Theraps as Techne Tapestry

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ABSTRACT

Xenakis's solo bass work *Theraps* provides a productive case study into the technological approaches of a composer renowned for his pioneering art/science hybrids.

An initial section focuses on the work itself, providing an updated account of the materials and form, informed by archival sources, secondary literature, and purpose-built visualization software. This account explores how the extreme performance demands of the work arise directly and deliberately from Xenakis's varied compositional approaches.

The construction of *Theraps* suggests broader reflections on the technologies employed and their relationships to the body, society, and knowledge; a second section provides speculative readings of *Theraps* through the work of two authors identified with the philosophy of technology: Albert Borgmann and Don Ihde.

1 *THERAPS*

1.1 Background

Xenakis's lone work for double bass, *Theraps* (1975–6), was written for and dedicated to Fernando Grillo. In the early stages, Grillo and Xenakis explored possible sounds and techniques for the work; Xenakis's notes from January 1975, for instance, show the option to "detune a string — hold it with a finger [the thumb] that can change the tension" or to use "two bridges for two strings". However, a note indicated that these techniques "don't provide much"; of all the techniques in this session, only an "engine sound" made on the bridge seems to have survived to the final work.

The manuscript of *Theraps* was finished in 1976 and premiered in March at the Festival de Royan [1], with successful followups at the Middelburg Xenakis Festival and Darmstadt, at which Grillo received the Kranichsteiner Musikpreis. Grillo thanked Xenakis by post, enclosing an annotated score with recommended notational changes and bowing indications. These were not incorporated.

In 1981, Éditions Salabert published a new edition of the work, professionally engraved by J. L. Sulmon [2]. In addition to the much-improved legibility, this edition includes

time signatures and drastically modified tempo markings, as well as expanded program and performance notes in English and French. [1]

1.2 Performance Difficulties

Much of the work's reception concerns its many performance difficulties. In an early account, Bernard David Neubert's 1982 dissertation addresses challenges he encountered working from the manuscript, such as the small, "cumbersome to read" notation [3]. [2] For the "microtonal passages", which he noted extend "beyond the practical limits of the instrument", he recommends two quarter-tone fingering patterns to simplify performance [3, p. 59]; the engraved edition instead urges that these sections be performed "as much as possible with just one finger" [2].

In the engraved edition, Barry Guy's program note describes the "mental and physical commitment" required in the work as "taking the player to the edge and beyond". In one passage, he focuses on the boundaries between the areas of flux and the natural harmonics, saying:

> Withdrawal to the ethereal harmonics is in many ways a painful process, but ultimately rewarding. Here lies a possible paradox, for the physical limitations of the human frame can all but cope with the intensity of the music leaving an area of instability in the ongoing music. [2]

Robert Black's account in *Performing Xenakis* details his approach to learning the work, which involved developing exercises to overcome a number of the technical challenges. He also describes "a coming to terms with the extremes of dynamics, range, tonal colors, and bow pressure", saying that "the emotional commitment, and sheer physical effort required to play the work was something that I had not encountered before" [4, p. 241]. Xenakis requested that he further exaggerate these extremes, making the work "more [...] savage, grotesque and beautiful" [4, p. 242]; a similar request was made of Guy, who was asked to exaggerate the dynamic range to "obtain both a sensitive fineness and a savageness" [2].

John Eckhardt noted that these extremes reveal fragile feedback cycles between a performer and the configuration of their instrument. For example, too little rosin compromises the bow's traction for the extreme dynamics, but

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[1] This engraving process faithfully preserved several idiosyncrasies of the original manuscript, but introduced some unintentional errors which remain to the present. Further details are available from the author.

[2] He also noted difficulties arising from the pitches being written at sounding pitch [3, p. 56].
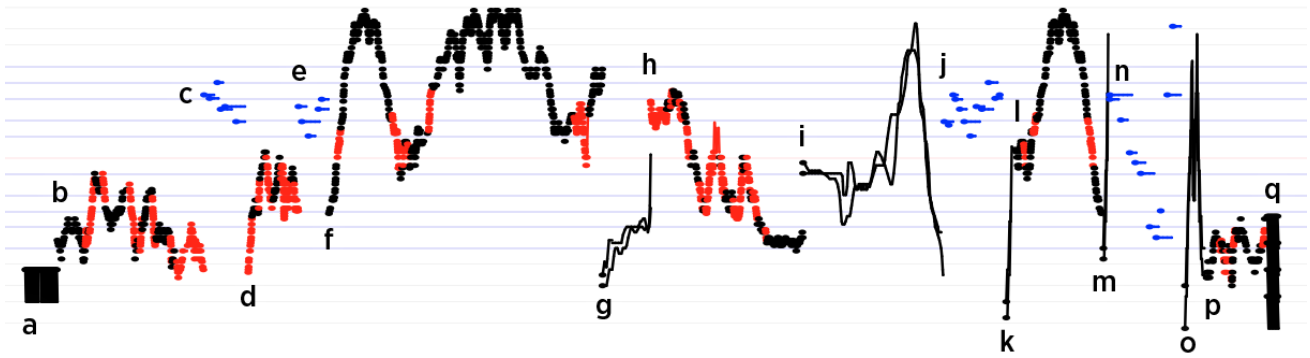
Figure 1. Overview of *Theraps*

too much rosin interferes with the random walks when they wander into the residue on the string. The height of the strings presents another compromise, between the increased fatigue of higher heights and the unintended slapping of the string against the fingerboard at lower heights. The instrument also pushes back: Eckhardt grows thick calluses as he prepares for performances, a manifestation of the required human-instrument symbiosis!

1.3 Examining the Texture Form

To understand these challenges more acutely requires study of the work's content and its varied compositional processes. As shown by the overview in Figure 1,[3] *Theraps* comprises seventeen musical "blocks" of four main types, here labeled according to Ronald Squibbs's dissertation.[4] These blocks are generally assigned to four types: "Short Glissandi", "Random Walk", "Harmonics", and "Two Voice Glissandi". This study further divides the "Two Voice Glissandi" into two subtypes: the "Freehand Glissandi" (g & i) and the "Leapfrog Glissandi" (k, m, & o) on the basis of their differing manners of composition.

1.3.1 Random Walks

Of the four main types, the random walks dominate the analytical discourse on *Theraps*, perhaps unsurprisingly, given their ubiquity in Xenakis's music of the seventies. Squibbs provides an overview of Xenakian random walks in his dissertation, clarifying their metaphorical relationship to Brownian motion and elucidating how the walks can equally apply to contours as to absolute pitches [5, p. 110]. This supports his detailed computer-assisted analysis of *Theraps* [5, p. 252].

While random walks could systematically supply content for instrumental music, Xenakis's approach at this time involved compositional "transfer", as discussed by Makis Solomos [6]. In *Mikka*, for instance, an initial transfer occurs in using an "image of Brownian movements (in the physical sense) to conceive a new way of sound synthesis"; a second transfer occurs in "transferring the graph of a sound curve to a graph for instrumental music" [6, p. 247].
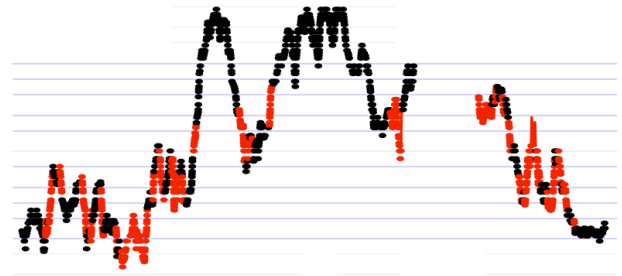

Figure 2. Random Walks

The random walks in *Theraps* unfold through a similar "double transfer". The sound curve graph exists as two hand-copied graphs on millimeter graph paper, preserved in the archives at Biblothèque nationale de France, reconstructions of which can be seen in Figure 2. Sections b, d, and f originate from one such graph, a single continuous curve broken into pieces; p and l present the same content in temporal retrograde. A second graph contains section h, a descending contour.

Several processes of curation, mapping, and rearrangement imprinted the resulting music with characteristic features, often quite different from other works exhibiting ostensibly similar conceptual foundations. *Mikka*'s highly volatile rhythms and unquantized pitches, for instance, would be hard to confuse with the mountain-like fractal symmetries of *Theraps*.

The graph paper sketches reveal the details of the curve mapping. Time was mapped horizontally in eighth notes, and pitches vertically in quarter tones; nearby were rhythmic calculations for determining the speed of the eighth note as well as desirable rhythmic derivations. The pitch mapping was anchored within the compass of the bass, extended somewhat by the technique described in a note, "pull the strings laterally to go very high!!!" Pitch sieves were marked next to the curves, used later to select specific pitches from the otherwise undifferentiated field. No further compositional debris connects the rhythmic calculations and eighth-note time mapping to the final score's tuplets.

The quantizations in pitch and time required Xenakis's meticulous intervention. Simply generating rhythms stochastically, as suggested by Neubert [3, p. 53], would ir-

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[3] The visualizations in this paper come from *thermograph*, a domain-specific encoding and visualization tool, available from the author.

[4] A form chart comparison is available from the author.

regularly sample the graph, interrupting the fluid contour. Conversely, deriving the rhythms from the pitch changes would not produce the consistent tuplet rhythms like those in *Theraps*. The sheer number of idiosyncrasies in the contour, pitch, and rhythm of the random walks corroborate that this final transfer was performed manually; this may well transform the "double transfer" into a triple transfer.[5]

In addition, these sections are characterized by continuously changing expressive techniques — most notably the *sul pont* markings, dynamics, accents, and additional glissandi. These decisions mirror Xenakis's self-described tendency to remove stasis, as described to Varga:

> The aim is to make the sound itself live. There are different ways of doing that: we change the timbre, employ tremolos and accents, repeat the sound and change dynamics. [...] In this way the inner life of the sound is not only in the general line of the composition, of the thought, but is also within the tiniest details. [7, p. 64]

1.3.2 Harmonics

The harmonics, a dramatic foil to the random walks, receive considerably less scholarly attention. Only Squibbs has analyzed these sections, collecting and describing the pitches [5, p. 263], noting that "only the random walks and the successions of harmonics show clear evidence of structural differentiation within the work's equal-tempered quarter-tone p-space" [5, p. 254].

To compose these sections required Xenakis to resolve a number of constraints: the "pre-sieved" pitch material arising from the instrument's tuning, the physical locations of the harmonics on a given string, and an apparent desire to mimic random walk contours. For the pitches, Xenakis made a table containing the first fifteen harmonics over each string, labeled in abbreviated solfège, connected by lines to show an ascending path. After eliminating some of the high partials, he then plotted these pitches as an ascending scale, which underwent some basic explorations.[6]

From these, he composed a single trajectory of harmonics, shown in Figure 3, which resembles the contours of the other random walks. In musical context, this trajectory is split into two parts, forming sections j and n, with sections c and e formed by reading j in temporal retrograde and at a slower pace. These sections, then, reconcile the resultant pitch structures, derived "outside of physicality", with the physical limits of harmonic dyads on the bass, ultimately forming a random-walk-like pitch contour through a physical "random walk" across neighboring string pairs.
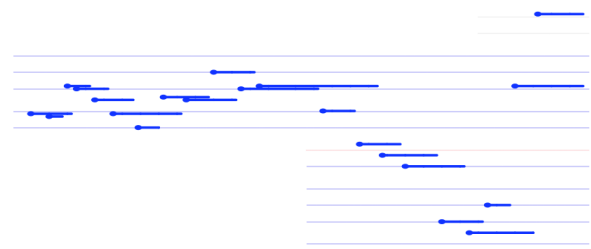

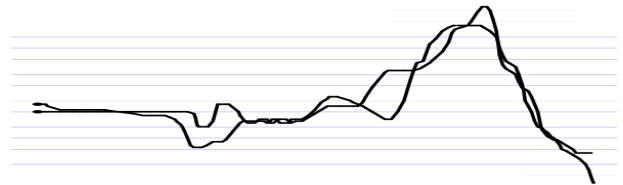**Figure 3**. Harmonics Trajectory (sections j and n)

Figure 4. Freehand Glissandi in section i

1.3.3 Freehand Glissandi

Where the random walks and harmonics involved curation and reconciliation, the freehand glissandi in sections g and i were conceived directly onto graph paper. This approach reflects his contemporaneous interest in visual and sonic feedback relationships, seen in his production of arborescences.[7] He described this in context of his piano work *Evryali*:

> The drawing and thinking of the sound-image go hand in hand, the two can't be separated. It would be silly to leave out of account, when drawing, what will sound in reality. We have also to be able to find on paper the visual equivalent of the musical idea. Any changes and modifications can then be carried out on the drawing itself. This feedback has to operate all the time. [7, p. 90]

Here, this feedback took place at the very least through starting, abandoning, and modifying paths. Much like *Evryali*'s arborescences, which facilitated "continuity on an instrument which has an opposite nature", these freehand glissandi served as a sound-image representation for direct composition, free from physical limitations.

Because transcending these limitations could only be temporary, he took additional steps to check their playability. We know from Robert Black's account that Xenakis made use of his "bass", a wooden board marked with the physical locations of pitches, to "determine that it was possible to play everything that he had written" [4, p. 242]. A page of sketches contains dyads representing the extremes of a hand span, labeled "for the two voice glissandi", as well as measurements of physical distances, suggesting he was particularly sensitive to this issue.

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[5] Since random walks yield self-similar, symmetric contours, visualizations aid in identifying the many small contour deviations. For example, measure 5 shows a three pitch melodic cell that repeats immediately at a faster speed, breaking the expected symmetry, and providing a sense of musical grouping. This pattern repeats in measure 8 (<c2+3, c2+2, c2+1>), measure 81 (<a4+0, g4+2, g4+1>), and measure 89 (<a3+0, g3+2, g3+1>). Many other asymmetries occur at moments of emphasis, for example the f2+0 in measure 4, the leaps ending measure 10, the prolonging c5+2 in measure 50, and the c6+2 by leap in measure 57.

[6] This also included identifying equivalent harmonics (for instance $II_3 = II_4$), and the quarter-tone relationship between II_4 and III_5.

[7] Incidentally, two small arborescence doodles, unrelated to *Theraps* occur alongside the surveyed sketches.
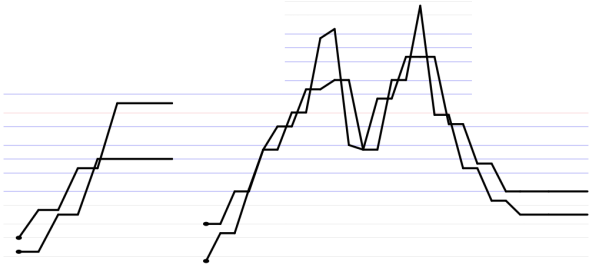
Figure 5. Sample Leapfrog Glissandi (left) and the Composite 'M' (right)

Figure 6. Short Glissandi and repetitions in section a

1.3.4 Leapfrog Glissandi

The leapfrog glissandi [8] found in sections k, m, and o make generative application of these same hand span dyads. Xenakis constructed six trajectories from the dyads, each assigned an identifying letter (section k is α, section m is γ). Pivot points on e3, marked on the trajectories, maintain the illusion of continuity while switching strings. A final dramatic appearance of these trajectories as a composite (taking the rough shape of the letter 'M') appears in section o, shown in Figure 5.

This dual use of the wooden "bass" typifies Xenakis's thoughts on playability. He describes to Varga that he will "take into account the physical limitations of the performers", but also consider "that what is limitation today may not be so tomorrow" [7, p. 65]. [9]

1.3.5 Short Glissandi

The short glissandi at the beginning and end of the work have an "effect of framing", as described by Squibbs. "Both occur at the low end of the p-space, thereby producing a gruff sound whose precise pitches are difficult to discern" [5, p. 255]. [10] While the short glissandi did not develop through sketching, they figured prominently in several form diagrams.

1.3.6 Texture Form & Self-Borrowing

The overall form of *Theraps* developed through sketching and sequencing blocks, represented by visual shorthands, alongside labels. One such sequence contained: four descending lines, unlabeled; a rough descending contour, labeled "*Mikka*"; a straight line with a wavy line against it, labeled "deux voix"; a single trill-like line, labeled "*Cendrées*"; five parallel horizontal lines, labeled "harmoniques"; and a random walk, labeled "Φλέγρα"

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[8] The intertwined pitch contours in these sections evoke the childhood game Leapfrog, in which children repeatedly jump over each others' backs.

[9] Similar dual uses occur in *Khoaï* and *Gmeeoorh*, where a double-manual cardboard keyboard supported the endeavor to play both organ manuals simultaneously in a single hand.

[10] Squibbs further notes that the staccato repetitions in the opening section were an "anomaly" in his categorization.

(*Phlegra*). These references corroborate the work of Benoît Gibson on Xenakis's self-borrowing [8]. [11]

Another sequence shows the random walk ("Φλ") alternating with the descending short glissandi. Converging towards the final form, another shows a balancing of the harmonics and the leapfrog glissandi towards the work's conclusion, including the constituent modules of the 'M'.

This interest in blocks finds elaboration in the program notes to *Phlegra*:

> As in other recent compositions of mine, I have continued here the construction of textures and their organisation on a higher level. I refer to textures in the general sense of form. For example, a melodic arborescence… a random walk… repeated notes following rhythmic rules…
>
> Textures in the sense of form are the keystone of art and knowledge. [9]

2 QUESTIONING TECHNOLOGY

By exploring the varied compositional approaches taken in composing *Theraps*, the above account suggests fruitful connections to surrounding philosophical inquiries into technology and its relation to society, the body, and knowledge. The following sections explore two such speculative connections: first, between the "transferred" random walks and Albert Borgmann's "device paradigm", then between the freehand glissandi, wooden "bass", and Don Ihde's "human-technology-world relations".

2.1 From Claustrophobic Molecules to Focal Practice

As described above, several acts of translation separate the random walks within *Theraps* from any scientific or algorithmic origin. These acts begin with a conceptual shift from Brownian motion to random walks, and proceed through several "musicalizing" processes, used to compose instrumental music from algorithmically-generated data.

While "Brownian motion" and "random walks" both identify stochastic processes, these terms differ significantly in their relation to the natural world. Brownian motion typically refers rather specifically to those "small, chaotic movements of molecules suspended in a liquid or gas" [6, p. 247]; random walks, on the other hand, carry no implied physical phenomenon, most often used to describe stochastic behavior of variables within a data set (or, to algorithms which yield such data).

Since Xenakis used algorithmically-generated random walks in his music, the references to Brownian motion in his writings, interviews, and program notes must therefore be understood metaphorically. This fluidity between scientific matters and practical compositional ones was not uncommon, as Matossian notes:

> Critics have often been confused by the balance of science and music, a confusion often fueled

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[11] Other mentioned works include *Orient-Occident* (in a margin), *Mikka S* (in the second random walk), and *Gmeeoorh*.

by Xenakis' own rhetoric. Their favourite insult in the old days was "scientist, technocrat, philosopher but not a musician", while scientists were quick to point out inconsistencies, errors and "unscientific" procedures. [10, p. 243]

As algorithm, random walks gain repeatability and controllability, and lose scarcity and physicality. The data they yield gains new means of manipulation, separable from the means of its origin. These new means of manipulation prove vital to an artistic appropriation. The "musicalizing" processes in *Theraps*, dependent on such a shift, inextricably forge the character of this material.

2.1.1 Borgmann's Device Paradigm

Albert Borgmann's 1984 book *Technology and the Character of Contemporary Life* took notable steps to diagnose perceived ills of technologized culture and propose shifts of thinking that could lead to their resolution [11].

His "device paradigm" identifies in technologized society a fundamental pattern by which *means* and *ends* become decoupled, subsequently supporting specialized *means* "machinery" and a culture of commodities and consumption [12, p. 14]. Those technologies with linked means-ends become identified as "things", and are associated with traditional forms of engagement. "Devices" on the other hand, with their severed means-ends, require specialized roles and impede engagement. In one such example, the hearth ("thing") centralizes activities of the home around the production and enjoyment of heat, while central heating ("device") dissipates these home activities and requires expertise to repair.

To rectify the device paradigm, he advocates a renewed engagement with what he identifies as "focal" things and practices [12, p. 22]. Examples include running, the culture of the table, and music. Since Borgmann considered philosophical discourse to be shaped by the device paradigm as well, he faced the challenge of finding a unified means-ends for his rhetoric. He finds resolution in *deictic* discourses, those identified by rhetorical appeal, denouncing those "quasi-rational" philosophical approaches of logical persuasion [12, p. 21].

The random walks in *Theraps* might mirror such a logical chain. To a composer who finds musically-desirable features in Brownian motion, their uncontrollability towards any specific ends presents a real challenge (keeping a house warm by neighboring volcano).[12] When random walks substitute for Brownian motion, as a simulation "device", they bring a severed means-ends relationship (central heating). The computational and statistical expertise required for servicing the "machinery" as a musical "means" bears no direct relationship to the perceived "ends" encountered by a listener.

The acts of transfer might then be understood as bringing the random walks into alignment with specific focal practices of music. Bringing random walks to the bass, for instance, activates those means-end relationships associated with acoustic music, here including exhaustive and exhausting practice by the soloist, the ritual of concert-going, and the culturally thick practices of notation and engraving. The additional "musicalizations" serve to further emphasize the linked means-ends; they reflect additional distinctions made in composition with the dual intentions of adding differentiation for the listener and challenges for the performer.

That the random walks contribute so strongly to an understanding of *Theraps* as an activity at the limit of human physical capability, and so weakly to it as an activity of science or computing, speaks to the effort by which Xenakis brought the random walk "device" into alignment with focal practices.

Borgmann's advocacy for deictic discourse also finds resonance within Xenakian rhetoric. The well-known opening of *Formalized Music*, for instance, extols music's power to "catalyze sublimation" [14, p. 1], a Dionysian "transportation of state" he compares to the effects of alcohol and love [15, p. 18].

2.2 Drawn Sound and the Wooden Instrument

Additional technological distinctions arise from Xenakis's varied relationship to physical artifacts, especially implements. This section proposes that the phenomenological approach to technology taken in Don Ihde's 1990 *Technology and the Lifeworld* can enhance an understanding of the two voice glissandi [16].

2.2.1 Pencil as Cane, Arborescence as Thermometer

As discussed above, the freehand glissandi intertwine acts of drawing and imagining sounds, an approach later exemplified by his arborescences. This practice unfolds across several "human-technology-world relations".

In terms of raw sensory perceptions ("microperception"), Xenakis would have at least felt the pencil in his hand, seen the graph paper lines, watched graphite curves fill the discretized space, and felt the uneasy friction of eraser debris as he brushed it from his working surface. In this context, the technologies may be subjects of perception, but perception itself remains technologically unmediated.

The pencil, while instrumentally essential to the act of drawing, also notably contributes to the drawer's sense of self. Within Ihde's classification, this special mediation constitutes an *embodiment relation*, mirroring Merleau-Ponty's oft-cited examples [16, p. 72]. The blind man's cane, for instance, serves as an extension of his senses "parallel to sight" [17, p. 143]. In embodiment relations, Ihde notes the necessity of special skills or techniques; a novice with a cane will find it a poor sensory organ.

Once drawn, these curves require additional acts of interpretation to transform them from *image* into *sound-image*. This interpretation finds music through a representational mediation, rather than mediated sensory perception. This constitutes a *hermeneutic relation* [16, p. 80]. By way of an example, the thermometer does little to extend our raw physical sensations of temperature, but shapes our understanding and interpretations of temperature through its

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[12] Dewey: "Nature as it exists at a given time is material for arts to be brought to bear upon it to reshape it, rather than already a finished work of art... The attitude of control looks to the future, to production" [13, p. 109].

form of representation [16, p. 85].

2.2.2 Wooden "Bass" as Spinning Top

Neither the embodied nor hermeneutic relation adequately explains the usage of the wooden "bass" in the two voice glissandi. The board, while instrumentally useful for composition, does not fuse into its holder's body image as in the embodied relation [(Xenakis-Board) → Music]. Additionally, while using the board requires acts of interpretation, these acts do not mediate macroperception as in the hermeneutic relation [Xenakis → (Board-Music)].

Instead, the board serves as a non-mediating object of relation, an *alterity relation* [Xenakis → Board-(-Music)] [16, p. 97]. The board replicates Ihde's example of the spinning top: "what was imparted through an embodiment relation now exceeds it" [16, p. 100]. Just as the top gains autonomy from its human spinner once spun, the wooden bass becomes a "quasi-other", detached both from the composer's perception and the double bass.

2.2.3 Hearing the Relations Revealed

In a review of Ihde's later book *Bodies in Technology*, Andrew Feenberg contributes an extension to Merleau-Ponty's cane example. Feenberg notes that the cane "does more than sense the world; it also reveals the blind man as blind". "The extended body, then, is not only the body that acts through a technical mediation, but also a body that signifies itself through that mediation" [18].

While this insight specifically regarded mediated relations, it applies equally well to each of the implement relations discussed above. The freehand glissandi project the conflicts of their construction into the musical result: what appear as two smooth curves in a sketch manifest musically as embodied struggles between the body and the bass. Drawing makes possible a music that seeks to transcend, but requires, bowing.

The wooden bass, meanwhile, as a two-dimensional pitch ruler, has a complex relationship to "playability". In common usage, basses are three dimensional, and while finger positioning and hand span may present challenges, they rarely dominate the musical challenges. Nothing about using such a ruler accounts for the complications of string height (Eckhardt), the many pains associated with the textural juxtapositions (Guy), nor the commitment and effort required (Black).

If anything, Xenakis's decontextualized measuring of pitches ensured that *even the pitches alone* would be difficult to play. Guy comments, "on paper it is all possible, but when overbalanced in favour of the final result, a new philosophy has to be reckoned with."

2.3 Considering the Techne Tapestry

The sections above explore the blocks as isolated entities, rich and variegated in their approach. When juxtaposed within the work's timeline, the resulting texture form only hints at the "techne tapestry" woven below. "Techne was for the Greeks a pro-duction, a leading toward, and a construction, a drawing together, of various parts and pieces in order to make something novel" [13, p. 18].

These interwoven compositional techniques reflect one attempt among many to resolve questions of the interrelations between art and technology. Xenakis often described these relations dialectically:

> Technology allows the exploration of new domains proposed by theoretical thought and esthetics; but once these domains are explored, we must push further. In fact, computer science is a product of simple rationality; as a composer, I unceasingly bring complexity, sometimes irrational, to this rationality. [15, p. 27]

If viewed through the lens of John Dewey's instrumentalism, such a conflict recedes. "'Technology,' as [Dewey] understood the term, cannot be the enemy of art. It *is* art" [13, p. 68]. In *Theraps* one finds a musical artifact, a "focal thing" that brings the technologized world to bear on art, but also a philosophical inquiry into what art might mean in such a world.

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