“WYPYM”: A Study for Feedback-Augmented Bass Clarinet

Claudio Panariello
Sound and Music Computing
KTH Royal Institute of Technology
Stockholm, Sweden
claudiop@kth.se

Chiara Percivati
University of Antwerp
AP Hogeschool Antwerpen
Antwerp, Belgium
chiara.percivati@ap.be

ABSTRACT

This paper explores the concept of co-creativity in a performance for feedback-augmented bass clarinet. The bass clarinet is augmented using a loudspeaker placed on the bell and a supercardiod microphone placed inside the instrument's body, allowing for the generation of feedback that is subsequently processed by a computational system to create new sound material. This feedback loop creates a symbiotic relationship between the performer and the electronics, resulting in the co-creation of the final piece, with the performer and the electronics influencing each other. The result is a unique and ever-evolving musical experience that poses interesting challenges to the traditional instrument–electronics and composer–opera relationship. This paper reports on both the hardware and software augmentation of the bass clarinet, and presents *“WYPYM - Were you a part of your mother?”*, a piece written especially for this augmented instrument and its feedback system.

Author Keywords

Augmented instruments, Feedback systems, Co-creativity, Music Human-Computer Interaction, Performance

CCS Concepts

•Applied computing → Sound and music computing; Performing arts; •Hardware → *Sound-based input / output;*

1. INTRODUCTION

This paper describes a long–term collaboration between the two authors, respectively a composer and a clarinetist. The collaboration started in 2020 as part of the project “Different Tubes” [1], aimed at investigating clarinet preparation, in its widest sense, through collaborative practice. The project evolved into realizing a DIY (Do It Yourself) augmented bass clarinet based on feedback, and exploring its potentialities through a music performance. This paper summarizes the technical implementation of the augmented bass clarinet, and presents *“WYPYM - Were you a part of your mother?”*, a piece written for this augmented instrument and its feedback system.

2. BACKGROUND

An augmented instrument is the result of adding new sensors to an existing instrument, thus allowing the performer to control digital audio effects through their gestures. [1] Some notable examples include the augmented trumpet [9], trombone [4, 11], violin [2], and piano [3, 14].

One sub-category of augmented instruments uses audio feedback to enrich the acoustic instrument's timbre. These instruments generally employ an actuator and a microphone [2], which are coupled through the resonant body of the instrument and connected in a feedback loop that includes analogue and/or digital signal processing [7] (see e.g. [22, 18, 6, 15, 21, 13]). Examples of feedback-augmented woodwind instruments include the WindBack [12], a feedback-augmented alto saxophone, and the ResoFlute [12], an electronically augmented traditional Western concert flute. Interestingly, little attention has been devoted to augmenting the (bass) clarinet via feedback. Only one attempt has been documented in the academic literature [3], the feedback-augmented alto clarinet by Stelios Manousakis[4]. As of yet, there are no examples of feedback-augmented bass clarinets in the literature.

2.1 Co-creation and collaborative practice

The primary objective of this collaboration was to explore the preparation of the bass clarinet. We initially focused on the potential use of feedback as a means of enhancing the instrument's timbre and capabilities. Furthermore, both of the authors were keen to investigate how they could break down the traditional hierarchy of roles, specifically the relationship between the composer and performer, the composer and the piece, and the performer and the instrument. In the development phase of the feedback-augmented bass clarinet, we approached the system from an ecological perspective [5], in which the performer and the instrument are coupled via feedback processes. Eventually we framed the research collaboration through the lens of co–creativity. Co–creativity refers to the possibility that artists and computers can collaborate integrating their specializations and ultimately co–acting in the creation of the final musical work

[1] `http://www.chiarapercivati.net/different-tubes/`

[2] Or any means that can transduce acoustic vibrations to an electrical signal.

[3] One of the examples outside – and undocumented by – academia is the work by Edith Steyer, `https://edithsteyer.bandcamp.com/album/beat-keller-edith-steyer`.

[4] `https://modularbrains.net/portfolio/feedback-augmented-alto-clarinet/`

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[8]. In this sense, our feedback system and the composer extend each other's creativity. The feedback-augmented bass clarinet becomes a sort of living organism performing with the instrumentalist. In this extended collaborative process artists and machines do what they can do best, at their own pace. This collaboration can lead to unexplored music outcome that might not be possible with traditional music composition techniques alone.

Figure 1: The final augmented bass clarinet.

3. BASS CLARINET AUGMENTATION

The hardware and software components of the implementations are described in detail below. The design was guided by the fact that we wanted the augmentation to be as simple as possible, require cost–effective materials, and adopt open–source software, thereby allowing for replication and elaboration by others.

3.1 Hardware

The augmented bass clarinet consists of a miniature microphone placed inside the body of the instrument and a speaker cone placed on its bell (see Figure 1). Since the aim was to produce feedback inside the instrument, the hardware placement was crucial, resulting in many refining prototyping stages.

We used a common $5''$ woofer (40 W power, 8Ω impedance) placed on the bell of the instrument. To keep the speaker in place, a self-made wooden double frame was built (see Figure 2). The speaker cone was connected to a cheap stereo amplifier.

We found that placing the microphone inside the bass clarinet's body was most effective for triggering feedback with all keys closed. However, using one of the tone holes to insert the microphone would block a key and limit fingerings. To solve this, we built a plastic extension for the neck, from which a miniature microphone could be passed through (see Figure 3). This allowed us to test different microphones with different capsule dimensions. In the final setup, we used a dynamic super–cardioid miniature microphone. Interestingly, the neck extension had the collateral effect of introducing a non–linear pitch deviation throughout the entire range of the instrument and altering the timbre. These aspects were explored in the final piece (see Section 4.1).

Figure 2: Close-up of the self-made wooden double frame to attach the loudspeaker to the bass clarinet's bell. The speaker cone is screwed to the first frame, and the internal border of the two frames is lined with foam insulation tape, self-adhesive, to avoid scratches. The two frames are then held together with four screws.

3.2 Software

The software implementation is written as a SuperCollider[5] [23] patch that can be run on any computer connected to a standard soundcard (see Figure 4). The patch is based on a network of feedback delay lines fed by the sound incoming from the microphone placed in the body of the bass clarinet. The input is processed undergoing self-regulating mechanisms using adaptive criteria [19] and sent to the speaker cone placed on the instrument's bell, thus re–entering into the microphone. As such, the input is shaped by the instrument itself. The augmented bass clarinet and feedback system thus become one single unity, that shapes itself over time.

In terms of signal flow, the input audio signal is analyzed to extract audio features that will be used to allow the system to self-regulate. In particular, the electronic patch computes spectral flatness, spectral entropy [16], and adaptive spectral centroid. The latter, inspired by the work of Sanfilippo in [20], is a measure of the spectral centroid

[5] https://supercollider.github.io/

Figure 3: Close-up of the miniature microphone passing through the neck thanks to a plastic joint made from segments of PVC pipe (a T-piece with a lateral segment). The microphone is then plugged with a cylinder of cork.

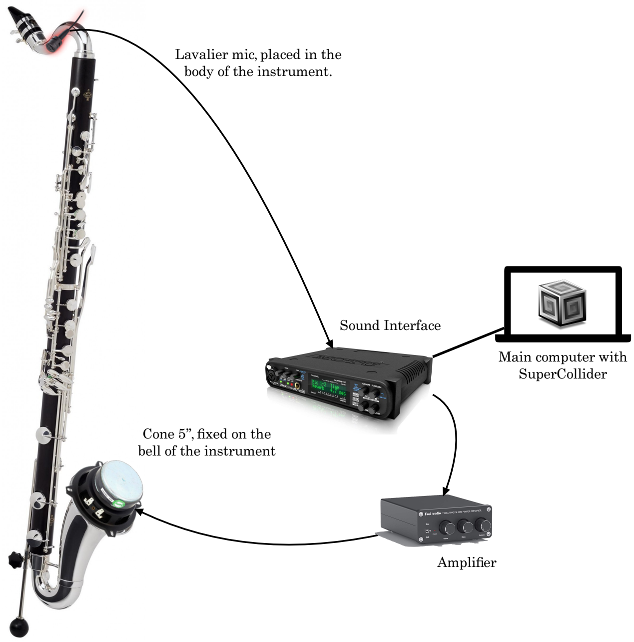

Figure 4: Schematic of the overall technical setup.

which dynamically moves trying to minimize the differences of the RMS spectral regions above and below the centroid.

The measure of the adaptive spectral centroid is used to drive the centre frequency of a bandpass filter, which bandwidth depends on the spectral entropy measure. This signal feeds the network of feedback lines. The network consists of two main lines with delays which feed themselves and each other. The amount of signal added onto itself is regulated by the flatness measurement. The network also includes two granulators, with grain size and grain trigger as functions of the adaptive spectral centroid, spectral flatness, and overall input amplitude. A final control curve based on negative feedback is used to prevent the output to saturate.

The patch also provides a graphical user interface (GUI) (see Figure 5) that displays the adaptive spectral centroid frequency, the value of the spectral flatness, and the value of the spectral entropy. The GUI also shows a timer, the spectrogram of the output sound, and volume levels of input and output.

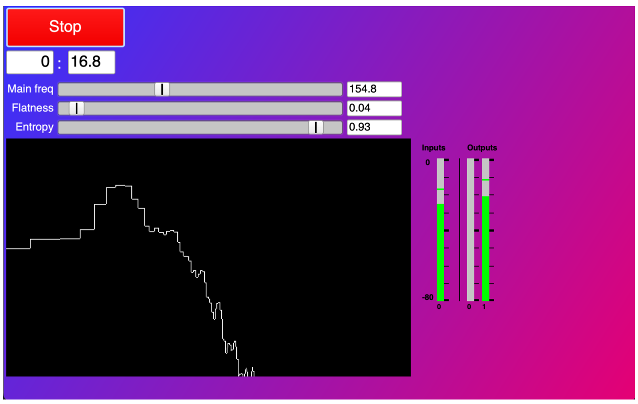

Figure 5: Screenshot of the GUI (developed in SuperCollider) that is shown to the performer.

4. CASE STUDY: "WYPYM"

After several months of iterative prototyping and fine-tuning, the final version of the feedback-augmented bass clarinet was used in several music performances. A music piece was also specifically composed for the instrument: *"WYPYM - Were you a part of your mother?"*. The title of the piece is a nod to the paper with the same name, published in [10], in which the author discusses if a mammalian embryo/fetus is a part of the gestating organism, or merely contained within or surrounded by it. This topic, apart from all of its biological and physiological considerations, resonated immediately with our project: what is the relationship between the augmented bass clarinet and its performer? Where do we set the border between the sound produced by feedback and its interaction with the environment? And finally: who is actually part of this environment?

"WYPYM" attempts to tackle these questions from an artistic perspective, representing a music exploration of the relationship between the performer on the augmented bass clarinet and the feedback system. The speaker cone establishes the first loop of feedback with the microphone placed within the body of the instrument. The performer manipulates and modifies this initial feedback loop while playing. Conversely, the performer is also heavily influenced by the sounds that are sent back into the instrument by the speaker cone. Both the performer and feedback system are in a state of constant adaptation, moving between different regions of precarious balance.

The final version of the feedback system described in Section 3.2, is the result of several stages of creative coding, a discovery-based process based on code exploration, iteration and reflection [17]. In these stages, the code was tested in the composer's studio, where he could confront himself with the music outcome and self-reflect on the aesthetics that he tried to embed in the code, and the aesthetics that was emerging from it. Stable versions of the code were then deployed to the performer. The two authors repeatedly engaged in a discussion about aesthetic and technical outcomes, after which the process was iterated with a new version of the code. Eventually, the final code of the feedback system tended to exhibit a somehow temporally dilated handling of sound events. While an appropriate amount of time is usually necessary for feedback to be activated, it is also true that the timing of this specific system was influenced by personal artistic inclinations of the composer who coded it.

Although *"WYPYM"* includes a music score, it should be viewed as a starting point rather than a destination. The performer is encouraged to independently explore the system and discover paths that are particularly interesting, thus creating their own unique interpretation of the piece. It can be helpful to begin with simple gestures to become more familiar with the system: opening and closing keys without blowing; playing sostenuto pitches to create beatings with the feedback material; working on finding balance regions; working on the opposite, playing in a region where the feedback material is not currently located and trying to force the system to follow the instrument.

The performance of *"WYPYM"* is constrained by a time limit of 10 minutes, which serves as a creative challenge to develop a meaningful and coherent musical evolution within the given time frame. This constraint becomes a driving force for the creative process, encouraging the exploration of new forms and techniques. The emphasis is on listening and reacting to the electronic system's response in order to create a cohesive and dynamic performance. As a matter of fact, the most important aspect of this piece is to listen to the electronic system's reaction and try to create a dialogue with it. As a result, there is no unique or correct way to perform it.

4.1 Performance challenges

The augmentation of the instrument and its incorporation in the above described technological setup offer to the performer a number of challenges and points for reflection. A first set of performance challenges is experienced by the performer already when playing acoustically on the augmented instrument. The lengthening of the instrument neck to accommodate the microphone produces a non-linear pitch deviation throughout the range of the instrument. Depending on the region, this deviation can vary between a minor second and a major third from the expected tone (see Figure 6).

Moreover, the instrument's timbre is slightly transformed by the presence of the preparation. To the trained ear, the augmented bass clarinet sounds a bit less concrete and defined than an ordinary one. This is due to the heterogeneity of the materials that we used for the neck extension, and can be experienced by listening to the full recording of *"WYPYM"* (see Appendix A).

It is important to bear in mind that this collaboration was born in an artistic research context set out to explore the artistic potential of clarinet preparation, a defamiliarising practice par excellence. For this reason, we not only accepted these deviations from the instrument norm (in terms of pitch and partially timbre) but fully embraced them as additional challenging and enriching elements of our work.

On the other hand, a detuned bass clarinet can be challenging when trying to react extemporaneously to feedback sounds. The performer must identify the note, find the correct fingering on the detuned instrument, and play the desired pitch. This process requires extra effort from the performer and may not be suitable for all players or performative contexts. To address this, the performer initially practiced with the support of the tuning chart until the resulting sounds became more familiar. She then focused her attention on some pitches that seemed to trigger the feedback better than others, and annotated fingering patterns that proved to be particularly effective in this respect.

The greatest challenge for the performer is the very presence of the feedback, of an autonomous sound that runs through the whole body of the instrument and up until the performer's mouth cavity. The performer can filter and, to a certain extent, control the feedback sound by modifying the acoustic properties of the clarinet as a resonant tube. This can be achieved by opening and closing finger holes, using the mouth cavity as a resonant chamber, or using the position of the tongue to control and block the upper end of the clarinet. The feedback sound is perceived from the performer's position as a quasi-autonomous wave which grows within the clarinet bore, at times gently, at times extremely forcefully – in fact, when detaching the mouth from the mouthpiece, the performer felt air blown strongly out of the instrument through the mouthpiece tip.

The actions operated by the performer and the instructions computed by the patch shape and combine the two sounds in a multitude of different ways. They can blend smoothly, create beatings, or clash violently. Together, these sounds create a sort of *metasound*, not clearly identifiable as either an ordinary clarinet or pure electronics. As a matter of fact, this unique resulting sound is the product of the containing and filtering effect of several interconnected bodies: the "body" of the instrument (its bore), the performer's one, and the technical objects that form the feedback system. This makes it practically impossible, even for the performer while playing, to clearly determine the source of certain sounds, especially in more agitated or loud moments.

At the same time, the perception of one's body and surroundings while playing is dilated by the use of feedback: in particular, this setting brings the well-known role of the fingers and mouth cavity as filters to a new level of complexity and interest. But even more importantly, the feedback-augmented bass clarinet questions and breaks down the traditional hierarchy of roles between the performer and

Figure 6: Tuning chart for the augmented bass clarinet, starting from the lowest possible note and moving upwards in a chromatic scale for three octaves. The lengthening of the instrument neck to accommodate the microphone produces a non linear pitch deviation throughout the range of the instrument. In the chart, the first staff shows the expected pitch, while the second displays the actual resulting sound. The colored lines represent deviation from the expected pitch expressed in intervals. Depending on the region, this deviation can vary from a minor second (m2) to a major third (M3).

the instrument, that conventionally considers the performer as the active part in the process and relegates the instrument to a more passive function. The feedback-augmented bass clarinet presents then an ideal setting to disprove this usual paradigm, since both the performer and the feedback-augmented bass clarinet are alternately "active" (generating sound, proposing materials) and "passive" (filtering sound, reacting to the materials) parts in the creative process.

5. CONCLUSIONS AND FUTURE WORK

In this paper, we present *"WYPYM"*, a study for augmented bass clarinet and feedback system. The feedback-augmented bass clarinet extends the traditional approach to classical bass clarinet performance, utilizing feedback as a means to expand the creative potential of both the performer and the composer, fostering a dynamic and collaborative process of music co-creation, not only between artists, but also between artists and computers.

The collaboration between the performer on the augmented bass clarinet and the feedback system, exemplified in the performance of *"WYPYM"* described in Section 4, is integral to the creation of the final outcome. The performer's actions and the system's responses are inextricably linked, to the point that it becomes impossible to separate the performer from the computational system. The performer and the system co-create the final performance, with both playing equally important roles in shaping the outcome. This highlights the unique nature of this type of performance, where the traditional distinctions between performer and instrument, and between performer and composer, are blurred.

Lastly, this work also demonstrates the potential for innovation in music performance through the use of low-cost, easily accessible resources, both in terms of hardware and software, highlighting the DIY approach that can be potentially replicated by any bass clarinetist [6].

Through the performance of *"WYPYM"* we also identified some areas of further investigation. As discussed in Section 4.1, some of those are of technical nature (like the non-linear pitch deviation), or of more performative nature (the co-acting with the feedback sounds). Other areas of improvement relate to the feedback system itself: although the time constraints described in Section 4 served as a creative challenge, they also had the effect of revealing some limitations in terms of responsiveness of the system. As a matter of fact, the system showed a tendency for temporally dilated music actions. Constraining the performance to 10 minutes required then for some ad-hoc adjustments in the code to make it more responsive.

To conclude, the performance of *"WYPYM"* served as an artistic and technical evaluation of the feedback-augmented bass clarinet by the two authors, showing its potentialities and weaknesses. The latter will be addressed in future iterations and developments of the project. Future work will also include more explorations of the augmented instrument with additional musicians.

6. ETHICAL STANDARDS

This work was carried out under the research programs "Different Tubes" of the University of Antwerp/ARIA and "Dig-

[6]However, we acknowledge the uneven distribution of material and epistemological resources globally, particularly between the Global North and South. Moreover, we recognize that some may face greater challenges in accessing the necessary resources. Therefore, we encourage further exploration and collaboration to make innovative musical expression accessible to all, regardless of their geographic location or access to resources.

ital Tubes" of the Royal Conservatoire Antwerp. The authors have no conflicts of interest to declare.

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APPENDIX

A. SOUND RECORDINGS

A full recording of the piece, together with the SuperCollider code of the feedback system and the score of *"WYPYM"* can be accessed at the following link: `https://tinyurl.com/mr37zed9`.