IMPROVING SIGHT-READING SKILLS THROUGH DYNAMIC NOTATION – THE CASE OF COMPROVISADOR

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ABSTRACT

This paper proposes an approach to sight-reading improvement using a dynamic notation system – Comprovisador. The system was created with the goal of coordinating musical performances in which a soloist improvises and an ensemble of musicians sight-read a staff-based dynamic score. This situative score is therefore generated by Comprovisador's algorithms which feed on the soloist's improvisation. Musicians read the score from computer screens, in a local network. This kind of musical practice requires performers to be good sight-readers. A good sight-reader (of traditional notation) often relies on pattern recognition, understanding of musical structure and other abilities which come from being familiarized with certain repertoires – but when dealing with situative scores these abilities are seldom relevant. With this consideration, a Practice Tool was developed as part of Comprovisador to allow musicians to get acquainted with the system's notation interface and to learn (not the notes, but) how to deal with not being able to predict patterns or structure. After further development, this tool was tested by music students and teachers in order to assess its applicability in an educational context regarding improvement of sight-reading skills. A study with those participants is presented to validate the utility of the system and identify areas for further development.

1. INTRODUCTION

The motivation on addressing issues related to sight-reading has evolved from two directions: 1) as a qualified solfege teacher with over fifteen years of experience, the author has been interested in ways to help students improve their skills, and 2) as a creator, while developing a real-time notation system and putting it into action during rehearsals and performances, the author has worked in collaboration with competent sight-readers, looking into ways of improving the system's notation interface in order to meet and expand their abilities.

The system – Comprovisador – was originally designed to carry out comprovisation performances using real-time algorithmic composition and dynamic staff-based notation. To engage in such musical practice, performers are expected to have excellent sight-reading skills as well as the ability to adapt to new performance situations. A Practice Tool was created within Comprovisador to help performers improve those skills while getting acquainted with the system's notation interface. Later, this was seen as an opportunity to broaden the system's application and adapt it as a tool for music students.

In order to assess the system's applicability in this new educational context, a user study with quantitative and qualitative data is discussed herein.

2. BACKGROUND

As described in recent publications [1, 2, 3], Comprovisador is a system designed to enable mediated soloist-ensemble interaction using machine listening, algorithmic compositional procedures and dynamic notation, in a networked environment. As a soloist improvises, Comprovisador's algorithms produce a score in real-time that is immediately sight-read by an ensemble of musicians, creating a coordinated response to the improvisation. This interaction is mediated by a performance director who does so by manipulating algorithmic parameters. Implementation of this system requires a network of computers in order to display notation (separate parts) to each of the musicians playing in the ensemble. More so, wireless connectivity enables computers – and, therefore, musicians – to be far apart from each other, enabling space as a compositional element.

Comprovisador consists of two applications – host and client. Both are developed in Max 7 [4] using Bach library [5] for its notation features and computer assisted composition tools. To this date, the system has been used in eight public performances, which are documented in the project's website: comprovisador.wordpress.com [6]. The website [1] also contains video examples of the dynamic score in action.

The name "Comprovisador" derives from the term comprovisation, which has been used by several authors such as Lawrence D. "Butch" Morris [7], Richard Dudas [8] and Sandeep Bhagwati [9], among others. Bhagwati has

[1] Furthermore, it is possible to download and install the client application. Musicians can install it if they are to perform in a future "Comprovisação" or simply if they wish to practice sight-reading.

proposed an eloquent definition of the term [2]. A simplified version according to my reading of his definition, would be: a musical performance context where both composed and improvised elements coexist in aesthetically relevant interdependency.

Comprovisador was indeed conceived as a tool to enable such musical performance contexts where solo improvisation and composed response are, in fact, interdependent: thanks to real-time composition algorithms, the composed response is highly dependent on incoming improvised material; and by virtue of a feedback loop, the improviser's decisions are affected by composed elements. One can say it forms a dialectical relationship, for a composed response could not exist without the improvisation and the improvisation could not be the same without the composed response. This interdependency is further extended by the presence of a mediator.

Aesthetic relevance is the main concern when tailoring composition algorithms [3]. Likewise, it is of utmost importance when making choices in notation type and notation interface design [4]. In Section 3, these choices will be examined in order to better understand what the system demands from the performer in terms of sight-reading skills and, consequently, the original goals of the Practice Tool which was later adapted for use in an educational domain.

3. DEVELOPMENT

3.1 Notation Type

Although there are several different approaches to real-time notation (many of which are featured on animated notation dot com [10], a website run by Ryan Ross Smith), most choices fall into two broad categories: staff-based notation and non-staff notation [5]. The latter has many advantages: it encourages performers to be creative in translating non-conventional signs into sound and music, it exempts performers from the responsibility of not playing wrong notes and, potentially, it embodies an aesthetic value as a visual or multimedia experience.

On the other hand, while it is true that staff-based notation may put performers in a less creative and less forgiving situation (and the idea of projecting the score so that audiences may follow performers' mistakes might create additional anxiety to the situation), it is also true that it enables a greater compositional control over certain musical parameters – namely, pitch and harmony. Wrong notes as well as timing discrepancies and other audible mistakes are bound to occur. But it is possible to take this failure expectancy into account and somehow incorporate it in the aesthetics of the piece.

A good example of this incorporation is Nick Didkovsky's "Zero Waste" [11, 12], for sight-reading pianist and real-time transcription algorithm. In this piece, the performer sight-reads two initial measures of software-generated music while the algorithm transcribes the performer's rendition. The transcription is immediately displayed to the performer and the process repeats itself. Both performer and algorithm are expected to fail in order for proliferations of the initial gesture to take place. As Georg Hajdu points out [12], the abstract, chromatic quality of the material selected for the opening bars prevents an error from being perceived as such. Instead, error becomes the shaping force of the piece.

During early development stages of Comprovisador, the concept of "extreme sight-reading" proposed by Jason Freeman [11] had an influence on the choice of using staff-based notation. The influence came from the concept expressed in the title itself rather than from a particular example found in the article. Strategies were conceived towards the design of a functional notation interface, considering the problem of error and all its surrounding issues. The element of time was found to be crucial in this conception, as will be exposed in Section 3.2.

3.2 Notation Interface Design

3.2.1 Synchronized Attacks

In a hybrid type of performance such as comprovisation, it is presumable that the listener will be looking for clues as to what is being improvised and what is being composed – and even how effective is the notation system. Regarding listener's ability to discern between composed and improvised music, Lehmann and Kopiez propose that " 'togetherness' and precision of an ensemble may indicate composition, while a higher degree of entropy could signal improvisation" [13]. In this line of thought, we find synchronization to be an effective way to let the listener perceive organization as opposed to chaos, hinting at what is being composed in real-time.

In a synchronized attack, even if a few notes are false or missing, there is no way the listener can tell. And, as we have seen, it is plausible to have a mistake becoming a shaping force – in this case, by influencing the improviser's playing.

In order to have synchronized attacks in an extreme sight-reading context, the issue of time is of great importance. Firstly, musicians need time do recognize each note or group of notes (or, as John Sloboda would phrase it, to register pitch symbols in memory [14]); secondly, they need time to prepare the notes on their instrument; lastly, they need to be precisely cued – and effective cuing involves very specific timing. And motion (see [15]). In any of these three steps, problems may arise leading to delays and jeopardizing synchronization. Hence, establishing a reading time window and implementing a visual cuing device (consisting of a bouncing ball – see Figure 1) were our first design choices. Both would have to be time-adjustable, according to musical goal and/or technical difficulty.

[2] "[M]usical creation predicated on an aesthetically relevant interlocking of context-independent and contingent performance elements" [9].

[3] The compositional procedures used in Comprovisador are explained in [1]. A discussion on performance mediation using the system's control interface is made in [3].

[4] A thorough description of the notation interface can be found in [2].

[5] One could say graphic notation, but that term would not encompass works where notation goes beyond the scope of graphical signs. Such is the case of Jason Freeman's "Glimmer" where colored LED light tubes convey pitch and loudness information to performers. [11]

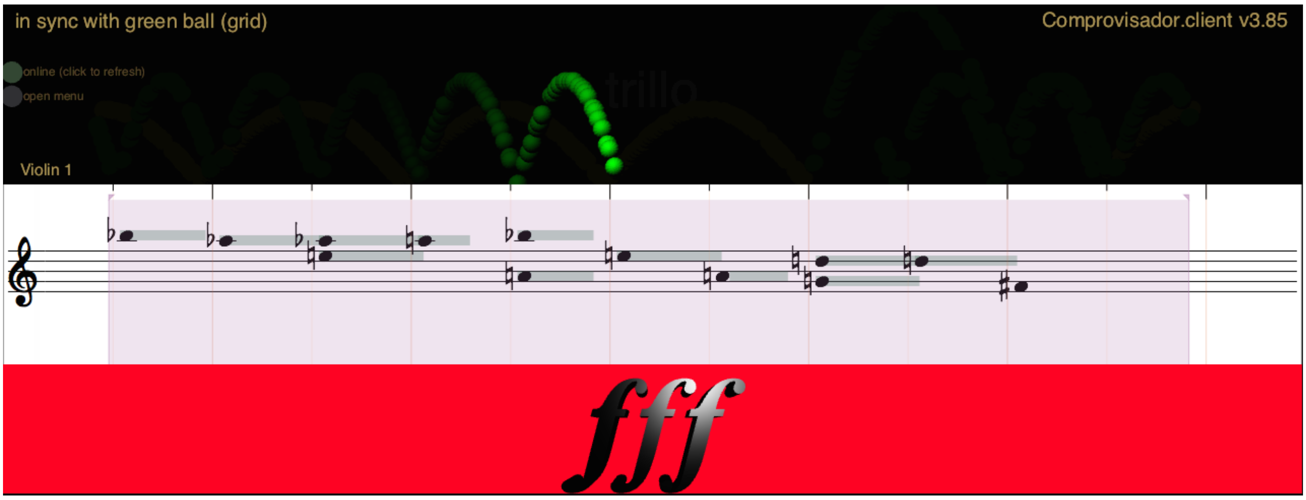

Figure 1. Comprovisador.client – notation interface – proportional notation and bouncing ball.

Figure 2. Comprovisador.client – notation interface – “loop (non-sync)” – dual instrument configuration.

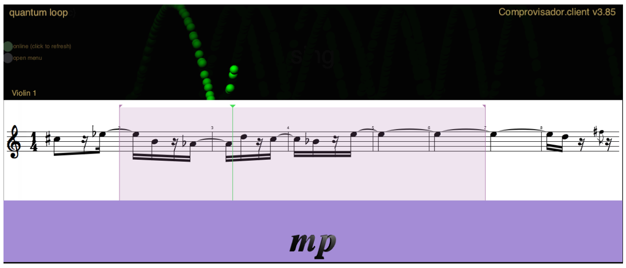

Figure 3. Comprovisador.client – notation interface – standard rhythmic notation and loop region.

3.2.2 *Motivic Exploration*

Apart from synchronization, another perceptual evidence of compositional process could be motivic exploration. If the listener is confronted with a melodic fragment being played simultaneously by various instruments and/or transformed in a coherent manner, he or she might perceive it as composition. Here, simultaneity refers to a given short time interval we perceive as present (specious present – see [16]). It does not imply unison or homophony but rather polyphony (and even micropolyphony).

This textural procedure, if done with no regard to synchronization and no special attention to meter or rhythm, allows musicians to serenely read the score and render the melody with far less mistakes than otherwise would be possible. At the same time, a dense texture will help in disguising the occasional missed note. This led to the use of proportional notation, a looping melody, a linear cursor and the verbal instruction: “non-sync” (see Figure 2).

3.2.3 *Standard Rhythmic Notation*

It should be interesting to provide rich and cleanly organized textures, made of melodic, rhythmic and harmonic elements, as well as formal ones, like repetition and variation. Standard notation (see Figure 3) allows all that while adding two new levels of time: meter and rhythmic durations. The problem lies in the fact that the more elements are added, the more difficult sight-reading becomes and the more exposed musicians feel.

A progressive approach to the various elements could conceivably be the answer. We can compare it to when a musician is learning a new piece of music. If they encounter a difficult passage, they might focus solely on the notes, repeating the passage several times until they are sure to play all the correct pitches. And only then will they try and play those pitches in precise rhythm and tempo. Emulating this process, when in Comprovisador standard rhythmic notation is activated, the notes that were previously displayed in proportional notation will be kept the same, enabling the performer with the chance to focus solely on the new element: rhythm.

3.3 Practice Tool

Development and enhancement of these and other features of Comprovisador was only possible thanks to the feedback of musicians who tested the system in rehearsals and performances. As a way to enable performers to get acquainted with the system’s notation interface and its idiosyncrasies, a Practice Tool was developed featuring an elementary graphic user interface (GUI) for parameter control. This way, even before the first rehearsal, they were able to experience sight-reading in a simulated performance context, being subject to unpredictable note patterns (thanks to a random walk algorithm) and to a specific cuing strategy – the bouncing ball.

The Practice Tool was especially useful in situations where musicians and developer were in different locations. The tool allowed to obtain valuable feedback from a distance and perform bespoke enhancements in time for the first rehearsal.

4. A POSSIBLE NEW DIRECTION

Carlos Guedes [17] states that one of the goals on the development of real-time composition applications is “to open a new and potentially revolutionary way of education and active enculturation with unfamiliar musical styles”. What about dynamic notation applications? Can they play a significant role in a new way of improving sight-reading skills?

Music sight-reading has long been a subject of research in the field of music cognition. Many authors have pointed out pattern recognition and understanding of musical structure as a few of the most important skills among good sight-readers [18, 19, 20, 14, 21]. Pianist Boris Goldovsky, interviewed by Thomas Wolf, said: “you read only a fraction of the notes and you guess at the others. A good sight-reader gets a total image of a page and extrapolates what is going on exactly” [19]. Evidently, such an ability can only come from being familiarized, through years of training, with the rules and patterns common to a certain style of music, a certain repertoire. Also, this statement is based on the assumption that the sight-reader will have the chance to at least take a glance at the whole music page before beginning to play. But most dynamic score sight-readers do not have that luxury. Hence, they have to develop other skills in order to become successful at that task. Could generative algorithms, such as the one implemented in Comprovisador’s Practice Tool, be of aid to the development of those skills?

While searching for applications or systems that use dynamic notation and aim for sight-reading improvement we did not find anything relevant. There are great amounts of smartphone applications intended for music notation learning and some do use dynamic score technology. Yet, the majority uses previously written (coded) music excerpts and it is rare to find one that joins dynamic notation technology with the power of generative algorithms.

In July 2017, during a talk at the 2nd ”European Saxophone Congress”, the possibility of using Comprovisador’s Practice Tool as a way for saxophonists to improve sight-reading skills in a microtonal context was presented. A trial had been carried out with a small group of professional saxophone players and results were presented during the talk. Some adaptations were done to the system in order to be possible to collect user practice data for study. No other changes were made. Results pointed to potential benefits in using the application but it became clear that a progressive learning approach strategy would have to be devised.

parameter name	parameter description
range	allows control of range in concert pitch and in transposition (automatically set when choosing an instrument)
note selection	a selectable keyboard allows turning on or off certain notes or even whole registers
microtone selection	microtones can be hand-picked from a `[bach.tonnetz]` object
microtones length	enables the user more time to stabilize fingering and tunning whenever a microtone is output
tone division	selects all notes matching the set tone division
scale picker	selects all notes matching the chosen scale
polyphony	sets maximum, ranging from single notes to full polyphony (value depends on the instrument)
chord threshold	sets a threshold in milliseconds under which no chords are allowed (only single notes)
reading time window	adjusts the sight-reading window in milliseconds
maximum step	sets the maximum melodic step in half-tones
note rate or “flux”	ranging from slow to fast (proportional notation)
rhythm base	minimal units for standard notation (allowing creation of simple patterns, and to progress)
variation rate	limits the occurrence of variations of a melody (in loop mode), ranging from static to frequent
user presets	enables the user to store and recall parameter presets

Table 1. Comprovisador.client – Practice Tool’s parameter list (user controlled). New parameters are marked in bold.

Such a strategy was indeed planned out aiming not only at the microtonal issue but also at a more general context. Its implementation consisted on designing a new GUI for the Practice Tool with more controllable parameters and the possibility of storing user presets (see Figure 4 and Table 1). The goal was to enable the user to match the difficulty level of the algorithmic outcome to his or her degree of proficiency.

During the implementation of this GUI, another trial was carried out – this time with music students and teachers of different instruments – in order to assess the usefulness of this tool in a generic music education context [6]. However, parameters controlling standard rhythm notation were not yet implemented when the trial took place.

5. METHOD

The trial was carried out in a music school in Portimão (south of Portugal), with 14 participants, 9 of which were students and 5 were teachers, playing the following instruments: saxophone (3 participants), violin (4), piano (3), guitar (2), double bass (1) and trombone (1). Students’

[6] It is worth noting that this tool should never be considered as a substitute for actual repertoire sight-reading, which is the best way to acquire pattern recognition skills.

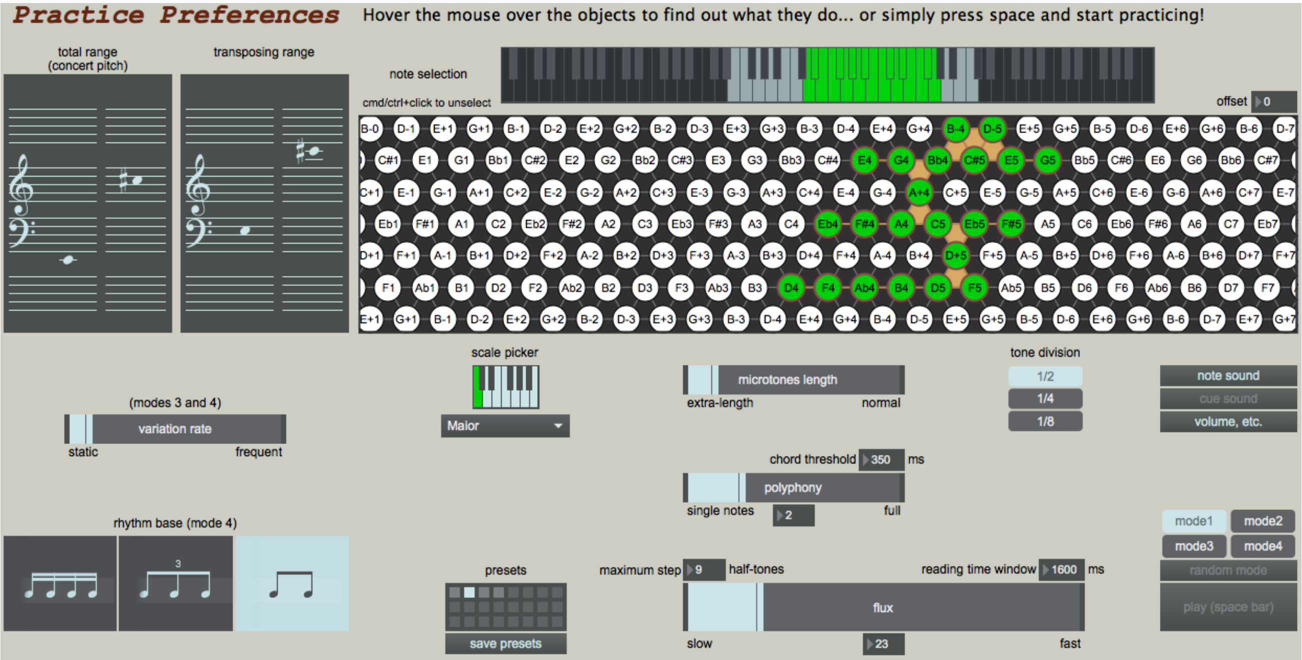

Figure 4. Comprovisador.client – practice preferences window.

ages ranged from 13 to 18. The level of experience of the participants was heterogeneous, as can be inferred by the age range and by the fact that it mixes students and teachers. Yet, none had had experience with microtonality.

Participants were individually asked to sight-read from the computer screen without any detailed explanation. As they were playing, some parameters would be manipulated in an attempt to match their proficiency level and, while doing so, we would explain what each parameter was meant to do. Towards the end of the exercise, it was explained how parameters could be stored as user presets for later recall as a way to keep track of progress. Participants were then asked to explore this feature in conjunction with the parameters previously manipulated.

With instruments that enable microtonal playing, an approach to the matter was carried out, activating only one microtonal note (in some cases, two notes) [7] and limiting the range so that the algorithm would focus on the register surrounding the chosen microtonal note. Also, longer duration time was assigned to this same note in contrast to regular notes, this way allowing stabilization.

Participants were directly observed and were videotaped while playing, for further observation. After the exercise was complete (which took around 15 minutes per participant), they filled up a form containing three sections: quantitative assessment, qualitative assessment and suggestions.

[7] Some solfege books [22, 23] address note reading through a block-building approach where, for example, lesson 1 features only notes C and D, lesson 2 introduces note E, and so on. This approach may be useful when applied to any type of exotic notation – as microtonal is for a large number of musicians, students and professionals alike.

	Notes	Micr.	Std.R	Prp.R	Dyn.S
N Valid	14	11	14	14	14
Mean	5,14	4,55	4,14	4,57	4,57
std.Dev.	,770	,873	1,351	,938	1,158
Min.	4	3	2	3	3
Max.	6	6	6	6	6

Table 2. Assessment of Comprovisador.client as a tool for sight-reading skills improvement. Categories: standard notes, microtones, standard rhythm, proportional rhythm, experience with dynamic notation systems. Rating: from 1 to 6 (1 being not useful and 6 being very much useful).

6. RESULTS AND DISCUSSION

From observation, it was possible to perceive that all participants, with the exception of two students, were able to figure out (by themselves or needing very little explanation) how to play in sync with the bouncing ball.

In all cases, with proportional notation it was possible to match the parameter settings to the proficiency level of each individual so that it always became an interesting sight-reading challenge.

The progressive microtonal approach, starting with known notes / fingerings and adding only a selected microtonal note (assigned with a longer duration), was regarded as successful (from observation, backed by answers to the form). Violinists seemed to struggle a bit more than other instrumentalists but we were not able to find a relevant cause for that contrast. Pianists obviously did not experience this part of the exercise.

As expected, it was observed that work needed to be done in the standard rhythmic notation part, in order to enable beginner students with a viable tool.

From form responses and regarding quantitative assessment of the application as a tool for sight-reading skills improvement (see table Table 2), results were encouraging in the category of standard notes. Results were also positive in the categories of proportional notation, experience with dynamic notation systems, and microtones. Although, the latter had less three responses (pianists). The lowest rated category was standard rhythm, as expected.

There was an optional category “other” where two participants (both of them wind instrument teachers) added “tuning”, rating it with the highest score. They highlighted the benefit of playing in tune with the sound produced by the computer.

Regarding qualitative assessment of functionality and appearance, the responses were the following. The bouncing ball was considered useful / effective / helpful, except for two students who deemed it confusing. The dynamics bar was considered useful / effective / legible, but nonetheless some participants reported it to be too fast / difficult to comply with / very challenging; one participant highlighted the 3D animation as a good solution. Verbal instructions had very similar responses.

Regarding the observed and reported ease to synchronize with the bouncing ball, it is in line with Richard Picking’s findings on his study where he compares three types of animated time-location tracker, in the context of reading music from computer screens (versus reading from paper). The subjects of his study reported the “jumper tracker” (which is analog to our bouncing ball) to be the preferred one [24].

My preliminary conclusion taken from observation and commentaries is that young students tend to ignore dynamics and verbal instructions – and they are fine with it. Advanced students and teachers tend to get a bit frustrated when not able to comply with everything (notes, dynamics and instructions) but also feel rewarded when they do.

There were many voluntary commentaries and suggestions. The preset management system and GUI for parameter control were regarded as having good configuration / ease of use / good control over “excess of randomness”. Pianists complained about insufficient spacing between staves. There is actually only enough space for the central C line – which is standard in many computer music applications that use GF staves – but pianists are not necessarily used to it. Some participants mentioned that the duration line should be of a lighter color because it interferes with the perception of the staff-lines. This is now fixed, as shown in Figure 1. An interesting suggestion was to implement a way to have harmonic structures as a base for the generative algorithm.

Without surprise, many comments about standard rhythm were made, for example: “Everything is changing all the time due to excess of variations”, or “It needs patterns”.

To sum up, results seem encouraging (although they have to be put in perspective regarding the small sample size) suggesting there are advantages in the use of Comprovisador.client’s Practice Tool as a way of improving certain sight-reading skills, with special focus on skills pertaining to the dynamic notation realm. Regarding the least explored field – standard rhythm – we believe there is equal potential, now that the GUI’s development is complete.

7. FUTURE WORK AND CONCLUSIONS

Much work has been done, meanwhile, in terms of correcting the reported issues, namely the color of the duration line, which is now translucent green, as well as the standard rhythm controls.

Apart from the controls, standard rhythm was enhanced at the quantizer level. Here, instead of writing two 4/4 measures, the algorithm writes eight 1/4 measures. This allows two things: 1) complex patterns are conveniently delineated by bar lines and thus easier to decipher; 2) long notes unfold into tied quarter notes, making it easier to count the beats – which is especially important when a loop is set in a way that a long note becomes truncated. In Figure 3, we can see this happening: there are three tied quarter notes that would otherwise be written as a dotted half note. The loop region is truncating the 3rd quarter note. If it was written as two 4/4 measures, the loop region would end in an ambiguous, white portion of the measure, corresponding to the duration of the dot, which would be confusing for the reader.

In the medium term, we might pursue the suggestion of implementing a way of having the generative algorithm obey a harmonic structure. This structure could be cyclic or generative.

Future developments shall include articulation signs and other features that will be made available in the upcoming Bach version. Among these features is an algorithm for respelling accidentals in a more musical way, in atonal contexts.

One goal, of course, is to do further testing, if possible with a larger sample size and during a longer period of time, so to be able to measure actual learning progressions and observe commonalities that might emerge among multiple participants.

Acknowledgments

I should like to thank my PhD supervisors Christopher Bochmann and António de Sousa Dias for their advice and continued support. I would also like to thank Filipe Valentim, for providing all the conditions necessary for the trial to take place, and all the participants. Furthermore, I want to thank Adriana Ferreira Alves, from the Institute of Social Sciences of the University of Lisbon, for the data analysis and Sara Ross for proofreading. My attendance to TENOR 2018 conference was only possible thanks to the financial support of Câmara Municipal de Lagos, Portugal. This research is supported by FCT by means of a PhD studentship (POCH / EU). I dedicate this work to the memory of composer José Luís Ferreira, avid supporter of this research.

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