Co-Tuning Virtual-Acoustic Performance Ecosystems: observations on the development of skill and style in the study of musician-instrument relationships

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ABSTRACT

In this paper we report preliminary observations from an ongoing study into how musicians explore and adapt to the parameter space of a virtual-acoustic string bridge plate instrument. These observations inform (and are informed by) a wider approach to understanding the development of skill and style in interactions between musicians and musical instruments. We discuss a performance-driven ecosystemic approach to studying musical relationships, drawing on arguments from the literature which emphasise the need to go beyond simplistic notions of control and usability when assessing exploratory and performatory musical interactions. Lastly, we focus on processes of *perceptual learning* and *co-tuning* between musician and instrument, and how these activities may contribute to the emergence of personal style as a hallmark of skilful music-making.

Author Keywords

Constraint, Improvisation, Musical Skill Acquisition, Parameter Space, Perceptual Learning, Physical Model

CCS Concepts

• **Applied computing → Sound and music computing**;

1. BACKGROUND

As part of our ongoing development of a virtual-acoustic string bridge plate instrument [1, 2, 3], currently known as *VASBPI*, an observational study was designed to evaluate how different musicians explore and perform with the instrument over multiple practice sessions. This study is part of a wider research project that is investigating the potential of physical modelling as a means of creating new and complex musical interactions (i.e. non-linear, modally rich, with a degree of unpredictability) that are both constrained by mechano-acoustic physical laws and tunable through real-time parametric exploration. These design principles are motivated by our desire to create instruments that leverage the musicality of experienced performers while encouraging the development of novel techniques, strategies and configurations in performance. In the case of VASBPI, a string-bridge-plate model is driven by a string-board interface, with real-time control of the model's 32 adjustable parameters via a Knobbee 32 interface [4]. Parameter configuration allows for adjustments to model behaviours such as gain, frequency, dimensionality, coupling positions, dampening, inharmonicity, modal mass ratio, bridge stiffness and spring nonlinearity (for a detailed description of parameters, see [3]). Our aim in combining multiple tunable parameters with tactile interactions through the string-board interface is to allow for musicians to explore a rich, diverse and sometimes surprising sonic environment, thus creating performance ecosystems [5] that are particularly suited for improvised musics.

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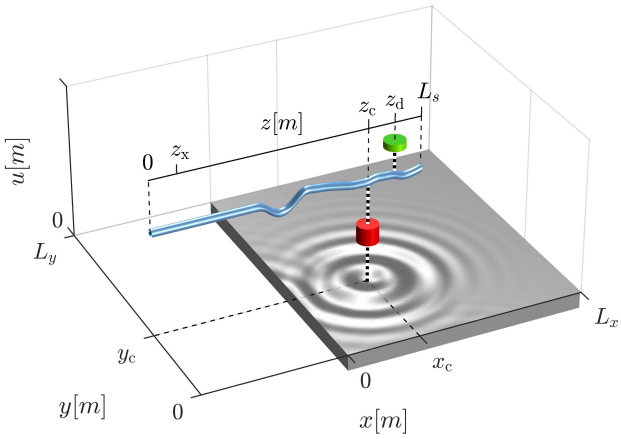

Figure 1: Geometry of the string-bridge-plate model. The red cylinder represents the bridge mass, and the green disk indicates where the string damper is located.

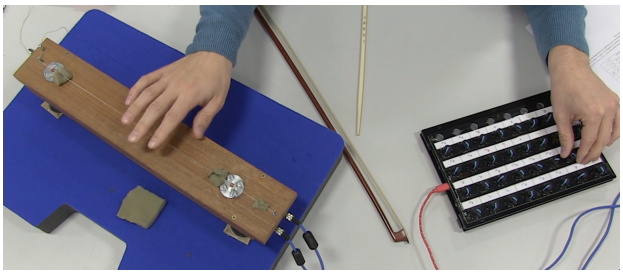

Figure 2: String-board and Knobbee 32 interfaces

2. PERFORMANCE ECOSYSTEMS

Our methodology for studying how musicians explore and perform with VASBPI embraces a performance-driven ecosystemic approach, which contrasts with the quantitative usability and evaluation metrics commonly found in traditional HCI research. Our use of "performance ecosystems" as a contiguous and contingent view of musical interactions across people, places and things draws on the work of Simon Waters [5] as well as earlier formulations cited by Waters from other artist-researchers such as John Bowers, Jonathan Impett and Agostino Di Scipio. This body of work points towards the need to move beyond cognitivist frameworks that focus on the assumed continuities between information processing, intentionality, expressivity and control. Arguments have been made [6, 7, 8, 9, 10, 11] that greater attention needs to be given to how skilful music-making emerges through a distributed sense of agency, playfulness, agility and adaptation brought about by instabilities, resistances and ambiguities within performance ecosystems. These arguments also resonate with certain trends in HCI research that advocate for greater attention to be paid to *felt experience* over musical artefacts [12], as well as to the role of ambiguity as a positive resource for design [13]. All of this suggests that when designing musical interactions we should not be focused on helping "users" to *cope* with a device in an effort to realise a predefined task; rather, we

should be aiming to provide diverse opportunities for *exploration* and *play* within an open yet tangible scene of constraint.

Our approach also recognises the importance of working with experienced musicians throughout our research process as a way to ensure that design and engineering expertise is informed (and challenged) by performance expertise (and vice versa). We follow Owen Green's insight that practice-led research can be "complementary to quantitative, controlled-condition methods" by augmenting the "generality of observation" found in these methods "in order to contend with musical practice in local, socially entangled, contentious and noisy complexity" [14]. As in the author commentary accompanying [15], we view the need for an increase in "critical reflection and communication across different areas of the NIME community", and suggest that sustained engagement with professional music-making practices will allow for "the long-term development of performance pedagogies, repertoire and critical discourse necessary for the legitimisation of a performance community within the wider NIME community" [ibid.].

3. DESIGNING FOR STYLE

In [16], *personal style* is presented as an alternative to *musical expression* as a hallmark of skilful music-making. Likewise, expression in the context of NIME has been critiqued by [17] as implying the problematic view that performances of music (or music-making devices in themselves) should be judged on their ability to communicate extra-musical content which is somehow added on to a pre-existing text. Instead, personal style, i.e. "a pattern of stylistic variations that may be uniquely attributable to a particular performer-system interaction" [16], allows us to account for "non-expressive" improvisatory music-making practices where meaning emerges *through doing* rather than *by declaring*. Even outside of the context of explicitly improvisational musics, performers are commonly celebrated not simply for technical accuracy and fidelity to a score or oral tradition, but for their unique interpretations and signature style of playing (e.g. Lauryn Hill's vocal performance on the Fugees' version of *Killing Me Softly With His Song*, or in Glenn Gould's version of Bach's *Goldberg Variations*). Therefore, with VASBPI we have aimed to develop an instrument capable of not just *low floors* and *high ceilings* (i.e. easy entry for beginners with longer-term potential to develop technical virtuosity), but also what [18] refers to as *wide walls* (i.e. diverse interaction possibilities).

The role of constraint in the development of personal style has been studied [19, 20, 21]. These studies demonstrate that personal style is often developed because of (rather than in spite of) constraint, and they corroborate the view that musical skill can be meaningfully cultivated through interactions with highly restrictive or simplified musical devices [22]. While VASBPI clearly has a much wider range of potential interactions than the single-button instruments or *infra-instruments* cited above, primarily as a result of a complex and tunable parameter space, we likewise value the role of designed constraints to help focus musical engagement and exploration. In our development of VASBPI, our decision to use physical modeling for sound synthesis allowed for the system to be inherently constrained by mechano-acoustic physical laws. Our design has aimed to preserve the limits imposed by the Newtonian nature of the model, as our experience suggests that such a constraint allows for a sense of material *physicality* to be recognised in performances with VASBPI by performers and audience members alike (similar yet distinct motivations can be found in [23 and 24]).

4. STUDY METHODOLOGY

The design of our study was informed in part by qualitative observational research methods [25], and shares similarities with methodologies employed in other recent studies involving musicians and new musical instruments [6, 19, 20, 21]. Our mix-mode methodology enabled us to collect multiple types of data on the interactions between musicians and VASBPI, including self-reported participant experiences, audio-visual documentation and quantitative measurements of parameter changes. Data was collected at multiple points during the study, allowing us to observe how behaviours and perceptions changed over time.

Six experienced musicians were recruited to take part in a four week study involving two 1hr individual practice sessions per week. Each participant first completed a consent form and entry questionnaire, the latter of which was used to gather information on their musical background and experience of working with computer-based music systems. The first session included a short introduction to VASPBI explaining how the system functioned, i.e. how to provide an input signal using the string-board and how to adjust various parameters using the Knobbee. This introduction was verbal with limited demonstration in order to minimise encouragement of specific modes of interaction. A user manual listing basic operations with a description of all parameters was also provided to all participants. A number of items were provided to actuate the string-board interface (e.g. guitar plectrum, cello bow, metal rod), and participants were told they were welcome to bring their own tools for this purpose. In sessions 2 through 8, each musician engaged in approximately 40-50 minutes of unstructured practice time with VASPBI. Directly following each practice session, musicians were instructed to play a "short piece of music" (generally ~5-10 minutes in length), and complete a practice log describing their experience in the session. Recordings were made of the "pieces" at the end of each session, including parameter changes (via OSC), audio, screen capture and video of physical interactions with the system. After the second week participants were given a midpoint questionnaire, and after the final week an exit questionnaire, both with the purpose of capturing additional details on their experience of playing with VASBPI.

4.1 Preliminary Observations

The study was specifically designed to give us greater insight into how different musicians explored VASPBI, as well as which parameters tended to invite exploration. In an informal pilot study with an earlier version of VASBPI [2] we observed two distinct approaches to how musicians engaged with the parameters of our system: 1) what we called "a design sense", in which musicians focused on open exploration of the parameter space; and, 2) "a gestural sense", in which rapid adjustments to parameters were delivered in a performatory manner. We have observed similar yet also more nuanced combinations of behaviour in the current study, which has led us to develop provisional definitions for the following two modes of engagement: 1) *exploratory*: actively testing out the affordances of the instrument in relation to each musician's apparent capabilities and curiosities; 2) *performatory*: deployment of specific musician-instrument configurations including techniques, gestures, and longer-scale compositional and/or improvisatory strategies. It is important to note that *these two modes of engagement are not mutually exclusive*, as we observed several instances where both of the above definitions fit the same sequence of actions, e.g. exploration of the edges or breaking points of the system as an explicit performance strategy. Additionally, it is important to note that *these two modes of engagement do not comprehensively describe all possible forms of engagement*; yet, focusing on how musicians engage in these two modes over multiple practice sessions may reveal meaningful insights into artistic learning processes [6].

Figure 3 below illustrates our estimated levels of engagement in the recordings at the end of each session for two different musicians.

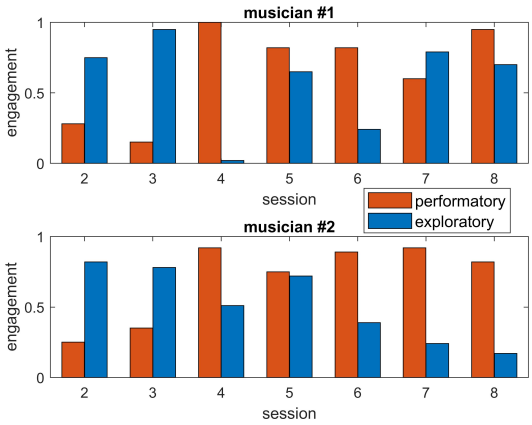

Figure 3: Performatory & exploratory modes of engagement

Exploratory and performatory level estimations were arrived at through intersubjective agreement between the three authors of this paper based on observed levels of engagement with these two modes as defined above (for extracts from sessions with musician #1 see supplementary videos or www.paulstapleton.net/portfolio/vai). This process began with independently assessed scores (from 0 for no engagement, to 1 for total engagement) derived from the recorded and self-report data from each session. Where discrepancies in estimations occurred, differences were debated and evidence was reviewed before arriving at an agreed score. Initial debates included how to score musicians that played minimally, with very gradual parameter adjustments. In such cases where focus was clearly maintained, it was agreed that these instances should be judged as having high levels of engagement through *active listening*.

Once initial "performatory" (P) and "exploratory" (E) estimations were completed, we shifted focus towards calculating the level of change for each parameter in the OSC data recordings from each session. For each parameter, "activity" (A) was calculated as the sum over the absolute values of all changes over the session time. All parameter activity values were then normalised such that the highest value (over one session) equaled 1. The engagement-specific activity values were then computed as $P = w_P \cdot A$ and $E = w_E \cdot A$, where w_P and w_E are the 'weight' estimations that we assigned to each session. This is one approach to merging qualitative assessment with quantitative measurement to aid in the descriptive analysis of musical processes.

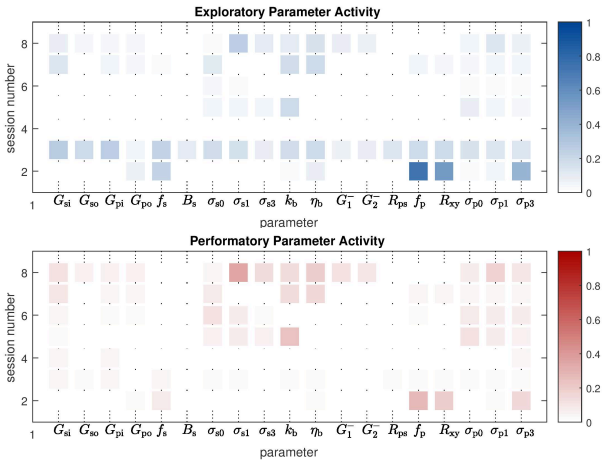

Figure 4: Activity levels in selected parameters

Figure 4 is a representation of these calculations for a selection of parameters across all sessions for musician #1 from Figure 3 (note, no recordings were made in the introductory session). Our aim in this stage of the process, which is still ongoing, is to better understand which parameters were interacted with broadly over time and across different modes of engagement. Notably, for musician #1 our observations and interpretation of the data suggest an initial period of exploration across an increasingly wide range of parameters in sessions 2 & 3, followed by a highly performatory session with virtually no parameter adjustments from the start of the recorded "piece". In the logs for session 4, musician #1 reports: "Today I wanted to create a stylistically different recording to the two previous. I kept the dampening of the plate completely off and tuned the size of the plate to the note the string produced when bowed." Rather than staying with this single configuration, subsequent sessions reveal continued exploration of the parameter space with activity clustered around a select group of parameters including: input gain, frequency dependent string and plate dampening, bridge stiffness and spring nonlinearity. High levels of performatory engagement are maintained during these later stages of exploration.

For most musician-participants in our study, such as those plotted in Figure 3, we have observed a general trend towards increased performatory engagement between earlier and later sessions. For both musicians #1 and #2, a noticeable shift toward performatory engagement appeared to occur in session 4, which we speculate was motivated by a desire to focus on performing with a specific configuration of parameters based on experience gathered from prior explorations. This is in part evidenced by the log entry for session 4 by musician #2: "I decided to build on the previous session's approach […] playing with the parameters 'dialled in'." Despite this shared performatory shift in session 4, the configurations, techniques and strategies deployed were remarkably different for each musician.

Notable at this stage of the analysis are the highly divergent approaches to performance which appear to emerge not only in the playing of musicians #1 and #2, but across all six of our musician-participants. Different approaches ranged from gestural frenetic playing common to much free improvisation (e.g. Derek Bailey's guitar playing) to slow-moving textural drones or rhythmically driven compositions. The development of numerous techniques were observed across all musicians, employing the string-board and Knobbee both individually and in combination. Established instrumental techniques such as *con legno* bowing and percussive finger tapping were used to drive the model through the string-board, as well as more unusual techniques including the use of eye glasses or a battery powered cappuccino whisk. Such string-board techniques at times resulted in a significant degree of sonic diversity without the need for real-time parameter adjustments, although string-board focused playing was generally preceded by careful parameter tuning as described in the logs of musicians #1 and #2 above. Rapid adjustments to parameters such as the modal mass ratio of the plate, as well as the exploitation of system noise and feedback via high gain settings, were used to drive the model without direct contact to the string-board. Percussive techniques with chopsticks were combined with quick changes to string and plate damping parameters to create gestures that rapidly expanded or contracted the scale of reverberation. Adjustments to spring nonlinearity combined with string plucking and board scraping created chaotic rattling noises. We view the emergence of these techniques, which support the development of diverse performance styles with VASPBI across a range of musicians, to be an encouraging preliminary outcome warranting further evaluation in the next stage of our analysis.

5. LEARNING & CO-TUNING

Our preliminary observation of stylistic developments with VASPBI in relation to both *exploratory* and *performatory* processes builds on Adnan Marquez-Borbon's [6] use of *perceptual learning* [26, 27] in the context of musician-instrument *enskilment* [28]. In Marquez-Borbon's words: "Exploratory activity yields knowledge about environmental possibilities, affordances, and one's own capabilities" [6]. This was observed as the primary mode of engagement in early sessions for all musician-participants in our current study. Marquez-Borbon goes on to suggest: "Performatory activity, on the other hand,

works as a process of expectation and confirmation. Performatory activities also yield knowledge that may further spur exploratory information seeking" [6]. This view is likewise corroborated by our preliminary observations, where most musicians increasingly alternated between free play, testing out of specific constraints imposed by both VASBPI and themselves, and more deliberately structured actions such as the use of new techniques to create specific musical gestures. Observation and analysis of alternations between exploratory and performatory action may contribute towards a deeper understanding of how musical skill acquisition occurs within novel musical ecosystems, and is therefore worthy of further study.

Lastly, our prioritisation of real-time *parametric explorability* over the modular connection of elementary objects more common to virtual instrument design [2], can be underpinned by the concept of *co-tuning* [9, 10]. Drawing on enactive approaches to extended cognition [29], co-tuning recognises that musicians, instruments and other actors within a performance ecosystem do not simply have a causal relationship to each other; rather, they are "mutually constituted in this relation" [29] through acts of performance. Otherwise put, co-tuning moves away from an understanding of musical interaction that is primarily based on what the instrument or performer can do on their own, towards how the two (re)configure each other in the process of bringing a performance ecosystem into being. Our current study has been explicitly designed to gather observational and experiential self-report data on how musicians tune the parameters of our instrument, but our preliminary analysis suggests that co-tuning is also happening more broadly across individual instrument-musician relationships. Such tuning may be a crucial part of the learning process that shapes the development of stylistically individuated musical interactions.

6. FUTURE WORK

Full analysis and findings from our current study will be the subject of a future journal article. Informed by these findings, VASBPI will continue to go through additional design iterations and, along with our future related virtual-acoustic instruments, will continue to be developed through ongoing performance-based research. We have also identified the need for further research into: different methods of interacting with certain individual or groups of parameters beyond what is afforded by the Knobbee; alternative methods of driving the model beyond the current string-board; and, potential embedded computing solutions to allow for VASBPI to be integrated into a wider range of custom instrument designs.

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