From Passive Agent to Musical Partner: Insights from the MAD Clarinet Project as a Case Study

Rui Travasso
rui.travasso@ipbeja.pt
Polytechnic University of Beja | CIEQV - Life Quality Research Center
Beja, Portugal

Enrico Dorigatti*
enrico@enricodorigatti.com
G. Rossini Music Conservatory
Pesaro, Italy

Abstract

This paper examines the evolution of the MAD Clarinet, a technologically expanded acoustic instrument, as a case study of the relationship between a human performer and an algorithmic system in performative settings. Based on a practice-based and case study approach, the proposed research traces the development of the system from a passive agent to a more active performative partner. Reflecting on observations from successive iterations of the instrument, the paper shows how changes in system design affect performer-system interaction and the shaping of musical form. The MAD Clarinet highlights how algorithmic systems can participate in performance by influencing musical unfolding in real-time, contributing to a distributed but performer-driven creative process.

Keywords

Expanded Instrument; MAD Clarinet; Practice-Based Research; Performance; Creative Technologies

1 Introduction

The MAD Clarinet is a technologically expanded musical instrument developed in 2020 and based on an acoustic clarinet. The MAD acronym stands for *Média-Arte Digital* (New Media Art), and its evolution has progressed through several phases involving distinct hardware and software expansions. Its modular design enables ongoing updates while preserving standard clarinet playing techniques, supporting longevity and continued usability, both central concerns in NIME discourse [14–16]. Rather than altering the physical instrument itself, the MAD Clarinet expands it through a variable network of software and hardware. Across its successive iterations, it has outlined evolving relationships between the performer and the algorithmic system as a digital agent within a performative context.

2 Background

Technologically augmented instruments became widespread from the 1980s onwards, as electronic and computational tools became increasingly available for artistic experimentation. An early landmark in this field was Machover's notion of hyperinstrument, describing systems that combine sensing, sound processing, and computational expansion of musical gesture [11]. More broadly, research on augmented and expanded instruments has addressed issues of interaction, responsiveness, design, and performance [13]. Within this context, the MAD Clarinet can be understood as a technologically expanded acoustic instrument. This framing aligns with Turchet's discussion of augmented instruments as systems combining acoustic performance with sensing and computational processes [23]. It also relates to perspectives that consider instruments as evolving and relational systems, although the present study focuses on the practical development of performer-system interaction through successive iterations of the instrument [12]. In this sense, the MAD Clarinet is approached as a modular system whose technical configuration changes over time in response to performative needs.

From a design perspective, the MAD Clarinet and its development can be situated within the broader HCI field. Tanaka [19] identifies three waves of HCI design, moving from device-centred experimentation to user-centred approaches and, later, to broader cultural and situated forms of interaction. In musical contexts, this perspective highlights how computational systems may move beyond utility and control to support surprise, co-creation, and more open-ended performative relationships. In this paper, agency is understood in a practical and performance-oriented sense, referring to the extent to which the computational system influences music production and redirects the performer's choices in real-time, thereby shaping the performance.

3 Methodology

This study adopts a case research strategy [1] grounded in performances, recordings, and experimentation sessions involving the MAD Clarinet. As a qualitative approach, case research is particularly suitable for investigating a unit of analysis within its natural context through field observation, interpretation, and triangulation of different forms of evidence. In this case, the method is especially appropriate because one of the researchers is also the designer, builder, and performer of the instrument, possessing relevant and detailed experiential and technical knowledge. While this approach does not aim at statistical generalisability, it is well suited to producing in-depth insights and transferable reflections within emerging artistic and technological contexts. In parallel, the study is framed through a practice-as-research perspective, which understands both the artefact and the process of its creation as forms of knowledge [3]. Following Zagorski-Thomas [25], such knowledge requires documentation and critical reflection in order to become communicable. In this sense, the paper aligns particularly with practice-based research, as discussed by Candy [4, 6], since it examines both the creative process behind the MAD Clarinet and the resulting artefact. This combined methodological approach supports a retrospective and holistic analysis of the MAD Clarinet iterative development, allowing the study to identify how design decisions, performative use, and technological reconfiguration combined and informed the development of the instrument over time.

*Both authors contributed equally to this research.



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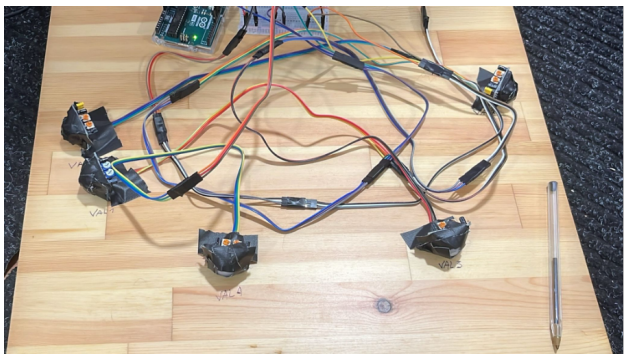


Figure 1: PIR sensors in MAD Clarinet 2.1



Figure 2: MAD Clarinet 2.1 performed at ARTeFACTo2022MACAO. Detail of the visual module output

3.1 Research Questions

While some of the questions underpinning this research project were pre-established and concerned the features, affordances, constraints, and technical stability of the MAD Clarinet, others emerged through retrospective reflection on the instrument's development. In particular, the study examines the role of the digital system within the MAD Clarinet, asking how its evolution reshapes performer–system interaction and to what extent it contributes to the unfolding of musical form beyond a purely reactive role. These questions were addressed by systematically considering all stages of the instrument's evolution. More broadly, the study seeks to identify insights from this trajectory that may be relevant beyond the specific case of the MAD Clarinet.

4 Case Study

The MAD Clarinet is examined as a case study across the distinct phases of its evolution, each prompted by specific performative experiences and necessities. The following subsections outline each stage in the development of the instrument, providing the technical and performative context necessary for the analysis.

4.1 MAD Clarinet

In its first version, the artistic intent of the MAD Clarinet was not clearly defined. As a project exploring strategies to technologically augment a clarinet, its initial purpose was limited to test solutions to mix the sound of the acoustic instrument with delay and reverb effects during live performances, without relying on a digital audio workstation (DAW). These effects were triggered by passive infrared sensors (PIR sensors) controlled by an Arduino Uno board. The sensors were to be placed on the floor, activated by the performer's position changes on stage. The sound of the acoustic instrument was captured by a microphone and processed through the aforementioned effects, whose parameters were set to random values at each sensor activation. This initial version, although simple and limited and never tested in public, laid the groundwork for the subsequent evolutions of the system.

4.2 MAD Clarinet 2.1

The MAD Clarinet 2.1 [20] was the first functional upgrade of the system, conceptually inspired by Erik Cohen's taxonomy of travelers [8]. Technically, it combined Processing 4 with five PIR sensors, each triggering sound processing parameters and presets. The performer's movements across the stage activated the sensors, aligning physical gesture with the concept of travel.

In this version, a visual module was introduced, generating geometric shapes from pitch analysis of the clarinet sound. Frequency ranges triggered specific drawing functions (Table 1), producing a real-time generative visual layer. The system was tested in performances at FIC.A (Oeiras) and ARTeFACTo2022MACAO.

The performance presented at ARTeFACTo2022MACAO[1], shown in Figure 2, contextualised the MAD Clarinet 2.1 and its relationship with travel-based scenarios. The performance combined improvisation, bodily movement, pre-recorded sound samples, and visuals, establishing a clear cause-and-effect relationship between gesture and multimodal output. Among these, one scenario associated with forced travelers integrated percussive patterns performed on an Arabic percussion instrument, the *darbuka*, and melodic material derived from the Libyan *ma'lūf* tradition [7], exemplifying how culturally situated sonic references were embedded within the reactive structure of the system.

From a performative perspective, the system operated primarily as a trigger-based mechanism, producing predetermined audiovisual responses to sensor input. As such, performer-system interaction remained largely one-directional, with no real-time negotiation. While this configuration ensured clarity in the relationship between action and output (reaction), it limited generative capacity and constrained the development of a performative dialogue, motivating the design and development of MAD Clarinet 3.0.

4.3 MAD Clarinet 3.0

Building on insights obtained from MAD Clarinet 2.1, the development of MAD Clarinet 3.0 [22] aimed to establish a digital, algorithmic performative partner capable of contributing to the generation and redirection of sonic material. The hardware components used in earlier versions, namely PIR sensors and the microcontroller, were removed, and the Processing-based software was replaced by two independent Max/MSP patches, a harmoniser and a stochastic system. This further evolution marked the removal of the visual module.

The stochastic system analysed the clarinet sound, converting it into MIDI pitch values and duration data. Pitch information was organised into triadic sets with repetition counts, enabling the construction of probabilistic chains, while durations were processed independently. This approach allowed the system to generate material recognisably related to the performer's input while introducing stochastic variation. The harmoniser, in contrast,

[1] http://youtu.be/NAhVfi6BCQs?si=qjfQLnq5DlWRmVZj. Online recording of the performance. Accessed on April 10, 2026.

Table 1: Outline of the visual module and drawing functions in relation to pitch analysis

Frequency range (Hz)	Triggered drawing function	Visual output	Description
21–192	`doQuadraticVertex()`	Quadratic Bézier Curve	Draws a single curve using `quadraticVertex()`
193–390	`doLine()`	Line	Draws a line
391–500	`doRect()`	Rectangle	Draws a rectangle
501–792	`doArc()`	Arc	Draws an arc with random radius and angle parameters
793–993	`doCircle()`	Circle	Draws a circle
994–1200	`doCurve()`	Bézier Curve (Complex)	Draws a curve using four control points with the `curve()` function
1201–1510	`doQuad()`	Quadrilateral	Draws a four-point polygon using the `quad()` function
>1511	`doCurve()`	Bézier Curve (Complex)	Default shape when frequency falls outside defined ranges

operated through beat-aligned capture windows defined by a predetermined tempo and time signature. Within these frames, the clarinet sound was captured, converted to MIDI events, and used to generate harmonies selected stochastically from performer-defined harmonic series via a Max/MSP-based interface. Acoustic sound capture relied exclusively on the Clarinet as a Tangible Acoustic Interface (CTAI) [21], a strategy making use of a transducer placed inside the instrument bell, responsive to both the sound produced by the instrument as well as any percussive interaction with its body.

In *Grés de Silves*[2], created for the Festival Som Riscado, the performer improvised with the harmoniser in a freely flowing context. Although tempo-defined, the sound capture windows opened unpredictably in relation to the performer's phrasing, generating harmonies that frequently redirected the musical trajectory and required rapid adaptation. In *Mr. Harmonizer*[3], vocal material and clarinet gestures were processed through the harmoniser, producing variable harmonic outcomes that frequently redirected the musical discourse. Conversely, works such as *Mr. Max*[4] and *Discordância Ângular*[5] foregrounded the stochastic system, which generated material derived from performer's input but showed limited variation and a tendency towards repetition. *Dialogue for 3*[6] combined both patches, including a brief moment of autonomous machine-machine interaction.

Overall, MAD Clarinet 3.0 represents a significant leap from the unidirectional interaction model represented by version 2.1. The harmoniser exerted a strong influence on musical structure, requiring continuous performer adaptation, while the limited adaptability of the stochastic system constrained its role in sustained real-time musical negotiation. These limitations directly informed the design of MAD Clarinet New Set, which further developed the system by emphasising greater algorithmic immediacy and machine autonomy.

[2]https://on.soundcloud.com/MqchqRwrcHE3jUdxga. Online recording. Accessed on April 10, 2026.
[3]https://on.soundcloud.com/4bflYINbFM0UT9Ssat. Online recording. Accessed on April 10, 2026.
[4]https://on.soundcloud.com/OwPq2xKM0SCopvQMKT. Online recording. Accessed on April 10, 2026.
[5]https://on.soundcloud.com/Eam3WFGJATGZw2EQuy. Online recording. Accessed on April 10, 2026. Example of the stochastic patch with the CTAI in *Discordância Ângular*, a solo movement for the festival performance.
[6]https://on.soundcloud.com/qVshhvG49uI4lFJZ7z. Online recording. Accessed on April 10, 2026.

4.4 MAD Clarinet New Set

The MAD Clarinet New Set emerged as an upgrade of MAD Clarinet 3.0. This version introduced new features that further developed the performative affordances explored in 3.0. The harmoniser was removed, and the stochastic patch was replaced by the integration of the ml.markov library for Max/MSP, which leverages Markov chains [24]. Additional features include:

- sound samplers for playing back pre-recorded sounds
- the creation of an enveloping ambient sound based on pure tones
- real-time sound manipulation capabilities
- the use of external controllers, such as MIDI keyboards and other control surfaces.

In MAD Clarinet New Set, the ml.markov Max/MSP object is fed by the system developed for MAD Clarinet 3.0, providing MIDI data and duration values. This allows the patch to respond melodically and harmonically in real time with significantly faster adaptation to incoming acoustic material than the earlier stochastic version. The MAD Clarinet New Set evolved beyond the exclusive use of the clarinet, broadening the performer's affordances beyond the instrument itself. While in previous versions the acoustic clarinet and the performer shared a unified central role, New Set establishes a wider performative framework, as shown in Figure 3.

The MAD Clarinet New Set was tested in a trio performance involving clarinet, Portuguese guitar, trombone, and a bio-sonification system. The performance[7] opened with a clarinet solo that provided initial data to the ml.markov object, which subsequently engaged in a duet with the Portuguese guitar. Additional layers were introduced through samples and live sound processing. Although the provided recording is brief, everything but the sound samples was improvised. The Max/MSP system extends and re-elaborates the clarinet player's input in real time, retaining its sonic identity while responding with greater immediacy than the stochastic 3.0 version. This supports a dynamic interaction in which the system behaves more like a performative partner, enabling continuous negotiation between performer and algorithm.

[7]https://youtu.be/t-mmwOIA60c. Online recording of the performance. Accessed on April 10, 2026.



Figure 3: The MAD Clarinet New Set expands the performative possibilities by introducing new interfaces for the performer to use.

5 Discussion

The evolution of the MAD Clarinet, summarised in Table 2, reveals the progressive shift of the digital algorithmic system from a passive agent to one with structural agency over the resulting performance. In version 2.1, the algorithm functioned primarily as a trigger-based mechanism, with predetermined audiovisual events prompted by sensor data. Version 3.0 introduced algorithmic processes that adapted to the clarinet sonic output. Thanks to the CTAI system, which enabled a closer relationship between the algorithm and the physical instrument, stochastic modelling and harmonisation patches elaborated new musical material in real-time and contributed to shaping the performance. This relationship was further explored in the MAD Clarinet New Set, where the ml.markov library enabled dense and continuous negotiation between the physical instrument, thus the performer, and the algorithm through its immediate adaptation to incoming pitch and duration data. In this last version of the MAD Clarinet, the digital system is responsible for generating musical material, becoming a performance partner directly linked to the compositional logic of the performance.

Simultaneously, the role of the performer shifted from being the absolute protagonist and director of the performance to sharing performative processes with the algorithmic system. In version 2.1, artistic choices were made exclusively by the clarinet player, and the system merely supported them, extending the sonic palette and expanding the performance into the visual domain. With version 3.0, while the visual component was abandoned, the system acquired the capacity to redirect musical trajectories and obstruct cadential closures, thereby requiring the performer to adapt rapidly and continuously. The MAD Clarinet New Set reinforced the agency of the system over the performance by introducing algorithmic immediacy, with the computer responding to musical input with nearly instantaneous generative sonic material based on the performer's input. This produces a sonic clone that simultaneously mirrors and diverges from the human player's phrasing.

The trajectory outlined by the development of the MAD Clarinet suggests that its contribution lies less in technological expansion per se than in the evolution of performer-system interaction across successive versions, experienced and documented by the designer and user of the instrument. Through its modular structure, the MAD Clarinet was repeatedly reconfigured in response to performative needs, progressively repositioning the algorithmic component within the performative process. Notably, as the MAD Clarinet relies on an acoustic clarinet exclusively due to the musical background of the designer, the same augmentation process may be applied to other acoustic instruments.

5.1 Performative Perspective

The algorithm embedded in the MAD Clarinet has significant performative implications. Firstly, it redefines virtuosity, which is no longer seen as a matter of dexterity on the physical instrument. Instead, virtuosity becomes the performer's responsiveness in the human-machine dialogue, where creativity is measured by their ability to adapt to algorithmic contingencies.

Secondly, it reshapes improvisation by merging the musical discourse with unpredictable events, ranging from blocked cadences to probabilistic divergences. Unpredictability therefore becomes an expressive feature and a driver of the musical form of the performance, rather than an occurrence to be wary of.

Thirdly, especially in the last iteration of the instrument, the affordances of the MAD Clarinet expand the notion of authorship. While the human performer still retains authorship by exhibiting creative intention, the outcome of the algorithmic processes significantly shapes the unfolding of a performance, which evolves through a distributed performative process in which both the human performer and the computational system contribute towards shaping the musical form. This way, any structural pre-planning of the performance may be challenged, affected by the unpredictable, yet contingent, contribution of the algorithm. Despite not possessing authorship, the algorithm is indeed enabled to exert choices that structurally influence the performance.

In MAD Clarinet New Set, algorithmic decisions merge with the intention and authorship of the performer. The resulting blend unlocks new artistic, aesthetic, and expressive possibilities [2, 5, 10]. This perspective on shared performative processes is crucial. In its development, the algorithmic system of the MAD Clarinet evolves from an agent with very limited agency into an entity that embodies a prominent role within the performative process, despite lacking the cognitive activity and artistic intentionality that characterise human creativity [9]. The MAD Clarinet New Set produces an output that is not necessarily directly related to the input it receives, thus breaking any linear input-output relationship. This way, perceptually, it operates as a black box [17], while the processes it carries out remain constrained to design choices of the programmer.

Similar to the dynamics established between various human improvisers, the MAD Clarinet New Set is influenced by the performer's creative intentionality. However, in response to that input, it produces an output that elaborates on that intentionality, thereby offering new stimuli, sparking novelty, and influencing the direction of the performative discourse. This process establishes a feedback loop between the human performer and the

Table 2: Technical and conceptual evolution of the MAD Clarinet

Project version	Technological layer	Algorithm and performer's roles
MAD Clarinet (initial version)	Arduino Uno and Processing. Two PIR sensors trigger sound processes. Sound captured via a microphone	Basic mechanism based on triggers. Delay and reverb effects activated with random values
MAD Clarinet 2.1	Five PIR sensors and a visual module. Mappings are rigid and non-adaptive	The system responds to movement with prerecorded audio/visual effects. No algorithmic agency within the performance
MAD Clarinet 3.0	Two independent Max/MSP patches (harmonizer and stochastic system). Uses CTAI for sound capture	System with limited agency in the performance, requiring the performer to adapt to the algorithmic choices. The stochastic system is generative but can be repetitive
MAD Clarinet New Set	Harmonizer removed. Stochastic system enhanced with the ml.markov library for faster reactivity. Expanded with independent sound layers and hardware controllers	The system contributes to the performative process by re-elaborating the performer's material in real time. This clone blurs the boundary between imitation and autonomous contribution. Agency is redistributed between the entities involved in the performative process but remains contingent on the clarinet player's performative choices

digital agent, strengthening their artistic cooperation. Despite the algorithmic potential of the system, indeed, the MAD Clarinet, in both its more advanced versions, namely 3.0 and New Set, still requires the creativity and intention of the human performer to initiate the performance. Only then, upon receiving a certain amount of data, however minimal, can the computational agent respond by proposing new cues and directions through the analysis and elaboration of that input. Therefore, while the capability of the machine to co-direct the performance is clear, this agency is ultimately contingent on a discourse established by the human player. While bonding the agency of the computational system to the creativity of the performer may mitigate possible tensions arising from attributing performative responsibility, which is strongly linked to intention, to the algorithm, the MAD Clarinet promotes a vision in which the digital system can unlock, by working symbiotically with the performer, new expressive and artistic opportunities otherwise impossible for either of the involved entities to achieve alone. This way, a more profound connection between the performer and the instrument, escaping and moving beyond utilitarism, is exposed. It is worth highlighting that, from the perspective discussed and in relation to the broader HCI field, the MAD Clarinet as a computational agent adheres to the tripartite abstraction of interactive systems proposed by Rowe [18], who describes an initial sensing stage (input) followed by processing and output.

5.2 Limitations and Future Work

Each iteration of the MAD Clarinet introduced new possibilities alongside limitations. Version 2.1 was susceptible to noise due to its sound capture strategy, and the requirement for physical movement to activate PIR sensors often limited interaction precision. Version 3.0 was characterised by the low responsiveness of the stochastic system, which introduced ambiguity in the musical discourse and reduced novelty, flattening the result. The New Set version improves both sound capture and algorithmic responsiveness but still presents limitations in performer-system interaction. In particular, the need for the performer to explicitly trigger the learning process of the ml.markov system makes the relationship between gesture and sonic outcome perceptible, reducing the element of surprise. Rather than lowering the value of the MAD Clarinet as a NIME, these limitations informed its iterative development. Future work will extend the system to include two human performers and one algorithmic agent. In this configuration, the clarinet remains the primary source of data, while the second performer will control additional sonic layers and live-process both the instrumental and algorithmic output. This setup aims to expand the system's performative ecology, enabling more complex forms of interaction, negotiation, and shared responsibility in performance.

6 Conclusion

By investigating the MAD Clarinet through a case research strategy and a practice-based methodology, this study has shown how algorithms embedded in technologically expanded acoustic instruments can shift from peripheral, reactive components to systems that actively shape performative outcomes. Rather than treating algorithmic agency as a fixed attribute embedded in the design of the interface, the longitudinal evolution of the MAD Clarinet illustrates how such agency emerges through sustained performative use, iterative redesign, and the negotiation of breakdowns encountered in real performative contexts. In this sense, the instrument can be understood as a modular system whose components are continuously added, removed, or reconfigured according to artistic needs and ergonomic constraints. From this case study, three design implications relevant to the NIME community can be highlighted. First, algorithmic agency should be considered an emergent and situated property, best supported by modular and reconfigurable system architectures rather than by stable, idealised designs. Second, algorithmic contribution becomes musically meaningful when it operates at the level of form and temporal organisation, for instance by redirecting phrasing, delaying closure, or reshaping structural expectations, rather

than solely extending timbre or gesture-sound mappings. Third, a controlled degree of algorithmic unpredictability may function as a performative affordance, fostering heightened listening, adaptability, and a form of virtuosity grounded in real-time negotiation rather than instrumental dexterity alone. Together, these observations suggest that designing NIMEs as evolving performative systems, rather than transparent and fully predictable tools, can support deeper and more sustained musical engagement. Implicitly, from this perspective, technologically expanded instruments, especially those involving algorithmic expansions behaving as musical agents as in the case of the MAD Clarinet New Set, may also be valuable in pedagogical contexts. These instruments reconfigure virtuosity as the performer's ability to respond to algorithmic-driven contingencies, with the musical form emerging from the ongoing dialogue between human intention and computational processes, requiring the performer to hone and master not only skills regarding playing techniques, but also sharp listening and rapid adaptation.

7 Ethical Standards

The authors declare no conflicts of interest and no funding sources other than those acknowledged. This research involved no human or animal participants beyond the authors. In line with the NIME community commitment to sustainable creative and research practices, the project was developed to minimise waste and support maintenance, further upgrades, and long-term usability of the artefact presented.

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