the "success of science and engineering (and all sorts of other practices) shows us that there are . . . islands of stability in the flux of becoming."[4] On the other hand, our text will follow philosopher Yuk Hui's recent book *Art and Cosmotechnics* as it challenges epistemic understandings, deriving from Ancient Greek philosophy, of antagonisms as something to be overcome by renewing "contradiction as limit without searching for a reconciliation."[5] Against this discursive background, a qualitative survey among our fellow researchers presents some tentative analytical categories to investigate how collaborative research is situated in complex and organic environments, often torn between indeterminacy and variety—how reciprocal perspectives on our tools confuse and augment the whys and hows of our endeavors, and, through such processes of placing continuity over reconciling contradiction, challenge seemingly static disciplinary boundaries of our research culture (fig. 1).

Disciplinarity: Discarding Stabilization for Continuity?

Obviously, such an argument builds heavily upon existing work on notions of disciplinarity. Our working definition of disciplinary boundaries, and, notably, the manifold ways of gathering and crossing them, locates such actions as a "purpose-oriented" way of working: A) intra- or monodisciplinary, that is, working within a single discipline; B) cross-disciplinary, that is, viewing one discipline from the perspective of another; C) multidisciplinary, after what physicist Basarab Nicolescu refers to as "studying a research topic not in just one discipline but in several at the same time . . . yet limited to the framework of disciplinary research;"[6] D) interdisciplinary, that is, integrating knowledge and methods from different disciplines, using a real synthesis of approaches; and E) transdisciplinary, that is, creating a unity of intellectual frameworks beyond disciplinarity.[7]

The resulting diagram (fig. 2) may be read as a reflection on the productivity of boundaries, how researchers stabilize and destabilize their relation to each other as well as their body of research—an approach that may invoke sociologist Andrew Pickering, whose abstract to a 2014 paper titled "Islands of Stability" argued:

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4 Andrew Pickering, "The Ontological Turn: Taking Different Worlds Seriously," *Social Analysis* 61, no. 2 (2017): 140, https://doi.org/10.3167/sa.2017.610209.

5 Yuk Hui, *Art and Cosmotechnics* (Minneapolis: University of Minnesota Press, 2020), 45.

6 Basarab Nicolescu, "In Vitro and In Vivo Knowledge: Methodology of Transdisciplinarity," in *Transdisciplinarity: Theory and Practice – Advances in Systems Theory, Complexity, and the Human Sciences,* ed. idem (Cresskill, NJ: Hampton Press, 2008), 1–21.

7 Helga Nowotny, Peter Scott, and Michael Gibbons, *Re-Thinking Science: Knowledge and the Public in an Age of Uncertainty*, Repr (2001; repr., Cambridge: Polity Press, 2011).

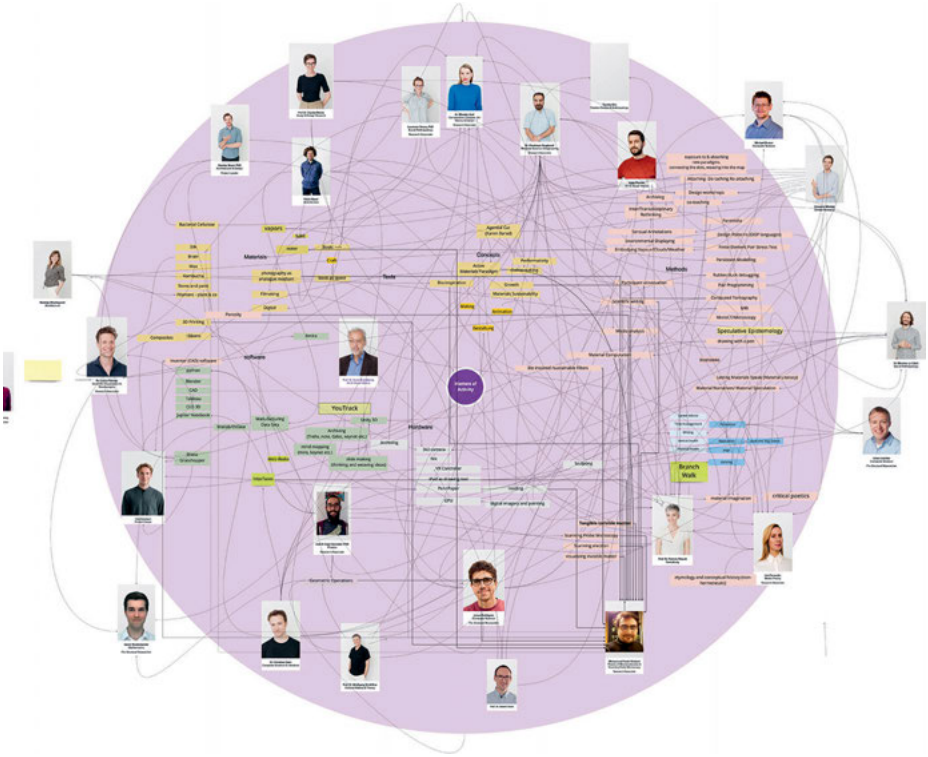

Fig. 1: Collaborative Miro board screenshot of the workshop "Share your Toolbox" during Brown Bag Brunch at the Cluster of Excellence "Matters of Activity," 2021.

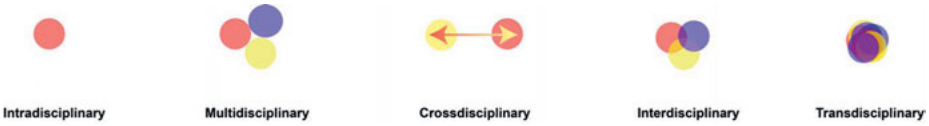

Fig. 2: Frank Bauer and Yoonha Kim, "Disciplinarities," 2022, after Alexander Refsum Jensenius, "Disciplinarities: Intra, Cross, Multi, Inter, Trans," blog post, 2012, https://www.arj.no/2012/03/12/disciplinarities-2/.

> Instead of considering "being with" in terms of non-problematic, machine-like places, where reliable entities assemble in stable relationships, STS conjures up a world where the achievement of chancy stabilisations and synchronisations is local. We have to analyse how and where a certain regularity and predictability in the intersection of scientists and their instruments, say, or of human individuals and groups, is produced.[8]

8 Andrew Pickering, "Islands of Stability: Engaging Emergence from Cellular Automata to the Occupy Movement," *ZMK* 5, no. 1 (2014): 121–34, here quoted from the abstract, 166, https://doi.org/10.28937/1000106410.

While Pickering declares stabilization of relationships as a way of engaging epistemic emergence, we would invite our readers to look at things the other way around. Adding on our introductory image of MoA as a dynamic network, we would pose the question: What if one considers "being with" as the way in which seemingly rigid disciplinary boundaries dissolve in "confluences of instability" (fig. 3)? While Pickering's "Islands of Stability" focuses on the "chancy" local moments where regularity is produced, this perspective would invite readers to look for the dynamic emergence of vortices A, B, C, to I depicted by Thomas Wiering, a northern German illustrator. His contribution to the enlightenment as another period of epistemic change renders the demand for more contingent dances of agencies that lead anywhere but to predictability. Rather, confluences of instability invoke the moment when established tools, notions, and materialities more or less suddenly change and reveal innovation. Soon, they swirl together and form irregular and unpredictable movements dealing with the specific constraints that tag along with individual agencies. These confluences of instability can be thought about in the line of what anthropologist Anna Tsing calls "productive 'seams' between varied intellectual trajectories, where 'seams' are the visible line in the swirl where two or more currents of water hit each other without fully merging."[9]

Pickering discusses stabilizations, such as British cybernetician W. Ross Ashby's homeostat, a mechanical apparatus that retrieves stability when disturbed. The machine composed of a set of four identical units uses the others as a source of their input and direction of their output in a dialectical logic. With every additional player added to his game, however, his search soon becomes a practical impossibility. Therefore, one may ask whether an alternative way of dealing with the "chancy stabilizations" of knowledge could begin once we embrace the necessary initial "mess" of any interdisciplinary work. This bridges to recent formulations of "slow science," which, as Belgian philosopher Isabelle Stengers puts it, "needs to enable researchers to accept what is messy, not as a defect, but as what we have to learn to live and think in and with."[10] Let us complement this argument with a line of thinking that sees polarity not so much as contradiction—that is, discontinuity—but as continuity. Yuk Hui in his book *Art and Cosmotechnics* remarks how Ancient Greek tragedy and Daoist thinking use oppositions as necessities for unfolding their respective logics (and cosmologies), although oppositions are resolved in different ways:[11] while the ancient Greek hero tries to overcome the clash between freedom and destiny through sheer will, in his Eastern, Daoist example, "[c]ontradiction doesn't mean there is need for reconciliation,"[12] as opposite forces bring together a dynamic system of trans-

9 Anna Tsing, "When the Things We Study Respond to Each Other: Tools for Unpacking 'the Material'," in *Anthropos and the Material*, ed. Penny Harvey, Christian Krohn-Hansen, and Knut G. Nustad (Durham, NC: Duke University Press, 2019), 221–43.

10 Isabelle Stengers, "'Another Science Is Possible!': A Plea for Slow Science," in *Demo(s)*, ed. Hugo Letiche, Geoffrey Lightfoot, and Jean-Luc Moriceau (Leiden: Brill, 2016), 66.

11 "Opposition" here meaning a contrast or antithesis.

12 Hui, *Art and Cosmotechnics*, 45.

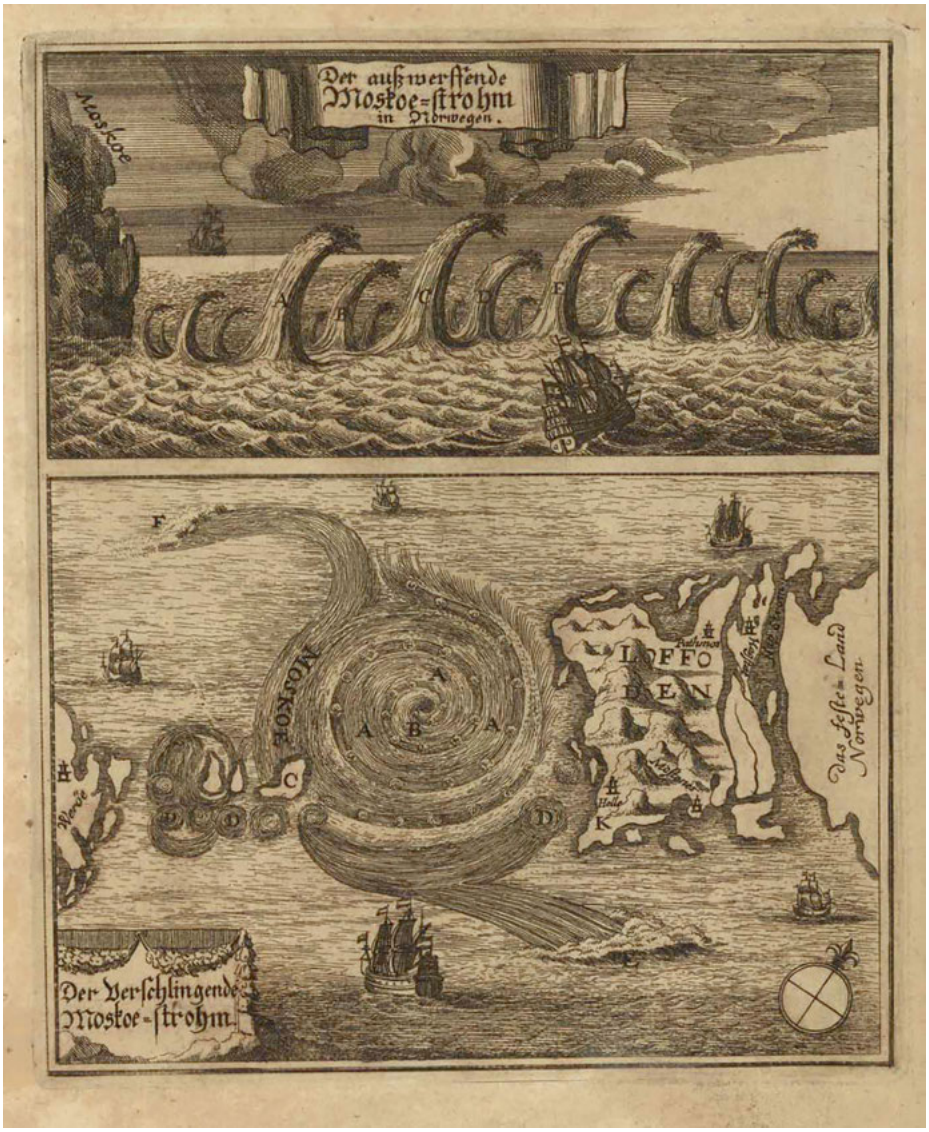

Fig. 3: Thomas Wiering, *Der außwerffende Moskow=Strohm in Norwegen, Der verschlingende Moskow=Strohm*, 1683, copperplate print, 15.5 × 13 cm.

formation.[13] In part, this also brings a shift of perspective, turning Pickering's "islands," the moment when and where predictability or regularity is produced, into

13 Which is often rendered as "The successive movement of yin and yang constitutes the Way (Dao)"

more contingent confluences of instability. To operationalize such conceptions through methodology, we invited our fellow PhD researchers into the process of developing this paper and asked them to share and discuss inquiries, insights, and incidents that may be useful to qualitatively test its hypothesis. As a result, the following paper will discuss four approaches to interdisciplinary work in the program that we would refer to as "points in making."

Dance of Agency

Doing science in and for a messy world can be described as "dance of agency,"[14] another term borrowed from Pickering. As such, he directs his interest toward knowledge production, rather than scientific cognition and reasoning, toward interactions between people and things, processes that oscillate between phases of activity and passivity—a form of performative experimentation as these varieties meet and turn into an organic movement. Arguably, such performative notions of structure may only materialize in performative methods of research.

> What we need is a space that will allow us to merge these heterogeneous structural fields in order to make room for something new, something yet unknown. . . . This is the challenge facing us today: instead of a theory of a new structuralism, we rather need multiple practices of an interdisciplinary laboratory focused on structure.[15]

Resonating with Wolfgang Schäffner's 2016 ambition to reveal a "New Structuralism" as an epistemic vehicle for research, MoA's "Experimental Zone" may be seen as a form of performative experimentation (fig. 4). If a science lab controls the environment, this space allows living organisms and modern devices across diverse fields to flow. The mildew smell of a self-assembling "fabric" from cellulose merges with a hint of chili following an explosion of a jar from a fermentation experiment in another corner. The scented air drifts to the corner of busy hands forming willow structures that are later put on bodies, sparking discussions on wearables as homeostatic membranes. As the scent floats without knowing the borders of disciplines, contingent physical actions and conversations emerge across modes of thinking. Physically locating oneself in such an interdisciplinary setting increases the chance of contingently encountering new ideas and methods. As our fellow Michael Tebbe explains, "[w]hen I'm stuck in

(一陰一陽之謂道). See I Ching, "Appended Remarks," pt. 1, ch. 5. Cf. James Legge, "The Yî King," in *Sacred Books of the East* (Oxford: Clarendon Press, 1899), XVI: 355–56.

14 See Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (Chicago: University of Chicago Press, 1995), 21–24.

15 Wolfgang Schäffner, "New Structuralism: A Field of Human and Materials Science," in *GAM 12: Structural Affairs: Potenziale und Perspektiven der Zusammenarbeit in Planung, Entwurf und Konstruktion / Opportunities and Perspectives for Cooperation in Planning, Design and Construction,* ed. Technische Universität Graz (Berlin: Birkhäuser, 2016), 31.

my work, I don't need to plan and go see an expert. I just ask someone nearby to see how it is in their field. And something new emerges."[16]

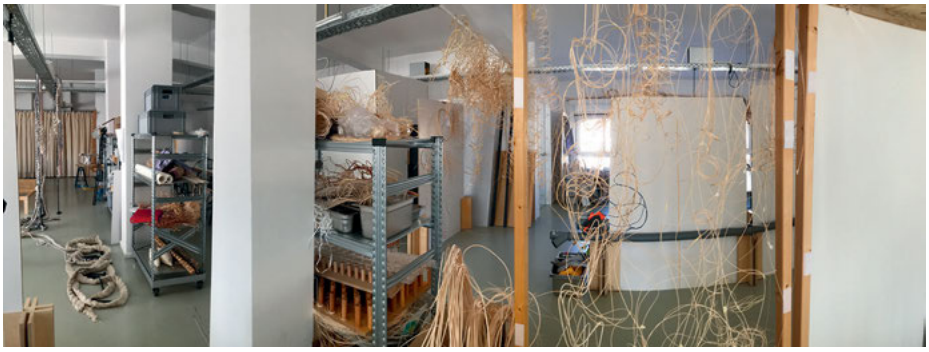

Fig. 4: Experimental laboratory at the Cluster of Excellence "Matters of Activity."

Oppositional Continuity

Bridging rather complex fields of knowledge often begins by asking for simple analogies and differences, whether formal or functional—even though they, too, may eventually turn out to be fiction or failures. Adding to Hui's thoughts on reconciliation, one may frame this as "oppositional continuity," referring to antagonism rather complementing than contradicting each other to invoke a larger unifying moment. As another dimension of our survey, we would see traces of such "oppositional continuity" in Binru Yang's example. Dealing with clean and optimized data sets from forward design[17] and engineering throughout her previous studies, her current work in collaboration with biologists and material scientists finds inspiration in inverse design logic, forcing her to deal with the opposite: a superimposed, unpredictably huge amount of biological data from examples such as a stingray bone, with complex material properties reflecting gradual evolution over hundreds of millions of years. Being trained to look for stabilized settings, she was perplexed to encounter dynamic data in biology where things evolve overtime, turning "messy," to speak with Stengers again:

> A civilized mode of appreciation would imply never identifying what is experimentally well-controlled and precise, with a truth that is valid in emergent circumstances and in a messy world. Laboratory science rarely transcends the boundaries of its assumptions. Under such and such restricted conditions, something may be true; but in the complex reality of life, subjected to unpredictable change and characterized by indeterminate multiple relations, it may be nearly impossi-

16 Michael Tebbe, notes on "Points in Making," 2021.

17 Referring to the antagonism of forward and inverse design logic, where the former would go from cause to effect, and inverse ones from effect to cause.

> ble to identify any such 'truths'. What is messy from the point of view of fast science is nothing else than the irreducible and always embedded interplay of processes, practices, experiences, ways of knowing and values, which make up our common world.[18]

It is this paradigm of accuracy in engineering, which architectural theoretician Francesca Hughes recently challenged as a rather misfortunate outcome of modern standardization and industrialization. Taking her ideas on alternative and possibly augmented relations of matter and authorship seriously, this would mean to embrace disorderly information as natural complexity, while safely navigating the "redundant precision iceberg"[19] Binru was spotting as well. In response, and in order to collaborate on growing data sets, engineers and biologists continuously develop a filtering system to process outliers in the data reflecting each characteristic of organic matter. Through this ongoing correspondence, the biological data becomes clean enough for engineers to work with it while it still contains valuable meaning for biologists. The threshold would be considered for each case individually, with respect for the characteristics and requirements of both fields. Conventionally, opposing methodologies enter into a productive dialogue, whose recursive logic brings an epistemological surplus for all involved parties' epistemologies—in Hui's words, "to recognize the differences in order to reflect upon the question of diversity as a possibility for moving forward,"[20] in what he then frames as an "overtaking of recursive machines."[21] In Binru's case, it appears that precisely these dichotomies complement each other, constituting continuous reciprocal relations as her team aims to find explanations for the emergence and adaptation of certain patterns to functional or environmental stimuli.

Externality as Catalyst

The introduction of foreign knowledge and/or skills into production processes is a well-known creativity technique. While Horst Bredekamp traces it back to Leibniz's exploration of a notion of active spaces resonating between external impulse and internal activity,[22] Claudia Mareis maintains its significance for the emergence of knowledge

18 Isabelle Stengers, "'Another Science Is Possible!': A Plea for Slow Science", in *Demo(s),* ed. Hugo Letiche, Geoffrey Lightfoot, and Jean-Luc Moriceau (Leiden: Brill, 2016), 66.

19 Francesca Hughes, *The Architecture of Error: Matter, Measure, and the Misadventures of Precision* (Cambridge, MA: MIT Press, 2014), 5.

20 Hui, *Art and Cosmotechnics*, 48.

21 Ibid.

22 Horst Bredekamp, "Leibniz's Concept of Agens in Matter, Space, and Image," in *Active Materials,* ed. Peter Fratzl et al. (Berlin: De Gruyter, 2021).

in all sorts of creative processes.[23] We propose to unravel this concept usually reserved for the realm of art and design in the general scope of the interdisciplinary setting.

Felix Rasehorn, a practice-based researcher in product design, encountered a moment of externality functioning as a catalyst in bringing forth his research project. While attending one of the regular Zoom meetings of the Tessellated Material System group, Lennart Eigen from Nyakatura Lab[24] shared a micro-CT scan of the outer skin layers of a boxfish (*Lactoria cornuta*). An image from Eigen's research displayed the differences in stiffness and material density of the boxfish's scutes (tiles). It induced Rasehorn to translate the same image in terms of its structure. To him, this image demonstrated the constructive forces of nature expressing a geometrical principle that is the duality of patterns. He went on to summarize:

> These specific moments feed the development of my own thesis project. Sometimes I feel the thesis is a place where all those "moments" are being accumulated into one continuous stream of thought . . . . It is less your own work or findings that are essential but rather the accumulation of things that others see in your project.[25]

In an interdisciplinary milieu, Rasehorn's research, underlined by such externalities, potentially becomes a kindling, igniting whole of thoughts and practices for others who cross paths with it. Projects in such settings, arguably, accumulate greater significance when they catalyse thought generation and establish new practices with peers. Consequently, the completion of a confined research project within a single discipline may not be the paramount goal. Rather, the ensuing dialogue—particularly what "others see in your project"—might hold precedence. This dialogue mandates surmounting challenges related to diverse vocabularies and conceptual understandings, employing visualization techniques and analogies as bridging mechanisms.

Reasoning on these moments and their relevance for his working process with Rasehorn, one may partially connect them with anthropologist Annemarie Mol, using a baked French dessert (clafoutis) to discuss *what it is to hang together.* Mol outlines how in the making of clafoutis, diverse elements from the worlds of agriculture, cuisine, nutrition, and sensuousness are not only juxtaposed but rather assembled and recomposed into a new entity.[26] Speaking with her, this would mean to understand one's project as a cumulative embodiment of perspectives from externalities. Moreover, this emerging dialogue could be seen as "making the difference between a random jux-

23 Claudia Mareis, "Methodische Imagination—Kreativitätstechniken, Geschichte und künstlerische Forschung," in *Kultur- und Medientheorie*, ed. Martin Tröndle and Julia Warmers (Bielefeld: transcript Verlag, 2011), 203–05.

24 Humboldt-University of Berlin's Research Laboratory for Comparative Zoology.

25 Felix Rasehorn, notes on "Points in Making," 2021.

26 Annemarie Mol, "Clafoutis as a Composite: On Hanging Together Felecitously," in *Modes of Knowing from the Baroque,* ed. John Law and Evelyn Ruppert (Manchester: Mattering Press, 2016), 247–48.

taposition and a felicitous composite"[27] that catalyzes the *hanging together* of heterogeneous parts.

Werkzeug as Denkzeug

> A werkzeug (device for making) is finite and programmed, that is: perfectly suited to serve its purpose. . . . The denkzeug (device for thinking) is very different from this: it requires the permanent and open-ended interaction with its user. . . . A werkzeug, which is used as opposed to its conception, for other purposes and thus gets deconstructed, may at any time become a denkzeug.[28]

The embracing of such external perspectives may at times be complicating our workflows but can work as an inspiring device to use our tools differently. Michael Tebbe shared an example of a transdisciplinary knowledge-making process between disciplinary (here: the developer) and external knowledge (here: the domain expert, i. e., a person with particular knowledge and/or skills in the field), which required a change in perspective from standard procedure. As part of a workshop, developers were showcasing the "Similarity Checker" to domain experts; a module on the software platform Jupyter Notebook to compare sentences for their semantic similarity. Inserting two sets of sentences, one can compare and calculate a score between 0 and 1 on how much the lists mirror each other. In the early stages of the development of the pipeline, this module has been used as a first test of the model, and inputs were given without much concern for the actual content. Such probing practices are common in software development and serve to test the functionality of the written code. This is, however, usually not available as a function in a finished software product, because it does not serve any further purpose. However, as the external user started questioning the content of the probing, the "device for making" turned into a "device for thinking." Domain experts came up with sentences such as, "Where are my glasses?" or, "Can I have a glass of water?" to compare it with the word "empty." Which sentence out of the two is more similar to "empty"? Or what if we compare "empty" with a meaningless sentence such as "thing thing thing thing"? In this case, the content of the probing practices turned out to be very valuable as a way to understand the dynamics of the model and has potentially been made available outside of software development. At the same time, the developer had to change perspective by making the practices during the development process transparent, which Tebbe would consider a crucial result of *Critical Technical Practice.*[29]

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27 Mol, "Clafoutis as a Composite," 258.

28 Thomas H. Schmitz and Hannah Groninger, "Über projektives Denken und Machen," in *Werkzeug – Denkzeug Manuelle Intelligenz und Transmedialität kreativer Prozesse,* ed. idem (Bielefeld: transcript Verlag, 2012), 19–20. Translation by the authors.

29 Geoffrey C. Bowker, ed., *Social Science, Technical Systems, and Cooperative Work: Beyond the Great Divide* (Mahwah, NJ: Lawrence Erlbaum Associates, 1997).

Conclusion

This paper attempted to embrace *Points in Making* in their challenging of those disciplinary constellations and configurations that are taken as a given. While this given—Nake's distinct scientific methods and conventions—tend to solidify disciplinary boundaries and may therefore become an obstacle in conducting truly transdisciplinary research, there appear to be good reasons to take a more critical and challenging stance—encouraging ourselves to "share our toolbox," or to pose the question, "Where does our knowledge come from?" Through these and similar inquiries addressed in workshops by the authors and their fellows over the course of the past year at MoA, we can start to reveal oppositions and boundaries not only horizontally, but also vertically. This would mean entering into a discourse with positions like Marwa Elshakry's argument for more contingent and diverse knowledge-making practices from nineteenth-century Egypt and China:

> Perhaps the greatest lesson we can learn from revisiting the construction of global histories of science in this way, then, is why some forms and communities of knowledge have come to matter more than others. . . . Showing how international vectors of knowledge production, how missionaries and technocrats created new global histories of science through the construction of novel genealogies and through a process of conceptual syncretism.[30]

Reality is entangled, situated, and ambivalent. Rather than dissolving or constraining such complexity, transdisciplinary methodologies encounter and embrace such multiplicity. And while a simplified ontological plane guided by one type of logic can only reveal a partial perspective, complex realities call for just as complex ways of research.[31] While such disciplinary work will merely focus on specific and therefore partial perspectives, "a new culture of the material" may only emerge through a truly transdisciplinary collaboration of humanities, sciences, and design within a more-than-human world. Rather than tearing apart our capacities into different bits and epistemologies, to speak with Nake, the MoA PhD cohort from diverse disciplines deals with this reality pars pro toto by learning from and actively tipping methods, notions, and subjects of research they are initially assigned to in their respective fields. One could certainly argue how writing this text and selecting and highlighting certain aspects of confluences may also be thought of as generating stabilization. However, as this paper is contested and brought into dialogue again during the process of editing and sharing, it rather continues to be an active and instable piece. As each successive

30 Marwa Elshakry, "When Science became Western: Historiographical Reflections," in *Isis* 101, no. 1 (2010): 109, https://doi.org/10.1086/652691.

31 Basarab Nicolescu, 'Gurdjieff's Philosophy of Nature', in *Gurdjieff: Essays and Reflections on the Man and His Teaching*, ed. Jacob Needleman, George Baker, and Mary Stein (New York, NY: Continuum, 2004). Quoted in Linda Neuhauser, 'Practical and Scientific Foundations of Transdisciplinary Research and Action', in *Transdisciplinary Theory, Practice and Education*, ed. Paul Gibbs (Cham: Springer International Publishing, 2018), 31.

PhD cohort proceeds with its very own reflection on the confluences of instabilities, we hope to encourage not only the recognition of an inherent dynamic in interdisciplinary collaboration, but also foster an ecosystem that is vibrant and ever open to transformation.

Acknowledgements:

We would like to thank the PhD cohort of “Matters of Activity” and Franziska Wegener for the invaluable conversations on working across disciplines. We are particularly grateful to Léa Perraudin and Clemens Winkler for their insightful feedback on this text.