

## Chance and Creativity in Entangled Systems

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### 1. Chance and Ignorance

To shed light on how chance and contingency operate in relation to artistic creativity (where “artistic” is understood broadly to encompass visual art, music, dance, literature, theatre and so on), one needs, among other things, to engage with a complex web of interrelated ideas encompassing notions such as constraint, predictability, control and design. The goal of this section is to navigate that web. Special attention will be paid to music composition and music improvisation, although illustrative examples will sometimes be drawn from other areas of the arts.

Let's begin by ordering a slice of eighteenth-century Scottish philosophy, accompanied by a side plate of surrealist reflection. The philosopher David Hume is usually interpreted as denying that chance is a bona fide feature of the universe. As he himself puts it: “Though there be no such thing as *Chance* in the world; our ignorance of the real cause of any event has the same influence on the understanding, and begets a like species of belief or opinion” (Hume 1748/1999, 131). So, on the most obvious reading of Hume, chance doesn't actually exist, at least not as the kind of phenomenon that should animate metaphysicians. Nevertheless, he thinks, because we remain ignorant regarding the actual causes of some events, we form beliefs or opinions about those events that are the kinds of beliefs and opinions that we would have formed if the events in question were in fact the result of chance.

Around two centuries after Hume, the surrealist artist Max Ernst explicitly endorsed a conception of chance “as Hume defined it: the equivalent of the ignorance in which we find ourselves with regard to the real causes of events” (see Spies 1988, 51, as quoted in Watson 2020, 182). Here one might sense, in Ernst's reconstruction of Hume, a small but significant shift of emphasis, to a perspective in which chance is not actually eliminated, but instead treated as a purely epistemological notion rather than a metaphysical one: events *count as* chance events when we don't know what the real causes of those events are. In other words, chance is strictly equivalent to an ignorance of real causes. Undoubtedly, one would need to finesse this claim to make it compelling, since it seems possible that we might sometimes be ignorant of the real causes of events and yet still not be minded to categorise them as the result of chance (but rather of hitherto unknown deterministic causes), so maybe strict equivalence is not quite correct as a formulation of the core idea. Right now, however, that's not our concern. Our issue is this: why would any artist—surrealist or

otherwise—find such a view of chance attractive? One possible answer is that it brings into view a key dimension of how artists, composers, musicians, writers and so on experience chance in relation to their artworks and, indeed, incorporate it into some of those works. If a neo-Humean approach to chance is especially relevant to how artistic creativity engages with chance, it's no mystery that Ernst latches onto it.

Advancing in this direction, then, notice that, once we embrace the epistemological notion of chance in the spirit of Ernst, we can sign up for a healthy and productive kind of metaphysical agnosticism. For it's a consequence of adopting the epistemological notion of chance, properly understood, that whatever the fundamental causal workings of the universe turn out to be, where we are ignorant of the real causes of an event, we will categorise (or at least we are well on the way to categorising) that event as a chance outcome. Maybe the observed unfolding of things is, in actual fact, down to some sort of deep indeterminacy in nature that mandates giving chance a genuinely metaphysical presence; or maybe it is all down to sensitive dependence on initial conditions in a chaotic but fully deterministic system; or maybe there would be nothing at all unpredictable about events, if we could just eliminate our ignorance regarding their real causes. No matter. As far as we can tell right now, God is playing dice, and, on the current proposal, that is at least part of what we need to talk legitimately about chance.

Now notice that where we are ignorant of the real causes of an event and proceed to categorise it as a chance outcome, that event will strike us as being *unpredictable* and *beyond our control*. These judgments of unpredictability and lack of control are amongst the very beliefs and opinions about the event in question that one would have had if chance were in fact a real metaphysical feature of the universe (one needs to say all that with a Humean swagger), but they remain fully in force within our newly found metaphysical agnosticism. It's at this moment that the link with how artistic creativity engages with chance becomes visible. Here's the proposal: an element that functions to shape an artwork is usefully thought of as a chance element in that process if the artist does not, cannot, or chooses not to, explicitly predict or deliberately control the details of that element's contribution to the form of the work. Whatever else it is, chance, as it concerns artistic creativity, pivotally involves a lack of predictability and a lack of deliberate control, which are precisely the features revealed by our conversation with Hume and Ernst. Bringing these thoughts together, one might say that chance amounts to *un-designed* details in the created output.

The foregoing reflections tell us how, in the present context, to interpret the definitions of "chance" and "contingency" that were adopted for this chapter as a whole (see chapter introduction). In effect, embracing the recommended epistemological notion of chance licenses us to think of the terms "chance" and "contingency" as ways of latching onto the phenomenon that we really care about, namely those details in a created output that were neither explicitly predicted nor deliberately controlled by the artist (author, composer etc.). One way of thinking about such un-designed details is to portray them as arising *spontaneously in the process of production and/or reception* (which is how this chapter as a whole has defined "chance"). Another way to think of them is as details which, with respect to the artist's original specification, could take a variety of forms, meaning that whatever forms they actually take *could have been otherwise* (which is how this chapter as a whole

has defined “contingency”). The contrast case for contingency is with those details of an artwork that were explicitly predicted or deliberately controlled by the artist and, in that sense, might provisionally be thought of as *necessary* features of the artwork. Here, two comments are immediately in order. First, all of this is consistent with the fact that some artists consciously design-in the un-designed, that is, they deliberately leave gaps within their works for chance to contribute to the generative process. As one might put it, they make room for spontaneity (examples later). Second, some author-specified details of artworks—even details that are apparently central to the works in question—are regularly changed during subsequent implementations of those works (e.g., in productions of plays or cover versions of songs), without those implementations somehow failing to count as examples of the works. This undoubtedly complicates the picture, but that’s the force of the word “provisionally” in the characterisation of what “necessity” (and, by extension, “contingency”) means here. This complication surely needs delicate handling (some of the issues are explored in this chapter, in the context of eighteenth-century theatre, by Ballaster), but for present purposes it will be ignored.

The proposal that chance amounts to *un-designed* details in the created output might not seem especially revolutionary or exciting, but one needn’t suppose that it is to find that there’s something worth saying in the remainder of this treatment. The pay-off will be in a picture of how chance, when characterised in this way, operates in relation to the creative process, especially in its interplay with predictability, control and design. We will get to that picture soon. As preparation, we first need to think about the kinds of real-world systems that routinely underpin artistic creativity and in which chance, as it now concerns us, thus figures.

## 2. Entangled Systems

An increasingly prominent view in contemporary cognitive science proposes that psychological phenomena such as thought, reasoning, emotion and experience routinely depend, in various ways, on *entangled* systems of neural, bodily, and technological and/or socio-cultural elements. This focus on an intimate and intricate entanglement between brain, body, technology and culture contrasts sharply with the neuro-centric orthodoxy in cognitive science. According to that orthodoxy, any non-neural factors in play are standardly conceptualised as no more than (i) sources of essentially passive informational inputs to the inner neural cognitive system or (ii) the implementing means by which, or the stage on which, neurally-specified actions occur. By contrast, on the entanglement view, the highlighted extra-neural elements are no longer peripheral features about which cognitive science itself can remain largely silent. Rather, they are active causal-explanatory factors that contribute, in subtle and fundamental ways, and as collaborators with neural factors, to psychological activity. Entanglement so conceived is thrust to the fore principally in the growing body of cognitive-scientific research that self-identifies using terms such as *distributed cognition* or the *extended mind* (see Anderson, Wheeler & Sprevak 2019, 1–9, for an accessible introduction to these and closely related ideas).

When one first encounters psychological entanglement, it is tempting to reach straight for an image of contemporary human lives as intertwined with the smart, often wearable, increasingly personalised, gadgets and gizmos onto which we regularly offload important

aspects of a multitude of tasks such as remembering phone numbers and planning routes. Everyday cognitive achievements such as these are now, more often than not, the products of repeated brain-body-world loops built out of neural processes, embodied manipulations and off-body processing in technology. Moreover, the technological contribution to such loops is increasingly being delivered by ever-smarter apps endowed with AI (for this phenomenon, in relation to creativity, see Dumas' contribution to this chapter). However, this focus on systems that incorporate advanced feats of technological progress, while understandable, is optional. Take good old-fashioned long division, the kind of mathematical task that one performs using pen, paper and embodied manipulations of external symbol systems that have been handed down through cultural transmission. Long division is no less an achievement of an entangled system of neural, bodily and technological elements, with the movements and meanings of the symbols fixed by social norms. Indeed, counting on one's fingers already demonstrates how bodily movements may be incorporated into mathematical problem-solving routines. And for a case with an explicit social dimension, consider the manner in which the intelligent feat of ship navigation is realised through a pattern of embodied information communicating social exchanges between crew members who, individually, perform purely local information processing tasks (such as taking bearings) using specialised technology (Hutchins 1995).

One thing that this ready stock of examples indicates is that, as Haugeland (1988) once remarked, there's no real need to argue for an entangled understanding of human thought and experience. Once one points out the phenomenon of psychological entanglement, there are examples just about everywhere. It's no great surprise, then, to find that created products in art, music, theatre and literature — the outputs of creative artistic cognition — are routinely generated by or within such entangled systems (Wheeler 2018 and forthcoming; examples later). Still, just because this depiction of the creative mind is largely unsurprising doesn't mean that we already appreciate all of its features, complexities and implications. To move towards such an appreciation, we can combine a focus on entangled systems with our opening conceptualisation of chance, and so explore the delicate balance between predictability, control, design and chance that characterises creative cognition as an entangled phenomenon.

### **3. Creativity and Constraints**

Creative artistic cognition routinely involves non-trivial contributions from a range of constraints that, for all practical purposes, are beyond the artist's control, but which are the platforms for controlled design. In taking this idea on board, it is important to resist the seductive image of a constraint as a barrier or an impediment. For although a constraint will restrict certain possibilities, it may nevertheless be a productive, form-generating element in the creative system, precisely in virtue of that "limiting" contribution. In their treatment of improvisation in the performing arts in early modern Europe (more on which later), Cumming and Tribble (2019, 206) nicely capture this point when they observe that a "constraint—whether the notations on a page, the affordances of a musical instrument or of the human body, the space of performance, or the emergent configuration of bodies moving in time with one another—functions as a powerful sticking point around which complex assemblages are formed."

As the indicative list offered by Cumming and Tribble already suggests, a wide variety of constraints is operative in creative cognition. Some of these constraints are established by the way the brain is wired up, while others come from the non-neural body (from properties of muscles, bones and body shapes), from the tools artists deploy, from the physical spaces in which creation happens, from socially instituted genre conventions, and elsewhere. However, from the vantage point of entanglement, which, after all, operates as a corrective to neuro-centrism, it seems that, crudely speaking, things get more interesting the further out from the brain the constraints get. A compelling example is provided by the musician and songwriter David Byrne (2012; for further discussion, see Wheeler 2018). In the mid- to late 1970s, the CBGB club in New York was the spawning ground for a series of new bands, including Tom Verlaine's Television and Byrne's own Talking Heads. Some of these bands produced music with a particular and distinctive character, being both loud and intricate. According to Byrne, this was the direct result of CBGB's physical space. The artists had to play loud because of the club's noisy, bar-like atmosphere, but a lack of reverberation in the performance space meant that the details in the music could nevertheless be heard. In this way, the physical space in question emerges as a form-generating constraint.

So, how does a recognition of the creative power of constraints link up with our favoured notion of chance, with its particular emphasis on ignorance of causes, unpredictability and lack of control? Let's start with the detailed form of the created product, say with the intricate webs of guitar patterns interspersed with loud rock chords that one typically finds in the music of Television. As we have seen, if Byrne is right, this deep structure of the music in question is, at least in part, a subterranean consequence of the constraints imposed by the physical space at CBGB. Although it's an empirical matter, it seems likely that Tom Verlaine and his band-mates would have been ignorant of the way in which these constraints were operating so as to shape their creative outputs. (In this context, it's worth noting that Byrne's own analysis is retrospective.) Moreover, such constraints were not designed by, and were manifestly well beyond the control of, the artists in question. Thinking about unpredictability is perhaps a little murkier, but it seems unlikely that the constraints in question were being explicitly factored into the creative process in any sort of deliberate manner, or that their effects on the form of the created product were either estimated or tracked. It seems, then, that we have good reason to think of the music as being generated by an entangled system in which chance elements, in the form of productive constraints, make a crucial contribution to the details of the creative output. Marquee Moon will never sound the same again.

#### **4. Taking Control**

The foregoing discussion highlights the manner in which environmental factors beyond the artist's control may contribute, as chance elements, and in non-trivial ways, to created form. But sometimes artists deliberately take control of constraints, in order to harness their form-generating power. This is not to eliminate entanglement, but rather to give it a certain shape, one in which it is designed. In other words, it is to eliminate certain aspects of chance. In a general psychological context, this is one facet of what Clark has dubbed *cognitive niche construction*, the phenomenon in which human beings build external structures that, often in combination with culturally transmitted practices, transform problem spaces in ways that promote (or sometimes obstruct) thinking and reasoning (Clark

2008; see also Wheeler & Clark 2008). The parenthetical qualification, highlighting the existence of cases in which the designer environment ends up hindering cognitive performance, is a prompt to enter into debate over precisely how to characterise cognitive niche construction and especially its relationship with a widespread conception of cognition as essentially problem-solving (see e.g. Kukkonen 2019a). For today, however, those tricky issues will be placed to one side. That done, the idea of cognitive niche construction can be adapted so as to apply to the artistic creative process. Thus *creative cognitive niche construction* is the process by which artists build external structures that, in combination with pre-existing practices, transform psychological spaces in ways that aid creative thought.

A powerful illustration of this is provided by composers who build their own instruments. As noted by Cumming and Tribble (see above), different musical instruments present composers and musicians with distinctive sets of affordances (in this context, particular creative possibilities) that function as productive constraints on the relevant created products, whether those products be compositions or performances. In most cases, these instrument-dependent affordances are part of a culturally inherited cognitive niche that was constructed by prior generations of instrument designers and builders. However, some composers take control of these sorts of constraints and open up new spaces for creativity by designing new instruments. Consider, for example, the Oramics Machine designed by electronic music composer Daphne Oram. In this machine, elements of music such as pitch, rhythm and timbre were controlled by a method in which drawings on glass slides and 35mm film strips created masks that controlled the amount of light that reached photocells, thereby creating new affordance landscapes for Oram's compositions to traverse.

Creative cognitive niche construction, as a process of taking control of constraints and thereby eliminating chance, has a second manifestation. It goes without saying that how audiences experience artworks and texts will be partly a function of the cognitive and emotional histories that they bring to the table. However, it is equally true that artists and writers regularly construct designer environments, within which audience members are embedded, that are intended to overcome or sidestep such unpredictable chance elements in audience response profiles, with the goal of creating particular psychological effects. Thus, as Kukkonen (2019a) observes, eighteenth-century Jesuit moral and religious education thought of theatre as a way of inducing, in the audience, a state somewhere between immersion (in which the audience might actually experience the events and emotions represented on the stage) and reflection (in which the audience might contemplate the moral lessons of the play). As she concludes, the Jesuit theatre is thus a cognitive niche designed to create a particular psychological state in its audience.

## **5. Ceding Control**

Artists don't only take control. Sometimes they deliberately cede it. There are, famously, numerous instances, some of which are explored elsewhere in this chapter, in which artists design chance into the entangled system of interest, in order to build in unpredictability or un-designed (by the artist) elements. In this way, chance is designed into the creative process, either as a stipulated component or as a feature provoked by the cognitive niche in which creativity happens (for the latter, see the analysis of seventeenth-century salons

given by Kukkonen in this chapter). Consider aleatory music in which composers leave “gaps” in their specifications of the designed output to be filled in by the performers of the piece. For example, Stockhausen’s *Klavierstück XI* (1956) is made up of nineteen specified elements, but, for each performance of the piece, the sequence in which those elements are played is determined by the performer. Of course, there’s nothing essentially random about the performer’s contribution here. However, it is a chance outcome in the sense that it is unpredictable from the perspective of, and out of the control of, the composer. Relatedly, in what is explicitly called chance music, and with goals such as undermining the dictatorial role of the composer and suppressing the composer’s own musical predispositions, composers explicitly build some form of indeterminacy, such as flipping coins or throwing dice, into the compositional process, in order to make decisions about the musical content. The completed score is then followed, in an orthodox fashion, by the performer. One famous example of such chance music is John Cage’s *Music of Changes* (1951) in which the Chinese divination manual, the I Ching (Book of Changes), was used to determine musical features such as durations, dynamics and tempo (see also *Figures of Chance* Vol. 1, Chapter 5, section 3.3).

To be clear, the folding of chance into the entangled system does not necessarily eliminate all authorial decision-making from the process of creation. Exhibit one here might be Stockhausen’s *Klavierstück XI*, but consider also the serendipitous chaos of Francis Bacon’s studio, as described by Keazor (this chapter), a chaos that produced new forms which engaged and inspired the visual artist’s imagination. Even more dramatically, and returning immediately to the domain of experimental music, a composer may, in some cases, allow chance to generate, or partly generate, certain created pieces, but then retain selective control over which of those pieces ultimately see the light of day. Thus the experimental musician and composer Brian Eno has deliberately used a model of synthesizer (the Yamaha DX7) known to have an erratic oscillator, and he has deployed the random selection of playing cards featuring so-called “oblique strategies” (cryptic pieces of advice that need to be interpreted in ways that apply to the present situation), at moments when other creative processes stall (for discussion see Elton 1994). This deliberate deployment of chance is an element in a designed entanglement: part of the generative phase in the creative process is outsourced to an external element (the synthesizer, the cards) that introduces chance into the construction of the aesthetic form. However, that form is then evaluated aesthetically by the human being who sits at the core of the entangled system, namely Eno himself. Indeed, Eno has estimated that, using such methods, he produces a hundred times the amount of music he actually releases (again, see Elton 1994).

An alternative perspective on the relationship between artist, product and audience in relation to chance and entanglement is provided by the Surrealists (see Watson 2020 and Vol. 1, Chap. 5). The Surrealists adopted a range of artistic techniques and media selected precisely as the means by which reason, logic and conscious decision-making (and thus rational control) could be by-passed in favour of subconscious and unconscious psychological states and processes. Such techniques included automatic drawing, collage and decalcomania. (In the last of these—a kind of blotting method—paint is applied to one surface and then that surface pressed against another to produce a mirror image.) By incorporating these techniques into the entangled creative system, the Surrealists were also endeavouring to suppress the aesthetic judgments that accompany artistic skill, thereby

democratising the process of artistic creation and generating an outcome in which the detailed form of the artwork is just as surprising to the artist as it is to the audience (see Vogel, this chapter). Officially, then, the Surrealist method of incorporating chance into the entangled mechanisms of creation was designed to destabilise the traditional status of the artist. Unofficially, however, it is debatable whether Surrealism was successfully purged of all conscious decision-making, since one could argue that various conscious decisions still took place during the process by which, for example, the images were assembled. On this less radical interpretation, the Surrealist introduction of chance, as Watson (2020) compellingly argues, reverts to functioning more like a painter's preparatory sketching process, with the chance outcomes consciously and repeatedly evaluated, just like the preliminary sketches that figure in the more traditional entangled system that underpins painting.

## **6. Improvisation in Music**

We have now canvassed three aspects of the delicate balance between chance and design that characterises creativity as an entangled phenomenon—the sensitivity of creation to productive chance constraints, taking control of constraints to eliminate chance, and the designing-in of chance. So far, a range of different examples has been used to articulate these different aspects. However, musical improvisation provides an example of entangled creativity in which all three of these phenomena are arguably operative. So, it is worth bringing this treatment to a close with a brief analysis of such improvisation, so understood. Some of what follows adapts observations made by Torrance and Schumann (2019).

First, musical improvisation will be causally sensitive to various external constraints, such as the social setting of the performance and the dictates of the musical genre in question. Moreover, as Cumming and Tribble (2019) argue, if we look back for a moment to improvisation in musical performance (and indeed in dance and theatre) in early modern Europe, it is not merely genre and social setting that act as productive constraints on improvised outputs, but also certain heavily scripted foundations, since improvisation in this period was invariably less about spontaneous unscripted response (in the style of modern improvisational theatre) and more about ongoing skilled interaction with a given musical score (or choreography or dramatic text).

Second, although musical improvisation is often characterised as an in-the-moment event, the fact is that advance planning, involving the taking control of constraints, is a key element in delivering successful improvisations. Such advance planning encompasses such things as agreements about how long an improvised section should be, and lengthy prior training in relation to tone, harmony and rhythm that is then put into practice. A complex example that combines both sensitivity and control in relation to constraints is jazz improvisation. Here, drawing on a treatment by Zak (2000), is a necessarily brief and partial history of such improvisation. In swing, the improvising musician emphasised notes from the chords out of which the tune was constructed. In bebop, with Charlie Parker prominent, the improvising musician demonstrated that, within recognised chord forms, there were more “good” notes than those countenanced by traditional jazz musicians. Thus a certain constraint regarding what counted as “good” and “bad” notes was relaxed. In later bebop, the improvising musician also started spontaneously substituting different chords so

as to reharmonise a piece. This opened the door to post-bop, in which not only harmonic structure, but also further constraints such as tonal language and the instruments' sounds all became fully available for innovation. But even if one concluded that, at this moment, all the *musical* constraints in force in traditional jazz had been overthrown, other constraints—often embodied, social and communicative—were operative. For example, to bring out the best from his improvisatory ensembles, Miles Davis constructed what Smith (1995) calls a *symbolic ritual space*, where a ritual is (roughly) a system of customs (a form of social constraint) embodied in regularly repeated set practices. According to Smith's analysis, this symbolic ritual space was partly codified in tiny sonic performance cues that the musicians in Davis's groups deployed to inform each other about, and to comment on, the unfolding musical events.

Our third aspect of the delicate balance between chance and design, the designing-in of chance, is perhaps harder to see, but it (or something very close to it) is evident at the "risky," experimental end of improvisation (e.g., in some radical post-bop) in which instruments are forced to yield unusual sounds or effects, and "errors" are used to establish new creative possibilities. In this context, one might also mention Cage's attempt to free improvisation from the player's own musical proclivities. In his piece *Inlets* (1977), for example, the performers manipulate amplified conch shells partly filled with water, against a background sound of the burning of crackling pinecones in a fire. In this arrangement of elements, the performers have no control over the unpredictable gurgles and rhythms produced by the shells.

What this brief analysis of musical improvisation suggests is that if creative cognition involves a delicate and shifting balance within entangled systems between control and unpredictability, between design and chance, then there is a case to be made that musical improvisation is that phenomenon *par excellence*. That said, musical improvisation, as an exploration of that very same balance, remains essentially continuous with musical composition, and indeed with all other varieties of artistic composition. Perhaps that's the truth in Schoenberg's (1950, 98) claim that "composing is a slowed-down improvisation."

## References

- Anderson, M., Wheeler, M. and Sprevak, M. (2019) 'Distributed Cognition and the Humanities', in Anderson, M., Cairns, D. and Sprevak, M. (eds.), *Distributed Cognition in Classical Antiquity*. Edinburgh: Edinburgh University Press, 1-17. (Reprinted as Series Introduction in all 4 volumes of the *Edinburgh History of Distributed Cognition*.)
- Byrne, D. (2012) *How Music Works*. Edinburgh: Canongate.
- Clark, A. (2008) *Supersizing the Mind: Embodiment, Action, and Cognitive Extension*. New York: Oxford University Press.
- Cumming, J. E. and Tribble, E. (2019) 'Distributed Cognition, Improvisation and the Performing Arts in Early Modern Europe', in Anderson, M. and Wheeler, M. (eds.) *Distributed Cognition in Medieval and Renaissance Culture*, volume 2 of the

- Edinburgh History of Distributed Cognition*. Edinburgh: Edinburgh University Press, 205-228.
- Elton, M. (1994) 'Towards Artificial Creativity', *Languages of Design*, 2, 207-22.
- Haugeland, J. (1998) 'Mind Embodied and Embedded', in *Having Thought: Essays in the Metaphysics of Mind*. Cambridge, Mass.: Harvard University Press, 207-35.
- Hume, D. (1748/1999). *An Enquiry concerning Human Understanding*. Oxford Philosophical Texts edition, New York: Oxford University Press.
- Kukkonen, J. (2019), 'The Literary Designer Environments of Eighteenth-Century Jesuit Poetics', in Anderson, M., Rousseau, G. and Wheeler, M. (eds.), *Distributed Cognition in Enlightenment and Romantic Culture*, volume 3 of the *Edinburgh History of Distributed Cognition*. Edinburgh: Edinburgh University Press, 187-203.
- Schoenberg, A. (1950) *Style and Idea*. New York: Philosophical Library.
- Smith, C. (1995) 'A Sense of the Possible: Miles Davis and the Semiotics of Improvised Performance.' *TDR / The Drama Review* 39.3, 41-55.
- Spies, W. (1988) *Max Ernst: Collages: the Invention of the Surrealist Universe*. London: Thames and Hudson.
- Torrance, S. and Schumann, F. (2019) 'The Spur of the Moment: what Jazz Improvisation tells Cognitive Science', *AI and Society*, 34, 251–268.
- Watson, K. (2020) 'Surrealism, Chance and the Extended Mind', in Anderson, M., Garratt, P. and Sorevak, M. (eds.) *Distributed Cognition in Victorian Culture and Modernism*, volume 4 of the *Edinburgh History of Distributed Cognition*. Edinburgh: Edinburgh University Press, 171-188.
- Wheeler, M. (2018) 'Talking about more than Heads: the Embodied, Embedded and Extended Creative Mind', in Gaut, B. and Kieran, M. (eds.), *Creativity and Philosophy*. London: Routledge, 230-50.
- Wheeler, M. Forthcoming. 'What have the Arts and Humanities ever done for us? Disruptive Contributions and a 4E Cognitive Arts and Humanities', in Besser, S., Goede, N., Keestra, M. Kiverstein, J., Lysen, F. and Pisters P. (eds.), *Worlding the Brain*. Leiden: Brill.
- Wheeler, M and Clark, A. (2008) 'Culture, Embodiment and Genes: Unravelling the Triple Helix', *Philosophical Transactions of the Royal Society Series B*, 363, 3563-75.
- Zak, M. H. (2000) 'Jazz Improvisation and Organizing: Once More from the Top.' *Organization Science* 11.2, 227-234.