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(Micro-)Performing Ancient Weaving in the PENELOPE project

GIOVANNI FANFANI, DAVID GRIFFITHS, ELLEN HARLIZIUS-KLÜCK, ANNAPURNA MAMIDIPUDI & ALEX McLEAN

We do not know much about how weaving was performed in ancient times; although references to weaving are abundant in ancient sources like frescoes, vase paintings, coloured sculptures, poems or prose texts, no literal descriptions of the craft itself is extant. Unfortunately, hardly any remains of textiles did survive from ancient Greece.

In poems and prose texts, scholars tend to address textile terms as metaphors, not as technical terms that might convey structural order or a specific complexity. In the PENELOPE project instead,[1] we investigate ancient weaving terms as technological concepts that precede 'the history of science and the formulation of theory' (Neumann and Nünning 2012: 14). What we perceive from the sources is that weaving serves as a concept for a complex order of simple elements travelling across the dichotomies of nature and culture, of human and non-human agency, of micro- and macrocosm. Our research grounds on the hypothesis that there was a significant but tacit contribution of textile technology involved in the advent of science in ancient Greece.

It is possible, by comparative textual analysis, to argue that certain number properties and algorithms transferred from weaving into early theories of arithmetic, are the basis for mathematical laws (Harlizius-Klück 2004). In addition, the connection between patterned textiles and cosmic order is strong in the textual sources (see below). However, when we re-perform the ancient techniques of weaving, we realize that the concept of order in ancient weaving is never explicit. First, because of the complexity of conditions, and, second, because many of the conditions are easy to deal with in practice once we work with the material. This dimension of knowledge is termed 'tacit' and addressed as a personal rather than common knowledge type (Polanyi 1958).

Our question for this paper is whether it is possible to address this tacit dimension as microperformative – a behaviour or process too small to be perceived with awareness, but still travelling together with the concept of the order of weaving as a whole. We thus propose in this contribution to use the concept of microperformativity as a term describing the knowable but inexpressible inference that is at work when weavers perform. The two challenges we face are: A) What do weavers know, when they know how to weave? B) How do we grasp and represent that complex knowledge for people who do not know how to weave?

RESEARCH TEAM AND METHOD

The research team consists of an artist/mathematician/weaver (Ellen Harlizius-Klück), an ancient philologist (Giovanni Fanfani), a live coder (Alex McLean, making music with code), a historian of science and technology (Annapurna Mamidipudi) and a creative technologist who builds digital tools for our explorations (David Griffiths). Accordingly, we were in need of a method to help us communicate across these disciplines and investigate order in ancient weaving. In this regard, we follow advice from Gilbert Simondon where he refers to the calculating machines of the French mathematician Blaise Pascal. In order to understand Pascal, Simondon proposes to make a machine like his with one's own hands, not by copying it but by transposing it into an electronic calculating device, in this way reinventing rather than reproducing, by updating Pascal's intellectual and operating schemes (Simondon 2017). In this line, we exchange Pascal's machine with the ancient warp-weighted loom, and develop digital tools that enable us to perform the operating schemes of pattern weaving and understand what is going on at the loom.

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THE PERFORMATIVE PARTS

The concept underlying our experiments, and travelling through the different modes and epistemic contexts of our performances, is the distinctive order and logic of ancient weaving. Here, we can only list the most distinctive features without going deeper into technical details.[2] The warp-weighted loom as used in ancient Greece is an upright frame that can be made simply with sticks. The weave begins with a pre-woven band, the starting border that carries the warp-threads. Usually, this band runs along all sides of the weave and integrates into the whole while weaving the fabric (cf. fig. 1 depicting a warp-weighted loom leaning against the wall on the right-hand side; a pattern indicates the border). This means that adding or taking away one thread during the weaving process is not possible; the pattern needs to fit the threads from the very beginning. They form the first step of the ordering, producing the boundary conditions within which the weaver makes her[3] creative choices. Weights attached to the lower end of the warp threads provide the necessary tension for opening the warp to insert the weft. Although the loom looks primitive, it supports a great variety of weaving techniques.

Beginning with the craft performed at the loom, the act of performing is involved at several levels in our research project: (1) as object of study, (2) as internal method of demonstration and (3) as live public dissemination. Instances of level (1) are the practice of performing on the warp-weighted loom in our laboratory, and the investigation of weaving knowledge and technology in the performance culture of archaic Greece. Examples for case (2) include the vision guiding our investigations (cf. fig. 1) and the simulations with the pattern matrix or with live coding. Such simulations also happened in public, belonging to case (3) and we termed them PENELOPEan performances. In the following, we refer in detail to selected performances or performance ideas and provide the research context and concepts.

[2] For an overview on ancient textile technology cf. Harlizius-Klück (2016).

[3] We use the female form because weaving in antiquity was women's work.

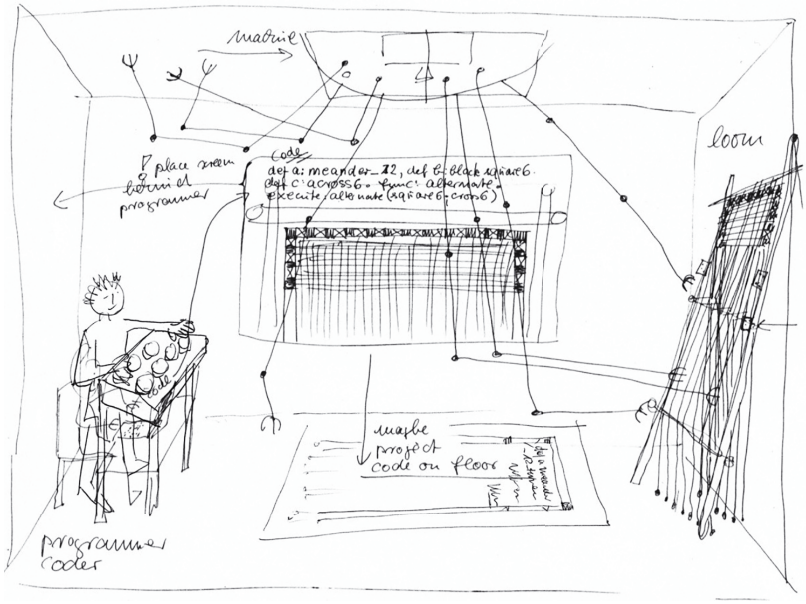


Figure 1. Sketch of vision for live-coded warp-weighted loom weaving in the PENELOPE project. *Ellen Harlizius-Klück*

WEAVING ON A WARP-WEIGHTED LOOM

When Ellen Harlizius-Klück performs in public on the warp-weighted loom, spectators do neither perceive the decisions nor the cascade of interactions at the loom. Although she performs a complex intellectual task of ordering through continual decision-making, she appears to act mechanically. The preparation and set up of the loom, the construction of the starting border and warp and the process of weaving can take weeks of work. Spectators, however, only consider the product, its function and how long it takes to make. Then they praise modern technology that works so much faster.

The public does not see abstractions at work in weaving until they are mechanized and automated on the Jacquard device on industrial looms. This device presents such abstractions simply as holes in punched cards. From then on, Jacquard receives full credit and praise for this idea, but not the artisan, whose abstractions do not take the shape of technical devices. However, in ancient Greece we see that weaving was highly valued when staged in public. The Panathenaic Festival, the major public event in ancient Athens, includes a procession where a huge fabric, a *peplos*, woven by girls and women selected from the noble families of the city, is carried to the Parthenon along a procession at the height of the festivities. The *peplos* is a gift for the goddess Athena. Such a public performance builds value for the craft of weaving not least as a means of social coherence. However, weaving on a warp-weighted loom in public spaces does not convey such value today, especially not as an instance of knowledge.

We began our project with an alternative vision of a performance that would bring forward the ordering knowledge of the weaver at work by including contemporary devices and concepts that now enjoy higher value (computers, robots) (fig. 1). It introduces distance between weaver and loom, via mechanical 'hands' to operate it, and code that makes the weaver's thoughts observable. This makes the weaver's rules and decisions visible as human-made algorithms. Then, the decision-making is not part of the loom-machine and weaving is not seen as simply a mundane, repetitive process.

The weaver's knowledge is embodied in the live coder improvising at a keyboard (the pattern matrix); the code is projected on a wall or onto the floor to display the changes they are making while the code is executed by an insect-like eight-armed arachnoid robot working at the warp-weighted loom. Splitting up the ancient weaving process into such diverse parts matched with disciplines in our team, allowing us to learn and explore weaving in terms of the domain of expertise – that is, choral lyric performance for the philologist of Ancient Greek, algorithm for the live coder, digital tools for the creative technologist. It enabled us to clarify what could be easily described and what still escaped our understanding, and it brought forward several possibilities for exchanging knowledge between us.

ARCHAIC GREEK THOUGHT: EPISTEMIC CONTEXT AND PERFORMANCE CULTURE

Early Greek philosophy and poetic imagery cast weaving as a technology capable of imposing order, creating complex structures and providing a reliable model for cosmic generation and the architecture of the physical world. This projection of weaving technology onto the macro- and micro-structure of the universe is found in the cultural milieu and epistemic horizon of the archaic Greek world at the rise of philosophy (sixth century BC).[4] The fundamental unity that nature and craft have in the early Greek mind is exemplified by the semantics and use of a couple of central notions, namely *kosmos* and *poikilia*. A brief discussion of the two terms in context will help position them as vehicles and bearers of that particular mode of generating and perceiving order through pattern and variegation.

Central to the early Greek usage of *kosmos* is the idea of a harmonious and well-balanced arrangement of parts, at both ethic and aesthetic levels: the idea of 'order' and of 'ornament, adornment' coexist in occurrences of the term in archaic poetry, often in association with products of craft. Ionian thinkers in sixth century BC introduced the technical meaning of *kosmos* as 'orderly structure of the physical world'. Cosmic order may invest as well the performance of a singing-and-dancing chorus: in a fragmentary choral song by Pindar (fragment 194 Maehler) the choral speakers self-referentially invite themselves to 'erect a *poikilos kosmos* of words that is endowed with speech'. *Poikilos*, the adjective qualifying *kosmos* as both song and choral performance, is another central concept in this epistemic system. It denotes the perception of an underlying pattern in both nature and craft-made items; the multi-sensory nature of *pokilia* may manifest as variegation in and through the combination of materials, colours, techniques, surfaces, and musical textures, and it conveys effects of radiance, movement and enchantment (Harlizius-Klück 2019).

The distinctive quality of *poikilia* has a vast range of applications: from the geometric patterns of snakeskin or the dappled plumage of particular birds, through the sound of a particular instrument or the manipulation of numbers, to highly crafted products of carpentry, metal-working and most eminently weaving (Fanfani 2018: 9–13; Harlizius-Klück 2019). Earth itself, its inner order and its variegated surface, are perceived as instantiating *poikilia*. In a divine act of cosmic generation, a pattern-woven garment may signify and become the *kosmos* (Pherecydes of Syros, fragment 68 Schibli) – a structure of discrete elements where diversity and variegation result from inner order and pattern, and where chromatic effects are not obtained from the blending of colours but, as in weaving, from the optical mixture of juxtaposed threads of simple colours. The way that patterns are constructed on the loom, and the perception of them as they emerge on the fabric, showcases *poikilia* in the performance of order that makes a textile, society and the cosmos. The notion of

[4] For a detailed discussion of weaving in presocratic cosmology, see Fanfani and Harlizius-Klück (forthcoming).

poikilia encompasses those tacit inferences that constitute the inexpressible mode of knowledge of the weaver. Microperformativity, here, is seen as a liminal notion between technology, knowledge and embodied practice – something that, for the Greeks, is also at work when nature displays pattern and order (*kosmos*).

The pre-scientific 'knowledge-through-order' that ancient weaving affords is embedded in what has been described as the 'performance culture' of archaic Greece (Herington 1985: 45).[5] In the numerous choral performances taking place on ritual occasions, festivals of the poleis and various dramatic contests, with active participation of citizens as performers, weaving travels as a prominent element of civic and social identity and cohesion (as in the Panathenaic procession), and, we argue, as a mode of ordering the world. A privileged vehicle of microperformativity in archaic Greek thought is the association of *poikilia* and weaving in the realm of choral performances. 'Weaving/plaiting a choral song-and-dance' is a recurrent image in archaic choral lyric (especially in Pindar), referring to the actual movements of the choristers and their interlaced feet as plaited/braided by the chorus-leader. Often the performed song, or the textile that stands for it, is qualified as *poikilos*. A passage like Pindar's *Olympian* 6.86–7 ('… while I am weaving for spearmen a *poikilos* hymn') invites further reflection. Is textile technology best suited for illustrating and conceptualizing the metrical patterns and thematic units of the ode as artefact? Or rather, for advertising the actual performance as a *poikilos*, multi-media *kosmos* where poetic verse, music and choreography exhibit their own structure in the making? Interestingly enough, ancient Greek metrical theory conceptualizes rhythmical modulation as 'interweaving'.

Furthermore, instances of *poikilia* in archaic Greek sources suggest that the synchronized performance of singers and dancers in a ritual context was perceived by the audience as an experience 'beyond-human', a *thauma*, 'a technologized thing of wonder' (Power 2011: 67). The choristers were imagined as divinely crafted dancing automata – daedalic moving statues, animals with marked cultic associations or even stars.[6] In turn, *thauma* is a concept grounded on the idea of otherness, a quality seen in artefacts, sometimes statues, sometimes patterned fabrics, in terms of their supernatural radiance, of their being at the same time inanimate and alive (Harlizius-Klück 2019: 415–17). As the description of the PENELOPEan performance will detail later in this article, the impulse for staging a chorus of dancing robots is grounded in just this assimilation of archaic Greek choral dancers to a 'cyberchorus' 'occupying the ontological interzone between animate and inanimate, human and machine' (Power 2011: 77).

RHYTHM OR ALGORITHM?

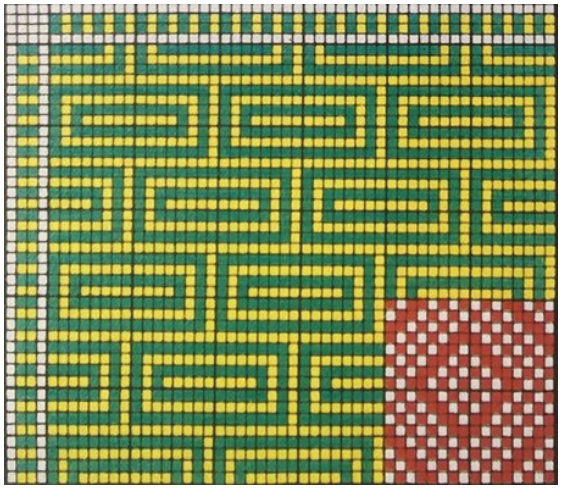
The PENELOPE Project investigates the knowledge of weaving on the archaic warp-weighted loom as a practice bringing threads as linear elements into a binary system of up-and-down. We not only explore weaving as a binary art, but also as a travelling concept that helps describe modes of order in areas that we today refer to as arithmetic, music, nature, dance and cosmology. We investigate the construction of a weave as an algorithmic movement included in the making of fabric, song, music, dance and colour. However, the algorithm performs with the material and not with notation or wording. This makes it invisible and imperceptible for audiences not accustomed to these practices or arts – and the knowledge gets lost.

Contributing to a handbook on the history of mathematics, the mathematician and ethnographer Carrie Brezine (2009) compares the mathematics within European and Andean weaves. She concludes that European looms increase efficiency and repetitive patterning whereas Andean looms leave design potential in the mental concepts each weaver brings to the loom. She describes this situation as a contrast of automation (Europe) and algorithm (Andes).

However, weaving in ancient Greece proceeded similarly to the Andean way: without treadles, by applying algorithmic patterning processes, and without cutting the threads from the loom (Harlizius-Klück 2004, 2014). Rules for patterns were not written down in archaic Greece, also as literacy was not widespread, but we can infer from Andean practice how ancient Greek weavers might have approached the patterning process.

[5] Herington (1985: 3) defines sixth and fifth century BC Athens as 'song culture', in the sense of 'a society whose primary medium for the expression and communication of its most important feelings and ideas was song'.

[6] The phenomenology of the 'cyberchorus' in archaic Greek poetry is discussed by Power (2011; see esp. 80–5 on 'Daedalus and choral poetics'); drawing on archaic literary descriptions of dancing choruses, Leslie Kurke (2013: 127) frames this in terms of Greek aesthetic perception: 'choral performance is a machine for the conjuring of absolute presence, whereby gods, chorus members, and audience are all linked or joined together by a single (mimetic) chain'.



(left) Figure 2. Draft for colour-effect pattern. *Ellen Harlizius-Klück*

Thus, Brezine's description of weaving also applies to the case of the warp-weighted loom: 'Because there is no automation, the design can change throughout the length of the cloth' (2009: 485). Still, the designs the weavers create are very complex, raising the question, how they could achieve this without sophisticated equipment or written memory? Brezine says, 'The answer is that the Andean weaver depends on algorithms rather than on automation' (486). She describes how the weaver responds to the steps already woven by shifting, repeating, mirroring or changing the series of threads to lift (or not) in one weft row (called a pick). The only points to remember are critical picks of a repeat where the design transforms. Let us look at an example to understand what Brezine refers to (cf. fig. 2).

The black and white squares in the lower right corner of the diagram indicate the picks that need to be performed: a black square means 'lift the warp thread'; a white one means 'leave it down'. If we read the instruction from right to left and from bottom to top, we see that one needs to lift two threads two times in the row. The rest of the row just alternates up and down. In the second row, the position of the two neighbouring warp threads to pick up shifts to the outside. The same happens in the next rows until the two threads to pick touch the border. This is one of the critical picks where the weaver needs to change something in the middle of the repeat, to pick three warp threads in the centre. From the next row on, the pairs of lifted warps wander from the centre to the border again until the weaver needs to consider the next critical row of picks, which is in the ninth row. From here, the direction of the two warps to pick is changed. With the overall diamond structure in mind and an awareness of the necessary turns, the weaver can proceed like this without a draft.

When we assume that all warp threads are black and all weft threads white, the relation of picks and patterns is easy to understand because the diamond appears as a visual pattern on the fabric. However, when the warp and weft consist of dark and light grey threads alternating, the fabric that results from the diamond structure shows a very different pattern of overlapping rectangles that the diagram (fig. 2) depicts beyond the diamond structure. Our assumption is that such surprising colour-and-weave effects underlie the concept of *poikilia* and the idea of patterns being a thing of wonder. Figure 3 shows a reconstruction of the bull leapers fresco from Knossos with such a typical intricate colour effect pattern in the background.

The production of textile patterns incorporates the organization of elements to wholes in a way that is logical and algorithmic, but is not conceivable through written descriptions. Weaving transforms single, discrete elements (threads) into a form (structure and pattern) through a dualistic process (threads going up or down within the rectangular grid of the threads) that has to account for complex interferences. We assume that in this dyadic transformation of elements into a whole, which is meaningful yet not easy to predict, lies the impact that weaving had on early Greek philosophy and science. The question for our present contribution is: can the concept of microperformativity help access knowledge that is otherwise tacit in the production process?

Figure 3. Detail of reconstruction of a bull leaper fresco, ancient Avaris, sixteenth-century BCE (McInerney 2011: 12).

Figure 4. The start of a PENELOPEan performance, Millenium Gallery, Sheffield, 2019.

It is obvious by now that the knowledge we grapple with here is inextricably at once embodied practice, reflexive decision-making and material agency. In particular, the challenge is to highlight non-propositional knowledge, and illuminate the conditions of intelligibility of such knowledge (Schatzki *et al.* 2001: 10), to reconsider dichotomies between human and non-human entities. It is here that performance and the concept of microperformativity become key to our project of weaving, one that addresses both challenges that we have set ourselves; first, what do the weavers know, when they know how to weave? Second, how do we grasp and represent that complex knowledge.

In order to explore ancient weaving, and its structural influence on music, dance and the fabric of the cosmos, we employed the approach of algorithmic music, especially live coding. Algorithmic music can be broadly defined as any music where focus is upon an underlying music-making system. Rather than hitting an object to make sound, algorithmic musicians *write about making sound*, in a way that is then interpreted and enacted to create actual sound by a computer. Christopher Small (1998) argues that music is itself an *activity* rather than an end result. Following this, just as weavers make systems to organize threads, algorithmic music refers to the activity of making systems for organizing sounds. In this, sound is mediated by textual code that is manipulated, as musical action.

Algorithmic music has dislocated agency. However, over the past two decades the practice of *live coding* has developed an algorithmic music culture that embraces improvised performance. Live coding performers challenge the assumptions of generative music by working hands-on with code, while it runs. At any point, the state of the code gives a snapshot of the music currently being generated. Indeed, live coders employ patterning techniques analogous to those we have already seen in weaving, and even refer to pieces of code as patterns. Musical techniques such as canon (shifting/following), retrograde and inversion (symmetry) can be both easily codified and explored as in algorithmic music, as well as related to movements on the loom, demonstrating the universal nature of pattern across discrete computation, music and weaving. This allows us to take the long view on computation, very well grounded in ancient culture, and look for ways in which interference patterns can introduce heightened experiences of *poikilia* to contemporary music technology.

Threads perform in unexpected ways, creating visual outcomes seemingly unrelated to their structures. Colour patterns of warp and weft, thickness, ply and structure of the yarns, the warp tension and the density of warp or weft – all these elements take part in the resulting appearance of the fabric. In this sense, the threads do not act out a script, but perform together with the algorithm employed by the weaver who needs to make decisions on repeats and recursions to generate a coherent whole.

PENELOPEAN PERFORMANCES

We have applied self-made technology to convey one of our most difficult results: that pattern generation in weaving includes inferences that are impossible to explain in writing alone, but easy to understand in performing. Opening an exhibition of collaborative works with Bolivian weaver and artist Sandra DeBerduccy, we gave our first PENELOPE performance, learning that it is possible for an audience to perceive the pattern order, still inexpressible, when it circulates across different media or modalities.

A performance (figs. 4 and 5) includes the recitation of two passages of ancient Greek poetry: (1) a piece of Homeric epic hexameters, in particular the description of the shield of Achilles in the *Iliad* being decorated with a circle of dancers (*Iliad* 18.590–605), and (2) a piece of a choral ode from Sophocles' *Oedipus the King* (lines 883–96 ~ 897–910), featuring rhythmical modulation (*epiploke;* see McLean *et al.* 2018). The metre and rhythm of this recitation leads into the live coded music, and is furthermore transformed by the pattern matrix into commands for the robot legs. The robots circulate around a pole, to which they are each connected by a ribbon, just like maypole dancers – and so the circle to the dancers of the *Iliad* closes.

It is through the multimodal practices that the (indeed still binary) order of weaving circulates. By this, we represent the tacit knowledge of ancient weaving when it disseminates its order into lyric, mathematics, code and social arrangements. Our performance can be broken down into the following cascade of interactions between different pattern systems:

1. Recitation of Greek poetry (Homer and Sophocles).
2. Musical live pattern manipulation as code.
3. Underlying rhythmic structure (and associated network communication).
4. Choreographic arrangement of robots (different groups of robots with roles, inter-robot communication, waiting for one another).
5. Underlying radio communication protocol between each robot.
6. The code running on each robot, controlling its high-level operation (walk forward, backward, turn, wait, signal).
7. Low-level movement sequence controlling leg rotations that result in different movements – this lower level is synchronized to the music.
8. The dance as a complex interaction between robot movements, the constraints provided by the maypole and audience manipulations.
9. The resulting maypole braid.

The braiding, maypole-like choreography for the robot dancers are grounded in a particular interpretation of an attested ancient Greek dance, the maze-like *geranos* ('crane dance'), originating in the practice of drawing a spiral with a string compass (Fanfani 2018: 22–32). In addition to this, the circular movements of the

Figure 5. An audience member corrects a robot's path during the PENELOPEan performance. *Photo David Griffiths*

robots are controlled using a tangible interface based on weaving, called the *Pattern Matrix* and synchronized with the rhythmic patterns created by the live coder that build on the metrical structure of Greek poetry. The Homeric passage we chose for our performance reflects this: there, a dancing chorus is inlaid (the Greek verb is *poikillein*) by the god Hephaestus on the bronze shield of Achilles, and the choristers may be imagined as animated artefacts, a *thauma*.

As the robots walk in different directions around the maypole, the audience needs little encouragement to interact with them, thereby taking part in the performance themselves. The braid that results is a woven record of the performance, until the dance switches direction and the braid is un-woven once more.

A central component of the PENELOPEan performance is the transitioning of code through three different modes, each manipulating a shared pattern. The binary system of ancient Greek metre, particular patterns of which provide the rhythmical architecture for the oral recitation of poetry, is the code that becomes appropriated by, and embedded into the music through the performance of the live coder.

CONCLUSION

On the way from sketch (fig. 1) to performance, we started by exploring the elements included as separate acts into which the weaving process splits up, and we ended by presenting the idea

of the order of weaving in three different modes: the rhythm of Greek poetry, the algorithm of music and the robotic movement of plaiting. A rhythmical but not completely predictive order circulates through the modes that we would like to address as the knowledge-in-between that constitutes the travelling concept of weaving. Addressing this as a microperformative dimension helps us to prevent the unhappy dichotomy of tacit versus explicit.

In the course of our investigations, we could see that presenting the rhythmical order again in a weaving performance like the one envisaged in our sketch (fig. 1) would not allow us to keep the dancing, counting, metrical and musical connections open. It was in the interstices of the three modes that our idea passed to the audience. It was only by performing them all and letting the interstices microperform that we could make this work. However, by insisting on the several modes, we lost weaver and loom. Our next task will be to find out if we can make weaving algorithms microperform by putting weavers and looms from different countries together in our laboratory.

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