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The Three-Dimensional Open Work

Reimagining indeterminacy through 360° virtual reality scores

JONATHAN PACKHAM

Virtual Reality is very physical. I won't just see changing images on a flat screen; I will have the feeling of occupying those images with my entire body. I will enter a graphic, three-dimensional, computer-constructed world that does not look real but feels real, one that may respond immediately to my movements and commands.
Karen A. Franck (1995: 20)

INTRODUCTION

This article concerns musical performance using scores viewed in virtual reality (VR) headsets. It explains the technological basis for VR headset scores, evaluates their affordances as a performance tool and demonstrates their relevance to ongoing critical discourses surrounding the performing body, indeterminacy, openness and notation and technologically facilitated performance. What are the impacts of such a technology on performers; what might it feel like – to borrow Karen A. Franck's words – to 'occupy [the score] with [our] entire body' (1995: 20)? How might these scores build on, alter or deconstruct conventional performer–audience behaviours? And what impact could implementation of this technology have on both existing open scores and newly created works? Musicologists have often asked: what kind of space is a score (see, for example, Cazden 1961; Born 2013: 9–11; Packham 2021: 16–18)? With VR, perhaps a more appropriate question is: what kind of score is a space?

LITERATURE REVIEW AND RESEARCH AGENDA

Literature on extended reality (XR) and music predominantly centres on interactive musical instruments built in VR (VRMIs) (see, for example, Çamcı and Granzow 2019; Zappi *et al.* 2023), pedagogical and/or accessibility-based

applications (Velev and Zlateva 2017; Serafin *et al.* 2017; Sai 2022), gaming or gamified musical experiences (e.g. *Electronauts* (2018); *Beat Saber* (2018); *Maestro VR* (2022)); see also Loveridge 2023), and experimental works (e.g. Björk Digital (2017–); Laurie Anderson's *Chalkroom* (2017–); Caitlin Rowley's *HAYDN SPACE OPERA* (2021–4)) that invite audience members to wear VR headsets (Anderson and Marranca 2018; Bresler and Hawkins 2022; Lawhead 2022). While this scholarship is hugely valuable, emphasis on the composer, the technology or the listener in such literature means that the particular affordances and challenges of VR technologies for the performer have received less attention. This article's focus on scores rendered using VR headsets is both a demonstration of a novel approach to scoring as well as an attempt to address this scholarly lack.

My interest in 360° video scores rendered in VR headsets emerged from previous research into open scoring practices, and especially on the way structural indeterminacy is negotiated at the point of performance. In 2017 I created what I believe to be the first 360° score rendered in VR (*look around you* (2017)¹), then refined and revised this approach in a series of compositions that formed part of my doctoral research project, including *SECRET ANIMALS* (2018)², *untitled (threshold)* (2018)³ and *untitled (THEY)* (2018)⁴, a collaboration with Crispin Lord (see Packham 2021: 145–6, 149–60).

Ultimately, the aim of this article is twofold: first, to demonstrate the potential of VR scores and assess their viability from a principally performative standpoint; and second, to encourage composers, technologists and performers to consider VR technologies as they might be used in their own practices, either as a means of rendering notated material more dynamically, or as operating productively in combination with existing wearable tech

¹ *look around you* (score): <https://bit.ly/4mtDe1T>.

² *SECRET ANIMALS*: <https://bit.ly/4ji0fkM>.

³ *untitled (threshold)*: <https://bit.ly/4jiXOKM>.

⁴ *untitled (THEY)*: <https://bit.ly/3Z1IU9m>.

increasingly used as part of technologically facilitated live performance (e.g. MiMU Gloves, Genki Wave Ring, Soundbrenner haptic metronomes).

OPENNESS AND VIRTUAL REALITY

My contention is that using three dimensions to render open scores is an extension of the existing linguistic focus on space evidenced in many accounts of openness in music (see also Packham 2024). Galia Hanoch-Roe suggests that engaging with an open score is ‘similar to that of a movement within a structural space, where the observer chooses [their] way about it’ (2003: 148). It follows that these figurative environments might be rendered in experiential (virtual) space.

One of the most well-known ‘open’ scores to involve performer decision-making at the point of performance is Karlheinz Stockhausen’s *Klavierstück XI* (1957). Fragments of notated material are spread across a single page, which players may perform in any order until they have played the same fragment three times. In this piece, there is a tension between the intentions of the composer and the reality of the performance situation. Most significantly, fragments of notated material accrue structural prominence based on their positioning on the page. Though there is a tendency to suggest that the page is an interpretative ‘blank slate’ – that performers are free to perform the fragments in any order they choose – the manner in which a score is put together can never be totally neutral. This is because – as David Pocknee notes – ‘the way in which people scan a page is not random at all and, in fact, highly predictable’ (2017: 7). Indeed, studies of performances of *Klavierstück XI* revealed an ‘increased probability of selection in the “facial circle” group’, meaning that fragments at a ‘comfortable reading height’ in the centre of the page were chosen more frequently (Boehmer 1988: 74). It is difficult to speculate to what extent Stockhausen accounted for the material limitations of the paper-based format in his arrangement of fragments, but the ‘increased probability of selection’ described by Boehmer seems at odds with the structural indeterminacy suggested by the organization of material. Pocknee goes on to suggest:

[I]f one did an eye-tracking analysis on a large enough group of people, looking at the ways in which their eyes scan over the piece and combining this with a sophisticated enough statistical model, it would be possible to calculate the order in which people would perform the work to a high degree of statistical certainty. (Pocknee 2017: 7)

Moreover, fragment selection – the indeterminate process underpinning the entire work – is mostly invisible to the audience. One might see the performer ‘moving [their] eye randomly between the sections of the work’, but to do this consistently would require either incredible eyesight or to completely forgo personal space (Pocknee 2017: 7). A suggested solution to both the problem of predictability raised by Boehmer’s and Pocknee’s critiques of *Klavierstück XI* and the issue of visibility is to create a three-dimensional score space. Rendering material in up to 360° and at varying heights – beyond a single field of vision – requires full head or body movement on the part of the performer in order to view all active areas of a score, problematizing the notion of a ‘comfortable reading height’ or ‘facial circle’ area while at the same time making the space of the score and a performer’s journey through it more visible to the audience (Boehmer 1988: 74).

Before discussing several implementations of VR in music performance contexts, it is valuable to briefly explain the technology itself. A headset comprises a pair of lenses placed over two screens, ‘focusing and reshaping the picture for each eye, and creating a stereoscopic 3D image’ (Pritchard 2022). The headset has sensors that monitor global movement and ‘adjust the image accordingly’, to simulate the impression of moving around a virtual environment (ibid.). The headset scores I have developed as part of my practice are built in Max/MSP & Jitter using the Worldmaking Package developed by Graham Wakefield and the Alice Lab for Computational Worldmaking at York University, Toronto.⁵

EDGES (1968)

Prior to surveying new work using VR technologies, this article assesses the performative implications of a 360° score architecture in the context of an existing open score: Christian Wolff’s *Edges* (1968). The modest array of book chapters, journal articles,

⁵ Worldmaking Package: <https://bit.ly/3SoDO3h>.

interviews, transcripts and liner notes form a constellation of literature on *Edges*. Within this small collection of material there is a tendency to describe Wolff's open scores – and *Edges* in particular – as 'spaces', occupied and explored by the performers. In liner notes for a 1963 release of *Summer* (1961) and *Duet II* (1962), Wolff describes a 'landscape' that performers walk in; in an interview with Richard Dufallo, he references an 'environment'; in an interview with Damon Krukowski, he references 'space within which the performer [can] operate' (Wolff and Cage 1970; Dufallo 1989: 110; Krukowski and Wolff 1997: 49; see also Packham 2024). This invitation into the space of his open scores demonstrates these works' malleability; they are shaped by the performer's engagement. Yet, like Stockhausen's *Klavierstück XI* this process of exploration remains mostly invisible to the audience. Digitizing the score and rendering the material in 360° around each performer serves to stage this embodied decision-making. A version of the score is hosted on YouTube for the purposes of this research article.⁶

⁶ *Edges*:
<https://bit.ly/4jiXDnC>.

By ensuring the performer has to move their head and/or body to encounter different elements of the notation, the audience is able to witness the performer's journey – in a gestural, generalized form – through the open work in real time. In many ways this approach echoes the way Lauren Redhead – after Williams and Bourriaud – has described notation, composition and performance: the 'journey-form negotiation of signs and symbols' (Redhead 2022: 271; see also Williams 2016; Bourriaud 2009). If, as Williams (2016) says, the performer-improviser is a 'wayfarer' who 'embrace[s] the contingency of their environment', then VR offers an infrastructure that stages the indeterminate cartography of this journey for the audience. Yet these journeys are not undertaken alone: *Edges* is an ensemble work, after all. In a rehearsal for *Edges* with the Cobra Ensemble, Wolff notes that 'you have to balance what you are doing regardless of what anyone else is doing' (Smiley 2010).

So, while on the one hand *Edges* speaks to a spatiality of score architecture in which individual exploration of the notation is central, so too does Wolff's score necessitate interaction

between performers. This poses a problem for a new 360° version of the score viewed in a VR headset: it is not possible to view the score, one's instrument, or other performers at the same time. Seeing one's instrument is less vital in a work with notation as open as *Edges*, as no specific pitches are ever indicated. The issue of seeing other performers is perhaps more pertinent. The digital version of *Edges* makes negotiation of the notation – or, in Franck's (1995) terms, 'occupation' of the score – more physically visible during the act of performance.

However – as the performers cannot see one another – 'opening up' the work in this way is at the cost of intra-ensemble interaction on a visual plane, part of what Georgina Born calls the 'intimate microsocialities of musical performance' (2013: 32). Wolff himself describes the importance of 'making it social – to [his] mind the only way that music exists at all' (cited in Saunders 2009). Moreover, while the digital version of the score in some ways grants audience access to the indeterminate processes at play in *Edges*, the physical boundary between performer and audience produced by a VR headset creates a new separation between these two entities. This is one of the primary issues with Interactive Virtual Musical Instruments (IVMIs) described by Victor Zappi *et al.* As they write, 'without a clear view of the virtual objects and their response to interaction, what remains is just a music piece almost completely disconnected from the gestures and the physical presence of the musician' (Zappi *et al.* 2023: 385). Similarly, comments on performances of my VR work shared online have in the past requested to 'see what the [performer] is seeing' (Packham 2018a). Perhaps then, using VR to make visible the structural indeterminacy underpinning paper-based open scores simply generates new issues native to the technology and its implementation: in this case, more limited intra-ensemble interactivity and instrumental ergonomics. Is this a price worth paying? Evaluating this new version of *Edges* – acknowledging its drawbacks alongside its particular affordances – has been necessary to establish my own methodology for the creation of new work using VR headset scores.

SECRET ANIMALS (2018)

Limited inter-performer communication – the principal problem with headset-based scores for ensemble work – motivated the development of my solo work: *SECRET ANIMALS* (2018), for cello and live electronics. The aim of developing a VR score for a single performer was to explore the potential of the technology while mitigating against the issues with interactivity detailed in the *Edges*' case study. *SECRET ANIMALS* employs a VR headset score produced for playback using Max/MSP & Jitter and an Oculus Rift CV1 headset. A version of the score – explorable using the mouse – is hosted on YouTube for the purposes of this article.⁷ One additional takeaway from the VR version of *Edges* was that developing digital scores in close collaboration with performers ultimately leads to more successful results. In this respect my approach echoes Zubin Kanga's emphasis on the collaborative potential of developing a 'work-specific performance practice', especially in instances employing non-standard notational systems (2014: 54).

Accordingly, *SECRET ANIMALS* was developed with and premiered by Deni Teo. An initial workshop with Teo revealed the importance of addressing two fundamental differences between conventional score playing and a 360° VR score architecture: the ergonomics of cello performance necessitating being seated, and the limitations of playing without being able to see the instrument. Regarding the first of these, solutions that would facilitate using a 360° score were discussed – including using a rotating office chair – but ultimately rendering the score in 180° proved the best compromise. In this configuration the performer is unable to see all the material in a single glance, but need not resort to instrumentally unwieldy movement. In the absence of a technological solution to being unable to see one's instrument – short of a 'mixed reality' approach – it was necessary to find a solution through notation. Like *Edges*, the notational system used in *SECRET ANIMALS* never specifies individual pitches, meaning close control over finger or bow position isn't a prerequisite for an acceptable realization of the score. While Teo's muscle memory and familiarity with the instrument meant that in

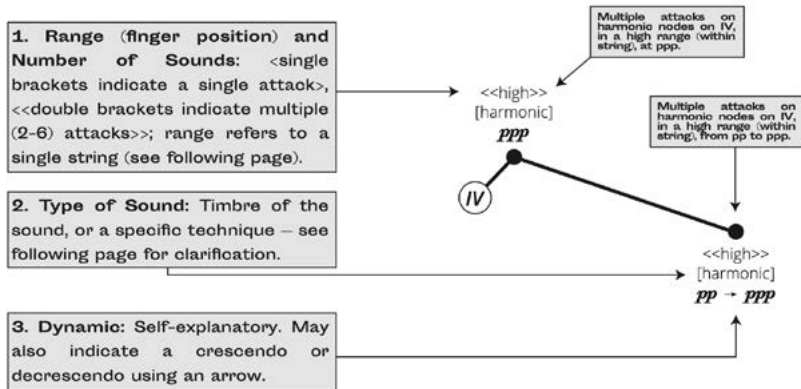
reality she was able to realize conventional notation with relative ease, ensuring the notation focused on generalized physical gestures rather than specific pitches facilitated a more controlled and less obviously cumbersome performance situation.

The constellation-inspired notation comprises nodes that performers can freely move between. Each node comprises a range (finger position within a string), a number of attacks (a single attack is indicated by single brackets (<>), double brackets (<<>>) indicate two to six attacks), a dynamic, and a type of gesture (indicated in square brackets) (see fig. 1). The square bracketed gestures were developed and workshopped in rehearsal according to what was possible with the limitations of the headset infrastructure; a full list is available in the score materials (Packham 2018b). The live electronics patch uses tracking data to manipulate processing of the live cello input. Accordingly, head movement determines which fragment the performer reads, but also the way it is processed electronically (see Packham 2021: 152 for more detail).

The score presents material across a 180° span, inviting the performer to explore the score environment and realize any visible fragments. Working with 180° – rather than the full 360° – necessitated finding solutions to more limited space within which to place notational symbols. Unlike *Klavierstück XI* or *Edges*, the score changes over time: while selection of fragments within any individual moment is free, the overarching structure is more fixed, articulated by the video infrastructure. This facilitates a more comfortable reading experience for the performer.

Thus, to some extent the development of *SECRET ANIMALS* was a reconciliation between the radical reimagining of the score environment I conceived, and the physical conventions of instrumental music-making. The central importance of the performing body to this development called into question whether these VR scores are really scores at all, but, rather, an extension of the performing body. While my initial impression was that these scoring practices would bring into play a new performer-score dynamic that would allow for the

⁷ *SECRET ANIMALS* (score)
<https://bit.ly/43eezHa>.



■ Figure 1. Excerpt from performance directions for *SECRET ANIMALS* (2018) indicating 'constellation' notation system (Packham 2018b).

visualization of an open work's indeterminacy, in fact the headset scores take on an instrumental quality. These new wearable scores perhaps have more in common with NIMEs (New Interfaces for Musical Expression) than with extended practices of score-making (e.g. animated scores, video scores and audio scores).

Earlier, Kanga's 'work-specific performance practice' was invoked (2014: 54). Perhaps in this context a technology-specific performance practice is also valuable, to mitigate against some of the more unergonomic impacts of the headset infrastructure. Such an approach might readily draw on the rich body of scholarship on technologically extended musical performance (see, for example, Tahiroğlu and Magnusson 2021; Dyer and Kanga 2023), echoing its emphasis on the value of developing performance practices and repertoires, not just individual use-cases (see also Kanga and Packham 2024). So too might the development of such practices be informed by the critical organology of Eliot Bates, whose emphasis on 'thinking through instruments' serves to bring to the fore 'how people, interacting with instruments (and perhaps at the same time with other objects) within particular spaces and places, are in a continuous and ever-shifting process of give-and-take' (2012: 368; 2019: 45). Bates' centring of both 'people' and 'instruments' is instructive. As the two case studies show, performers must be at the heart of this development process. To some extent, the serious limitations of *Edges* as an immersive infrastructure for ensemble performance are a result of my own excessively 'compositional' approach: overly conceptual thinking, focusing only on a single project

and undertaking my creative practice alone, rather than working – from the very start – with and through the advice and experience of performers. If *SECRET ANIMALS* represents even a marginally more successful implementation of a VR score architecture, it is in no small part owing to explicit performer involvement in its development process.

CONCLUSION

VR headset environments offer opportunities for live, multi-directional scores that stage embodied decision-making, visualizing indeterminacy for the audience in real time. Yet, as both *Edges* and *SECRET ANIMALS* demonstrate, there are myriad issues with the VR headset infrastructure as it might be implemented in performance situations.

I want to offer two directives for further research. The first concerns the conceptual basis for this research: namely, is a 360° open score still only a score? Do the solutions to Boehmer's and Pocknee's critiques of paper-based open scores actually improve the performance of a work like *Edges*? Is the VR score infrastructure simply a different – rather than a more genuinely indeterminate – way of realizing notation? And, perhaps more importantly, is 'genuine indeterminacy' – if it's even possible – actually musically preferable?

While there is value in creating score materials that more genuinely and visibly embody their underlying indeterminate processes, in my view the most interesting explorations of this technology will stage embodied demonstrations of such processes alongside instrumentalizing the headset more expressively. Headset tracking data in *SECRET ANIMALS* was used to manipulate the live electronic processing of the cello, but more could be done to blur the binary of headset-as-score or headset-as-instrument. Finally – and as indicated earlier – these experiments must be undertaken in collaboration with performers: if you're going to work with VR headsets, it's ultimately who is inside that counts.

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