

Resistance, Mastery, Agency: Improvising with the feedback-actuated augmented bass

ADAM PULTZ MELBYE

School of Arts, English and Languages, Queens' University Belfast, Northern Ireland
Email: mail@adampultz.com

In this article I describe the development of a performance practice with a new electroacoustic instrument – the FAAB (feedback-actuated augmented bass). Drawing on a background in improvisation, I discuss how the feedback-induced behaviour of the instrument sets it apart from an acoustic bass and how the implementation of operationally closed digital signal processing algorithms facilitates greater systemic autonomy. In identifying resistance as a key feature of improvisation, I propose the term ‘diachronic mastery’ as a way of addressing the equilibration of sensorimotor schemes in the context of developing a performance practice with a complex hybrid system such as the FAAB. Through a discussion of the term ‘agency’ as it appears in recent literature, I develop a preliminary framework for addressing both the immediate experience of agency emerging in performance ecosystems and the biologically informed definition of the term that may be useful in the design of increasingly autonomous instruments and performance systems.

1. INTRODUCTION

This article is concerned with the development of a new electroacoustic instrument – the FAAB (feedback-actuated augmented bass) – and the process of defining a relationship with it within a largely improvised setting. The term ‘improvisation’ is here understood as *open* improvisation: a practice that does not rely on composed or premeditated structures, yet, as any discipline, is deeply informed by cultural and aesthetic orientations (see Stapleton 2013: 65 Lewis 2002: 234).

My interest in developing the FAAB stems from 15 years of exploring the acoustic double bass within the context of improvisation, the last ten years with a focus on a solo practice that, broadly speaking, explores the resonant properties of the instrument. Alongside developing a number of extended and idiosyncratic plucking, bowing and preparation techniques, in more recent work I have integrated electronics into these endeavours (Melbye 2018) and moved towards the design of instrument-specific feedback systems (Melbye 2019). Being fuelled largely by artistic ambitions, this development has additionally been shaped by an interest in cybernetics, neocybernetics (a term that I, following Clarke and Hansen, 2009, will prefer over second-order cybernetics) and systems theory,

which has caused me to investigate the extent to which performance and improvisation with a traditionally acoustic instrument changes through its coupling to recursive and adaptive networks.

I will start by discussing group improvisation, focusing on the precarious, adaptive and agential properties of human performers and their enacted relationships. I will then move on to solo improvisation in order to identify how this discipline differs from its group equivalent. Here I will rely on first-person experience of solo playing, discussing how resistance and mastery can be understood in the context of an equilibration of the relationship between performer and instrument. Through observing an imbalance of autonomy in this relationship, I will discuss the creation of the FAAB and present an account of the development of an improvised performance practice with this hybrid double bass. The dual perspective of, on the one hand, aiming to design a responsive and semi-autonomous instrument and, on the other, performing with it, leads me to a discussion of agency in the context of *performance ecosystems* (Waters 2007; Bowers in recent private communication). By comparing the use of agency in recent literature on instrument design with developments in cognitive science, I conclude that we are in need of better definitions of agency and propose a preliminary framework for such a project.

For an understanding of group and solo improvisation, I rely on the enactive cognitive approach as initially developed by Francisco Varela, Evan Thompson and Eleanor Rosch (2016). Being closely related to neocybernetics, in my reading, enactivism presents a convincing argument for situating the performer in an embodied relationship to their environment, the latter constituted of (but not restricted to) other performers, instruments, audiences and sonic affordances. Through its application of neocybernetic terms such as ‘structural coupling’ and ‘operational closure’, I find that enactivism allows for the development of an embodied phenomenology of performance while also providing the tools for elucidating minimal conditions for autonomy and agency. Of specific importance to my discussion is the approach developed by Ezequiel Di Paolo, Thomas Buhrmann and

Xabier E. Barandiaran in their book *Sensorimotor Life: An Enactive Proposal* (Di Paolo, Buhrmann and Barandiaran 2017).

2. GROUP IMPROVISATION

Improvisation, in music as elsewhere, is a precarious process. Improvisation in music is most often invoked in the mutually enabling relationship between a human performer and their environment, the latter being partly constituted of, as well as co-inhabited by, other performers. Following Maturana and Varela, I will define such a relationship as *structurally coupled*, that is, constituted by ‘a history of recurrent interactions between two (or more) systems’ (1980: 75). A precondition for the structural coupling of living systems is their *operational closure*, defined by Di Paolo et al. as ‘a network of precarious processes in which each process enables at least one other process in the system and is, in turn, enabled by at least one other process in the system’ (2017: 113). Consequently, operational closure is a prerequisite for systemic *self-individuation*, understood to be the ability of the system to define itself against its environment through the continuous production of a boundary without which it would become assimilated by that environment (Varela 1991).

The openness required by structural coupling comes at a price: whether observed at the level of the individual agent or network-level of interacting agents and their environments, precarious relationships between far-from-equilibrium systems are the norm. We can see how this applies to the process of group improvisation: in order to facilitate interaction and hence sustain the improvisational process, the improviser needs to retain a structurally coupled relationship to their environment, including other improvisers. At the same time, merely adopting or mimicking the behaviour of other performers, or even the group, without somehow modulating the coupling to these, undermines the dynamics of improvisation. Reminiscing about the weekly improvisation meeting *The Gathering*, Maggie Nicols (in Rose 2017: 73–4) explains: ‘you’d get a period where it would be the same people and it would get incredibly coherent, almost insular, almost to the point where it was stagnating. And then somebody would come who would just completely disrupt everything – but it kept it fresh.’ Here, the maverick improviser defines themselves against their sonic environment, disrupting the equilibrium and hence maintaining the openness of the improvisation. In Rose’s words: ‘the process of improvisation develops and benefits through not being too tied to one way of doing things. This not fixed, potential instability gives rise to creativity and new opportunities within the continuum of the activity’ (Rose 2017: 74).

If indeed improvisation happens in the structurally coupled relationship between operationally closed agents and their environments, it follows that improvisation is not an essence of these agents but an emergent property of their relationships (Loaiza Restrepo 2018: 164). The social dynamics of group improvisation are sustained through this non-equilibrium and as such, the oft-used term ‘playing together’ does not do justice to what is essentially a precarious and open-ended process of equilibrating asynchronous relationships between individual agents. Experiencing group improvisation (from both a performer and an audience perspective), it is often evident how such relationships play out: conscious and pre-reflective intentionalities and actions of individuals as well as the affordances of the environment (Gibson 1979) and instruments are continuously negotiated and equilibrated at a number of time scales. In this article I will focus on performer–instrument relationships, first in the context of acoustic instruments and later in a discussion of how improvisation manifests in the relationship with a feedback double bass.

3. THE SOLO IMPROVISER

Drawing on Judith Butler’s work, in his discussion of group improvisation, Stapleton writes: ‘It [improvisation] requires a willingness to risk one’s values . . . to give up a stable understanding of identity, to risk one’s very being, in responding to the address of another’ (2013: 172). In the case of a solo performance, the enactment of improvisation, in the absence of *another*, may be less evident. If improvisation is enacted and relational rather than intrinsic and presupposes an agent open to environmental perturbances, then we need to understand how a precarious scheme may be established in a solo practice.

Quoted in Borgo (2016), in Phil Hopkin’s film *Amplified Gesture*, Evan Parker states:

You couple yourself to that instrument and it teaches you as much as you tell it what to do. . . . So there are things that you have under control, but every so often something will go wrong. You’ll lose control. (Hopkins 2009)

Parker’s use of the teaching analogy and his description of loss of control aligns with Di Paolo et al.’s development of a sensorimotor agency model:

In order for learning agents to be able to respond to varying environmental situations, they must be metastable (temporarily stable). (Di Paolo et al. 2017: 102)

For equilibration and hence improvisation to be possible, the relationship between performer and instrument must rely on a precarious and metastable learning agent (in this case the performer) coupled to an environment (here the instrument), the control over which can never be total. Why stability can only

be temporary, not just in improvisation, but in so many other instances of life, may be illustrated through Heinz von Foerster's *order from noise principle* (von Foerster 2003: 11); briefly, this principle states that a self-organising system depends on a supply of entropy in the shape of 'cheap, undirected energy' (ibid.: 13) from its environment, without which the system will be unable to adapt to changes in that very same environment. In the case of an improvised solo performance, the instrument not only translates musical ideas and gestures into sound waves but, in constituting an environment, also perturbs the stability of the performer, causing them to reconfigure their sensorimotor states through a process of self-organisation similar to that of group improvisation where 'critical levels of complexity, responsiveness, and surprise can be reached and maintained over the course of an extended performance' (Borgo 2005: 81). Edgar Landgraf observes that 'improvisation and the overall incorporation of contingent elements inject "noise" into the system: they provide a resource pool from which the system can draw new impulses to create new forms and build new structures' (Landgraf 2009: 188). As such, the instrument, rather than being a transparent technology for the performer's self-expression, is intrinsically tied to the musical process and outcome (see also Mudd 2017: 59 and Di Scipio 1998). I will argue that this contribution happens through a degree of *resistance*, defining the structurally coupled, asymmetrical and precarious relationship between an operationally closed system and its environment, that is, performer and instrument.

In my own acoustic solo practice, resistance is a key factor in establishing precarious relationships that challenge my own physical abilities as well as those of the double bass. The instrument is set up with a very high action (string height from fingerboard) and stiff steel strings, meaning that a large amount of physical effort is needed in order to project sound. What is gained is a highly resonant, responsive and lively instrument, the interaction with which leaves a fairly wide margin for unintended yet welcome sonic artefacts such as buzzing and string slipping (Melbye 2014). Exactly such artefacts constitute the noise that drives the self-organisation of sensorimotor agency: through my coupling with the double bass, such 'slips' or unintentional events become the entropy that pushes me out of my internal stability or comfort zone and elicits responses that equilibrate between intention and outcome. It is in this unstable and precarious space that solo improvisation unfolds.

Rather than being understood as a hindrance to the true intentions of an agent, resistance co-defines and enables improvisation in the same way that gravity is a precondition for, and not a hindrance to, Olympic weightlifting: the performer physically engages the

instrument and explores its and their own physical limits while sometimes, as in the case of Evan Parker, pushing the shared understanding of what these limits may be.

3.1. Mastery

However, it is manifestly *not* the case that if resistance is a precondition for improvisation, then it follows that abundant resistance makes for good improvisation. While solo improvisation is indeed a precarious process, it additionally relies on an instrumental command evident in the work of such musicians as Sainkho Namtchylak (1991), Magda Mayas (2015) and Okkyung Lee (2013) – performers whose deep and intimate relationship with their instrument plays out in a virtuosic physical command developed over years of practice and performance. A cue to resolving this paradox between precariousness and control may be found in Di Paolo et al.'s discussion of Piaget's psychology:

[But] in a diachronic sense, mastery also refers to the equilibration process itself, not just to its achievements. In this sense, mastery is the ongoing process by which the agent continuously adapts to the challenges of a changing world. (Di Paolo et al. 2017: 107)

In this sense, mastery is dynamic and never complete. It is enacted in the relation between an agent and its environment and, as such, relies on resistance inherent in this relationship. It is worth noticing that this definition of mastery differs from that offered by Stapleton (2008) and Hogg and Norman (2013) who both employ the term 'resistance to mastery', although making it clear that what is being resisted is the conventional understanding of mastery (ibid.: 116; Stapleton 2008). In contrast to the conventional understanding of mastery as an achievable goal, I will propose the term 'diachronic mastery' to describe the dynamic mastery enacted in improvisation and the electroacoustic ecologies discussed later.

3.2. Addressing autonomy

In the context just described, we see a complex relationship evolving between performers and instruments and while I have not touched on the physical properties of the environment in general, these of course play their very own and essential part in the enactment of what Simon Waters (2007) and John Bowers have aptly defined as *performance ecosystems*. Here it is worth noting that we can identify at least three discrete system-environment models: 1) the performer-as-system embedded in the instrument-as-environment; 2) the instrument-as-system embedded in the performer-as-environment; and 3) the meta-system of the performer-instrument dyad embedded in the environment-at-large, the latter constituted of

resonant physical space, audience and ambient sound sources.

I have argued that resistance is what makes solo playing precarious and hence renders improvisation in this context possible. However, despite all the quirks and non-linearities of the acoustic instrument, when left to its own devices it remains operationally inert, exposing its lack of autonomy that puts it at the mercy of the agency of the performer. While agency will be discussed later, in order to understand this lack of autonomy better, I will now return to von Foerster's *order from noise* principle and recall that for any system, access to energy (both ordered as well as well as unordered) is a necessary (although not sufficient) precondition for self-organisation. In the human–instrument relationship, the energy available to the acoustic instrument at any given time is directly coupled to the performer and while this relationship is often non-linear, the actuation of the acoustic instrument, and hence its self-organisation, remains at the discretion of the player. As a creative constraint, this dependency has resulted in a number of approaches, from the continuous circular breathing of Evan Parker (1986) to the extended use of silence in *Echtzeitmusik* (Beins et al. 2011); for example, on Radu Malfatti's album *One Man and a Fly* (2015). In my own solo playing I have addressed this in a number of ways, exploring the tension between sonically sparse and saturated textures (Melbye 2014), continuous bowing (Melbye 2017) and, recently, by immersing myself and the instrument in a sonically active environment constituted of dripping water, novel reverberation, frogs and birds (Melbye 2020). Stopping or refraining from playing in group improvisation allows the performer the possibility of changing the group dynamics or simply observing these from a perspective other than that of continuous interaction. In Rose (2017: 204), George Lewis observes that 'If someone makes the call you don't have to respond because you're already listening, just let it go and see where it goes. Over the long run what you get is a great deal of variety in the texture and in the orchestration'. In contrast, during solo improvisation, refraining from playing exposes the incapacity of the instrument to respond in any other way than following suit, leaving the performer the choice between using silence as a dramatic tool or surrendering to the sonic properties and behaviour of the environment-at-large. Obviously, an additional solution exists, namely that of separating energy from information, that is, decoupling actuation of the instrument from the actions of the performer. In other words, what happens if the energy available to the instrument becomes decoupled from the agency of the performer?

4. THE FAAB: A FEEDBACK-ACTUATED AUGMENTED BASS

As a double bass player, composer and improviser, I rely on the vast frequency range and physical power of the instrument, combined with the development of a vocabulary of extended techniques for bowing, plucking and preparations. While this acoustic practice affords many additional years (if not lifetimes) of exploration, it has spawned an investigation into how certain sonic features and behaviours may manifest in an instrument with an increased autonomous response, actuated and governed by forces operating outside the domain of my immediate agency.

In other words, my wish has been to explore how salient properties of my playing may become transported and mediated through a self-oscillating feedback instrument, partly actuated and driven by a force other than myself. In previous work, I have explored the double bass body as a self-actuating phenomenon (Melbye 2019) whereas with the current project, the strings take centre stage.

The FAAB was developed in collaboration with Halldór Úlfarsson, whose cello-like feedback instrument the *halldorophone* (Úlfarsson 2018, 2019) has been adopted by both composers and performers. Similar design strategies have been deployed (also in collaboration with Úlfarsson) by Alice Eldridge and Chris Kiefer (Eldridge and Kiefer 2017) and Thanos Polymeneas-Lioniris (2018). Briefly, the FAAB is a double bass equipped with a pickup placed under each individual string, the signals of which are sent to a microprocessor. The output is then sent to an amplifier driving a speaker embedded in the back of the instrument.

The nature of the coupling between the electronics and the instrument is such that as the system's amplitude is increased, the speaker mechanically vibrates the double bass body and consequently the strings, causing them to enter into self-oscillation (feedback). A technically involved discussion of the FAAB has been published elsewhere (Úlfarsson and Melbye 2020), while Movie Example 1 documents an improvisation with the instrument.

4.1. Openness and closure

Applying the terminology of operational closure and structural coupling to the FAAB, we see that structural coupling is established through the relationship between the FAAB and its immediate environment, the latter largely identical to the performer. Similar to acoustic instruments, the FAAB has operational closure at the mechanical level, established through a number of mutually enabling processes, in particular between the body and strings, the actuation of which

now additionally depends on the driving force of amplifier and speaker rather than the performer exclusively. In the digital domain, operational closure manifests in the relationship between audio feature extraction (AFE) algorithms and the digital signal processing (DSP) stage, where filtering and amplitude management algorithms shape the feedback loop by modulating the response of the instrument body and hence the behaviour of the strings. However, at the AFE stage, control signals derived from amplitude and pitch analysis of the strings are mapped to DSP variables, completing a self-referential secondary feedback loop such as initially described by Ross Ashby in his discussion of *double feedback* (Ashby 2014: 83) and widely used in audio feedback performance systems (Collins 2011; Sanfilippo and Di Scipio 2017; Úlfarsson and Melbye 2020). To fully appreciate the importance of this phenomenon, I follow Sanfilippo and Di Scipio in their juxtaposition of operationally closed algorithms with stochastic and automated processes and how the latter operate in a domain ‘fundamentally (in)different to, the domain where musical action takes place, namely sound’ (Sanfilippo and Di Scipio 2017: 22). By putting the system’s ability for action at the mercy of chance operations and automation, the ability for self-regulation, and consequently operational closure, is compromised. Additionally, through its origin in pre-described computations, the unidirectionality of random processes compromises structural couplings between systems and their environments and, as such, renders the establishment of a mutual relationship for interaction, and ultimately improvisation, problematic. In contrast, the double feedback loop allows for an increased degree of systemic autonomy and the establishment of what Varela refers to as *a surplus of significance* (Varela 1991: 88): Through its internal processes, the system makes *sense* of its environment and establishes a world with which it can interact. Sense-making is here understood in the enactive sense that an autonomous system does not operate on representations of an external world as such:

Representational ‘vehicles’ (the structure or processes that embody meaning) are temporarily extended patterns of activity that can crisscross the brain-body-world boundaries, and the meaning or contents they embody are brought forth or enacted in the context of the system’s structural coupling with its environment. (Thompson, 2007: 59)

For the FAAB, there is no performer bowing or plucking its strings, only perturbations from the environment regulated according to the instrument’s sense-making scheme. Following Borgo: ‘Human beings and their thoughts are necessary for communication to take place, but they are inaccessible within communication’

(Borgo 2016: 124). What is striking here is that, revisiting von Foerster’s *order from noise* principle, regardless of any intentionality on behalf of the performer, the human effectively becomes the noise in the system and, as such, a precondition for the system’s ability for self-organisation and adaptation.

4.2. Accommodating technique

Feedback systems are by no means new (Sanfilippo and Valle 2013; Sanfilippo 2019) but what sets the FAAB apart is the implementation of mechanical and digital feedback in a culturally highly defined instrument such as the double bass (Figures 1 and 2; see also Eldridge and Kiefer 2017; Úlfarsson 2019). The double bass has co-evolved with musical idioms, repertoires and techniques that can fundamentally be mastered. Consequently, the physical demands of the instrument, while being exploited for their spectral richness, have traditionally been something to overcome. With the previous discussion of resistance and diachronic mastery in mind, I will here attempt an account of the development of two specific techniques that embrace the inherent resistance and non-linearity of the FAAB. While these are more or less established techniques in the vocabulary of contemporary double bass playing (Thelin 2009; Dresser 2010), the way they manifest when applied to the FAAB is significantly altered by the adaptive and precarious processes of the instrument.

Bowed multiphonics are caused by a combination of bow pressure, speed, position and light left-hand fingering, causing the emergence of a complex harmonic spectrum (Thelin 2011). Previously, I have used multiphonics in both improvised and composed settings to induce spectral variation and ambiguity in single-string pitches. Since I am generally interested in variation and, to a certain extent, instability of harmonic and inharmonic spectra, the FAAB offers an exciting environment for working with multiphonics. Through variations in bow pressure and left-hand dampening and position, the feedback-induced self-oscillation of the string will contribute to the complication of stick-slip relationships, almost reversing the bowing process to that of the string bowing the bow. Further increasing bow pressure and slowing bow speed close to the point of arresting string oscillation results in interesting phase resets of the string’s oscillation pattern, akin to the string having hiccups (Movie Example 2).

Because of the fact that the FAAB is often in a state of mechanical excitement, what has traditionally been a largely monophonic instrument is now a potential four-voice continuous resonator. The manual actuation of any single string will often be accompanied

by the phenomenon of one or more of the other three strings feeding back, and while this may in some cases be musically desirable, the continuous shifting between four open-string drones easily becomes tedious. Consequently, I have needed to accommodate my left-hand technique to either dampening unwanted resonating strings or fingering pitches on those strings in order to create chords in addition to the intentionally bowed or plucked pitch. As an extension of this, using both hands for stopping strings has proven to be a very useful approach to generating chords with asynchronous individually blooming pitches. With this technique I can access an increased pitch range, creating sustained chordal textures beyond the range of conventional bass playing and allowing me to additionally explore beatings and interference between individual as well as clusters of pitches (Movie Example 3).

The DSP processes embedded in the feedback loop add an additional layer of complexity and interactivity to the system: adaptive filters will cause the spectral balance to shift in accordance with time-variant frequency and amplitude changes and as such, not only depend on the current state of the system, but also its history (hysteresis). Since the parameters controlling these processes are largely a function of the system state itself, my main access to them is through physical interactions with the instrument that now doubles as a detailed and non-linear DSP-interface (the control interface visible in Figure 1 only controls individual string volume and processing blend). As such, my interactions with the system have far-reaching and sometimes unpredictable consequences in both the digital and physical domains, in the latter case exemplified through the complex relationship between strings and bow. While these digital and physical domains phenomenologically ultimately fuse into a single perceptual object, to a certain extent they can performatively be engaged as discrete processes, thereby offering the performer the opportunity to engage with a variety of systemic granularities. For example, the centre frequencies of a bank of band-pass filters are modulated by the difference between instantaneous and running-mean string amplitude analysis, meaning that a steady increase in bow pressure will leave the filter response largely stable, while any sudden amplitude fluctuation, be it an increase or a sudden drop (e.g., caused by decoupling the bow from the string), will cause an accumulating increase in overall inharmonicity followed by a slow decay. While hysteresis manifests in acoustic phenomena such as the phase-locking occurring in multiphonics (Thelin 2011: 2), the extended digital working memory of the FAAB allows for me to engage and improvise with the instrument in an expanded temporal field.



Figure 1. The FAAB, front.



Figure 2. The FAAB, back.

4.3. Improvising with the FAAB: equilibrating sensorimotor schemes

In reflecting on the phenomenology of performing with the FAAB, an asymmetry between intention and outcome is often present and manifests on a number of time scales, the most immediately accessible being the present moment in which the process of improvisation unfolds. While I have already mentioned the relationship between bow behaviour and digital filtering, another example is constituted by how the actuation of one pitch causes the feedback-induced sympathetic vibrations of neighbouring or harmonically closely related pitches. Similar to this phenomenon is the sudden amplitude build-up on strings different from the one currently being played, necessitating the abandonment of preconceived intentions in lieu of the exploration of a new scheme permeating my embodied relationship to the entire digital and physical constitution of the instrument.

The idea of *scheme* is found in Di Paolo et al.'s use of *sensorimotor schemes*, as 'reusable, interlocking, organized sets of coordination patterns between body and environment' (Di Paolo et al. 2017: 81) and in Shaun Gallagher's *body schema*, understood as 'a system of sensory-motor functions that operate below the level of self-referential intentionality' (Gallagher 2005: 26). I understand these schemes to illustrate how the haptic and sonic perception of the instrument fuse together in the process of improvisation and how this perceptual intermodality (ibid.: 170) is a prerequisite for the intimate and embodied relationship between musician and instrument during performance. In the following, I offer a description of how sensorimotor schemes are established in my relationship with the FAAB. While being based on first-person analysis, I will stress that this understanding arises from an after-the-fact reflection on what, in the heat of the moment, happens at the level of the body schema and as such is largely unreflective.

When the FAAB approaches the threshold of feedback, amplitude saturation sometimes initially manifests as a haptic, rather than an auditory sensation: the accumulation of energy becomes noticeable in the parts of the body that support the instrument and only emerges as audio feedback milliseconds or seconds later. Yet this time lag is enough to tune the sensorimotor scheme to respond to what, in the audio spectrum, appears as a sudden eruption of energy. To give another example: bowing a multiphonic manifests as the sensation of energy travelling back and forth between the string and the right-hand thumb, the index and middle fingers holding the bow, as well as the motion of the string under the light touch of the left hand. Here, minute variations in physical sensation report on the current viability of the multiphonic and to which extent pressure and bow speed should be adjusted. However,

with the increased flow of amplitude through the FAAB, the control or mastery that can be exercised over the resulting spectra is incomplete, or rather diachronic. In other words, improvising with the FAAB is an equilibration process involving an unknown and practically infinite number of possible sensorimotor schemes. While this is true of any performer-instrument relationship, with the decoupling of energy available to the FAAB from the agency of the performer, a curious compound of resistance and enabling manifests: while performative agency is frequently disrupted it may also become empowered, such as when the upper harmonics produced by *sul ponticello* (bowing close to the bridge) become accentuated by the self-sustaining force of a feedback-driven comb-filter. Such seemingly autonomous behaviour almost inevitably leads to the question of whether the system has agency.

5. AGENCY

Agency is about the most difficult problem there is in philosophy. (Latour 2005: 51)

In recent post-humanist literature, agency is a frequently used term often assigned to humans and objects alike, as when Jane Bennett addresses 'the deceit that humanity is the sole or ultimate wellspring of agency' (Bennett 2010: 30) or Karen Barad, tracing agency's wellspring to relational properties, states that 'agency is a matter of intra-acting; it is an enactment, not something that someone or something has' (Barad 2007: 178). In writings on music and sound art, this relational attitude towards agency is often reflected in suggestions that the tools of the artist contribute to the enactment of an artwork different from the intentionality of the performer. An example is found in Tom Davis's discussion of the *Feral Cello* (Davis 2017): after an informative overview of agency in practice and theory, Davis concludes that 'We have reached a place where agency is not an attribute that is possessed by an object, be that human or machine. Rather agency is something that arises in activity in the moment' (ibid.: 280). However, only pages later he mentions 'the agency of the cello' (ibid.: 282) only to return to 'a single performer/cello/machine system with mutable boundaries, both in terms of agency and subjectification' (ibid.: 282). Here it is not clear if agency is in fact emergent and enacted – a relational property – or whether it can be attributed to a specific part – human, machine or cello – of the system. Agency, through *mutable boundaries*, almost seems to become a *deus ex machina*: a mystical force akin to the idea of *the social* criticised by Bruno Latour (2005: 97).

On the *Humanising Algorithmic Listening* project's blog¹ Alice Eldridge (2017) and Paul Stapleton

¹www.algorithmiclistening.org/.

(2017) both make use of the term ‘human-machine agency’. Without further clarification, it is difficult to pinpoint the authors’ exact meaning of the term, which is possibly intentional. The hyphen in the terminology suggests that agency is an emergent property of the human-machine assemblage, which seems to be supported by Stapleton’s additional use of the term ‘distributed agency’ (Stapleton 2017; see also Stapleton, Waters, Ward and Green 2016). It may simply be that agency is defined along the lines of a Latourian actor, that is, ‘any thing that does modify a state of affairs by making a difference is an actor – or, if it has no figuration yet, an actant’ (Latour 2005: 71). This resonates with a folk-psychological understanding of agency, which finds its philosophical exposition in Dennett’s *Intentional Stance* (Dennett 1987). But if agency is a purely perceived property of humans, objects, systems, relationships and possibly even ideas, then we run the danger of reducing it to a vague term that begs the question: is there anything that *doesn’t* have agency?

David Borgo is patently aware of the danger of flattening ontology to the extent that agency loses its meaning (Borgo 2016: 114), and instead turns to the term ‘interagency’ to describe human–machine relationships that are mutually co-defining in music performance. Here, Borgo follows Rammert (2008), who identifies three types of interagency: *Interaction* between human actors, *Intra-activity* between technical agents and *Interactivity* between people and objects (ibid.: 119). As such, Rammert avoids an ontological discussion of the term in favour of ‘questions of empirical changes and practical consequences’ (ibid.: 115). Borgo’s comparison of *Actor-Network-Theory* (see also Latour 2005) with neocybernetics is very relevant and importantly draws attention to the epistemological implications of how complex networks are traced in both theories. Yet, while the structural coupling of neocybernetics is fundamentally tied to the operational closure of a system with a distinct boundary, Latour’s ontologically flat networks comprise actors with no depth beyond that engendered by their relations and as such compromise the property of self-individuation crucial for self-organisation.²

Similarly, for Sanfilippo and Di Scipio (2017) agency is related to neocybernetics and defined through processes of operational closure and structural couplings – two features that Borgo also requires for interagency (Borgo 2016: 119). While the authors take great pains to define the term ‘autonomy’ (Sanfilippo and Di Scipio 2017: 22), in their definition of agency however, even automated stochastic processes seem to constitute an agent (ibid.: 2).

²See Hansen (2009) for a proposed conciliation of neocybernetics and post-humanism.

In his important paper ‘Performance Ecosystems: Ecological Approaches to Musical Interaction’, Simon Waters, although employing the terms ‘machinic agency’ and ‘shared agency’ (Waters 2007: 10, 7), points to the epistemological shaky ground from which such definitions arise:

Our sense of mutability between performer, instrument and environment is heightened by our engagement with computers, and our confusion in this regard is evident in our vernacular with regard to their place in performance. ... in some circumstances we imbue the computer with sufficient agency that we regard it as ‘performer’. (Ibid.: 4)

Waters draws attention to the opaque use of agency that often accompanies the acknowledgement that something certainly *does* change when we interact with computers and complex systems. While there has historically been an ontologically unjustifiable tendency to reserve agency to humans, I believe that simply granting it to an observed feature of complex systems and relationships ignores the diversity of these phenomena and the levels of their interactions, a problem that Rammert (2008) goes a long way to addressing. However, following Barandiaran et al.’s call for a ‘generative definition of agency’ (Barandiaran, Di Paolo and Rohde 2009: 369) in cognitive science, I believe that the community of musicians, sound artists and instrument designers may benefit from a discussion of what constitutes agency in the first place. If we simply say that *the machine has agency* and assume it to be a heuristic rather than an operational discussion, we may imbue the machine with a perceived agency, but the intentional stance will still be a property of the human perceiver. If, on the other hand, we choose to locate distributed agencies in the relations between biological and non-biological systems, I believe that we will still need to pose the question of what causes those agencies to emerge and whether the presence of human or biological agents is in fact the condition for minimal agency in these relationships. Only then can we move from the descriptive to a generative and explanatory definition of agency as a basis for a discussion of the use of the term with regard to both the creation of, and the interaction with, complex performance systems.

In the book *Sensorimotor Life: An Enactive Proposal*, Di Paolo et al. propose a definition of agents and agency that Meincke (2018) refers to as *bio-agency*:

The enactive approach suggests that agents are systems that actively define themselves as individuals, and may be identified as such without arbitrariness. Only systems that manage to sustain themselves and distinguish themselves from their surroundings, and in so doing define an environment in which their activity is carried out, are considered as candidate agents in this approach. (Di Paolo et al. 2017: 112)

According to Di Paolo et al., agency must fulfil three mutually enabling conditions: *self-individuation*, *interactional asymmetry* and *normativity*. *Self-individuation* is understood to be a process that relies on the continuous self-production of the physical boundaries between the system and its environment (ibid.: 154, see also Thompson 2007: 98), *interactional asymmetry* describes the ability of the system to modulate its coupling with the environment (Di Paolo et al. 2017: 117), while *normativity* is the ability of the system to act according to its own intrinsic desires or goals (ibid.: 120). While interactional asymmetry emerges in several contemporary feedback systems, the claim that current artificial systems exhibit normative behaviour is challenged by both Di Paolo et al. (ibid.: 178) and Thompson (2007: 260). The question here is to which extent normative behaviour can be ascribed to a system whose goals are defined by the designer rather than by the system itself. In the case of complex audio feedback systems designed for improvisation and thus exhibiting behaviour not strictly tied to an end-goal, the answer is not straightforward and calls for further investigation.³ As the first condition, self-individuation necessitates the continuous production of a boundary towards the agent's environment (Di Paolo et al. 2017: 116) and, as such, may be the most difficult condition for artificial systems to fulfil, requiring the establishment of a far-from-equilibrium – and possibly biological – system.

Through this brief overview of the subtle arguments of Di Paolo et al., what becomes clear is that bio-agency is not exclusive to humans or even self-aware organisms; a living cell is an agent (ibid.: 130). Yet, observed complex behaviour is not sufficient either. However, bio-agency does not do justice to the *felt* sense of agency that musicians and improvisers encounter when co-constituting complex performance ecologies. In our immediate musical interactions, we will probably ascribe more agency to the FAAB than we would, for example, to sourdough, even though the latter qualifies for bio-agency while the former does not. Consequently, I propose to adopt an epistemology that embraces the understanding of both interagency as it emerges in the relational domain of organisms and objects *and* bio-agency as a property of operationally closed, self-individuating and normative systems. This epistemology would embrace a top-down approach (interagency) for the understanding of performance ecosystems, structural couplings and assemblages, as well as bio-agency as a bottom-up explanation of what constitutes minimal agency as a property of operationally closed and self-individuating

systems. Having two definitions of a single term may seem confusing but reflects the tension inherent in the relationship between immediate musical encounters and analytical discourse which is the reality for many performers, composers and instrument-builders, such as those constituting the NIME (New Interfaces for Musical Expression) community. I believe that we can sustain the duality of the term through an increased clarity about *which* agencies are at play. As such, each definition, interagency and bio-agency, may ultimately help elucidate properties of the other, while nodes of intersection will emerge. As an example, I will suggest that interactional asymmetry in the individual (bio-agential) domain translates to minimal interagency in the relational domain, the latter understood to be the asymmetrical relationship between (non-biological) objects, such as two instruments or performance systems interacting.

As a design goal, bio-agency is admittedly ambitious, yet in a time where AI and genetic algorithms are ubiquitous in new instrument designs (Fiebrink 2011; Eldridge and Bown 2018), there is nothing preventing us from seeking inspiration in and pursuing other biological and cognitive theories. Here, evolvable hardware (Di Paolo et al. 2017: 172) and Gordon Pask's remarkable *Ear* (Cariani 1993) represent fascinating endeavours that may be worth pursuing further in the ongoing process of creating complex performance ecosystems with multiple agencies, biological as well as non-biological.

5.1. Agency reassessed

We are now able to approach agency in performance and improvisation with the FAAB from both an operational and a relational perspective: it is clear that bio-agency does not apply to the instrument due to the fact that its physical boundaries are not dynamically constituted and upheld by the instrument. Yet, its internal processes, through operational closure, do allow for the establishment of interactional asymmetry with its environment – a property that, at the relational level, manifests as a curious compound of increased sense of resistance and enablement.

The normativity of the FAAB is difficult to assess and goes to the heart of the discussion of designing intelligent systems that may develop goals beyond and distinct from those of their creators, and to which extent this is musically desirable. Yet on the relational level, the FAAB at times does seem to observe a certain intrinsic yet inscrutable logic – a weak normativity unlike anything I have encountered in an acoustic instrument. The fact that such behaviour is not random affords an engagement with the instrument not unlike the attitude with which I would approach improvisation with a sentient performer.

³See Meincke (2018) for a relevant discussion of normativity.

6. CONCLUSION

I have argued that the establishment of precarious relationships between performers and their environment is a necessity for improvisation and that, in solo improvisation, this precarity is manifested through a resistance between instrument and performer. In focusing on resistance, I have omitted improvisational approaches that rely on homogeneity, consonance and long-form structures, such as the highly developed group approach of The Necks (Abrahams, Buck and Swanton 2015). While I believe that resistance and equilibration still apply in these cases, such a discussion is beyond the scope of this article.

Based on my own experience as a group and solo improviser, I have described the development of a novel feedback double bass – the FAAB – and how design concerns with operational closure and structural couplings afford the establishment of precarious relationships negotiated through diachronic mastery – the skilful enaction of sensorimotor schemes that rely on equilibration rather than overcoming. The strong operational closure of the FAAB augments, but also transcends, the already salient non-linear features of acoustic instruments, in the sense that the FAAB exhibits a greater sense of autonomy than its acoustic siblings.

Through a discussion of agency as presented in the literature of performance with extended instruments, I have identified what I perceive to be a tendency to vagueness regarding the term. Using a generative definition of agency found in current enactivist cognitive science, I have proposed to apply a dual description of the term to an understanding of performance ecosystems; one that embraces both the heuristics of performance as well as an operational definition useful for systems design. This model is still preliminary and would benefit from further elaboration, in particular with regards to how each domain – description and explanation – intersects with and possibly defines the other. While this article has described design and performance as discrete processes, the intersections between the two understandings of agency suggest that performance with – and the design of – new instruments may be understood as closely related and mutually constitutive processes.

Whether approaching bio-agency in the design of new performance systems is a musically interesting endeavour must be decided on a case-by-case basis. This article has shown that concern with operational features of agency and autonomy may be an important future step in the creation of responsive instruments and hence in the establishment of dynamic instrument–performer relationships.

Acknowledgements

I wish to thank the reviewers for valuable critique and suggestions. This work was in part supported by a

grant from the Department for the Economy (DfE), Northern Ireland.

SUPPLEMENTARY MATERIAL

To view supplementary material for this article, please visit <https://doi.org/10.1017/S1355771821000029>

REFERENCES

- Ashby, W. R. 2014. *Design for a Brain*, 2nd ed. Eastford, CT: Martino Publishing.
- Barad, K. M. 2007. *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning*. Durham, NC: Duke University Press.
- Barandiaran, X. E., Di Paolo, E. and Rohde, M. 2009. Defining Agency: Individuality, Normativity, Asymmetry, and Spatio-temporality in Action. *Adaptive Behavior* 17(5): 367–86.
- Beins, B., Kesten, C., Nauck, G. and Neumann, A., eds. 2011. *echtzeitmusik berlin: selbstbestimmung einer scene*. Hofheim, Germany: Wolke.
- Bennett, J. 2010. *Vibrant Matter: A Political Ecology of Things*. Durham, NC: Duke University Press.
- Borgo, D. 2005. *Sync or Swarm: Improvising Music in a Complex Age*. London: Continuum.
- Borgo, D. 2016. Openness from Closure: The Puzzle of Interagency in Improvised Music and a Neocybernetic Solution. In G Siddall and E. Waterman (eds.) *Negotiated Moments*. Durham, NC: Duke University Press, 113–30.
- Cariani, P. 1993. To Evolve an Ear. Epistemological Implications of Gordon Pask's Electrochemical Devices. *Systems Research* 10(3): 19–33.
- Clarke, B. and Hansen, M. B. N. 2009. Introduction: Neocybernetic Emergence. In B. Clarke and M. Hansen (eds.) *Emergence and Embodiment: New Essays on Second-Order Systems Theory*. Durham, NC: Duke University Press, 1–25.
- Collins, N. 2011. Nicolas Collins 'Pea Soup': A History. www.nicolascollins.com/texts/peasouphistory.pdf (accessed 10 January 2021).
- Davis, T. 2017. The Feral Cello: A Philosophically Informed Approach to an Actuated Instrument. In *NIME 2017 Proceedings of the International Conference on New Interfaces for Musical Expression*, Copenhagen, Denmark, 279–82.
- Dennett, D. C. 1987. *The Intentional Stance*. Cambridge, MA: MIT Press.
- Di Paolo, E. A., Buhrmann, T., and Barandiaran, X. E. 2017. *Sensorimotor Life: An Enactive Proposal*. Oxford: Oxford University Press.
- Di Scipio, A. 1998. Questions Concerning Music Technology. *Angelaki: Journal of the Theoretical Humanities* 3(2): 31–40.
- Eldridge, A. 2017. Network Motivations: An Interdisciplinary Algorithmic Listening. Toward a Well-Rounded Design of Future Hybrid Ears. www.algorithmiclistening.org/introductions/distantlistening/ (accessed 10 January 2021).
- Eldridge, A. and Bown, O. 2018. Biologically Inspired and Agent-based Algorithms for Music. In A. McLean and

- R. T. Dean (eds.) *The Oxford Handbook of Algorithmic Music*. Oxford: Oxford University Press, 209–44.
- Eldridge, A. and Kiefer, C. 2017. The Self-resonating Feedback Cello: Interfacing Gestural and Generative Processes in Improvised Performance. In *NIME 2017 Proceedings of the International Conference on New Interfaces for Musical Expression*, Copenhagen, Denmark, 25–9.
- Fiebrink, R. 2011. *Real-time Human Interaction with Supervised Learning Algorithms for Music Composition and Performance*. PhD thesis, Princeton University.
- Gallagher, S. 2005. *How the Body Shapes the Mind*. Oxford: Oxford University Press.
- Gibson, J. J. 1979. *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin.
- Hansen, M. B. N. 2009. System-Environment Hybrids. In B. Clarke and M. Hansen (eds.) *Emergence and Embodiment: New Essays on Second-Order Systems Theory*. Durham, NC: Duke University Press, 113–42.
- Hogg, B. and Norman, S. J. 2013. Resistant Materials in Musical Creativity. *Contemporary Music Review* 32(2–3): 115–18.
- Landgraf, E. 2009. Improvisation: Form and Event – A Spencer-Brownian Calculation. In B. Clarke and M. Hansen (eds.) *Emergence and Embodiment: New Essays on Second-Order Systems Theory*. Durham, NC: Duke University Press.
- Latour, B. 2005. *Reassembling the Social – An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.
- Lewis, G. 2002. Improvised Music after 1950: Afrological and Eurological Perspectives. *Black Music Research Journal*, 22(supplement): 215–46.
- Loaiza Restrepo, J. M. 2018. Humaning through Music: An Enactive Approach to the Continuity of Mind and Life with Implications for Musicking. PhD thesis, Queen's University, Belfast.
- Maturana, H. and Varela, F. 1980. *Autopoiesis and Cognition: The Realization of the Living*. Dordrecht: D. Reidel Publishing.
- Meincke, A. S. 2018. Bio-agency and the Possibility of Artificial Agents. In G. Schurz (ed.), *Philosophy of Science – Between the Natural Sciences, the Social Sciences, and the Humanities*. Dordrecht: Springer, 65–93.
- Mudd, T. 2017. Nonlinear dynamics in musical interactions. PhD thesis, Open University.
- Polymeneas-Liontiris, T. 2018. Low Frequency Feedback Drones: A Non-invasive Augmentation of the Double Bass. In *Proceeding of the International Conference on New Interfaces for Musical Expression*, Blacksburg, Virginia, 340–1.
- Rammert, W. 2008. Where the Action Is: Distributed Agency between Humans, Machines, and Programs. In A. M. Uwe Seifert, J. Hyun Kim and A. Moore (eds.) *Paradoxes of Interactivity*. Bielefeld: Transcript.
- Rose, S. 2017. *The Lived Experience of Improvisation: In music, learning and life*. Bristol and Chicago: Intellect.
- Sanfilippo, D. 2019. Complex Musical Behaviours via Time-Variant Audio Feedback Networks and Distributed Adaptation: a Study of Autopoietic Infrastructures for Real-Time Performance Systems. PhD thesis, University of Edinburgh.
- Sanfilippo, D. and Di Scipio, A. 2017. Environment-Mediated Coupling of Autonomous Sound-Generating Systems in Live Performance: An Overview of the Machine Milieu Project. In *Proceedings of the 14th Sound and Music Computing Conference*, Espoo, Finland, 5–8 July, 21–7.
- Sanfilippo, D. and Valle, A. 2013. Feedback Systems: An Analytical Framework. *Computer Music Journal* 37(2): 12–27.
- Stapleton, P. 2008. Dialogic Instruments: Virtuosity (Re)Located in Improvised Performance. *Leonardo* 15:11–12.
- Stapleton, P. 2013. Autobiography and Invention: Towards a Critical Understanding of Identity, Dialogue and Resistance in Improvised Musics. *Contemporary Music Review* 32(3): 165–74.
- Stapleton, P. 2017. Beyond Control: Improvisation, Listening and Distributed Agency in Human-Machine Musical Ecosystems. www.algorithmiclistening.org/introductions/PS_beyondcontrol (accessed 10 January 2021).
- Stapleton, P., Waters, S., Ward, N. and Green, O. 2016. Distributed Agency in Performance. In *Proceedings of the 2016 International Conference on Live Interface*, University of Sussex, 329–30.
- Thelin, H. 2009. *A New World of Sounds. Recent Advancements in Contemporary Double Bass Techniques*. Norwegian Academy of Music.
- Thelin, H. 2011. Multiphonics on the double bass: An investigation on the development and use of multiphonics on the double bass in contemporary music. *Norwegian Academy of Music*. <https://haakonthelein.com/multiphonics/multiphonics-on-the-double-bass/acknowledgements-literature-and-list-of-scores> (accessed 16 April 2021).
- Thompson, E. 2007. *Mind in Life: Biology, Phenomenology and the Sciences of Mind*. Cambridge, MA: Belknap Press.
- Úlfarsson, H. 2018. The Halldorophone: The Ongoing Innovation of a Cello-like Drone Instrument. In *Proceeding of the International Conference on New Interfaces for Musical Expression*, Blacksburg, Virginia, 269–74.
- Úlfarsson, H. 2019. Feedback Mayhem: Compositional Affordances of the Halldorophone Discussed by its Users. In *Proceedings of the 2019 International Computer Music Conference*. New York: New York University, ICMC/NYCEMF.
- Úlfarsson, H. and Melbye, A. P. 2020. Sculpting the Behaviour of the Feedback-actuated Augmented Bass: Design Strategies for Subtle Manipulations of String Feedback Using Simple Adaptive Algorithms. In *Proceedings of the International Conference on New Interfaces for Musical Expression*, Birmingham, UK, 221–6.
- Varela, F. J. 1991. Organism: A Meshwork of Selfless Selves. In A. Tauber (ed.) *Organism and the Origin of Self*. Dordrecht: Kluwer Academic, 79–107.

- Varela, F. J., Thompson, E. and Rosch, E. 2016. *The Embodied Mind: Cognitive Science and Human Experience*, rev. edn. Cambridge, MA: MIT Press.
- Von Foerster, H. 2003. *Understanding Understanding: Essays on Cybernetics and Cognition*. New York: Springer-Verlag.
- Waters, S. 2007. Performance Ecosystems: Ecological Approaches to Musical Interaction. In *EMS : Electroacoustic Music Studies Network – De Montfort/Leicester 2007 Performance*. www.ems-network.org/IMG/pdf_WatersEMS07.pdf (accessed 4 April 2021).
- Melbye, A. P. 2017. *Measures*. Noema. <https://adampultz.bandcamp.com/album/measures-2> (accessed 10 January 2021).
- Melbye, A. P. 2020. *Dam*. BCS-C. <https://bogongsound.bandcamp.com/album/dam> (accessed 10 January 2021).
- Namtchylak, S. 1991. *Lost Rivers*. FMP.
- Parker, E. 1986. *The Snake Decides*. INCUS.

DISCOGRAPHY

- Dresser, M. 2010. *Guts*. Kadima Collective Recordings.
- Lee, O. 2013. *Ghil*. Ideologic Organ.
- Malfatti, R. 2015. *One Man and a Fly*. Cathnor Recordings.
- Mayas, M. 2015. *Terrain*. Gaffer Records.
- Melbye, A. P. 2014. *Gullet*. Barefoot Records. <https://adampultz.bandcamp.com/album/gullet-3> (accessed 10 January 2021).
- Melbye, A. P. 2018. *Schreber* (Solo Double Bass and Electronics). <https://youtu.be/7WKTK-ek3gk?t=547> (accessed 10 January, 2021).
- Melbye, A. P. 2019. *What the Frog's Eye tells the Frog's Brain*. <https://vimeo.com/327281165> (accessed 10 January 2021).

VIDEOGRAPHY

- Abrahams, C., Buck, T. and Swanton, L. 2015. *The Necks – Live in Concert*. www.youtube.com/watch?v=UMueDWG86JU (accessed 10 January 2021).
- Hopkins, P. 2009. *Amplified Gesture*. www.youtube.com/watch?v=Npiuh13QEBo (accessed 10 January 2021).