The Clarinet as a Tangible Acoustic Interface

Rui Travasso

Centro de Investigação em Artes e Comunicação – CIAC, Portugal
Email: ruitravasso79@gmail.com
Manuscript received April 3, 2023; revised May 6, 2023; accepted August 23, 2023; published January 18, 2024.

***Abstract*—This article proposes to support the concept that the clarinet can be transformed and considered as a Tangible Acoustic Interface (TAI) when under the influence of digital media art or digital components. The traditional instrument, developed over centuries by *luthier's* handcraft in collaboration with instrumentalists and composers, underwent an evolution triggered by digital means in the twentieth and twenty-first centuries. Instrumentalists became the new *luthiers* and began to explore this digital path by augmenting and actuating their instruments. This exploration brought new properties and directions for its performance and, also, new conceptions regarding the connection between the actors involved – instrumentalist, instrument, computer, microphone, software, and others. By comparing and analysing concepts and definitions related to interfaces and their interaction, this paper discusses the new concept of TAI, which results from an expanded vision of the subject and first-person experience. This concept discusses a point of view where the instrument can also be a communication channel between different domains, connecting the instrumentalist with other realities and giving the possibility to seek new artistic paths.**

***Keywords*—digital, interaction, interface, instrument, instrumentalist**

I. Introduction

Musical instruments are machines invented and designed by the art of the *luthier* to express non-vocal sounds [1]. It is therefore important to mention the art of the *luthier* because it is an art that is disseminated in a traditional way, reflected in the transmission of cultural heritage from a master to an apprentice who creates and develops the instruments over centuries [2]. Over the years, *luthiers* and instrumentalists have been working together to make the instruments ergonomic and playable and to try to make the instrument a kind of extended part of the instrumentalist's body. It is safe to say that all traditional musical instruments – instruments from the orchestral family - are tangible. In other words, they all require physical contact to function. However, this is not true for all instruments. If we look outside the orchestra, instruments such as the theremin, for example, are instruments of intangible execution. Another aspect to consider – regarding western art music – is the instrumental music performance, which for centuries focused on interpreting a score – by instrumentalists – for an audience. Nevertheless, this type of performance has changed significantly in the last decades, under the digital influence – not exclusively [3]. The instrumentalist has taken on a multidisciplinary role, and the instrument has expanded its functions. When they were invented, their function was to replace the human voice, but evolution has also led them to assume the role of a communication channel between different universes, such as the computer universe. Instrumentalists had to adapt to this new reality, using the instrument in different ways and for various purposes, taking on the role of creator and researcher several times. In summary, this type of instrument – instruments belonging to the orchestral family of western traditions – underwent several digital additions beyond its traditional design and acoustics properties, and they also started to be used to communicate with the computational component and/or with other actors involved in the instrumental music performance.

II. Interface

According to Shanbaum [4], the definition of interface evolved from something describing the communication between hardware and software to one in which an interface can be any technology that mediates relationships between people – artists, viewers, participants, among others - and artwork, influencing the movement and perception of those involved. In other words, an interface enables the communication between two distinct realities: biological, social, or technological. From this definition, we can conclude that an acoustic instrument, which is itself a technological device, can be called an interface. This conclusion is supported by Magnusson [2], who says that a digital instrument has an interface, while an acoustic instrument is an interface. Therefore, the acoustic instrument is the source of sound, and it is a device conditioned by the human anatomy to be playable. Lev Manovich [5] claims that the computer – through its function as a tool for authors, data storage, and distribution of access to what is stored – is a cultural source that functions in a *Human Computer Interaction* (HCI) model. HCI includes physical input and output devices such as monitors, keyboards, and others. With the massive use of computers, their role as an interface for accessing cultural data is changing. This act of using a computer to access online museums, multimedia encyclopaedias, and other digital cultural assets, is what Manovich called *Cultural Interfaces*. Hoven *et al.* [6], identified several designations within the definition of the interface. Accordingly, one of the wider ones is the Tangible User Interface (TUI). For these authors, TUI is the augmentation of the real physical world through the influence of digital information on everyday objects and environments that connect the physical to the digital worlds [6–8]. In this way, Shanbaum [4] states that the aesthetic interface associated with new media art should consider the activation of bodies in space and time, and the body that triggers the interaction should be seen as part of the technology.

In this manner, instruments, already considered as an extension of the instrumentalist's body, are also used as a physical interface to connect the instrumentalist with digital components, for example: to change the original sound; explore virtual environments; explore generative visual art; have a sonic dialogue with the computer or other musicians; to interact in different ways with other performative actors –

musicians, technologies, audience, among others; to achieve randomness; to produce generativity; and other possibilities.

III. Interaction for Several Purposes

Ecology by Garth Paine [9] and ambience by Simon Waters [10], interactivity has always been present in instrumental music performance, insofar as everything about the performance – audience, performative space, concept, musician(s), composer(s), social influence and others – serves as a backdrop in which it develops. Consequently, everything surrounding the performance could indirectly influence it. Although, the interaction in a music performance that allows for a direct influence on artistic pathways has only emerged in recent decades. Focusing on this type of interaction, and only on those that use a computational component, Dixon [11] identifies four categories: (1) navigation – a system of simple choices, for example, yes or no, allowing navigation through a predefined interactive system; (2) participation – a system with multiple choices; (3) conversation – an action/reaction interaction that is bidirectional; (4) collaboration – something that goes beyond participation and conversation and can significantly transform the space and the artistic work, by creating a system in which the intervener becomes the author or co-author. All these systems can be adapted to all actors involved in the performance, as shown in Fig. 1.

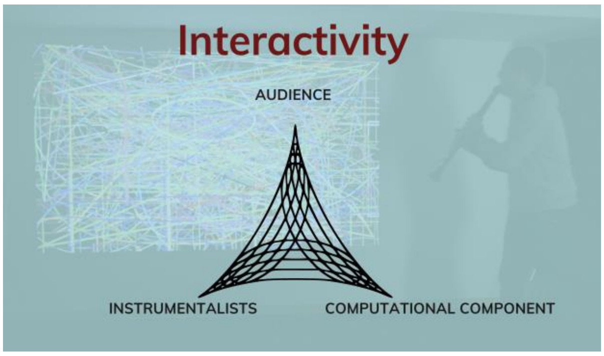

Fig. 1. Interactivity.

In the context of this exploration – in terms of the interaction triggered by an instrument – there is an interaction through various models, such as *Human Computer Interaction* (HCI), *Interactive Music System* (IMC), *Interactive Machine Learning*, and counting, which allow all the components of the performance to have a decisive influence on the performative paths. There are numerous examples, and it is impossible to cite them all, however, for this article, a few examples are given to support them. One of these examples involves the audience and is the project *Activating Memory* [12], which is a work for a string quartet and brain waves. Biosensors monitor the brain waves of four people to generate a score played in real time by the string players. This score and its interpretation, work in reverse, influencing the four people and their brain activity. Moreover, the interaction between musicians, with the instrument as an interface and mediated by a digital system, is the project *Comprovisador* [13] by Pedro Louzeiro. *Comprovisador* creates an interactive dynamic in real-time between a soloist, the other musicians, and the digital component.

Randomness is also explored through interaction with the instruments. *MAD Clarinet 2.1.* [14] explores the pitch of a clarinet performance to develop a real-time visual generative component. *Feedback Cello* [15] is a project about an augmented cello, in which the instrumentalist can play the cello in a traditional manner, but he has also devices to interact with the digital component through the cello, adding characteristics to the conventional sound. In terms of virtuality, the instrument could be used as an interface to interact with virtual musicians, for example, the *Human-Computer Duet System for Music Performance*, where a pianist can play a duet with a virtual violinist [16]. Finally, concerning generativity, *Fond Puction*, developed by Eldridge [17], is a generative duet through a system of live samplers between a cello and a laptop.

To summarize, a digital interaction must have an interface that connects both worlds – digital and non-digital – and this interface can be tangible or intangible. If we make a conceptual analogy with the instrumental music performance, a musical instrument – focusing on the instruments of the orchestra family – is already a kind of tangible interface device that connects the instrumentalist to the music/sound. In recent decades, however, musical instruments have also been used under the digital influence, resulting in augmented and actuated instruments. This influence has changed instrumental performance and increased the role of the instrument. In addition to its traditional function of acting as the instrumentalist's voice, the instrument connects the instrumentalist to the digital components and serves as a tool for interaction.

IV. Musical Instruments: Tangible or Intangible?

The musical instrument may be considered from two different points of view: (1) a device played by an instrumentalist – working as an interface that allows the instrumentalist the possibility to make his musical interpretation and communicate with other components; (2) a cultural artefact with historical value [18]. Concerning this second approach, the instrument can be observed in its function as a device to be played, enabling the recreation of a traditional performance, preserving these traditions, and making them possible through a live performance by serving as a vehicle for something intangible – for example, all baroque orchestras with period instruments. Regarding the first point of view, it occurs when we consider the musical instrument as an object. It is possible to imagine the craftsmen working on it, as well as all processes and developments it went through over years and decades until it reached this shape and these characteristics. In this last case, the instrument itself could be considered a tangible heritage – take, for example, the Stradivarius violins [18]. Still related to tangible heritage, Michael Horn [19] gives the example of an experience with two small groups of children in a room with two different ropes, one with and one without wooden handles. The rope with wooden handles has the connotation of a cultural artefact because of its traditional heritage, so it is more likely that the children who were in the room with the rope, will use it to jump. Like the rope with wooden handles, a traditional instrument has a cultural connotation, and for this reason, its cultural image cannot be separated from the object itself, which inevitably makes it a tangible heritage object.

In short, a musical instrument can be considered a tangible heritage because of its history, tradition, and construction, but it can also be considered an intangible heritage if the sonic result is the focus. In this last case, we could argue that the instrument is the interface that connects the instrumentalist and the audience with this intangible heritage, albeit from different perspectives – the instrumentalist as the promoter and the audience as the receiver.

A Tangible Interface (TI), which is something physical around the user that works as an interface between human and computer, enables a system for human-computer interaction [5]. In this perspective, the musical instrument can be seen as TI, exploring the relationship between the physical and the digital components [8], transforming the traditional instrument into something we might define as a Tangible Acoustic Interface (TAI).

V. Tangible Acoustic Interface

Musical instruments used as TAI can be/or not under digital augmentation – generally designated as augmented or actuated. The difference between a TAI system and actuated/augmented instruments is that the latter is developed to achieve digital features – beyond the traditional acoustic purposes of the instrument – by modifying the acoustic characteristics and/or changing the performance's conditions/environments. TAI systems, on the other hand, are instruments prepared to allow the instrumentalist to interact with the digital component(s) by means of its solid vibration, but not necessarily work with the instrument's sound. However, an instrument with a TAI system could also work as actuated/augmented. According to Crevoisier and Polotti [20], regarding classical musical instruments, the instrumentalist interacts closely and directly with the source vibration having control of the sonic generation. For these authors, for an instrument can be considered a TAI, it should combine the sonic production by the interaction with the instrument, while this process also takes over the processes to generate sound or other components employing a computer. There are two techniques used in TAI, the active and the passive [21]. The active is when the parameters used are based on the absorption of an acoustic energy; the passive is based on analysing the acoustic produced, such as tamping or the touch on a surface. In the specific case of a musical instrument, it can be used as both techniques, active and passive. It is possible to analyse the vibrations produced by an instrument on any surface or object, and it is also possible, for example, to analyse the vibrations produced by touching the instrument or pressing the keys.

There are several types of TAI systems, but one of the most common is related to the parameterization of the acoustic sound, for example, in the aforementioned *MAD Clarinet 2.1.* [14], where the sound of the clarinet, or more precisely the pitch, is used to trigger the generative visual component. The computer identifies the pitch captured from the clarinet's sound and matches it with a matrix. If the pitches produced are: between 21*hz* and 192*hz*, the computer draws a quadratic Bezier curve; between 193*hz* and 390*hz* a line; between 391*hz* and 500*hz* a straight line; between 500*hz* to 792*hz* an arc; between 793*hz* and 993*hz* a circle; and upper 994*hz* a triangle. With this system of TAI, the clarinettist, through its playing, can choose which figures to draw. The musical dynamics are also explored on *MAD Clarinet 2.1.*, in this specific case, de dBs are used as a gate. All sounds produced by the clarinet, with a level lower than -25dBs, do not trigger any geometrical figures.

However, the instrument is used not only as an interface through its sound but also its physical movements – for example the keys. An example is the project *LTU Business*[1], which consists of placing a microcontroller with Wi-Fi inside the clarinet's bell, motion sensors and a battery. With this dispositive, the clarinettist can control additions to the normal sound of the clarinet, lights, film projection, or other digital functions through the physical position of the clarinet. Yet, still relating to the clarinet, the *SABRE Multi Sensor*[2] explores aspects/devices such as air pressure, instrument temperature, sound characteristics, and motion sensors, to connect the instrumentalist to the computational component. *Ultrachunk*[3], although an example related to vocals and not to a traditional instrument, shows the interaction between a musician and an Artificial Intelligence (AI) system, enabling a musical interaction to be observed in the form of a dialogue. On extending the instrument's sonic capacity, *HASGS* is exploring the addition of devices to the saxophone to solve performative issues related to the use of external pedals [22], but other examples can be found in the Augmented Instruments Laboratory [23]. Many other examples could have been given, but those given allow the instrument to be seen as a TAI with different functions and uses. The instrumentalist has been forced to adapt and acquire new performative skills to follow the trend of the last decades [24, 25].

Table 1. New features

Parameter	Technology
Instrument vibration – playing and/or pressing keys	Solid vibration sensors
Using a key as a switch	Solid vibration senor or a tilt switch device
Reed vibration	Polymeter vibration sensor between the reed and the mouthpiece
Teeth pressure	Polymeter vibration sensor between the teeth rubber and the mouthpiece

Summarizing, the clarinet is used as TAI for several purposes in various projects by parameterizing its acoustic characteristics and physical conditions. Based on the examples mentioned, as we can observe in Table 1, it is possible to state that a clarinet can be used as a TAI through several parameters while the instrumentalist uses the instrument in the traditional manner. These interactions are distinguished from the general TUI or actuated/augmented instruments, making the clarinet a vehicle for interaction between the instrumentalist and the digital component(s). Finally, it is essential to mention that this is not a closed list because it is impossible to know about all the works developed regarding this matter.

[1] https://ltubusiness.com/customer-stories/nu-kommer-hightech-klarinetten/ accessed on January 19th of 2023.
[2] https://www.sabre-mt.com/sabre-multisensor accessed on January 19th of 2023.
[3] https://technosphere-magazine.hkw.de/p/2-ULTRACHUNK-3bT9YxV4FmMeGEwxjCedFe accessed on January 19th of 2023.

VI. Author's Experience

Through the author's experience as a clarinettist, collaborating with the project *Comprovisador* and with the project *MAD Clarinet* – Fig. 2, it is possible to verify that the experience regarding the musical performance, playing the clarinet, has changed. These projects change the traditional manner of playing the clarinet. For example, in an orchestra, the clarinettist interprets music with other musicians, using the clarinet only for sonic purposes, with the well-defined goal of interpreting the score. Performances that use the clarinet to interact with digital components, presuppose – possibly – different clarinet techniques and certainly different focuses of attention and concentration. For example, if an artefact requires physical movement to interact and/or has a sonic response to random possibilities, the clarinettist faces several issues that diverge from his traditional performance.

Regarding the movement, the non-stability of the instrument could be a problem in maintaining an excellent airflow to play it or even having control of the reed if the angle between the body and the clarinet is constantly changing. However, interaction with physical movements could bring several advantages regarding the visual context and add new features to different types of performance. In addition, the physical condition of the instrumentalist could be a problem because it could substantially reduce the thoracic capacity. Related to sonic matter, different and unexpected responses triggered from the digital component give rise to various reactions. In sum, there is no limit to the use of TAI, and every project/model has its specificity, using the clarinet in different ways for different purposes. All these kinds of projects have in common that they change the relationship between the clarinettist and the clarinet. Beyond its normal function, the instrument becomes a channel and/or device to communicate with others – digital or non-digital – allowing the instrumentalist to connect to different domains.

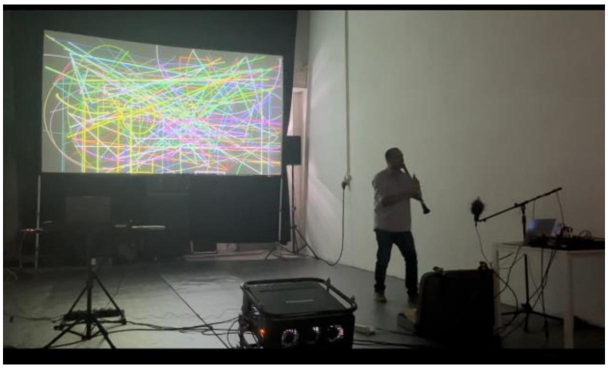

Fig. 2. MAD Clarinet 2.1. Live performance at the *Feira International de Ciência* of Oeiras 2022.

VII. Conclusion

The use of musical instruments has evolved in the digital world and, with this evolution, new definitions and concepts have emerged. As mentioned, this article attempts to identify one of these moments by bringing up the concept of identifying the clarinet as a Tangible Acoustic Interface (TAI), which changes how the clarinet can be used and understood under the influence of a new digital reality. The instrument is no longer used only for musical purposes but also as a device that allows the instrumentalist to communicate with digital components. In this sense, a clarinet as a TAI is when the musical instrument acts as an intermediary between the instrumentalist and the digital component. This connection enables the instrumentalist to interact not only with the digital component but also with other actors involved in the performance.

In summary, the clarinet as a TAI is a sonic device that acts as a remote control for digital music performance under the command of the instrumentalist. Indeed, the clarinet has seen its responsibilities extended, evolving from a sonic transmitter to a control device for various purposes. Lastly, this TAI definition could serve as a basis for new similar situations with other instruments, thus broadening this definition.

VIII. Ethical Approval

This research did not require an ethics committee or IRB approval. This research did not involve the use of personal data, fieldwork, experiments involving human or animal participants, or work with children, vulnerable individuals, or clinical populations.

Conflict of Interest

The author declares no conflict of interest.

Funding

This work is supported by national funds through FCT *Fundação para a Ciência e a Tecnologia, I.P.*, within the project UIDP/04019/2020 *CIAC Programático*.

References

[1] T. Gati, *Anamorphoses in Mixed Electroacoustic Music*, São Paulo: Academic Culture Editor, 2015. doi: 10.7476/9788579837074

[2] T. Magnusson, *Sonic Writing, Technologies of Material, Symbolic & Signal Inscriptions*, Bloomsbury Academic, 2019.

[3] R. Travasso, P. A. Veiga, and J. A. Gomes, "Major events that changed the instrumentalists' performance," *Int. J. Music Sci. Technol. Art*, vol. 4, no. 1, pp. 50–62, 2022. doi: https://doi.org/10.48293/IJMSTA-86

[4] P. Shanbaum, *The Digital Interface and New Media Art Installations*, Routledge, 2020. doi: 10.4324/9780429467899

[5] L. Manovich. (2022). Lev Manovich: All Articles, 1992–2007. [Online]. Available: https://eur-lex.europa.eu/legal-content/PT/TXT/PDF/?uri=CELEX:32016R0679&from=PT%0Ahttp://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:52012PC0011:pt:NOT

[6] E. V. D. Hoven, J. Frens, D. Aliakseyeu, *et al.*, "Design research & tangible interaction," in *Proc. TEI'07 First Int. Conf. Tangible Embed. Interact.*, 2007, pp. 109–115. doi: 10.1145/1226969.1226993

[7] O. Shaer and E. Hornecker, "Tangible user interfaces: Past, present, and future directions," *Found. Trends Human-Computer Interact.*, vol. 3, no. 1–2, pp. 1–137, 2009. doi: 10.1561/1100000026

[8] B. Ullmer and H. Ishii, "Emerging frameworks for tangible user interfaces," *IBM Syst. J.*, vol. 39, no. 3–4, pp. 915–930, 2000. doi: 10.1147/sj.393.0915

[9] G. Paine, "Acoustic ecology 2.0," *Contemp. Music Rev.*, vol. 36, no. 3, pp. 171–181, 2017. doi: 10.1080/07494467.2017.1395136

[10] S. Waters, "Performance ecosystems: Ecological approaches to musical interaction," *Electroacoustic Music Studies Network EMS-07 Proceedings*, 2007.

[11] S. Dixon, *Digital Performances: A History of New Media in Theater, Dance, Performance Art, and Installation*, The MIT Press, 2007.

[12] J. Eaton. (2022). The paramusical ensemble: A multi-user brain control platform for people with motor disabilities. [Online]. Available: https://joeleaton.co.uk/project/activating-memory/

[13] P. Louzeiro. Comprovisador. [Online]. Available: https://comprovisador.wordpress.com/

[14] R. Travasso, "MAD Clarinet 2.1.: Sound travels," in *Proc. 2022 Third International Conference on Digital Creation in Arts, Media and Technology (ARTeFACTo)*, 2022, pp. 1–4. doi: 10.1109/ARTeFACTo57448.2022.10061246

[15] A. Eldridge and C. Kiefer, "The self-resonating feedback cello: Interfacing gestural and generative processes in improvised performance," *Proceeding New Interfaces Music. Expr.*, pp. 25–29, 2019.
[16] Y. J. Lin, H. K. Kao, Y. C. Tseng, M. Tsai, and L. Su, "A human-computer duet system for music performance," in *Proc. the 28th ACM International Conference on Multimedia (MM'20)*, 2020, pp. 772–780. doi: 10.1145/3394171.3413921
[17] A. Eldridge, "Fond punctions: Generative processes in live improvised performance," in *Proc. Generative Arts Practice'05: A Creativity and Cognition Symposium*, 2005, pp. 41–51.
[18] K. Howard, "Musical instruments as tangible cultural heritage and as/for intangible cultural heritage," *Int. J. Cult. Prop.*, vol. 29, no. 1, pp. 23–44, 2022. doi: 10.1017/S0940739121000436
[19] M. S. Horn, "The role of cultural forms in tangible interaction design," in *Proc. TEI 2013 - Proc. 7th Int. Conf. Tangible, Embed. Embodied Interact.*, 2013, pp. 117–124. doi: 10.1145/2460625.2460643
[20] A. Crevoisier, P. Polotti, and I. Politecnico, "Tangible acoustic interfaces and their applications for the design of new musical instruments," in *Proc. 2005 Int. Conf. New Instruments Music. Expr.*, 2005, pp. 97–100.
[21] T.-R. Chou and J.-C. Lo, "Research on tangible acoustic interface and its applications," in *Proc. ICCSEE*, 2013, pp. 913–916. doi: 10.2991/iccsee.2013.230
[22] H. Portovedo, P. F. Lopes, and R. Mendes, "Composition models for augmented instruments: HASGS as case study," in *Proc. NCMM 18: Nova Contemporary Music Meeting*, 2018, p. 6.
[23] Centre For Digital Music Queen Mary University of London. Augmented instruments laboratory. [Online]. Available: http://instrumentslab.org/index.html
[24] R. Travasso, P. A. Veiga, and J. A. Gomes, "New aspects regarding the instrumentalists' performance," in *Proc. 9th International Conference on New Music Concepts*, 2022.
[25] R. Travasso and J. A. Gomes, "Evolving instrumentalist – A continuous trajectory," in *Proc. I International Congress "Intersection: art, society and technology in musical innovation"*, 2021, pp. 186–191.