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Finding Form in the Dynamics of a Quench

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ABSTRACT
This paper asks how temporal transformative energy can be captured in a form that would disclose the wonderment involved in making processes of artistic practice. Observations are discussed through the analysis of videos and photographs of a quench, a process of cooling and hardening steel utilised within the craft of blacksmithing. As a sculptor I observe particular features of blacksmithing, analysing and creating forms that express the energies involved. I argue, within this paper, that artists extend understanding of materiality due to their curious nature and increased willingness to test processes and materials in different and experimental ways. This curiosity, together with observation and analysis, leads to discovery and occurs in the practices of both scientists and artists when they interact with materials. Throughout this research the tools of artistic investigation, video and photography, have captured the energy involved within the quench in a way that does not happen in the industrial, or artisan blacksmithing.

KEY WORDS
Energy, quenching, form, blacksmithing, videos, photographs, artistic practice

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INTRODUCTION

Richard Serra's memory of the launching of a ship is of an artist observing temporal transformation of energy. It reveals his affinity with matter that is translated through his artistic practice. Blacksmithing can be likened to aspects of Serra's work as it incorporates the magic of a transformation. As a sculptor, I observe an aspect of blacksmithing utilising the tools crucial to my practice to analyse and create forms that relay the energy involved.

Figure 1 /
Image 113 from Gravity Wins, 2014.
Photographer: Mary Hackett

I have held a long-time interest in the chapter 'Weight', from *Serra's Writings*, Interviews (1994), which recounts the launch of a ship that he remembers from his childhood. Within it he recalls the sensations around him as the ship slips from the security of its scaffold and makes its way down into the sea. He evokes the colour of the brand new ship and the sound of the crowd as they watch with expectation and celebration. His descriptions mark time—the time of year, his birthday, the time of his life and that of his father's. He notes the temporal energy that transforms a vessel into a ship as it slides down the chute, rocking from the motion as it 'swayed, tipped and bounced' (Serra 1994, p. 184). He also considers the weight of the ship as it sinks into the water.

Serra's recollections reveal childhood wonderment and a connection with time and matter, which was then internalised to draw upon aspects of those memories within his work. He not only writes about his feelings of that moment as a boy but additionally as an adult. Within his adult thoughts he compares that memory to the labour carried out by Vulcan, the Roman god of fire, 'at the bottom of the smoking crater, hammering out raw material' (Serra, 1994, p.184). Serra's *Gutter Corner Splash: Night Shift* of 1995 recreates his earlier lead throwing performance pieces of 1968-69 (Serra, 1968/2000, 1969/2000b & 1969/2000c; Crimp, 1981 & 2000). The video of *Gutter Corner Splash: Night Shift* (see San Francisco Museum of Modern Art, 1995) shows how he uses his whole body to throw the molten lead demonstrating the physicality of working with this material. The result, the solidified lead inside the gallery space, encapsulates the temporality and power experienced by Serra through the action, as well as by the lead.

Serra's performance is reminiscent of blacksmithing where time is narrowed to a point of intent as the smith waits at the forge for the bright yellow glow of hot steel (1100º – 1300ºC). There is the rhythm of the hammer pounding as it counts time and the pulsing hiss as the object is pushed into the water to quench (a blacksmithing process of cooling and hardening steel by dropping it into a cooling agent). In these moments there is an understanding of the weight of the metal as it sinks. Blacksmithing is full of moments of vital energy that cannot fail to inspire awe. In the artistic research presented here I explore the form of the action of a quench through observations of a quenching video and photography, and describe the creation of sculptures of these forms as a way of mapping these moments of vital energy. The aim of this research is to build new knowledge within the field of blacksmithing (adding vital insight that only an artistic practice can achieve) by describing what is taking place within the water—the heat and entropy of the object and the energy within a quench.

My research is undertaken from the perspective of a sculptor who is interested in blacksmithing processes and who works in steel. In general a blacksmith is a person who uses fire, an anvil and a hammer to forge steel. Within this paper, however, 'blacksmith' refers to an artist blacksmith, or artisan blacksmith, as opposed to farriers (those who make horseshoes), steel fabricators (welders), or industrial blacksmiths (working in large factories). Artisan blacksmiths tend to work in small workshops using either a coke or gas forge, which is the vessel for holding a fire. They make decorative, functional objects. My practice as a sculptor, however, is concerned with objects that question blacksmithing processes. This forms a circular activity of creating, observation, analysis and creating once more that is capable of extending the meaning of blacksmithing itself.

NEW KNOWLEDGE

Industrial makers are intent on the immediate project and are unable to step back and analyse their practice. An artistic practice, however, is a relevant and important discipline which leads to an extended understanding of materiality due to the curiousity and an increased willingness to test processes and materials.

Blacksmiths (Eerhart, 2012; Raymond, 1986), alchemists (Mircea, 1978) and metallurgists (Veldhuijzen, 2005; Smith, 1975) have learned to exploit the distinctive attributes of steel to cope with living in this world. Nevertheless, I contend that knowledge of material agency began and advanced through artistic endeavour. Charles M. Keller and Janet D. Keller observed the manner in which blacksmiths work and described their making processes as 'thinking hot' (1996 p. 53). Every course of action within blacksmithing is determined by the tools and movements needed to complete a task undertaken once the steel has been heated, as well as by the material itself. Each task is thought through before the work begins or while the piece is in the fire before manipulation. Due to knowledge accumulated over a long period of time by the blacksmith, steel responds to this treatment predictably. This making arrangement does not encourage the curiosity and experimentation of artistic practice as the maker already knows the steps that are needed to be taken to make what is intended.

Cyril Stanley Smith (1970 & 1975) asserts that as artists create, exploiting material qualities, they are more likely to discover something new about their chosen material and processes, and that our cultures owe a debt to the curiosity of artists. He maintains that those intent on the practical uses of materials miss vital information. Engagement with materials and processes through curiosity enables new understandings which feed into practical applications and a deeper comprehension of the world in general.

> [I]n the earlier stage of discovery, first of form and later of materials that, once shaped, would retain desirable form, the motive can hardly have been other than simply curiosity, a desire to discover some of the properties of matter for the purpose of internal satisfaction. Paradoxically man's capacity for aesthetic enjoyment may have been his most practical characteristic, for it is at the root of his discovery of the world about him, and it makes him want to live. (Smith, 1970 p. 498)

Smith's concern here is for the early decorative arts, but can easily be applied to any kind of artistic endeavour. My research will add new knowledge to the general enquiry of materiality by finding artistic form to temporal transformations of the energy within quenching.

OBSERVATION, ANALYSIS AND THE TOOLS OF THE ARTIST

Discovery occurs through observation and analysis, which scientists and artists exploit. When scientists, and makers, interact with material, they explore through a series of testing and then watching to learn how to apply the discovery. Video and photography were used within my artistic practice to find a form that relates the energy involved within a quench and the forms found were a series of spirals.

Andrew Pickering describes analysis as a performative exploration within scientific practice. He calls it a mangle of 'resistance and accommodation' (Pickering, 1995, p. 22) where the scientist's intention is to solve a problem utilising familiar materials that are known to perform in a particular manner. The researcher then carries out a detailed examination of what transpires, taking note of failures or successes. The 'resistance' comes when the materials are unable to achieve the required result. 'Accommodation' is the revision of the intentions or material that relates to the problem.

Pickering (1995) argues that we spend our life working with and against material agency, which he describes as things being active in the world. He asserts that the role of science is an extension of coping with that energy. The research presented here widens Pickering's ideas to include the interests of art, as it aims to capture the energy involved within our sphere. Smith draws a parallel between artist and scientist by declaring that 'the artist has something of the scientist in him' (Smith 1970 p. 493).

Video and photography are observational tools utilised within an artistic practice to analyse a given subject. Video was employed to observe quenches of hot objects as they were dropped into a glass tank. Then, similar to Pickering's 'resistance and accommodation', natural material was photographed, seeking forms that express the transitional energy within a quench. My analysis of videos exposed the energy created through, and by, a quench by slowing down the process for the purpose of observation. I replayed and halted a video at points where new action occurred, and then wrote what I saw, searching for indicators of form. This approach enhanced my awareness of the intensity of a quench and expanded my understanding of the forces utilised by blacksmiths. From the videos I experimented with photography using natural material to capture and represent the form of these energies at different points in time. The energy of the quench evoked a sense of time.

For the photography I had chosen turnip peels as I had observed them fall when peeled. They called to mind the motion of an object as it was being quenched. These photographs were then compared to stills of a selected video and used as tools that revealed distinct funnel forms. From these photographs I uncovered a spiral form suggestive of the energy involved within a quench. Subsequent photographs and sculpture have affirmed that form.

Figure 2 /
Image 013 from *Gravity Wins*, 2014.
Photographer: Mary Hackett

EXPRESSING ENERGY THROUGH AN ARTISTIC PRACTICE

I assert that the activity of a quench can suggest the energy within metamorphic change. Matter is transformed through energy which is temporal. An artistic practice can communicate that transformation in ways that other disciplines cannot. It has the capacity to express energies associated with the connections that we make with material. This occurs when we are curious.

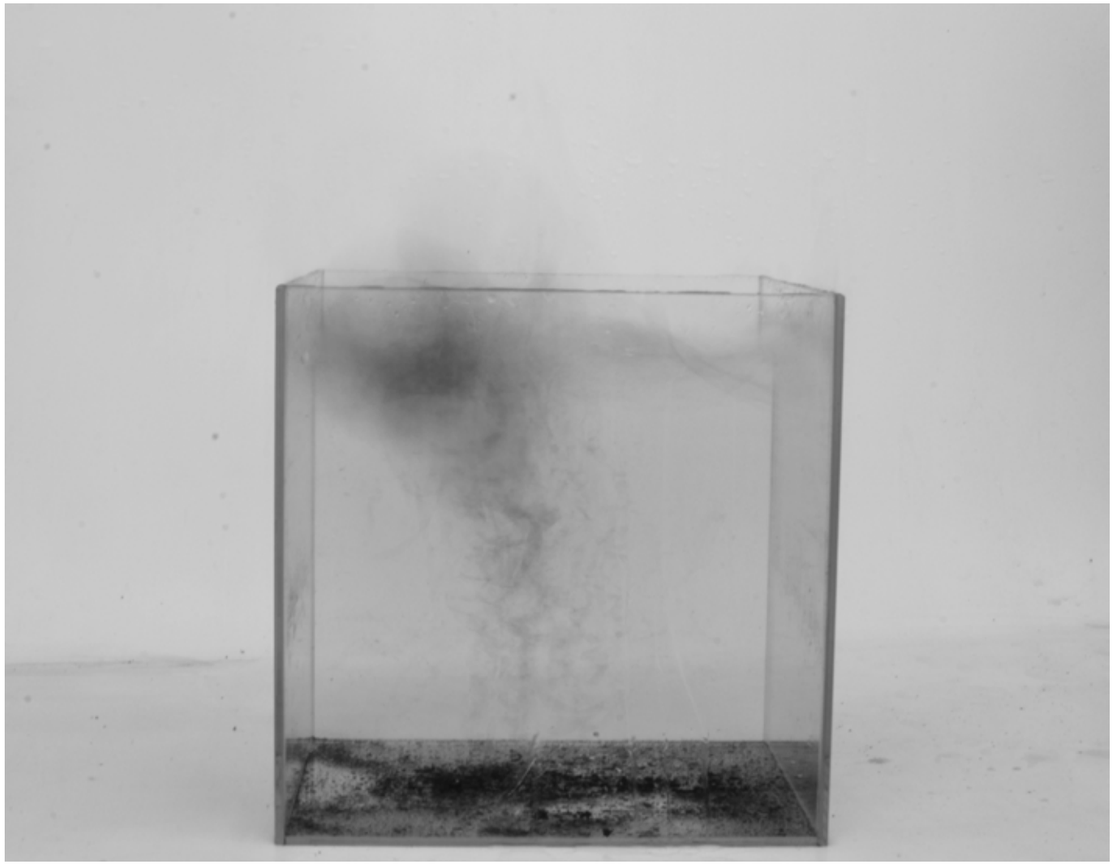

Figure 3 /
Long exposure of a quench.
Photographer: Angus Hackett

In *Vibrant Matter*, Jane Bennett (2010) explains that all matter has energy as, for her, movement is the indicator of life. Matter moves and shifts, forever changing, but not of its own accord. According to Elisabeth Grosz (2008) forces that make up the laws of being in the world enable transitions. Gravity, friction, magnetism: these energies work on, and with, matter creating movement, life and change. Indeed, we are made of substances that behave in certain ways to bring us into being. The minerals within us, as in all organic matter, along with their related forces have organised and made us, over lifetimes, become who we are and are still transforming us at this very moment.

While the molecules within us work together, shifting and changing, we spend our time learning to understand or control the natural forces that surround us. As Andrew Pickering states:

> The world is not filled with facts and observations, but with agency. The world is constantly doing things. Wind, storms droughts, floods, heat and cold—all of these engage with our bodies as well as our minds. (Pickering 1995, p. 6)

Our life, and indeed the life of everything on Earth, is a process of bringing together natural forces and matter, and science, according to Pickering, is a considered and concentrated approach to this activity.

Science and art are related, as both draw from the chaos of the energies surrounding us. Grosz (2008) maintains that artists, when they make, frame sensations to magnify what they experience from the world as a medium, or threshold, from the comfortable to the sublime. Energy is drawn from the environment not so much to make things for the purpose of use, but as a way of sharpening experiences. For Grosz, art is a system of rendering the senses visible, touchable, and audible, a way of understanding and interacting with the world that Pickering relates. I argue that art also renders energy visible.

The energies of making are what Astrid Heimer (2014) explores within her research on the dynamics between hand and clay within her ceramics practice, finding form in the clay through her hands. Her forms record the transformation that occurs through the interaction with the clay. Another example of the sensorial relationship with material is that of a knife maker, a case study of Camilla Groth and Maarit Mäkelä (2014), who worked with the traditional knife-making material, steel. Within the knife maker's project he questioned whether making a knife in other materials would matter. He explored the use of clay and glass to make a knife and found it awkward learning to work in clay. His project reinforces Smith's assertion (1970 & 1975) that those in an artistic practice are in a prime position to explore materiality. The results of his research showed that our connection with materials depends upon the energies that we experience when making. Barbara Bolt (2007) warns that artists can fixate on the purpose of their work while minimising the role played by material. I would add that artists may minimise the effect of the surrounding energies within their practice. Bolt advises that, when making, performance in relation to processes should be considered.

Pickering (1995) elucidates that scientists find answers within the chaos of natural forces, carrying out their intentions using what they already know and with materials that are available. They then assume a passive role, watching to see what happens and then adjusting their work accordingly. Their practice consists of action, observation and adjustment. Richard Sennett would call this 'metamorphosis, presence, and anthropomorphosis' (2008, p. 120), while Smith would propose that it would be an artist's curiosity.

METHODS OF MAKING AND TOOLS FOR OBSERVATION

There are energies involved in the quenching of steel that are utilised by both the maker and material, and these are the dynamics of natural forces within the world. Within this research I look to Raymond Higgins' *Materials for the Engineering Technician* (1991) as a reference for the technical issues related to the materiality of steel. In his book Higgins provides valuable detail on the performance temperatures and explains the benefits of quenching and the techniques used. The drama of a quench unfolds in the blink of an eye, and most of what a blacksmith witnesses is viewed from above the water. All else is hidden. Video and photographs are perfect mediums for slowing down and observing this performance.

The symbiotic relationship that is described by Pickering (1995, p. 15) 'temporal emergence' is evidenced in the relationship between man and steel. The amalgamation of iron and carbon was created out of necessity and explored through experimentation, evidence and mistakes. Iron is a difficult material to bring to a workable state, so the history of its making is marked with a strong desire to capture and create a usable material from it. Through experimentation at the smelting and forging stage, as well as the diligence of early alchemists, it was understood that iron absorbed carbon. As Bennett (2010) relates, the form of iron particles are responsible for carbon being drawn in, making it possible to form a harder material—steel. This absorption creates a working material that is strong, yet malleable, under the right circumstances. Smiths learned to control the strength of steel through quenching.

Quenching is a step in a forging sequence of cooling or hardening steel or wrought iron. It is integral to blacksmithing and requires specific knowledge of how steel behaves when worked. As noted above, steel is an amalgamation of iron and carbon—the carbon content being 0.15% – 0.25%. The carbon content determines the hardness of the material, whereby the higher the carbon the harder the material. Steel with a higher carbon content than mild steel is tool steel—which ranges from medium-carbon to high-carbon, where the percentage of carbon (and other alloying elements) determines the use. The carbon content is less than 0.08 within wrought iron. Quenching involves predicting reactions of steel as it enters the quenchant as well as understanding the tempo required for the quench to be carried out. Quenching can be either a simple matter of dropping steel into water to cool it or a considered process of dipping tool steel into oil while judging correct temperatures by steel colour.

Water is generally used (although there are other quenching mediums), when quenching to cool, which takes place after forging to allow hand-ability of the work. (Forging is either: the procedure of hammering [working] steel or wrought iron into an article, the vessel for holding a fire, or the facility for doing so.) Sometimes quenching can be carried out when the object in question is in the forge and the handling end is overheated. This process brings the steel back to a solid, and cooler, form from the malleable state created in the hot forge. To harden steel it is necessary to cool the work quickly. Quenching for hardening takes place generally after the steel is fashioned into the required items, such as tools. Quenching to harden therefore happens after forging is completed. The object is heated to approximately 750º – 900ºC and plunged into a liquid (the choice of which depends on the carbon content and alloy of the steel).

For complicated quenching, like tempering, the procedure is more precise, as the function of a steel tool depends on the exactness. Tempering is a process of controlled granular relaxation of hardened steel, where it is reheated and dipped into oil, water, brine or air releasing the stresses created from hardening. This process refines tool steel (high carbon content) after quench-hardening as it causes steel to become brittle. After the initial quench

of the tool steel the black oxidation on the new tool is cleaned away, making it bright. As the tool is heated again the bright area is watched carefully for the colour of the metal to change, and then plunged into water. The change in colour is important, as each colour corresponds to the hardness a particular tool needs to be for specialist work—for example, a light brown colour (250ºC) for a knife or purple (270ºC) for surgical tools.

Quenching is a routine process that is used to change the state of the stock material. An object is forged until it holds the required form and then it is plunged into the quenching bath beside the forge, using tongs. It is exciting! As the object is dropped into the water it hisses and spits as steam rises until the heat is extinguished. This all happens so quickly. It is over almost as soon as it has begun.

The movement of the object, and its transformation, is barely visible due to its speed. One complication is that the blacksmith views the object entering the water from above making it difficult to observe the action. The medium of video creates a distance between the blacksmith and the performance of the quench. The video can be slowed down and even stopped at a moment in time. Photography can capture these moments and even shift them around to explore temporality further. As mediums, video and photography both capture and cause form.

Figure 4 / Below
Image 099 from *Gravity Wins*, 2014.
Photographer: Mary Hackett

OBSERVATIONS OF A QUENCH

One of the videos for my research was of a hollow steel ball that I fabricated for this purpose. The shooting of the video was a collaborative event. While one person filmed, another heated the object until yellow hot (just as would happen in a work-based quench) and dropped it into the water using a pair of blacksmithing tongs. From the very beginning the visual strength of the action was evident, though once slowed down the video revealed what transpired.

Figure 5 /
Quench Video, 2014. Videographer Angus Hackett
Video not playing? Click here to view.

It showed the ball falling from open tongs, glowing orange from the heat. As it dropped, the water reached up to accommodate it, and evaporated before contact. The ball resembled a glass orb. The water dished and streams of bubbles rose to the surface where a circular wave exploded. The orb, now fizzing with tiny hot beads of air, sank to the bottom of the tank. The crown at the water's surface widened and rose as the fizzing ball broke away from the concave of the water. Air was trapped, being pulled in by the water gathering around the ball. Scale, oxidation on the surface of the hot steel, broke free of the bubbling ball and descended to the bottom of the tank. As the still-hot steel sphere sunk further, a jet of water leapt into the air. The crown and funnel disappeared as bubbles detached from the ball.

Since the ball was hollow, it spun and rose before it could touch the bottom of the tank. As it did so, it followed the large bubbles of air as they travelled up through the original entry point of the object. The jet soared higher and widened at the base while the turmoil on the surface of the water increased. Scale hit the bottom of the tank. The centre of the wave surged while the water at the edge of the tank sank and the water jet shrank. Beads of air accumulated around the ball, which pushed them to the water's surface. The ball followed. The jet lingered for a short period of time while scale coated the bottom of the tank. Eventually, the water flattened and steam, which began to appear when the ball rose, covered the water's surface. As the now-cooled orb began the descent to the bottom of the tank, steam billowed. Large bubbles again formed and rose at the uppermost segment of the ball. Then, with a sharp 'clink' sound, the steel globe hit the bottom of the tank.

The entire experience was swift, taking less than a second. The video allowed a closer inspection of the action by contributing distance and slowing the incident down. This provided the opportunity for repeated viewings of the event enabling new discoveries. It showed the energy that transformed the very molecules within the ball and the water to vapour. The force of the process was expressed by both 'protagonists'. For instance, while the object was in the water it was encased in a foam of bubbles which were due to the heat and cold reacting together. Blacksmiths call this 'steam jacketing'. I have been told that in larger workshops, using bigger pieces of steel, there are machines that agitate the water as the large steel chunks are enveloped in boiling water, and the agitation helps to break up that encasement. Blacksmiths know of the boiling casing because they see it when they drop their objects into the water and understand that they need to agitate to cool. Time was observable within the video, though even when the speed was reduced it was impossible to know that there were actually three jets that travel at the speed of sound—a phenomenon which was brought to my attention while reading 'Supersonic Air Flow due to Solid-Liquid Impact' (Gekle et al., 2010).

CAPTURING THE FORM OF TRANSFORMATION

I have taken numerous photographs representing the energy within the quench that I had witnessed. What I had discovered through them was a spiral form that conveyed the motion which suggested the temporality of the quench itself. The effects that gravity had on the peel were obvious immediately. It took a while for me to balance it on top of the frame. Once it did the centre would drop down to reveal a spiral. The portion that remained at the top corresponded to the crown made by the dispersal of the water. I had hoped to capture a moment when the peel was in flight, in between resting on top of the frame and sitting on the bottom. It proved too quick for my camera. However, some of the photographic sequences revealed the duration related to the movement of the ball.

At times the reflection on the backdrop card that I had used when taking photographs expressed the energy within the transformation as it resembled the turmoil that occurred.

Figure 6 /
Images 047, 048 & 049 from *Gravity Wins*, 2014,
Photographer: Mary Hackett

Figure 7 /
Image 062 from *Gravity Wins*, 2014.
Photographer: Mary Hackett

Ultimately, the photographs will lead to a body of sculpture that will reflect the spiral forms, representations of the energy and temporality occurring in a quench. The form is a contribution to an important, though overlooked fragment, of a blacksmithing process.

Figure 8 /
A work in progress of the sculptural form.
Photographer: Marc More

CONCLUSION

Previous approaches to understanding making processes have explored material with utilitarian objectives. The focus of this research was to examine and communicate the awe-inspiring energies of a temporal transition occurring within the blacksmithing process of a quench. For this purpose, videos of a quench and photographs of natural material were analysed to discover forms that expressed this energy. The forms found demonstrate the developmental dependence involved within an artistic practice.

These observations and analysis provided beneficial information for further interpretations of the dynamics of a quench to apply to a sculptural practice. As a consequence of the quenching videos and photography, my awareness of the role that time plays within a quench increased. In addition, shifting my focus from looking down (as a blacksmith would) to a side view has resulted in the realisation of the unique perspective of the viewing point of the maker. Most importantly, however, analysing these images and describing what I saw has afforded me an understanding of the force of the quench and the forms made by the object as it enters the water. Through the decreased speed of the videos and the gravitational pull involved in the photographs I was able to decipher formations that relayed the magic within a quench.

The distinctive attributes of steel have been studied and exploited by blacksmiths, alchemists and metallurgists to cope with living in an energy-driven world, and anthropologists have discussed workshop practice as it has related to human endeavour. Yet it is within an artistic practice that materials are tested, including iron and its amalgams, pushing them to the limits. Through curiosity and a desire to understand the world in which they inhabit, artists contribute necessary knowledge, enabling a deeper understanding of materiality.

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Mary Jane Hackett is a current PhD candidate in Fine Art at the Royal Melbourne Institute of Technology where, through a sculptural practice, she examines and maps the forces involved in forging processes. Hackett completed a Master of Fine Art with distinction at the Royal Melbourne Institute of Technology in 2011, was granted a Master of Fine Art Graduate Award and placed on the Vice-Chancellor's List for Academic Excellence in that year. She teaches silversmithing and jewellery design at Melbourne Polytechnic and is a founder of Blacksmith Doris, a blacksmithing group just for women. Hackett began as a metalsmith in the early 1980's, expanding her interest to sculpture over the last six years. She has been invited to exhibit and present papers on her sculptural practice and research throughout Australia and internationally.