Donohue+: Developing performer-specific electronic improvisatory accompaniment for instrumental improvisation

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Electronic systems designed to improvise with a live instrumental performer are a constant mediation of musical language and artificial decision-making. Often these systems are designed to elicit a reaction in a very broad way, relying on segmenting and playing back audio material according to a fixed or mobile set of rules or analysis. As a result, such systems can produce an outcome that sounds generic across different improvisers, or restrict meaningful electroacoustic improvisation to those performers with a matching capacity for designing improvisatory electroacoustic processing. This article documents the development of an improvisatory electroacoustic instrument for pianist Maria Donohue as a collaborative process for music-making. The Donohue+ program is a bespoke electroacoustic improvisatory system designed to augment the performance capabilities of Maria, enabling her to achieve new possibilities in live performance. Through the process of development, Maria's performative style, within the broader context of free improvisation, was analysed and used to design an interactive electronic system. The end result of this process is a meaningful augmentation of the piano in accordance with Maria's creative practice, differing significantly from other improvising electroacoustic instruments she has previously experimented with. Through the process of development, Donohue+ identifies a practice for instrument design that engages not only with a performer's musical materials but also with a broader free improvisation aesthetic.

1. INTRODUCTION

The Donohue+ project is an effort to design a system that fuses ideas of performer/computer interaction established in the fields of Music Information Retrieval (the extraction of meaningful information and data from musical material) and audio descriptor analysis (the analysis of an audio signal for defining characteristics such as loudness, pitch and timbral roughness) with the practice of free improvisation. Donohue+ attempts to centre computer accompaniment at the most immediate level of a performer's interaction, making programming decisions based around the aesthetic of pianist Maria Donohue[1] and

free improvisation more broadly. As such, it is a system providing augmentation to an improvising player, contributing material to Maria's performative interests thematically, technically and structurally, while always rooted in the moment. This article will discuss the decision-making process that informed Donohue+, in the context of the conceptual threads of free improvisation, computer improvisation systems and Maria's own performance interests.

2. FREE IMPROVISATION: IDEAS AND DEFINITIONS

Donohue+ is, first and foremost, a musical project centred on the electronic augmentation of the musical lineage of free improvisation. Maria's work operates within the sphere of free improvisation, and, as such, it is important to consider the broader context of this field. The ideas that shape free improvisation are self-referential and, at times, contradictory, constructed not from a shared ideology but from a diverse range of practices, histories and interactions shaped by the players that populate the community.[2] One of the most complex questions posed by free improvisation is: 'What does it mean to "freely" improvise?' In developing Donohue+, it was important to begin with this question and to understand the range of responses to it in relation to Maria's practice in order to conceptualise an instrument that could contribute meaningfully to an improvised musical situation.

Free improvisation is a title given to the form of musical production that is most often considered to have originated in the 1960s as a response to and branching of the American jazz and avant-garde genealogy. However, the title 'free improvisation' is not accepted unanimously. This 'non-idiomatic' music, as Derek Bailey (1980) would describe it, is called many things, sometimes controversially, depending

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[1]Maria Donohue will be referred to in this article by her first name to avoid confusion between referring to Donohue the performer and the Donohue+ program.

[2]Maria identifies many different improvisation communities as essential to her practice, having worked with the Glasgow Improvisers Orchestra (GIO), the Instant Composers Pool and the Australian Art Orchestra among others.

on who you are talking to. To some it is 'free music',[3] 'instant composition',[4] 'spontaneous music',[5] 'free playing'[6] and to some it is just 'improvisation'. The wealth of vocabulary referring to the field is only another unique aspect of this music; its contradictions and co-existences are a central part of its nature – something David Toop (2016) refers to as the 'maelstrom' of improvisation. These complexities are not to be ignored, and, as Bailey also highlighted, they are best considered by speaking directly to the players themselves: 'I couldn't imagine a meaningful consideration of improvisation from anything other than a practice and personal point of view' (Bailey 1993: x). The nature of free improvisation is that it is best represented as a dialogue across various practices. The discussions that follow are from leading figures in the field of free improvisation and are all people Maria has either worked with or interviewed. From these discussions, we propose four perspectives of how free improvisation functions: 1) as freedom; 2) as connection; 3) the sociopolitical; and 4) as a pursuit of the undefinable.

2.1. As freedom

The weightiest theme of this musical practice is the notion of 'freedom'. Joëlle Léandre points out that this freedom in its most immediate form is 'meaningless', calling it improvisation without a unifying style:

> Of course, the term 'free music' is meaningless. Improvisation, yes, without a given style – jazz or whatever. But if there's anyone who is not free, it's the musician. How can you be free with an instrument in your hands? There are motions, rhythms, colours, the diversity of the musicians one meets, the instrumentation, the energy, etc. (Léandre, interviewed by Marley and Lyons 2000)

For John Butcher, the idea of freedom is a changing balance as we gain understanding, the new knowledge framing how a performance practice might bind itself:

> [How would you define free improvisation?] As a sort of fantasy? Because, okay, once you gain knowledge you lose a certain amount of freedom. So, I think it's a mistake to necessarily lump the two things together. The concept of freedom and the concept of improvisation have elements of overlapping-ness, but they're not intrinsically linked in any way. And I think most people who stay with improvisation for any length of time develop many conceptual frameworks and sets of experience

where nobody could call what they were doing 'free'. (Butcher, interviewed by Donohue, November 2019)

The element of freedom plays a role in the shaping of musical forces, but ultimately it is accepted as a utopian ideal. Nonetheless, it is the pursuit of that ideal that shapes and defines the music and living. Certainly, with this creative process comes an idea that anything *could* happen, so the augmentation of the performer generated by Donohue+ must also dance with the boundaries of spontaneity and freedom.

2.2. As connection

Free improvisation centres on the element of connectivity, of social collaborative interactions through spontaneous music-making:

> Improvisation is the art of becoming sound. It is the only art in which a human being can and must become the music he or she is making. It is the art of constant, attentive and dangerous living in every moment. It is the art of stepping outside of time, disappearing in it, becoming it. It is both the fine art of listening and responding and the more refined art of silence. It is the only musical art where the entire 'score' is merely the self and the others, and the space and moment where and when this happens. Improvisation is the only musical art which is predicated entirely on human trust and love. (Alvin Curran, interviewed by Donohue, November 2019)

For Curran, the essence of free improvisation is in the spontaneous communion of performers, of producing an emergent musical phenomenon. Included here are the very human processes of listening, provoking, reacting and responding freely where musical frameworks are altered to human frameworks. For Marilyn Crispell the unique elements of each individual combine to become a collaborative skill for creating 'generous' shared expression:

> Everything that you've ever heard, seen, learned, studied, experienced, felt in your life comes into play as a background from which your intelligence and intuition draw, and they are formed spontaneously into an innately logical, personal expression … Creating spontaneous improvisations with other musicians requires a deep level of communication, being tuned in to the general flow of the music, feeling where there's a need for silence or for your voice to be heard- rather than imposing your ideas on the music; it's about generosity, sharing a space of mutual creation and allowing it to take its own shape, giving it wings. (Crispell, interviewed by Donohue, May 2020)

For Maggie Nicols these human connections happen by being present, open to the space and its indeterminacy:

> It's almost indefinable but the closest I can get is being fully present, aware and responsive in each moment, to whatever arises in oneself, the other musicians and the environment. (Nicols, interviewed by Donohue, April 2020)

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[3]For example, Joe Morris (2012), *The Properties of Free Music*.

[4]The Instant Composers Pool provides a good example – for example, Floris Schuiling (2019), *The Instant Composers Pool and Improvisation Beyond Jazz*.

[5]For example, The Spontaneous Music Ensemble, or Alvin Curran (1995), *On Spontaneous Music*.

[6]For example, Stephen Nachmanovitch (1990), *Free Play: Improvisation in Life and Art*.

Essential to these ideas is an element of letting things occur within context, tapping into a sense of intangibility, of a communicative action beyond that which can be summarised in descriptive words. In particular, the idea that the musical product should be emergent and not a sense of a declarative statement is essential to the development of Donohue+. Throughout the design process great care was taken to ensure that the musical output did not generate original material or reproduce musical gestures made by the performer but would rather create material that could augment the performer's actions as immediately as possible.

2.3. Sociopolitical

It is also worth pointing out a more resistant idea of free improvisation, held by some practitioners who treat it sceptically as something that has become a genre, a historical reference, a categorisation placed *upon* the music.

> Whenever I speak I generally just like saying improvisation. I have associations with free improvisation. It is a kind of idiomatic point of reference. So like, when I hear the words 'free improvisation', I picture a sort of 'European free improv', as a genre, as opposed to like an approach, which isn't necessarily what those words mean. (Rodrigo Constanzo, interviewed by Donohue, October 2019)

These ideas are echoed in what George Lewis refers to as the 'Eurological' lens, which is anchored in the deeply entangled ramifications of 'white aurality'[7] as a result of the defining of genre:

> While genre markers – improvised music, classical, contemporary, jazz, zeitgenössisch, Neue Musik – are often framed by scholars as ontologically salient, promoting both community and intelligibility, one might ask a race-aware curation to address more pointed discussions of the gatekeeping, border-policing, and kinship-enforcing functions of genre; or, perhaps, the less salutary aspects of how genre assignations can devolve into rigid binaries between insider and outsider, margin and center, overgeneralized moral imperatives, restrictions on mobility of practice, and questionable divisions between good and bad music – often enough based not so much on the content of the music as on its assumed provenance in terms of gender, race, ethnicity, or national origin. Here, assumed genre actually affects what we are able to hear. (Lewis 2020)

In developing Donohue+, it was important to be aware of the trap of genre and the deeply rooted sociopolitical nature of this field. Ultimately, preference was given to generating processing structures that deliberately did not reinforce the genre tropes of, as

Constanzo puts it, 'European free improv'. Donohue+ is augmenting an individual's personal definition, not an all-encompassing attempt to refract this highly diverse field. Any material produced by the program that fits this description should only reinforce that the performers themselves are operating within this field of musical references and not responding to a predetermined architecture of the software.

2.4. As the pursuit of the undefinable

By far the most common descriptor of free improvisation, however, is that the thing itself is undefinable:

> I think the definition is almost impossible. Every time you come to a definition, you find another caveat. Another possibility, which makes it inadequate as a definition. (David Toop, interviewed by Donohue, November 2019)

> It's the language of poetry, or religion, or high philosophy, but not the language of the interview. (Evan Parker interview in Scott 1987)

The most important takeaway is the notion that the field is about openness and the incomprehensible; that it is a site for making music that in a way pushes against the idea of making sense. There is an openness to the idea that what is made might not make sense, and that this is an essential element of the practice. The thing itself lacks clear definition, represented instead by a field of possibilities.

3. IMPROVISATION IN MARIA'S PRACTICE

Although Donohue+ originates as a tool for solo performance, for Maria free improvisation is about relay and creating community; an acknowledgement that collaboration happens between all agents at play in improvisation.[8] As is common with free improvisers – for example, in Maggie Nicols's championing of 'social virtuosity' (MacDonald, Burke, Birrell, DeNora and Donohue 2021) – the social and political contexts of improvisation are crucial to creating the work. In designing a system for Maria to play with, we consider the sociopolitical entanglement of precarity and indeterminacy as defining aesthetics of Maria's playing. Free improvisation for Maria is 'what the precarity of freedom teaches us' (Donohue, interviewed by Gillies, August 2020). She describes precarity as 'life without the promise of stability' from which, through the 'arts of noticing', we can create a

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[7]'[W]hite aurality can be understood as co-constitutive with, amongst other things, Eurological histories, practices, ontologies, epistemologies and technologies of sound, music and audition' (Thompson 2017: 274).

[8]The terminology that Maria uses to describe her practice is inspired by the 'making-with' theories of Donna Haraway (2013). Haraway uses 'relay' to describe collaborative working between the 'many hands': human, non-human, 'critters'. This is not unique to her practice alone and is found in feminist improvisation practices such as those outlined in 'Feministing Free Improvisation' (Reardon-Smith, Denson and Tomlinson 2020).

community practice (Tsing 2015: 2). Through this notion of a precarious freedom, Maria utilises the social 'arts of living' (Millar 2014). In essence, the precarious present (ibid.) becomes a technique for collaboration. These notions of community and 'making-with' are important to Maria, and she is interested in expanding the possibilities of what we include as artistic partners; Donohue+ offers her the possibility of a non-human relationship to engage with.[9] This element combines her interest in computer-assisted playing with the possibility for communication between agents co-creating within the precarious nature of real-time spontaneous playing.

For Donohue+ the goals were to create a system that echoes more of the collaborative and social aspects of free improvisation; a tool that expands the possibility of influence, by providing new opportunities to create further precarious ideas. To achieve this, the program needed to become a partner in logic while retaining the potential to surprise. A number of different approaches were considered based on historical explorations of musical improvisation systems, with the final product veering off in a notably different direction.

4. HISTORICAL IMPROVISATION SYSTEMS

Donohue+ operates within a larger sphere of interactive performer/computer musics, but seeks to develop a response that is structurally unique compared with previous methods of developing an improvising computer accompaniment. It is worth considering here some of the most notable examples of computer improvisation systems and the elements of their practice from which we sought to differentiate. We will consider the approaches taken by George Lewis's Voyager, Robert Rowe's Cypher, Ben Carey's _derivations and IRCAM's OMax softwares. This selection does not represent a complete list, but rather provides a sampling of approaches from which we can identify ideas pertinent to Donohue+.[10]

4.1. Prior examples

The first challenge undertaken when addressing an interactive computer improvisation system is making sense of the performer's musical activity in a way that allows for outputs to be derived by a machine. The use of musical descriptors, however, is a double-edged sword: while computer analysis can provide a numerical quantification of a particular parameter, the output of a

descriptor is often based heavily on the assumptions of the creator of the descriptors themselves. These lead to unpredictable or undesirable outputs later on. Therefore, the kinds of descriptors used to analyse a performance for music information retrieval, and for sense-making later in a system, are paramount.

A common starting point for musical description is that of pitch and periodicity, since developing an understanding of these features can allow for the derivation of other second order characteristics. George Lewis's Voyager analyses incoming MIDI and audio data to derive streams of music information, calculating averages of pitch, velocity, probability of note activity and spacing between notes to determine musical streams. This descriptor information is then used by a number of different processes to determine the behaviour of each of the 64 instrumental voices in the Voyager system, determining factors such as volume range, microtonal transposition, tactus, tempo, probability of performing a note, spacing between notes, interval width range, acoustic ornamentation (such as chorus, reverb and portamento), as well as variations to any of these features (Lewis 2000: 35). Importantly, the system is designed to have no hierarchy of 'human leader/computer follower' and has no input signals other than audio, allowing the musical output to take place independently of the performer or without any human input at all (ibid: 36).

Robert Rowe's Cypher instrument primarily focuses on the interpretation of MIDI data, gathering descriptor information regarding the density, speed, loudness, register, duration and harmony of a given musical event. This event data is then gathered into clusters of similar musical phrases, and analysed to determine if a descriptor in a particular musical event is acting regularly or irregularly (Rowe 1992: 43–44). The improvised output takes place in one of three ways: 1) transformation of the gathered MIDI data; 2) algorithmic generation of new material in one of a variety of textural and gestural styles; and 3) output from a library of existing musical sequences (ibid.: 45). In this context, the performer is given a large amount of control over the musical output and able to determine the kinds of musical output directly.

Ben Carey's _derivations software by comparison is concerned with the audio domain. This software seeks to 'harness the entire history of a musician's performance in a systemised fashion, to be accessed for regeneration and processing by linked synthesis and processing modules' (Carey 2016: 143). A single large audio buffer captures the performance and segments passages of the performance (determined by drops in amplitude) into phrases ready to be accessed. These phrases are then selected by matching stored phrases to the performer's input based on pitch, loudness, brightness and noisiness. While there are some

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[9]This is not dissimilar to Haraway's cyborg women of *Simians, Cyborg, and Women* (2013).

[10]A full taxonomy of 23 different computer improvising systems (including Cypher, Voyager and OMax) was conducted by Gifford, Knotts, McCormack, Kalonaris, Yee-King and d'Inverno in their 'Computational systems for music improvisation' (Gifford et al. 2018).

elements of synthesis available in the system, the overriding focus of _derivations is on matching incoming performance phrases to the database of phrases built over the course of the performance through a balanced matching of these descriptors.

This approach is similar to that of OMax, which measures the pitch, velocity and onset-offset detections (Assayag, Bloch and Chemillier 2006: 4) of musical phrases. The stored audio that these measurements are taken from is then used to drive OMax's audio segmentation processes. Through statistical analysis taking place in OpenMusic, different parts of the recorded signal are able to be recombined into a unique audio stream. This statistical approach allows for far faster learning and audio generation phases, due to OMax's highly segmented approach, whereby phrases are divided into subphrase, and further subphrases, allowing for a high level of combinatoriality of segments of audio signals and a more dynamic construction of improvised phrases.

Of these examples, Maria has only previously performed with OMax, which was used in her 2016 collaboration with the artist Gino Ballantyne on *Tonotopy* (2016–20).[11] OMax is capable of creating interesting replications of gestures (which are marginally altered from the originals), but she describes the content as 'ideas frozen in time', becoming static. Maria's practice instead relies on evolving ideas, and she finds the notion of always being drawn back to older phrases (however much altered) too structured a form for her to want to continue to work with it.

4.2. Lessons for Donohue+

While a number of the examples mentioned were about building a meaningful improvisation style from the performers' materials or looking at higher level systems for organising, categorising and retrieving musical materials, these systems gave us a good idea of the kinds of organisation to avoid: the goal of Donohue+ was to generate material affected by Maria's performance in the moment, not tying this material to specific phrases/gestures. In the spirit of free improvisation, the output needs to retain looseness, to appreciate the broad contexts of her playing, but not elevate musical gestures.

The project quickly centred around MIDI as the primary format of data for two reasons: first, it gave Donohue+ the flexibility to be utilised with various soft-synth instruments and to be interfaced with a Disklavier; and second, the format is particularly useful at conveying pitch, velocity and rhythmic information. In our reflection of Maria's practice it was clear that these were the primary elements that Donohue+ would

be working with; however, it is also important to note that by using MIDI, certain extended techniques common in Maria's playing style are sacrificed.

Donohue+ does not seek to analyse Maria's notes or rhythms as a finite material from which to create a response, but rather develops through the logic of Maria's decision-making in her practice (see section 6). Donohue+ avoids duplications or accompaniment and instead relies on the processing of information in order to create new scenarios for Maria to respond to. As in Maria's broader focus on 'making-with', the entanglement with Donohue+ is a fluid and evolving relationship, each alternating as the source for how and when new creative responses occur.
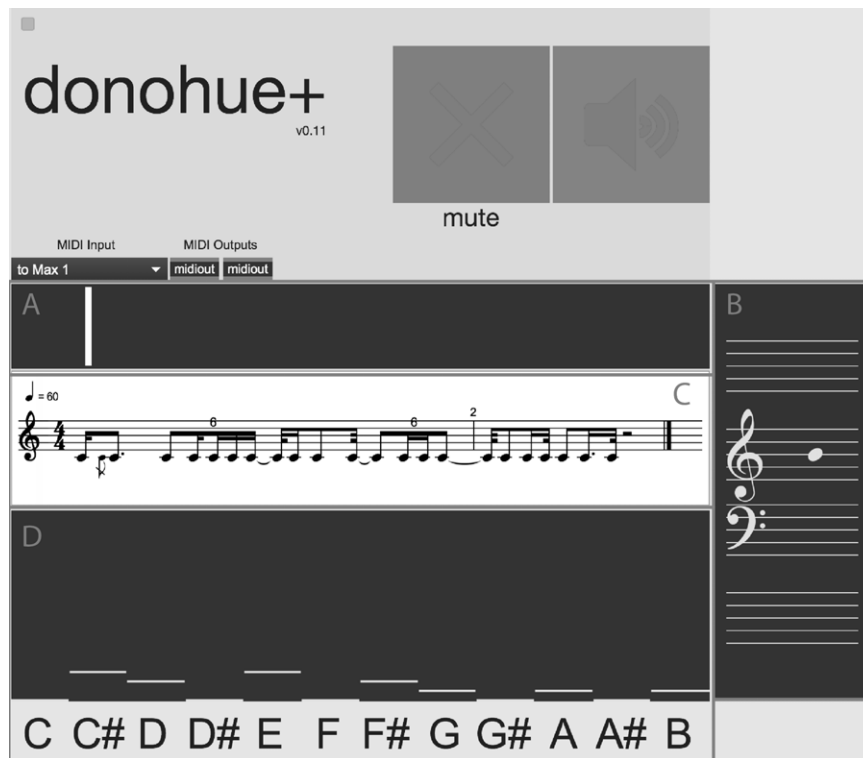
5. DONOHUE+

Maria's most striking musical characteristic as a performer is her use of minimal harmonic materials. Her performances eschew the idea of repeating cells of harmonic and rhythmic familiarity; instead, her work constantly suggests familiarity while feeling like a spontaneous creation. Non-tonal pitch sets may be derived and pivot sharply to others without rhythmic connection, or rhythmic gestures may be articulated with constantly changing harmonic content. This speaks to a difficult problem in designing some sort of responsive system to this kind of playing: what does it mean to augment this performance? Is the material something worth recalling or should the augmentation retain an aspect of the performance that remains complementary? How could Donohue+ think with Maria, making decisions on repeating, altering and drifting voices?[12]

The initial design of Donohue+ (see Figure 1) was to begin with recording and reproducing material generated by Maria spontaneously. The first outline of Donohue+ sought to record MIDI information and performance data and allow this to be triggered by some sort of conditional operation. However, within the first trial it became clear that this approach would keep Maria locked into a single performance space, difficult to move beyond. Maria's distinctive lack of material grounding was a poor application of a tool of musical generation that was so literal. Instead, what was clear was that Donohue+ needed to be highly responsive to Maria's shifts in musical material and needed to act as an outlet of Maria's expressivity, rather than a separate contributing voice.

Donohue+ v0.1 (henceforth just v0.1 or subsequent version numbers) developed a solution to this problem by first stripping down Maria's performance into component parts. Since harmony, melody and rhythm could, to a certain extent, be decoupled from one

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[11]This project sought to develop a sonic relationship with the process of *creating* (movement) visual art versus its final finished form.

[12]Videos of Maria performing with Donohue+ are provided in section 6.

Figure 1. Donohue+ display: a) buffer writing progress indicator (0–20 values); b) current note output; c) current periodicity buffer; and d) current pitch probabilities.

another in a live performance, the obvious starting point was to treat these elements as independent component parts to be recombined at a later point. V0.1 began by addressing the question of how pitch would be used in this system, and focused on building up a histogram of the last 20 pitches played. These pitches were translated into values of 0–11, resulting in a histographic pitch set. Random pitches could then be recalled from the histogram at a probability equal to the degree to which they were present. This means that in a pitch set of C (25%) C♯ (50%) and D (25%), C♯ would statistically be twice as likely to occur as C or D, resulting in a tonal emphasis of C♯ for as long as the histogram was present in the system.

At first the older data values in the pitch histograms were slowly replaced by new values, creating a gradual crossfade of pitch material. The idea here was that as Maria introduced new pitch material, the statistical probability of that new material would be slowly updated. In practice, however, this resulted in several unsatisfying states. While this system worked well in cases where Maria would slowly adjust a pitch set, more commonly she favoured large or sudden shifts in material, a change that needed to be updated immediately, otherwise the system would create an audibly separate stream of musical material. Instead we opted for simply clearing the histogram buffer after every

20-note update. This meant that she was now free to shift between wildly contrasting materials, with Donohue+ creating augmentations that reflected the pitch world accordingly.

Initial experiments with this method for deriving meaningful pitch materials proved to be favourable. The results were stylistically fitting to Maria's approach: they sounded related to the context established but unique, clearly creating additional musical materials but complementary to the overall performance. Maria, in turn, confirmed that this strategy felt more spontaneous for her, and that the material gave her the opportunity to develop additional musical ideas and interactions without feeling as though she was playing with looped recordings of herself, or a completely separate stream of generative musical materials. Satisfied that the method for selecting pitch was suitable for the augmentation of Maria's performance, the next challenge was to consider how periodicity would be handled.

V0.1 utilised a rudimentary method for triggering the probabilistic generation of pitch content, recording rough differences in time between note inputs and quantifying these to a bach.roll object, translating inputs into notated rhythmic material, and playing these back in a loop. While this was satisfying for test purposes, it became clear that conceiving of note
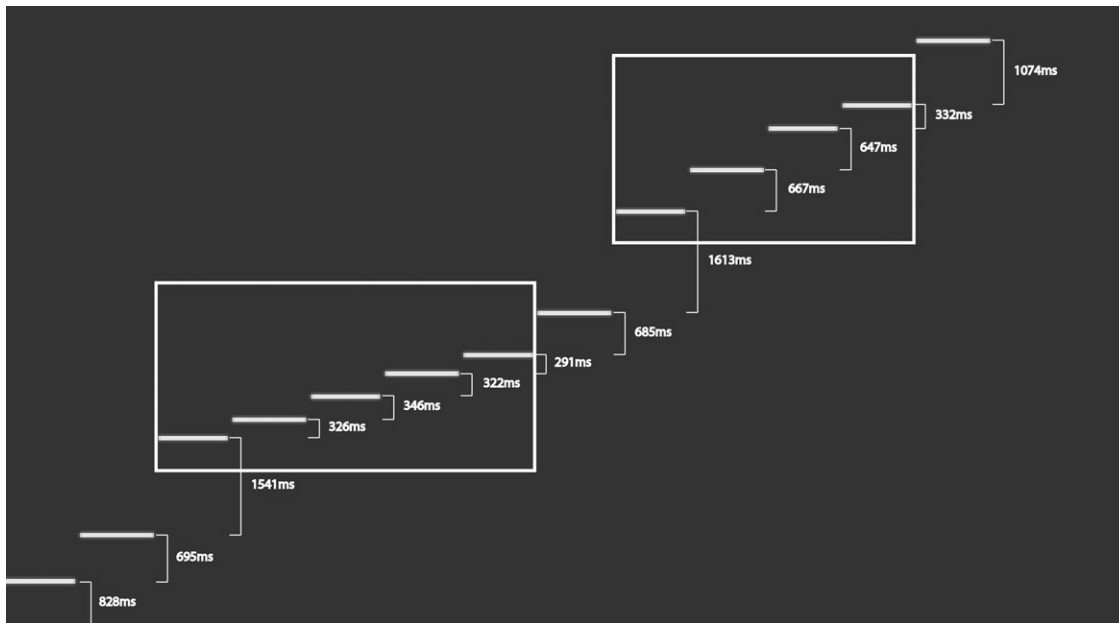
Figure 2. A diagram of the first 13 values of a periodicity buffer.

periodicities as rhythmic materials was mistranslating the intention of the musical material. Rather, the more pertinent musical question was: when and how often are notes being sounded?

In v0.11 we decided to focus on building a structure that would record the time difference between two notes. This information was stored in another 20 number buffer (21 including the onset) that would be refreshed concurrently with the pitch buffer. For example, the first three numbers in a periodicity buffer might be 0, 828 and 695, indicating that after the first recorded note of the buffer (0) the second note occurred 828ms after this initial onset, and the third note occurred 695ms after the onset of the second. Mapping this information graphically it becomes easy to see how it indicates the proportional relationships between notes: for example Figure 2 shows the first 13 values in a periodicity buffer, with two long notes lasting a duration of ˜1500ms, before a five-note cluster, a held note, a four-note cluster and another one held note.

Once again, rather than storing this information in a format that could be retrieved later, it was determined that enabling the buffer to be overwritten with new information would provide Maria with the greatest amount of flexibility in a live performance. In v0.11, as each pitch is decided probabilistically, the periodicity buffer is counted through, and a MIDI note is generated with a duration drawn from this buffer. Initially, the exact durations of the buffer were used; however, this quickly led to recognisable musical materials emerging that had an audibly literal relationship to Maria's performance. In its most extreme state

it sounded too similar to a loop-style effect, even with probabilistic pitch materials. The solution to this was to utilise a pitch duration randomly derived between 0.5 and 1 times the value stored in the buffer. So, for example, for a recorded duration of 828ms, a generated note would have a duration of between 414ms and 828ms. The unused portion of the buffer would generate silence. So for a generated note duration of 414ms, there would be another 414ms of silence following it before another note would be generated. Again, this approach places the musical materials within the same sonic space that Maria is performing in, in a nuanced way; the generated materials retain the broader musical activity but are not copies of musical phrases or a constant stream of notes. Some small variations are able to occur, and generated notes are able to clump together perceptually in a stochastic manner but within the limits set by Maria's performance in the moment.

At this point we observed that our method for deriving pitch dynamics thus far was insufficient. Until this point we had essentially reused a similar buffer system to that used for pitch periodicity, where the pressure of the note input was stored to a buffer of 20 values and a random value was removed from the buffer for every pitch. This system led to wildly different outcomes and, in many cases, very clear computer-sounding changes in dynamic volume were evident. V0.11 saw us replace this system with a different approach, in which a dynamic volume was generated for each pitch that was generated. The primary dynamic value was derived from a median value taken from the last 20

values recorded by the system, with a value of ±7 randomly added to this median. Changes in median value are then smoothed out so that any dynamic change must reach its destination via as many values of 7 as necessary, creating a smooth dynamic ramp between values, but not so much so that Maria is unable to change dynamics immediately in performance.

The way the patch dealt with pitch range was also revamped in v.0.11. While previously the range of pitch outputs was decided based around the octave at any given point in time, we found that this meant that the material generated by Donohue+ failed to adapt dynamically to Maria's style, which involves large octave shifts across the keyboard. This update rebuilt the system that decided where on the keyboard a generated pitch would be placed, opting for a similar process as used by the pitch-generation system, generating a histogram from the octave bands of the keyboard that the last 20 pitches were performed in and then generating an octave for each pitch to be placed in according to this weighted probability. The result ensured that the pitch materials would better follow the momentum of Maria's performance while still remaining an independent augmentation of her improvised material.

V0.11 also saw the introduction of user interface additions to help orient Maria with the patch's behaviour and give her some flexibility in performance to overwrite behaviour quickly and easily. These included some graphic displays of the buffer behaviour and the amount written to the buffer, and a mute option to halt the output of Donohue+ while maintaining the patch's input and material generation. These additions were made to help Maria immediately understand what the patch was doing and where it was in the process of making decisions. They also allow her to dynamically control how much of Donohue+ is present in a given moment and to time the changes in her performance based on the content of the buffer.

6. THE FINGERPRINT OF FREE IMPROVISATION IN DONOHUE+

The concepts that underpin free improvisation and which embody themselves in Maria's work form the conceptual underpinning of Donohue+. In appraising these connections, we focus on several relevant threads – form, musical parameters and agency – and how both Maria's practice and Donohue+ engage with these ideas.

6.1. Form and presence

As seen previously, Maggie Nicols highlights the role of being fully present in the moment within the practice of free improvisation. Similarly, presence is a key element to Maria's own practice, deliberately seeking musical situations where she is responding to the

moment within a relatively short window of time. This results in work characterised by shorter phrases that build upon each other, with a focus on the moment-to-moment interaction of material. The fundamental design decision of Donohue+ was to deliberately remove any long-form recollection of musical material from the design, instead relying on the last 20 instances of recorded data to drive the musical output. In this way, Donohue+ aims to only track Maria's most recent activities and supplement her performance through the momentary contribution of complementary material. This process creates a dialogue, where Maria performs phrase-like ideas that are re-imagined by Donohue+ in the moment. In Video example 1, Maria plays a combination of rhythmic chords in a low register and single-note phrases in a mid-register; Donohue+ stays with her, allowing her to negotiate the fluidity between these ideas, maintaining a precarious present through real-time spontaneity and indeterminacy that nonetheless remains tethered to her sense of presence.

6.2. Pitch, rhythm, range and dynamics

Donohue+'s approach to pitch, rhythm, range and dynamics was developed based around Maria's own 'conceptual frameworks' (discussed previously by Butcher); style output for the system is therefore a product of the collection of influences that is unique to the practitioner.[13] Pitch in Maria's work is largely a by-product, a result of a free playing technique focused on the sonic outcomes of hand shapes and patterns.[14] While she does not consider pitch, she does consider range, often opting for variation across octaves over the duration of a piece. This makes the length of the keyboard and distance between events deciding factors in the sonic outcomes of a performance. Rhythm is a product she views as context-based, often set by the group in ensemble work. When performing solo, she considers drifting states of phrased pitches in sequence: placement of hands, notes chosen, distances between them, oftentimes resulting in cycles of repeated rhythmical phrases. Dynamics are generally rounded and sharply controlled; they are often associated with phrases, working towards robust and smooth changes. Maria usually prefers legato and pedalled playing, with dry or staccato used for musical variance.

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[13]This contrasts with the aesthetics arising from Bailey's 'non-idiomatic music' (1980), which is perhaps too closely tied to the problems raised previously by Constanzo regarding 'European free playing' and by George Lewis regarding 'Eurological' aesthetics.

[14]While she has trained to specifically break down the traditional Western shape patterns of her hands, as is common for free improvising players, Maria is not concerned with always adhering to atonal hand positions.

Donohue+ collects information based on these musical characteristics and generates momentary frameworks that shape the sonic output. By treating pitch, rhythm, range and dynamics as distinct features of a musical output, a separate but related stream of musical material is generated that remains connected to Maria's performance state. This has the effect of augmenting Maria's performance, adding material to her performance that would not otherwise be possible. Importantly, this separation enables the by-productisation of sonic elements to be retained, ensuring that no musical element is elevated in the performance and that no musical gesture is repeated or emphasised. As a result, when playing with Donohue+ it is difficult to tell who is playing what. Instead of mostly hearing duo complementary lines, we experience the embedded, self-referential sound world we might normally hear from one pianist.

Video examples 2 and 3 demonstrate two instances of parameters and probability interacting, which can be best seen in the probability chart on the bottom left of the Donohue+ screen. In Video example 2, Maria develops and alters a cell of notes, which becomes enveloped in Donohue+ augmentation, and in Video example 3 they both work closely around a core repeated single note. In both instances the musical parameters and the probability that Donohue+ mimics allow Maria's initial ideas to be fleshed out via the relationship with the system. These general frameworks for pitch, range, rhythm and dynamics are shared, therefore seeming to emerge from the instrument thanks to both human and machine.

6.3. Agency

As mentioned earlier, Joëlle Léandre points to the distinct affordances that arise when playing an instrument, which define one of the consistent issues with the notion of freedom in performance. If players are indeed influenced by the instruments that they perform – 'how can you be free with an instrument in your hands?' – then Donohue+ furthers this dilemma. The technological limitations of a keyboard (no strings, lack of acoustic extended techniques, single pedal) and the physical limitations of the pianist (two hands, limited memory, stamina) are factors that will coexist during performance. Donohue+ relieves some of Maria's limitations, offering more hands, returning notes and unlimited stamina; yet further agencies are added to the mix. The moment/form relationship (discussed previously) between human and machine ensures that ideas and phrases move in parallel, so that spontaneity between Donohue+ and Maria is in (relatively) real time. But beyond this, there was a concern with broader ideas of musical time: How does a piece start? How can it end? How can we find silence? If

Donohue+ could conceptually play forever (always retaining a 20-input phrase), then how could we design a system that still retained human group free improvisational practice? The solution was to further consider agential shift between human and machine.

Donohue+ comes with a mute/un-mute button that Maria controls with the space bar or iPad. She is free to decide when Donohue+ joins, giving her the agency to end its contributions at any point,[15] but the system is still constantly present, it is always thinking and generating pitches, even when we do not hear them. While this continues the traditional agency between humans and instruments (the human decides when instruments make sound or not), it is also something of a hybrid – Donohue+ augments the existing keyboard with material similar to that of Maria, on the specifics of which Maria has no input. In this light we might consider Donohue+ another player generating parallel material, the only unusual element of control being that Maria can silence it. She is therefore able to impose traditional ensemble techniques such as 'laying out' (listening but not contributing).

In Video example 4, Maria allows Donohue+ to begin the improvisation,[16] meaning the opening content is unknown to her, utilising previously stored materials. In this example, she moves intermittently between experimenting and letting Donohue+ expand phrases on its own; this is an important aspect of any free improvisation, the 'indeterminacy of lived relations within the present' (Han 2011: 8). In this interaction, Maria must create space for Donohue+, not imposing ideas on the music as described by Crispell, but working with a bespoke improvisational instrument that aims for 'sharing a space for mutual creation' (Crispell, interviewed by Donohue, May 2020). As we develop this further and the Donohue+ system enters Maria's public performing career, it offers a positive example of human/machine collaboration.

7. FUTURE DEVELOPMENTS

As of April 2020, v.0.11 is the most current version of Donohue+. Two planned residencies to work on adapting the patch to communicate with a Disklavier for live performance have unfortunately been postponed by the Covid-19 pandemic, which in turn has delayed a definitive finalisation of a v1.0 build. However, there are several developments planned for Donohue+.

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[15] The issue of computer generated 'endings' is of continued debate, as seen in conversation between George Lewis and Tia DeNora (Lewis and DeNora 2020) with almost all programs including Lewis's own Voyager requiring human-aided termination of improvisational materials.

[16] In all of the other trial examples Maria starts the improvisation, and therefore purposefully generates the inputs that Donohue+ will join with when she decides to unmute it.

The first is to adapt the core systems of Donohue+ to work in more flexible improvisation performances. Aside from performing with a Disklavier, much of Maria's live performance incorporates different MIDI keyboards that can vary in how they are inputting and outputting data. As such, with its systems for material generation now in a relatively stable state, Donohue+ is focused on refining the input and output stages of data and ensuring that these function in as large a number of cases as possible. This extends to the number of virtual instruments that can accept MIDI data for both literal and abstract sonic outputs, all of which have the potential to be granted greater expressivity through the use of Donohue+.

We are also looking towards exploring how the requirements of Donohue+ change between Maria's solo performance and her work with other performers. Maria's performative intentions often vary considerably between her work as a soloist and her ensemble work. Our goal is to ensure that Donohue+ remains an augmentation of Maria's performance practice and not a separate improviser in its own right. As we continue to refine the project, we look to ensure this remains the case in a number of different incarnations of Maria's performance practice.

8. CONCLUSION

Donohue+ creates a great uncanny Maria-verse, by expanding the possibility for spontaneous ideas on a theme, without simply mimicking her choices. The project is tailored not only to Maria's musical language but also to her performative aesthetic, shaped by a broader engagement with the conceptual underpinnings of free improvisation. The Donohue+ project, now capable of the desired level of complexity, is ready to be trialled in a number of Maria's musical projects. Depending on creative focus or ensemble dynamic, further development discussions will likely continue. Ultimately this project's goal is to open up the expressive potential of human/computer improvised interaction, while also maintaining the program's bespoke quality, which our experience to date demonstrates that we have achieved:

> I acknowledge that freedom is precarious, and for me the purpose of this term 'free improvisation' is to utilise sociality to address this. When I falter, which is inevitable, I must trust in the things around me. We have techniques in which to do this, I make-with my environment always, but Donohue+ is something more. Donohue+ extends me and I extend her, and we create a tangible sociality through our connection. Donohue+ reminds me that moment-to-moment community building is how we strive towards freedom. (Donohue, interviewed by Gillies, August 2020)

SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit https://doi.org/10.1017/S1355771821000121

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