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THE IMPORTANCE OF TACIT KNOWLEDGE IN GEOSCIENCE BROUGHT TO THE SURFACE THROUGH ARTISTIC METHODS

Nicole A. L. Manley
British Geological Survey and
Queen Margaret University
nicarc@bgs.ac.uk

Nicole A. L. Manley is a multi-media environmental artist and soil hydrologist. She uses creative practices with the intention of expressing different ways of thinking to understand patterns, relationships, and processes within nature, focusing on the relationship of water and human activities. She has a PhD in ecology and hydrology and is presently undertaking an art-based PhD at Queen Margaret University, Edinburgh, UK.

Abstract: This study of scientists' reactions to the experience of an art exhibition, researches Polyani's (2009) tacit knowing, a knowledge that we cannot easily express into words, and Deleuze and Guattari's (1987) *striated* and *smooth* spaces, with *striated* being a channelled and restricted way of thinking compared to *smooth* as free flowing and creative. To research these concepts, a psycho-social method—the Visual Matrix (VM)—is used as a research method. Two groups of geoscientists were brought together to first view *Waterways*, an art exhibition, and then participate in a VM. The research concludes that the scientists were able to express tacit knowledge elicited through the experience of *Waterways*, enabling them to think differently about their work and form new understandings about the natural environment in relationship to themselves and

society. For artists, the VM can be an effective tool when working with scientists and the public. The study argues the importance of bringing tacit knowledge to the surface, allowing greater possibility of combining scientific and artistic approaches.

Keywords: tacit knowledge; ways of thinking; geoscience; environmental art; water; post-human

Introduction

This study is concerned with realigning perceptions and feelings around our relationship with the natural world. It focusses on the difficulty geoscientists (i.e., scientists who work with Earth processes) have in moving from reductionist scientific data to understanding relationships between the external world and human beings. The objective framing of Western science requires quantifiable data to create and communicate knowledge about the natural world. Human experience, however, because it is subjective, is not part of the epistemology of science. For example, when Western scientists physically go to places like the Antarctic to measure changes of ice, they return with data to analyse and produce factual knowledge; none of the emotional experience of their interactions with the physical environment have a part in creating the factual data for the scientist. This factual data is ultimately what creates knowledge for the scientist. As a scientist in hydrology and an environmental artist, I suggest that for a full understanding of the natural world, art can express what natural sciences cannot. Even though scientific knowledge has an obvious place in our understanding of our world, Western science cannot account for the full range of knowledge that is required to understand complexity.

Grillo (2009, p. 103) defines art as "human creativity" which starts from "the spiritual, the subconscious, the imaginative": a person brings into being something that has never existed outside his/her own being. He defines science, on the other hand, as "systematic knowledge derived from observation and experiences," which starts from a definite point of knowledge and ends at another specific point, leading to an outcome that has been demonstrated. In accordance with Grillo, my own art begins as a creative approach, and can start from the spiritual, the subconscious, or the imaginative. Above all, the basis of my art attempts to take a *whole approach* that encompasses the human experience of the natural world in a holistic way that is un-fragmented and complex, as opposed to reductionist and positivist. The scientific approach described by Grillo is also perfectly adequate for the purposes of this article and can certainly be applied to the hydrological sciences, which is an important basis of my scientific research (Archer[1] et al., 2013). The basic range of methods employed in the hydrological sciences are all quantifiable and include many field measurements, such as river discharge, rainfall, infiltration, chemicals in water, groundwater levels, humidity, evapotranspiration to develop mathematical operations and conceptual modelling.

The aim of this research is, therefore, to investigate to what extent the experience of art might influence scientific approaches to the natural world. The primary task of the research is to investigate the reactions of a group of hydrological scientists to the

experience of an art exhibition centred on the theme of water as symbolic of the potential for bridging scientific and artistic experience.

Literature and Context

Artists Working with Water

Artists such as Kovats, Goldsworthy, and Christo have worked in different ways with rivers and water. Kovats 'work "Rivers" (2010) displays one hundred specimens of water from one hundred rivers from around the British Isles in a boathouse: "each sample holds the memories of time, place and events, preserving them forever" (Wilson & Wilson, 2010). Goldsworthy (2015) often works with water to portray a sense of time and ephemeral existence reflected in the processes of life and death reflected in nature. Christo, on the other hand, imposes an idea of art on the exterior landscape (Grande, 2014), as we can see in "Over the River" (Christo & Jeanne-Claude, 2013), 9.5 kilometres of silvery, luminous fabric panels to be suspended high above eight distinct areas along a 67.8 kilometre stretch of the Arkansas River, bringing into focus the process of building rather than aspects of nature.

My own work as displayed in the exhibition *Waterways* (Manley, 2017), intends to share an experience of our human relationship to rivers by focusing on water and its environment. In the context of this research, the *Waterways* exhibition also serves as a stimulus for research into the experiences of scientists when faced with a very different portrayal of a world with which they are very familiar: water and rivers. The intended effect of the exhibition is not dissimilar to the actual effect of Dombrovskis '1983 photograph *Rock Island Bend, Franklin River*, *South West Tasmania* which, it is claimed, helped to transform people's attitude to the river and its natural beauty, leading to the cancellation of a dam being built in Tasmania (McLean, 2002). Unlike Dombrovskis', however, my art intends to bring the spectator into experience with water, whereas Dombrovskis attempted to suggest an untouchable reverence for the river (Bonyhady, 1996). This is partly why *Waterways* asks its audience to become immersed in the experience, rather than to be mere viewers of something representational. This is done by viewing the river that has the agency of being the artist, where blocks of clay were placed in the river, to become shaped by the water flow. At the same time the sound of the flowing water sculpting the clay was recorded. The audience could, therefore, listen to the water that sculpted the clay, while looking at the clay sculptures in the exhibition.

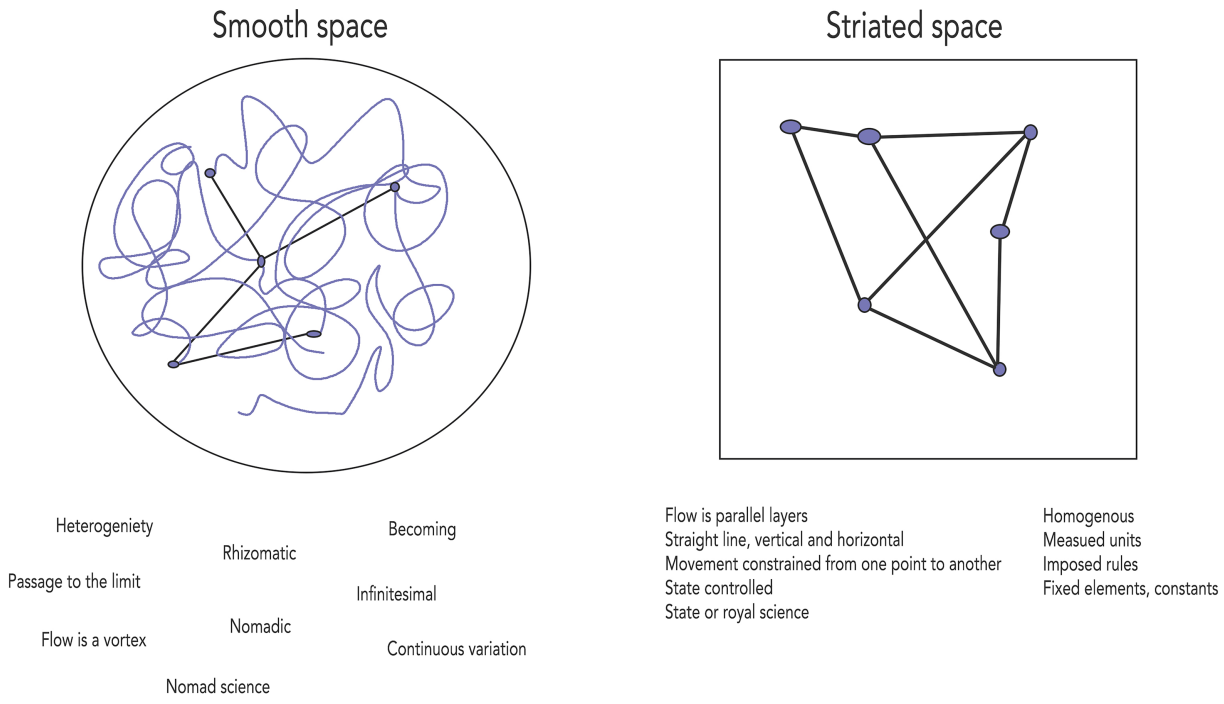
Non-Representational and Representational Thought—Smooth and Striated

It is in this non-representational context that I use the philosophy of Deleuze and Guattari to understand the method, the analysis, and the discussion of results. In Massumi's (1987) foreword to Deleuze and Guattari's *A Thousand Plateaus*, he describes how Deleuze and Guattari present their views as either "State philosophy" or "Nomad thought." The former is "representational thinking that has characterized Western metaphysics since Plato" (p. xi). This representational thinking establishes a framework of three domains of representation: subject, concept, and being. In forming analogies between these three domains, each term has essential properties in relation to the others, creating what Deleuze and Guattari termed logos, or laws and hierarchical ranking, which provides truth and judgement. In doing this, there is self-resemblance to everything that we know; this self-resemblance is in relation to a supreme standard, which is us, as human beings. Unifying principles of thought, where we as human beings are central as a single idea, creates the State. As opposed to this, "Nomad thought" is free from the ordered interiority of "State philosophy." It is not centred on the human and it is perpetually in states of heterogeneous "becomings"—a way of thinking that is the basis of post-humanist theory as described by Braidotti's Nomadic theory (2011).

The study considers ways of thinking as "spaces of creativity" and equates this to Deleuze and Guattari's (1987) concept of the *smooth* and *striated* to describe such spaces as complex mixtures between sedentary confines and nomadic forces (Lysen & Pisters, 2012). For Deleuze and Guattari, while the striated is a confined space of movement and thought, the smooth is related to nomadic free action and an unconfined space (see Figure 1). Braidotti's post humanist theory sits as part of the smooth space, where "thinking is framed by perceptions, concepts, and imaginings that cannot be reduced to human, rational consciousness" (2011, p. 2). I interpret the process of the earth scientist to be in the striated space and the artist in the smooth, for reasons that I discuss below. The concepts of the smooth and the striated were partially explored in an exhibition on the connections between art, science, and philosophy in July 2009[2]. My arts practice, research, and scientific pursuits are centred around the effects of water in the environment; the research outlined here combines scientific hydrological concepts (as described by Savenije, 2009) and Deleuze and Guattari's hydraulic model (1987), which describes nomadic thought in this context as smooth space that is "distributed by turbulence across space, in producing a movement that holds space and simultaneously affects all of its points" (p. 363). In contrast to scientific hydrological concepts, Deleuze

Figure 1

Summary of smooth and striated space (Nicole A. L. Manley)



and Guattari's hydraulic science is "held by space in a local movement from one specified point to another" (p. 363).

For the purposes of clarifying the differences between the concepts used for art and science in this study, I presuppose understanding science as *striated*, closely related to the mechanical in terms of cause and effect. This has also been suggested by other studies of the sciences. Capra and Luigi (2014), for example, detail how the dominating Western view has developed a world based on a mechanical system reduced to separate parts, shaping people's perceptions of nature, the body, society and human organizations. During the industrial revolution, the mechanical metaphor became dominant and, as Morgan (1998, p. 13) states, "Organizations that used machines became more and more like machines." Even though art for centuries was considered fundamental for understanding the relationship of natural knowledge to material culture, the concept of *technology* became a keyword that overtook meanings of art and became synonymous with *applied science*. The concept of art lost its "utility in the theoretical

discourse on the relationship between knowledge and practice" (Schatzberg, 2012, p. 555). As a result, scientific thinking is especially useful for conducting experiments, and is one of the principal philosophies of science today (Okasha, 2002).

This logical way of thinking is expressed by writing statements or mathematical terms that represent things or properties that are objectively determined (Ladyman, 2002). Such expression creates a separation of the internal from the external world where "objects are independent and distinct from the emotions and ideas that permeate the inner self" (Weisskopf, 1981, p. 239). The inner emotional self as part of the embodied mind—i.e., including both the body as a lived experiential being and the body as the context or surrounds of cognitive mechanisms as described by Merleau-Ponty (1962) and Varela et al. (1991)—is therefore not recognized or included as a part of the mechanical or technological thought process. This way of thinking creates a separation from our physical world because people are the supreme witnesses/observers of the world. Such thinking becomes *striated*; the flow of thought remains within one logical plane, where, even if the scientist tacitly recognizes an embodied mind, it cannot be expressed.

Tacit Knowledge—Difficulty for Spoken Expression

Art may rely more on subjectivity and intuition (Richmond, 1984); it invites interpretation and is free to reach beyond the rational and what cannot be seen (Setlow, 1994); it contains a vast realm of relationships, feelings, emotions, reactions, attitudes, and moods (Weisskopf, 1981). An artwork tends to develop "through interpenetrations of figure and space" (Miller, 1995, p. 189) in which multiple viewpoints of perspective create a whole view rather than component parts. Art and creativity use all aspects of the mind, from the rational or objective view of the world to the embodied mind; it takes a more subjective and intersubjective view where mind, body and the outer environment are all interrelated. Flows of thought run in constant variation, between the outer to the inner self, forming a smooth space for creation. Even though much art functions on an objective level, as explained by Johnson (2011), the general public does not think that the arts provide knowledge and may even consider art meaningless; Johnson suggests that knowledge "should be a term of praise for success in a process for intelligently transforming experience" (p. 142). Experience, however, might itself be understood as a human process that forms part of "knowing" yet is difficult to communicate. As Polanyi famously stated in 1966: "we know more than we can tell" (2009, p. 4). He described this as "tacit knowledge," that is, a "functional relation" consisting of two terms, *the proximal* and *the distal*, where the proximal refers to knowledge that perhaps we cannot articulate. He uses the example of identifying someone by their face: "we are attending from the

features to the face, and thus are unable to specify the features" (p. 10). In other words, we have a tacit knowledge of the features that make up the face.

Apart from this tacit knowledge, there are also difficulties of reaching a conscious understanding of artistic work. This is shown by Pallasmaa (2009), who states that an artistic work "impacts our minds before it is understood, or without ever being intellectually understood" (p. 127). So how can we verbalize and make sense of artwork if it impacts our minds, but we cannot intellectualize it? In attending to these questions, I have chosen to use a research method that provides a deeper understanding of artwork: the Visual Matrix (VM). This method has been developed in psychosocial research, including in the evaluation of artworks (Froggett et al., 2015), and focuses on visual imagery rather than words. Because its focus is on visual images, it has been found to be a useful qualitative technique in understanding the context and meaning of artworks (Crossick & Kaszynska, 2016; Manley 2018a). As part of this use of visual images, as opposed to the written narrative or description, the role of affect (*affectus* in its Spinozian Latin origin) is key. More than simply emotion, Spinoza's affect is a physical, moving sensation that occurs in the relationship between things, including the person and their environment. Images, as part of this process, become the moving parts of affect, as adopted by Deleuze and Guattari (1994) in their discussion and definition of the concept of "becoming." According to Manley (2018a) the images in our minds are "always 'becoming 'affects, in transformation and conjunction with the mind"; meaning that affect "does not belong to either the subject or the exterior world; it is a thing in itself" (p. 82). Manley continues describing affect as having space and duration, emphasizing process, such as activity, action, and transition, which forms a holistic approach to space and time that are otherwise dualities in a Cartesian paradigm. In this study, affect has an important relevance as it is also a form of tacit knowledge. While tacit knowledge denotes anything that might remain unexpressed, affect as tacit knowledge remains unarticulated because of its specific inner complexity and its shifting of intensities of emotions in ways that are difficult to put into words.

This study uses the VM to enable the emergences of affect as a key process in a person's interaction with visual stimuli. This is especially important in this study because the affective aspect of human experience is deliberately excluded from scientific approaches. The VM can become like a Deleuzian *rhizome* of affects, where temporal, fluctuating, heterogeneous connections of intensities of affect occur, allowing for multiple layers of images to emerge, creating expression and meaning.

Deleuze and Guattari (1987), define a *rhizome* as "an a-centred multiplicity, where multiplicity has neither object nor subject, only determinations, magnitudes and dimensions" (p. 8) which can change in nature if the quantity changes and it has no structure. This conceptualization helps us to understand that everything is multiple and interrelated, where any point can be interconnected or broken with any other point, no matter how similar or different. Deleuze and Guattari (1987) consider the rhizome as a map that can be entered or exited at any point and is an immanent process. This way of conceptualizing thought as rhizome questions hierarchical organization and processes. It allows thought to be more dynamic. This Deleuzian approach to thought and affect provides the ontological background that is applied throughout this research. This study, therefore, investigates the VM as drawing meaning and understanding of tacit knowledge, especially that active, becoming tacit knowledge that I am calling affect, following a Deleuzian approach, from people's experiences of an exhibition. The particular focus of the research is aimed at the use of this method with geoscientists.

Methodology and Methods

The methodologies employed are art-based practice and psychosocial, emphasizing the use of unconscious, subjective and affective aspects of perception, and an understanding of engagement in social and environmental contexts at the micro, meso, and macro levels, which are all aspects of tacit knowledge that are difficult to verbalize.

The methods were in two parts (1) developing an art exhibition and (2) undertaking a VM.

The art practice was based on visualizing aspects of Deleuze and Guattari's (1987) contrasting concepts of *smooth* (uninhibited and free flowing) and *striated* (channelled and restricted) space. The exhibition used the concept of water as a metaphor of smooth space, where water moves in formations of spirals and vortices which are simultaneously held within a space while also constantly moving, influencing, and disturbing every point within that space in processes of becoming (p. 361). On the other hand, according to Deleuze and Guattari, water movement becomes striated by human intervention when flow becomes confined to conduits, pipes, and embankments, preventing turbulence and constraining movement to the flow between specified points, creating striated space (p. 363).

The aerial collages, therefore, took on the form of the Deleuze and Guattari's hydraulic model, where the river exemplifies the flowing through the topographical smooth

space. This was also the intent of the collage (Figure 2) and embroidery (Figure 3) of the upper reaches of the river valley, where the water emerges as springs, as a new beginning. This mode is interrupted when the landscape changes and becomes striated by human intervention. As described by Deleuze and Guattari, the spaces of the sedentary space are "striated, by walls, enclosures, and roads between enclosures," whereas smooth space is effaced and displaced in this case by the trajectory of the river (p. 381). Once the river enters striated space, it must conform, as it can no longer become flow as curvilinear form.

A series of photographs called "smooth and straited" shown as a projected slide show (Figure 4) depicted both man-made waterways—such as canals, drains, channelled rivers—and natural waterways (unaltered by human activities) which were arranged to provide a constant contrast of the different kinds of waterways in our environment. These contrasting photographs provided an element of "tension" between water in a smooth space and water in a striated space. Deleuze and Guattari (1987) suggest that striated is not only "limited," where, in this case parts of the landscape are divisible by boundaries, orientated to one another, and interlinked, but also "limiting," because it prevents the growth of smooth spaces (p. 1227).

The purpose of the artwork was also to take the *viewpoint* of the river. It was to shift into the mode of "Nomadic notions" (Deleuze & Guattari, 1987, p. 1227) (aimless wandering with no preconceived direction) and "become" the river. How would this be possible if, according to Deleuze and Guattari, our Western way of existing is representational of "the State," which is to constrain movement and limit ourselves to order (p. 1227)? To remove the human from representational thought, the river had to become the artist, and for this I added clay blocks into the river for the water flow to mould them (Figure 5). In doing so, the river was given agency and it acted upon the clay and became the artist. The presence of the river was captured by audio recordings for each waterfall and these were used to provide an immersive experience in the artwork. The use of a hydrophone gave the added impression of the force of water acting against the blocks of clay. In the process of bisque firing the clay sculptures, the sculpture that had been created by the strongest waterfall exploded in the kiln. This gave me the impression that the river had done its worst and the clay sculpture had succumbed to the forces of the river. I decided to rebuild the sculpture with the intact pieces and showed its pieced-together-form by using white putty to accentuate its brokenness (Figure 5C). In the making of the sculptures, the discharge of each waterfall acting on the clay blocks was scientifically measured in litres per second to provide a contrasting element of quantification, typical in hydrological sciences. The arrangement of the clay sculptures on

plinths with headphones to listen to the sound of water falls alongside the silent “smooth and straited” slideshow of different types of waterways are shown in Figure 6.

Figure 2

The three collages showing different sections of a river system. The left-hand collage is the upper part of the river, where springs begin, the middle collage is midway in the valley and the right-hand collage is the main river (Nicole A. L. Manley, 2017).

Figure 3

Tapestries representing three river sections, as described in Figure 2. The left-hand collage is the upper part of the river, which is the source of the river, the middle collage is midway in the valley and the right-hand collage is the main river (Nicole A. L. Manley, 2017).

Figure 4

An example of the types of waterways shown in the slide show. The top two photos are of natural rivers considered not having anthropogenic change, in contrast to the bottom two photos of a channelled river and a man-made canal (Nicole A. L. Manley, 2017).

Figure 5

12.5 kg of white grogged clay being sculpted by waterfalls (above) and resulting clay sculptures (below) with their measured flow rates shown in brass plaques below each sculpture (Nicole A. L. Manley, 2017).

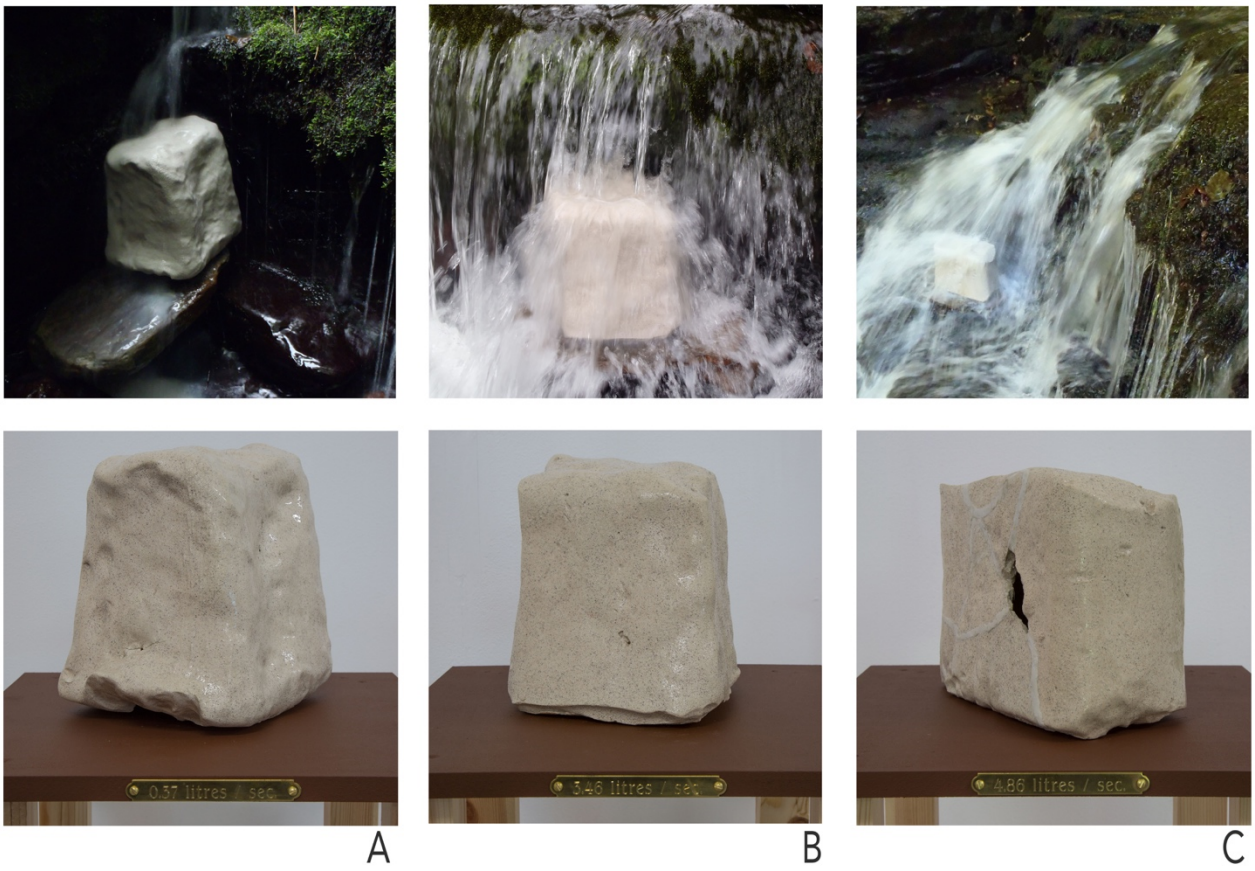


Figure 6

The clay sculptures sculpted by waterfalls displayed on wooden plinths, with headphones to listen to the waterfall that had sculpted each clay sculpture. The screen on the wall is the slide show of "'smooth and striated" waterways (Nicole A. L. Manley, 2017).

The Visual Matrix (VM)

Once viewers had seen the exhibition, they were invited to take part in two VMs. Twenty-three scientist participants took part. The participants of the VMs were all over 18 years old and worked in geoscience at the British Geological Survey as hydrologists, hydrogeologists, volcanologists, geologists, or modelers. Following guidelines for ethical procedure approved by the Glasgow School of Art, participants were provided with information sheets explaining the VM process, including an explanation of the VM, the

steps taken in the process (stimulus, snowflake pattern, post-matrix discussion), the purpose of the study, the reasoning behind the participation of scientists in the research, and that taking part was purely on a voluntary basis. Confidentiality and anonymity were emphasized and guaranteed, and contact details of the researcher were provided in case of the need for follow up questions or comments from participants. There were opportunities for the participants to clarify the proposal and to ask questions. The questions that were posed beforehand were about the study as a whole, rather than questions about the method of the VM. An accompanying consent form was distributed and signed by all participants to ensure they agreed to take part in the VM process, and that the VM could be audio recorded, to be later transcribed for analysis, allowing interpretation and publication of results from the VM and the viewing of the exhibition.

To begin, the VM chairs were arranged in a snowflake pattern, as described in Manley (2018b) (see Figure 7). The snowflake pattern enables people to be seated within a group, but each individual gaze avoids eye contact because the chairs are off set. This provides each participant with an opportunity to contribute affect-laden images without a sense of judgement or embarrassment from others.

Figure 7

The arrangement of chairs for the visual matrix (Nicole A. L. Manley).

In my role as facilitator, I began the VMs by explaining that the purpose of the VM is to allow the emergence of images, associations, feelings, and ideas, on the theme of *Waterways*. During the VM, which had a duration of 45 minutes, there was no turn taking or obligation to speak, and there were no comments on or interpretations of other people's contributions. The images, feelings, and associations during the VM were allowed to float and eventually accumulate into a type of verbal visual collage.

Post Matrix Discussion

After each VM, there was a 5-minute break, and the chairs were re-arranged into a semi-circle. Participants were then encouraged to reflect and discuss for approximately 25 minutes on what had emerged during the VM and to identify any clusters of imagery, thoughts, and feeling that came from associations. A flip chart was used to write down the main ideas, themes, and intensities of feelings that occurred during the discussion.

The post matrix discussion mainly focused on the images and themes that arose in the VM, but there was also space for participants to ask other questions or give their feedback about the actual process itself. The main question asked about the VM was how the data could be analysed, when the images were so subjective. In the scientist's point of view, it was difficult for them to consider the images as data; however, through the post matrix discussion there was a general consensus that they felt there were definite patterns in the images that arose, and they felt new connections relating to water that they had not expected, as shown in the following results.

Results

Visual Matrix Results

The Emotional Work of Scientists and the "Viewpoint of the River"

The VMs allowed spontaneous images and feelings to emerge and were an opportunity for broadening the scientists 'perceptions of water from a scientific paradigm to include a *viewpoint of the river*. The data are expressed in images that are sometimes startling but are expressive of tacit knowing. The following extract, evoking *Doctor Who*[3], was linked to previously unexpressed feelings towards the scientific work. In this image, the river takes on a malevolent, encroaching, indifferent presence, provoking a feeling of anger:

> *I find myself feeling quite angry because the photos and the sculptures, they really highlighted the indifference of water, that it just doesn't care and I think, … Especially the photos and this is where the Doctor Who thing comes in, it was just everywhere and it just seemed to be just encroaching and a little bit malevolent and I thought of all the things that waster's used for that isn't very nice, but it doesn't care and those blocks really… I thought it was really interesting that they could be so deformed by something that is utterly indifferent to what it does, and I never thought about water like that. I've always enjoyed babbling brooks and streams and stuff. Somehow it just hit something else. (VM2-Ex.1*[4]*)*

Here the water seems to be the malevolent, indifferent foe against humanity, which perhaps only Doctor Who*,* the Time Lord, can save us from. Considering that all the scientists in the VM are also doctors, there may be an ironic representation of the scientists as the ultimate controllers of the enemy, water, soon to encroach upon us. Here the river is given human qualities that express the way the scientists might feel about their work, which is a shift from the positivist paradigm.

This "indifference" of the river is continued in the following extract, also suggesting that the river has a will of its own:

> *A poem by T.S. Eliot, where he speaks of the rivers being "strong brown god" and essentially…indifference comes in and also the fact that it waits placidly and then suddenly there's a flood...so you might go for a long period of time and the river is perfectly placid and you live with it and relate to it in a very placid way and then you know, at a time of its choosing…it may flood… (VM2-Ex.2)*

When the speaker references a poem, it relates to T.S. Eliot's (1944) "The Dry Salvages," which begins:

> I do not know much about gods; but I think that the river
> Is a strong brown god – sullen, untamed and intractable. (p. 35)

The connection of the river to this poem suggests that the river has the power of a god, where it can be placid for long periods of time, yet we do not control the river, because "it chooses" to flood. Here the river takes on a personality as a "strong brown god." As in the previous example, this is a shift from the scientific objectifying of the river.

> *In another passage evoking indifference, a river spirit "shrugs its shoulders":*
> *My image is a river spirit shrugging its shoulders. If you can imagine a tall watery being shrugging its shoulders, not really caring, which is similar from what you were describing…counter to what people were saying, I don't have that sense of anger or, logically I do, but…and I was thinking of a dark water inwards, green moss around it and triggered by the ka-plonk and your tin-can made me think of just one droplet of water from one branch is dropping in the middle, ripples coming and being very calm which is quite a contrast to what has been discussed. (VM2-Ex.3)*

The "river spirit" suggests a mystical aspect to water. In this case, even though the spirit does not care, the river can also have absolute calmness, to the point you can actually see the droplet of water reflecting outwards on its calm surface. This part of the image closely resembles one of the slides in the *Waterways* exhibition (Figure 8) and demonstrates how images are emerging in the VM in a rhizomatic way, from feelings of fear to calmness. Such extreme relationships cannot be explained by cause and effect, but intensity of affect, sensations and perceptions that are alien to scientific thinking.

Figure 8

An example of one of the slides in the 'Smooth/striated' projection, relating to Extract 3 (Nicole A. L. Manley, 2017).

This leads to the concern that the river cannot be controlled, which may be part of the scientific remit, due to an innate power which was expressed in the following consecutive extracts:

> *I find the discussion about upland rivers and the pictures of them very much give me emotions of friendliness and the peacefulness can actually be actively friendly. But lower…the pictures of the larger rivers at the bottom, there's trepidation. I look at that and I feel slightly fearful and I got that as soon as I came in to and looked at them. That was my reaction to them. (VM1-Ex.4)*

> *I think I feel more sad when I look at the third one. When I look at the upland one, it makes me feel perhaps happy, perhaps calm, but certainly looking at the last one, of the bigger rivers I felt sad. (VM1-Ex.5)*

> *The upland one, it's just, I feel free, whereas the lowland one is just really chaotic and stressful. (VM1-Ex.6)*

These comparisons were stimulated by the three collages (Figures 2 and 3), where upland rivers emit friendliness and peacefulness but, once they become larger in the lowlands, these feelings change to fear and sadness; this may be related to the lowlands feeling stressful and chaotic, as opposed to the freedom of upland rivers. The paradox of sensations that scientists are able to express through the experience of the artwork is far removed from the fragmentary focus of the scientific paradigm. This leads to feelings of dismay at the power of a river that can undo or defy the efforts of the scientist who is working with people who have had their homes flooded.

> *So, I get a lot of emotions, because in another life I worked in Wallingford in the Environment Agency, not long after the big floods that had hit Oxfordshire. So, there was a lot of anger. You know, people lived in these beautiful houses, you know, hamlets with lovely rivers going past, but they were very angry, because they had all been flooded and there was a lot of blame and then I started associating like with rivers with fear on my own behalf, so not…, not fear as individual, but fear of, "Oh God!, What if there is a flood event again, These people will blame us. What if we don't do our jobs properly"…at that time something that I enjoyed as sort of passively or you know, as an environmental thing became something really wrapped-up in a series of quite powerful emotions not just for me, but for the people that were around me as well.* (VM1-Ex.7)

Here there is a feeling of not living up to expectation in one's job and being blamed for something that the scientists have no control over, and how this illustrates the possible clash between caring for the environment and caring for people.

Scientists Working with the River and Tacit Knowing

The VM expressed the physical feelings scientists have when they take measurements in the environment. The scientific detachment from the object of study was disrupted:

> *That brings to mind the temperature of water for me. Sampling in Iceland in really cold water. Trying to take a CFC sample, whilst still feeling your fingers, but how in some cases, it can be really warm and it's really nice and relaxing to get into and other times it really makes you take a sharp breath… (VM1-Ex.8)*

Feeling the differences of being in cold or warm water during scientific fieldwork is not normally part of scientific objective dialogue. Spending time working and interacting with water perhaps allows scientists to experience an almost personal relationship with the river, as suggested in the following extract:

> *Standing in a river is one of the most relaxing things that one can do and there is definitely…something very intrinsic about that for me and you're suddenly embedded in the landscape. (VM2-Ex.9)*

The suggestion in the above extract of being "embedded in the landscape" may relate also to Sullivan's (2012) *embodied knowing*, where the act of knowing comes from the process of experiencing and making (in terms of art). Perhaps, for the scientists experiencing the river, taking physical measurements is a similar process. Feeling that "standing in the river" is something "intrinsic" may also be part of Polanyi's description of *indwelling* (1966, p. 17) where the appreciation of the river "dwells" on the mind through the intimate physicality of being in the river.

Waterways and the VMs were also able to bring to light the conceptual difficulties that arise in the realization of such tacit knowledge which is normally hidden from view in the routine work of scientific investigation. In the work of hydrologists, it is difficult to conceive of the hierarchical interconnectivity of water along the length and breadth of a river, including its surrounding environment. If viewed holistically, this should be understood in a three-dimensional complexity which challenges the reductionist paradigm that scientists frequently adhere to. Within the first VM these problems in conceptualization were expressed in the following extracts:

> *We have this wee line of water making its way through the landscape, but you know, in many places, there is this mass of water flowing underground that we don't see. (VM1-Ex.10)*

> *You only ever see a river at one point often…it's very difficult to appreciate the whole network, which is feeding into that river and contributing and is part of that river and what happens downstream of the point which you're looking at. …It's very easy to see a river as it is right in front of you, rather than almost a neural network which is embedded in the landscape and how it interacts with the landscape around you. Whether that's in the downstream urban area or a much more rural upland area. (VM1-Ex.11)*

> *That just makes me think of the Ganges again where, you know on the plains you're walking over this sea of groundwater and then it's hard to relate that back to where it came from up in these mountains at 9000m. (VM1-Ex.12)*

Issues of scale and quantification are often a problem in science, but *Waterways* and VM1 created an environment where the scientists could conceptualize their tacit understanding of water connectivity and describe how difficult it is to understand the complexity of rivers using conceptual hierarchical understanding of linear networks.

Post Visual Matrix Discussions

During both post VM discussions, the scientists discussed that they were surprised about their emotional responses to water and they enjoyed the process of being able to discuss their experiences about their work differently; some even felt that it was quite liberating to talk more empathically, rather than searching for evidence to develop a statement which is necessary for working in geoscience.

There was an interesting discussion about viewing some of the artworks, in particular, the three collages. Some of the volcanologists were surprised that the hydrogeologists viewed the three collages as being connected together. The volcanologists had not viewed them as being connected until they heard the hydrogeologists discuss the images of the river connecting within the landscape (an example of this can be found above in VM1-Ex.11). As for the hydrogeologists, they were surprised that people, even working in geosciences, do not think about the connectivity of rivers within catchments. This then began a conversation about how the hydrogeologists need to communicate differently to non-hydrogeologists and not simply assume that people think in the same way. There were also discussions after both VMs about how there is a personal separation from water and how they could create better understanding to bring a better relationship to rivers. One person who was working with local authorities to restore river function concluded the discussion by saying:

> *We are all of water, 70% of it, but we have forgotten how to live with it. …One of the things we have lost is the wonderment of the world. (Post discussion VM1-Ex.13)*

Discussion

Becoming Aware of Tacit Knowledge

The results reveal scientists' tacit knowing. During the post VM discussion the scientists were able to discuss how they could not assume that their tacit knowing is necessarily available to others to think in the same way. The Waterways exhibition and ensuing VMs made awareness of these assumptions possible and helped the hydrogeologists discuss how they needed to communicate differently to non-hydrogeologists. This could lead to more holistic, realistic evaluations of water and associated problems, such as flooding, which are becoming increasingly complex with the advent of climate change. During the VM, hydrogeologists expressed problems of conceptualizing the intricacy of rivers across the landscape (Extracts 10 to 12). This may enable scientists to open up discussion about concepts that are taken for granted within their discipline.

Becoming aware of the emotional aspects of one's working environment as shown, for example, in Extracts 8 and 9, provides a more complete understanding of their relationship to their working environment. It also brings up difficulties arising within the job of the scientist relating to the public, as shown in Extract 7, where the "elevated" position of being scientists forms an expectation from the public that they will be protected from the river. This knowledge could be used to improve understanding of the relationship between scientific work and the public's relationship with their environment.

Recent developments suggest a tacit knowledge in the air, so to speak, that is already bringing the arts into close contact with scientists. For example, for the first time, the British Geological Survey (BGS) has recently introduced an art exhibition to be displayed in their main scientific centre in Keyworth, UK. The head of BGS stated that the intent of the exhibition was to "enhance the dialogue about Earth and its future with the public" (Ludden, 2017). This combination is not new (Binitie, 2017; Gabrys & Yusoff, 2015; O'Neill & Smith, 2014) but, in this case, art is being brought into a scientific institute to develop a broader dialogue. This is not easy and, during my research, there were some concerns expressed by some of the scientists about not understanding the art displayed. This would suggest that undertaking a VM to support scientists in overcoming the initial uncertainty of experiencing an artwork would be useful.

Influence of Art on Scientific Approaches

The art exhibition was central to stimulating and shifting the viewpoint of rivers and water from an anthropocentric viewpoint to a non-anthropocentric one. It was the images and sculptures that began to form the descriptions, which were given in the VMS. This can be seen, for example, in Extracts 4 to 6, where the descriptions relate to a sequence of three images from upland to lowland rivers, as they begin small and become bigger. These images allowed the scientists to then connect their own experiences to the art exhibition and develop new thoughts and associations.

Even though the scientists in this study use a positivist paradigm in their work, they were able to shift their perception of rivers through experiencing an artwork and hearing the descriptions of others during the VM. Shifting away from objectified thought, as shown in Extracts 1 to 3 and 4 to 6, allows the scientists to express their experiences through emotions (intensities of affect) related to the river resulting from the rhizomatic structure of the VM. This subjective knowledge differs from imagination because of immersion in the totality of the intensity of affect; what emerges is real, affective information rather than fantasy. It is a movement away from the subject-object focus of scientific work to an inter-relational vision of the world. For example, the perception that the river "does not care … it just encroaches," moves scientists away from being central in relation to the river, to the river being in rhizomatic relationship with the scientist. Extracts 3 to 6 show how the scientists feel about the duality of rivers: when the rivers are calm and small, they feel tranquil and peaceful, but when the river is larger, there is a feeling of trepidation and fear. The idea that the river is "indifferent" and will "encroach" or "flood" at its own "choosing" (Extracts 1 and 2), suggests the river includes some uncontrollable power. Perhaps the river controls us. By shifting to a smooth space of thought, the scientists no longer assume the elevated human position that places them at the top of a hierarchy of cognition, defining them as observing/witnessing scientists. Instead, they are free to contemplate through their direct and empathic sensations and emotions developed through experiences, and they do so by "becoming river." This also perhaps relates to what Deleuze and Guattari mean when they say: "the organism is that which life sets against itself in order to limit itself, and there is a life all the more intense, all the more powerful for being inorganic" (1987, p. 525). The river is inorganic, and for the human—an organic being—to have sensations of being part of the river gives a sense of wonderment, as is suggested in Extract 13, reminding us that we are 70% water, something which is truly wonderful. The inorganic element of water does give a sense of intensity with life. Within the process of experiencing an art exhibition followed up by a

VM, the scientists were able to move from the *hydrological* model to Deleuze and Guattari's *hydraulic* model.

Maybe, rather than controlling the river, we can better adapt ourselves to it. There are already changes suggesting such a stance, such as, for example, the Te Awa Tupua Act (2017) that recognizes the rights of the Whanganui River as being "an indivisible and living whole…from the mountains to the sea, incorporating all its physical and metaphysical elements" (Part 3, clause 69). Bollier (2017) suggests that the river is not simply a resource to be managed, but "an organic whole that is impossible to divide." Perhaps the combination of artistic and scientific thinking can provide the holistic creative space to uphold such a law.

Conclusions

In today's world, where so many aspects of our environment are changing rapidly, it is necessary to adapt and broaden our thinking in order to adjust to and solve increasingly complex problems. By using Deleuze and Guattari's concepts of *smooth* and *striated*, this study develops a way of understanding the different forms of thinking relating to artistic approaches (considered here as being smooth) and geoscientific approaches (considered here as being striated). Developing concepts of smooth (i.e., freedom and creativity of thought) and striated (i.e., restricted by set patterns of scientific approaches that reject abductive and imaginative thinking) helps us to understand how *tacit knowing*, which is located in the Deleuzian smooth space, can be situated in our thinking. This helps us to shift our knowledge between different paradigms, leading to a rich amalgamation of epistemologies with the potential to provide a more complete, holistic way of thinking, and therefore of reaching decisions that have real life consequences. This is beautifully illustrated in the example above, where the holistic nature of a river is turned into law, and where this river, apparently in defiance of a certain rational and scientific logic, is given legal rights as if it were a living being in itself.

The use of the VM in this research has demonstrated how exposure to art can create a shift in thinking for scientists. The results reveal that the hydrogeologists in the study, even though they work with positivist approaches, harbour significant amounts of tacit knowing. In the scientific approach used by these scientists, this tacit knowledge is not considered useful in terms of thinking rationally in an objective way. In other words, such knowledge (if indeed a scientist can even call this knowledge) is not included in scientific results and decision making which might emerge from such results. In the

creative artistic approach, however, tacit knowledge took on significant meanings for the scientists in the study. These were:

- The ability to "become river" enables the freedom of mind to allow the possibility to think of solutions that scientific approaches have difficulty providing. Examples of this might include managing rivers in a different way, where flood management considers natural rhythms associated within the natural environment. This is an important shift for scientists, as they are no longer in an anthropocentric paradigm of objectified thinking. Instead, the scientific stance has changed from that of the detached observer to that of the intersubjective participant in nature.
- A rhizomatic space, such as the VM, can provide the space for the creative thinking necessary for scientists to transition from a striated to a smooth space of thinking. In this space, the scientists are able to move from the linguistic rational to the evocation of affect through visual images, thereby broadening their horizons and modifying their sense of the possible.
- Smooth and striated concepts developed by Deleuze and Guattari (1987) in A *Thousand Plateaus*, enabled a conceptual framework of thinking that distinguish paradigmatic differences between scientific and artistic methods of knowing, enabling greater understanding of tacit knowledge.
- The realization that scientific concepts many scientists take for granted are not obvious to everyone, lead scientists to become aware that they need to communicate differently to non-hydrogeologists.
- Awareness of emotional aspects in the working environment can help scientists understand their emotional relationships with people and the natural environment, and take these into account in the dissemination of their scientific work.

The study demonstrates that there is an episto-ontological struggle for the geoscientist to substantiate the affective aspects of the physical experience of working in environmental situations because tacit knowledge developed from experience is not considered to be objective within the scientific epistemology of a geoscientist. This research shows that art forms a stimulus towards transforming ways of thinking, which can be expressed through the VM space by sharing thoughts, associations, and feelings, to form other ways of thinking beyond a scientific paradigm. This may enable geoscientists to form a more creative dialogue, outside of paradigms that demand objectivity, through new possibilities offered by artists. Combining experiential and tacit knowledge with objective thought, has the possibility of creating richer, more substantial and holistically informed understanding, leading to the development of better solutions for complex problems.

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REFERENCES

Archer, N.A.L., Bonell, M., Coles, N., MacDonald, A.M., Auton, C.A., & Stevenson, R. (2013). Soil characteristics and landcover relationships on soil hydraulic conductivity at a hillslope scale: A view towards local flood management. *Journal of Hydrology*, 497, pp. 208-222.

Binitie, W. (2017). Data as art: Sonic form and surface in glass. *British Antarctic Survey*. https://www.bas.ac.uk/project/data-as-art/data-as-art-sonic-form-and-surface-in-glass/

Bollier, D., (2017). “I am the river, and the river is me”. *P2P Foundation*. https://blog.p2pfoundation.net/i-am-the-river-and-the-river-is-me/2017/07/28

Bonyhady, T., (1996). The photo that changed us. *The Australian, 20*, 5.

Braidotti, R. (2011). *Nomadic theory: The portable Rosi Braidotti*. Columbia University Press

Capra, F., & Luisi P. L. (2014). The systems view of life: A unifying vision. Cambridge University Press. http://dx.doi.org/10.1017/CBO9780511895555

Christo & Jeanne-Claude (2013). *Over the river*. Project for the Arkansas River, State of Colorado. http://christojeanneclaude.net/mobile/projects?p=over-the-river

Crossick, G., & Kaszynska, P. (2016). *Understanding the value of arts & culture: The AHRC cultural value project*. Swindon, UK: Arts & Humanities Council Research. https://ahrc.ukri.org/documents/publications/cultural-value-project-final-report/

Deleuze, G., & Guattari, F. (1987). *A thousand plateaus: Capitalism and schizophrenia*. Continuum. http://dx.doi.org/10.1017/CCO9780511753657.008

Deleuze, G., & Guattari, F. (1994). *What is philosophy?* Verso.

Eliot, T. S. (1944). *Four quartets*. Faber and Faber Limited.

Froggett, L., Manley, J. & Roy, A. (2015). The visual matrix method: Imagery and affect in a group-based research setting. *Forum: Qualitative Social Research*, *16*(3). https://doi.org/10.17169/fqs-16.3.2308

Gabrys, J., & Yusoff, K. (2012). Arts, sciences and climate change: Practices and politics at the threshold. *Science as Culture*, *21*, 1–24.

Goldsworthy, A. (2015). *Ephemeral works: 2004-2014*. Abrams Books.

Grande, J. K., (2014). *Balance: Art and nature*. Black Rose Books Ltd.

Grillo, Y. A., (2009). When does art become science and science art? *Leonardo*, *42*, 103–4. http://www.jstor.org/stable/20532611

Horton, R. (1945). Erosional development of streams and their drainage basins; Hydrophysical approach to quantitative morphology. *Geological Society of America Bulletin*, *56*, 275–370. http://dx.doi.org/10.1130/0016-7606(1945)56[275:EDOSAT]2.0.CO;2

Johnson, M. (2011). Embodied knowing through art. In M. Biggs & H. Karlsson (Eds.), *The Routledge companion to research in the arts*, (pp. 141–51). Routledge.

Kovats, T. (2010). Rivers 2010. https://www.jupiterartland.org/art/tania-kovats-rivers/

Ladyman, J. (2002). *Understanding the philosophy of science*. Routledge.

Ludden, J. (2017). Impossible Views. *British Geological Survey*. Published by the British Geological Survey and Quarrylab. National Environment Research Council, Keyworth, UK. http://quarrylab.org/impossible-views-private-view/

Lysen, F., & Pisters, P. (2012). Introduction: The smooth and the striated. *Deleuze Studies, 6*(1), 1–5.

Manley, J. (2009). When words are not enough. In S. Clarke & P. Hoggart (Eds.), *Researching beneath the surface* (pp. 79–98). Karnac Books.

Manley, J. (2018a). Every human being is an artist: From social representation to creative experiences of self. In A. Cummins and N. Williams (Eds.), *Further researching beneath the surface (Volume 2); Psycho-social research methods in practice* (pp. 97-120). Routledge.

Manley, J. (2018b). *Social dreaming, associative thinking and intensities of affect*. Palgrave Macmillan.

Manley, N. (2017, May 25-26). *Waterways* [Exhibition]. British Geological Survey at the Lyell Centre, Research Avenue South, Edinburgh, UK.

Massumi, B. (1987). Foreword. In G. Deleuze & F. Guattari, *A thousand plateaus: Capitalism and schizophrenia* (pp. ix-xv). Karnac Books.

Mclean, I. (2002). Sublime futures: Eco-art and the return of the real in Peter Dombrovskis, John Wolseley and Andy Goldsworthy. *Transformations*, *5*.

Merleau-Ponty, M. (1962). *Phenomenology of perception* (C. Smith, Trans). Routledge Classics.

Miller, A. I. (1995). Aesthetics, representation and creativity in art and science. *Leonardo*, *28*, 185–92. http://dx.doi.org/10.2307/1576073

Morgan, C. L. (1998). *Images of organizations*. Berrett-Koehler.

O'Neill, S. J., and Smith, N. (2014). Climate change and visual imagery. *Wiley Interdisciplinary Reviews: Climate Change*, 5, 73–87.

Okasha, S. (2002). Philosophy of science: A very short introduction. *Imagine*, *67,* 144.

Pallasmaa, J. (2005) *The eyes of the skin: Architecture and the senses*. John Wiley & Sons, Ltd.

Pallasmaa, J. (2009). *The thinking hand: Existential and embodied wisdom in architecture*. John Wiley & Sons, Ltd.

Polanyi, M. (2009). *The tacit dimension*. The University of Chicago Press.

Richmond, S. (1984). The interaction of art and science. *Leonardo*, *17*, 81–86. http://dx.doi.org/10.2307/1574993

Savenije, H.H.G. (2009). HESS opinions; "The art of hydrology". *Hydrology and Earth System Sciences*, *13*, 157–161. http://dx.doi.org/10.5194/hess-13-157-2009

Schatzberg, E. (2012) From art to applied science. *Isis*, 103, 555–63. http://dx.doi.org/10.1086/667979

Setlow, N. (1994). Art and science: A personal perspective. *Leonardo*, *27*, 249–52. http://dx.doi.org/10.2307/1576062

Spinoza, B. (1992). *Ethics, treatise on the emendation of the intellect and selected letters* (S. Feldman, Ed. & S. Shirley, Trans.). Hackett.

Sullivan, G., (2012). Artistic cognition and creativity. In M. Biggs and H. Karlsson (Eds.), *The Routledge companion to research in the arts* (pp. 1–21). Routledge.

Te Awa Tupua Act (2017). Whanganui River Claims Settlement, Public Act 2017, No 7. http://www.legislation.govt.nz/act/public/2017/0007/latest/whole.html

Varela, F. J., Thompson, E., & Rosch, E. (1991). *The embodied mind: Cognitive sciences and human experience*. MIT Press.

Weisskopf, V. F. (1981). Art and science, *Leonardo*, *14*, 238–42. http://dx.doi.org/10.2307/1574288

Wilson, R. & Wilson, N. (2010). Tania Kovats: Rivers 2010. https://www.jupiterartland.org/art/tania-kovats-rivers/

ENDNOTES

1. I use Archer in my scientific work

2. The Smooth and the Striated in the Foundation Frankendael and Nieuw Dakota, Amsterdam, 2 July – 1st August a double exhibition, Presented within the framework of the Third International Deleuze Conference (https://thesmoothandthestriated.wordpress.com)

3. Doctor Who is a long-running British TV programme. Doctor Who is the main character, who is a millennia-old alien humanoid called a Timelord, who can travel through space and time. One of Dr Who's main trait is to save the human species from extinction from alien adversity.

4. Each transcript quote is referenced to the transcripts relating to one of the two VMs. For example: (VM2-Extract 1) is the second VM, extract 1.