List of appendices

1. Introduction

The notes here aim to complement the main body of the thesis and are divided into three broad sections. The first gives detailed descriptions of the various material investigations conducted during the course of the project. These largely focus on the refinement of the hot glass techniques that laid the foundations for the final body of work. The second brings together notes from a selection of the interviews conducted during the course of the project and quoted in the text. The final set includes notes from two of the many conferences and workshops that have informed the project.

A. Technical notes

1. Basic parameters of screen printed ceramic transfers
2. Comparing screen- and digital-print transfers on borosilicate glass
3. Approaches to inclusions in hot glass
4. Inclusion through casting
5. Coloured effects from glaze materials
6. Coloured effects from commercial colour products
7. Colour mixing
8. Refining tonal effects
9. Refining coloured effects
10. Exploring optical effects

B. Interviews

1. Ingeborg Wilding, widow of the artist Ludwig Wilding
2. Patrick Hughes, artist
3. Professor Nick Wade, psychologist
4. Professor Brian Rogers, psychologist

C. Conferences

1. Notes from study day, Mondrian, Nicholson and 20th century abstraction, Courtauld Institute, London, March 2012
2. Notes from IIRG Conference, 'Working with light as a means of interaction between space and mind', National Glass Centre, Sunderland, May 2012

I. Basic parameters for screen printed ceramic transfers

1. Context

The digitally-printed ceramic transfers available from companies such as Fotoceramic in Stoke on Trent are convenient and accurate[1]. However, they are currently produced using laser copiers adapted to use ceramic pigments in place of the usual toners. This process has been designed to deliver a very fine layer of colour for speed and economy. However, as a result, the image tends to lack density, especially after firing.

Equally, as with a document produced with standard office equipment, bands of slight variation in tone become apparent when printing larger areas of flat colour. Digital prints are a relatively cheap route for initial experimentation, but the costs rapidly mount when producing multiple copies, or working at larger scale in comparison with screen printing the transfers in the studio: the maximum size for a digital print is 280 x 400mm, whereas the paper currently available for screen printing using the UWET system measures 420 x 590mm[2].

[1] Fotoceramic website: www.fotoceramic.com/ accessed 05/12/2013
[2] Available from John Purcell, see http://www.johnpurcell.net/ceram.html

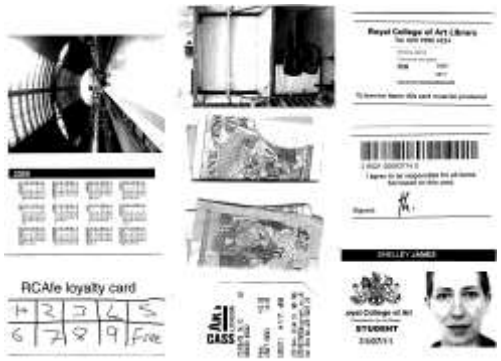

Figure 1: Images used for initial print tests

2. Objectives

In this context, although requiring basic equipment and skills, screen printing offers important advantages over digital transfers for some situations. The manual process also allows for more creative interpretation of the image by varying parameters such as the size of the screen mesh, density of the pigment and the thickness of the final 'covercoat' layer.

A series of tests were designed with these aims in mind:

a) Orientation and introduction to the facilities at the RCA
b) Understand the effect of the different screen mesh sizes
c) Review the effect of covercoat application
d) Consider the impact of firing cycles and position in the kiln

3. Process

Image preparation: A series of images were chosen to test a variety of graphic effects: block lettering, reversed out lettering, fine lines, tones / greyscale. The file was printed onto a standard A4 inkjet transparency purchased from a local office stationery shop using the Hewlett Packard laser printer in the Ceramics and Glass computer room.

Screen preparation: The stencil was exposed to three different screens with contrasting mesh sizes: 120, 90 and 49. We chose an exposure time of one unit because the density of the stencil was relatively poor. We washed the screen very delicately as we were concerned not to lose the image: with such a short exposure, the emulsion will still be relatively soft and fragile. However, although a surprising level of fine detail came through, some areas of the image did not wash out at all.

Printing: Familiar with the UWET transfer paper which does not require a covercoat sealing layer, these experiments used the Tullis Russell Trucal transfer paper[3] to experiment with the expressive potential of this variable. Ferro black 14-1600D black powder[4] with Ferro transparent medium were blended to produce the printing ink. Although proportions of 4 parts powder to 1 part medium are a rough guide, adding powder to the consistency of toothpaste gives a dense tone. The simplest technique is to sieve the powder over a pool of the medium on a clean sheet of glass and mash together with a palette knife.

[3] Trucal transfer paper, technical details from http://www.tullisrussell.com/our-products/transfer-technology/ceramic-and-glass.html, accessed 05/12/2013
[4] Ferro ceramic pigments, technical details from http://www.ferro.com/Our+Products/PigmentsPowdersOxides/Pigment+Systems/ accessed 05/12/2013

Figure 2: Detail of wrinkled section (90t mesh fired to 720 on second shelf, front loading kiln)

An upright squeegee angle and a relatively slow pull speed seemed to be important to achieve a dense but reasonably sharp result.

Covercoat: Spreading the covercoat with a palette knife or rubber kidney produces an uneven layer that is 'stiff' in some areas and extremely fragile to the point of breaking up entirely in others, creating 'skin-like wrinkles' during the application process. This effect was not relevant to this project but may be worth exploring in another context.

Firing: I used the same front loading kiln for all the tests, installing the work on four shelves using the following cycle:

a) Ramp 1: 50°c per hour to 50°c, hold 3 hours (drying)
b) Ramp 2: 350°c per hour to 720°c, hold 10" (fusing)
c) End

4. Results

A/ Impact of position in the kiln

I chose to fire the 120 mesh prints first onto heavily-marked shelves in order to see how soft the glass had become with this firing cycle. I was surprised to see the great difference between the heat at the top and at the bottom of the kiln. A longer soak may help to even out the temperature.

Top shelf: These tests picked up a lot of shelf texture but the edges do not seem to have softened significantly: this suggests that with this type of glass in this kiln, 720°c would be a god soft slumping temperature. The prints on the top shelf were fully mature but still 'on the surface' of the glass. The images seemed to have the same density as the tests on the lower shelves, suggesting that there is no fading at this temperature. At 720°c, there were no visible covercoat edges, suggesting that it had fully matured. However, it is hard to see if there are any cloudy residues because of the effect of the shelf texture.

Second shelf: The sheets on the second shelf seem to be indistinguishable from those on the top shelf, with a great deal of shelf texture and fully-matured prints, although they are still 'on the surface' (i.e. the glass is slightly matt in the image areas).

Third shelf: These tests were only just mature (dull, matt texture) and the edges of the covercoat could be clearly seen, There was very little shelf texture, suggesting that glass placed this low in this kiln does not soften with this firing cycle.

Bottom shelf: These prints were not fused to the glass at all and rubbed off immediately.

Figure 3: Details of original scans plus fired samples (49 and 90 mesh) to show rendering of line graphics

Figure 4: Original scan plus 49 and 120 mesh fired samples to show different densities

Figure 5: Detail of original scans alongside fired samples (49 and 90 mesh) to show rendering of photographic images

B/ Impact of screen mesh size

As could be expected, the larger, 49T mesh allowed a much thicker layer of pigment to be applied, resulting in much denser image. However, this was at the expense of detail in the photographic images and all the subtlety of hand drawn marks was lost. The coarse screen is likely to be an excellent solution for larger blocks of colour where registration or sharp edges are not needed.

The 90 mesh seems to offer the best compromise for simple photographic and line work, while the 120 mesh renders textures and hand-drawn marks most sensitively. The 120 mesh gave very light but finely-detailed results and the 'wrinkled' effect described earlier suggests that building up an image through multiple firings could give a very rich and exciting result. The 120t sample, an uneven layer of covercoat resulted in some very fragile, stretchy areas (see the signature area) – potentially an interesting effect.

5. Conclusions

The transfer prints were blobby, blurry and uneven at the outset, leading to indistinct, grainy, distorted results after firing. When combined with the substantial amount of china clay and texture from the kiln shelf, these tiles are poor ambassadors for the graphic potential of transfer prints on glass.

Figure 6: Comparison of 49, 90 and 120 mesh screen with original scanned image top left to show the balance of density and detail between different mesh sizes

This is due in large part to lack of time in preparation, lack of practice and experience with this environment, especially in terms of pigment/ medium mixing and covercoat application.

However, the test did achieve its basic objective, providing a broad introduction to the set-up at the RCA and demonstrating that the use of a range of mesh sizes can create very different results from the same stencil. This creates a whole new range of expressive possibilities, especially in comparison with digital prints.

2. Comparing screen- and digital-print transfers on borosilicate glass

1. Context

Having learnt the basic procedure and parameters for screen printing transfers at the RCA, the next series of experiments sought to compare their performance with digitally-printed transfers to guide the choice of technique for future tests.

2. Objectives

In this context, this set of tests was designed to compare screen and transfer prints on two criteria:

a) density, covercoat residue and multiple layers
b) timing - fired on the same day, left overnight or pre-fired in a kiln

Figure 7: Graphic devices used for tests

3. Process

Image preparation: The three basic graphic devices were chosen to test different dimensions:

a) tonal rendering: four three concentric circles of different densities (100 to 20%)
b) large blocks of solid colour: stylised 'E'
c) fine lines and lettering (simple grid with numbers 1 to 10)

The digital prints were produced by Fotoceramic using the same file as the one used to generate the stencil for the screen print: an A4 illustrator-generated graphic in greyscale at 300dpi in tiff format. I specified Italian toners (which give a denser black than the German toners) and an unfluxed covercoat in order to give the most direct comparison with the screen printed transfers, which also have an unfluxed covercoat.

The stencil for the screen prints was generated on the laser printer and exposed for one unit to a 90-mesh screen in the printmaking department.

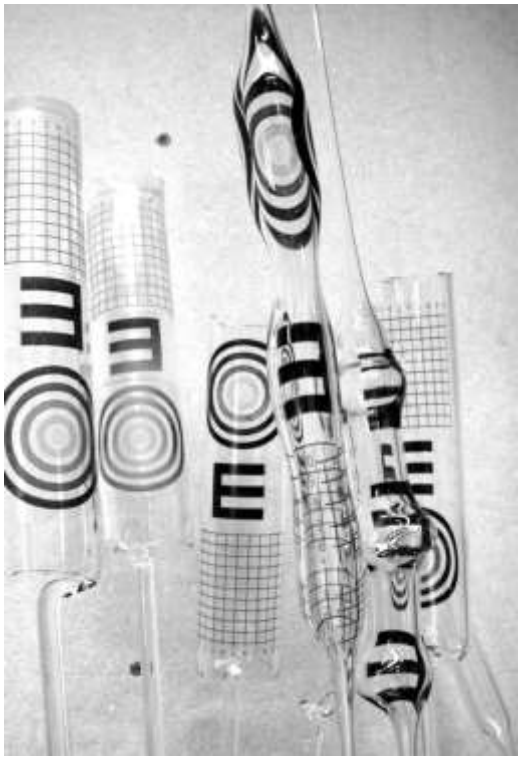

Figure 8: Borosilicate tubes with 'legs' to facilitate firing to the edge

Screen printing: The first set of screen printed transfers was made onto Tullis Russell transfer paper. The pigment was Ferro black 14-1600D black powder sieved into Daler Rowney acrylic medium. These were mixed together in a borosilicate beaker using a metal knife using a palette knife. Again, I did not measure the amounts, but chose to add powder until the mixture was dense when rubbed out onto the paper and a reasonably stiff consistency.

Covercoat: I used 'Hereus colourless covercoat L406' covercoat and screen printed this through a coarse mesh screen.

Glass: I used 40mm diameter borosilicate tubes cut to 160mm length to allow space for each print to be clearly seen when alone and in multiple layers.

Application: Each print was floated using clean boiled water onto a tube cleaned with methylated spirits. Those testing the impact of immediate firing were left two hours between application and firing and were almost wet to the touch. Those left overnight were applied in the morning and fired the following morning, while those that were pre-fired were fired a frontloading test kiln using the cycle: 350°c per hour to 720°c, 10 minute hold, then end.

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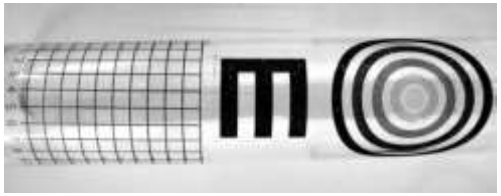


Figure 9: Tube after firing showing small pinpricks (fired within 3 hours of print application)

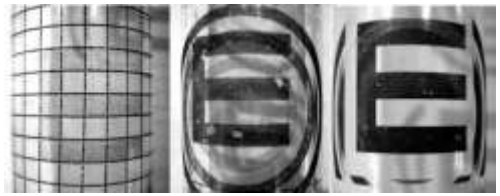


Figure 10: Illustration of two prints together, from the left: two layers of screen printed images ('E' is first print), two layers of screen printed images ('E' is second print), two layers of digital printed images (concentric circles are second print)

Firing: In order to make it possible to heat the glass to the edges, firing the prints along the whole length of the tube, I attached 'dog's legs' to each end. Initially, I did this before adding the prints as I was concerned that the additional heat needed to melt the rim to make the attachment might affect the prints. But, although necessary while firing, these 'handles' proved fragile and cumbersome during the preparation stage. As there was no discernable difference to the density or covercoat residue when I added them to the tube at the firing stage, I simply added them as I went along.

Using the larger setting ('5'), I gently heated the entire length of the tube at the outer end of the flame for 20 to 30 seconds before bringing the tube closer to the lamp. Keeping the tube turning using thedog's legs, I noted when the covercoat started to burn off showing a flame (usually after a further 30 seconds at around 15cm away from the lamp) and kept the tube turning there until this process was complete (usually around 5 seconds). I then brought the tube close to the lamp (three to four cm from the lamp) and slowly heated the tube, allowing the prints to glow red for between 15 and 20 seconds. I then slowly moved the tube away until it was around 20cm from the lamp and let it warm gently for a further 20 seconds before removing one of the dogs legs and leaving the tube to cool in the wooden rack. The tubes were then annealed (using the standard cycle of 600 degrees to 560, 20 minute soak, end).

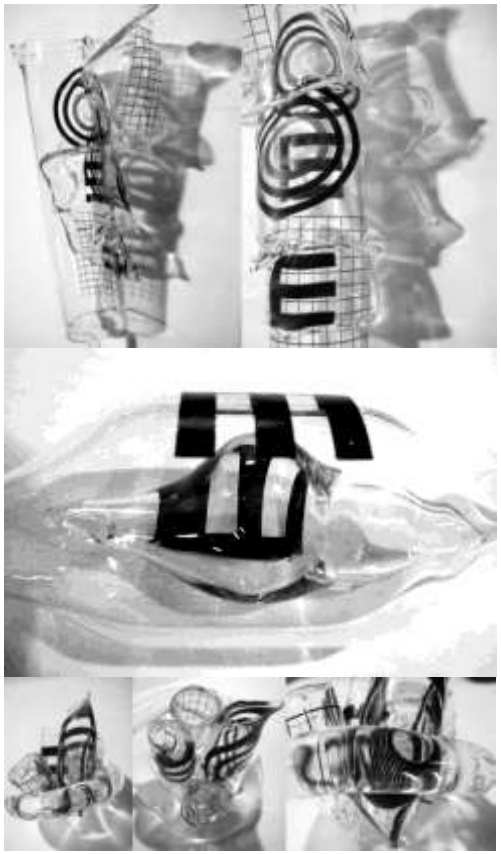


Figure 11: Examples of borosilicate tubes with prints: added 'sheets' of glass with printed images, 'russian doll' (one element inside another), 'basket' of printed elements surrounded by a solid borosilicate rod.

4. Results

There are fewer bubbles and pinpricks when the print has been left to dry overnight. There is no apparent difference in print adhesion or covercoat residue between pre-firing the print and fusing the print onto the glass directly after leaving overnight. However, direct fusing does create noxious fumes. So, where possible, it is better to pre-fire the prints and work in a well-ventilated environment.

The main difference between the digital and hand-printed transfers was the quality of the half-tone screen in the concentric circles: the digital print was much sharper and more even. With practice, my technique improved to the point where the precision of the screen prints was comparable to the digital version. However, the screen-printed transfers were significantly denser, especially in 'blocks' of tone such as the 'E'.

The other important difference was in performance when two layers of prints were fired together. When two layers of screen-printed transfers were applied in successive firings, the top image was distorted. This was particularly apparent in the 'grid', where the fine lines became 'wavy'. Where two sets of pigment appeared together, the effect was a richer, denser tone.

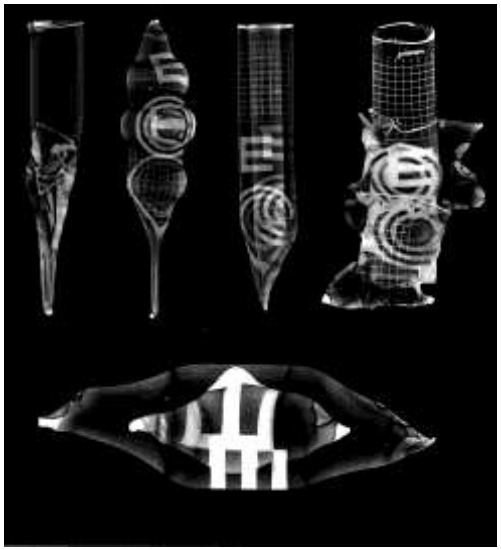


Figure 12: Photograms produced with printed borosilicate

However, when the two prints were applied and fired at the same time, the outer layer did not adhere evenly and several large holes appeared.

A similar effect appeared when two layers of digital transfer prints were applied, the top image appeared not to fuse fully with the tube across the whole area of the underlying covercoat, even when the prints were applied in two firings. This created an interesting 'subtractive' pattern.

5. Other observations

Layering

- Applying the print to the inside of the glass in combination with a print on the outside creates a subtle depth effect.
- Combining multiple printed tubes one inside the other as a 'Russian doll' and applying broken fragments to the outside of the tube also suggest movement.
- Printed elements distort to express the movement of the glass. Shining a light through these objects generates clear, detailed shadows**.** This was explored using a simple photogram technique.

Figure 13: Silver leaf fired onto borosilicate

Colour

Experiments had found that, while transfer prints remained 'chalky' and on the surface of the borosilicate tubes despite heating to very high temperatures for prolonged periods of time, the application of silver foil may offer one way of producing transparent coloured images on this type of glass. In this test, sandblasted an area with the 'E' and halftone patterns and heated the tube until glowing red. I then applied the silver foil and continued to heat the tube until the foil had become fully fused. It became a golden colour, similar to the silver stain effect used in architectural glass.

3/ Approaches to inclusions in hot glass

1. Context

Having established a system for screen printing transfers at the RCA and confirmed that they are comparable in terms of precision and deliver greater density than the digital version, attention shifted to consider ways of encapsulating these images inside the glass with the aim of expressing Ruskin's ideals of 'ductility and transparency'.

2. Objective

In this context, the aim was to consider ways to emphasise the movement of transfer prints through the encapsulation process. As I have experience of the 'embryo' process (building successive gathers over a core), this exercise sought other ways to build up multiple layers of print as quickly and efficiently as possible. I opted to work with 'tiles' of furnace glass in two different ways suggested by the historical research:

- fused 'blocks' to be blown or manipulated, suggested by marbling techniques
- as 'leaves' which could be embedded within the glass, suggested by architectural glass.

3. Process

The first stage was to prepare the flat glass elements. The glass technician James Devereux blew a series of large cylindrical vessels that I cut up using the crack-off process, then a glass cutting tool to make sections which were slumped to flat sheets.

Figure 14 : crack off process: turntable, scoring the glass, flame directed at the surface of the glass

The 'crack-off' technique

1. Turn on the gas and light the flame, adding the oxygen slowly to make a small, tight flame
2. Then place the piece on a turntable, wedging with clay if needed
3. To score the piece, adjust the level of the diamond tip to cut on a relatively vertical area on the piece so that the flame is perpendicular to the surface of the glass. Present the piece to the diamond tip and, holding the work firmly, rotate the turntable to make a light horizontal mark between one and two inches long
4. Adjust the gas burner to be at the same level as the cut, then, constantly rotating the turntable, bring the gas burner close to the surface so that the tips of the flames create the hot line which will eventually crack

Figure 15: Segments prepared for firing

The resulting cylinder was split, washed and placed into a kiln to slump. The first test pieces were slumped in a front loading kiln using the following cycle:

a) Ramp 1: 125°c to 250°c
b) Ramp 2: afap to 580°c
c) Ramp 3: hold 3 hours
d) end

This program gave the least possible kiln texture – the sheets were still slightly curved at the edges. The sheets were cut into 6cm squares, screen printed transfers applied, placed onto sheets of shelf release 'thinfire' paper and fired in a front loading test kiln using the following cycle:

a) Ramp 1: 30°c / hour to 50°c, 2 hour hold
b) Ramp 2: 250°c / hour to 720°, 10" hold
c) end.

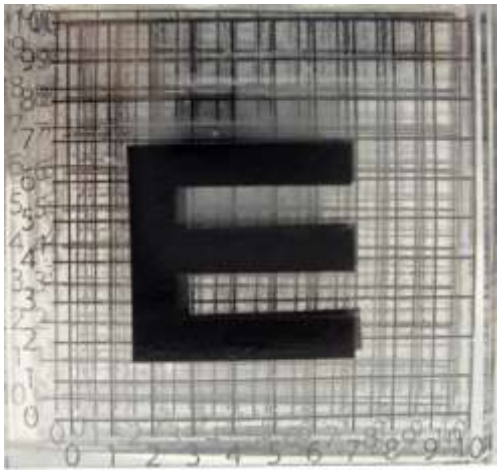


Figure 16: Printed tiles stacked together to experiment with pattern and depth

Figure 17: Kiln set up with shelf and fibre paper

I experimented with a number of different ways to stack the tiles together but opted to use one tile of each image interleaved with a clear tile in order to generate more depth and space between the images and to see how all the different types of graphic would be affected by the process.

These stacks were refired in the same kiln, surrounded by strips of kiln shelf material lined with fibre paper to ensure they did not flow when held at high temperature. The following cycle was used:

a) Ramp 1: 30% power to 600°c, 1 hour hold
b) Ramp 2: 30% power to 790°c, 1 hour hold
c) end

Figure 18: detail of tiles after firing

Figure 19: multi-layered blocks after firing

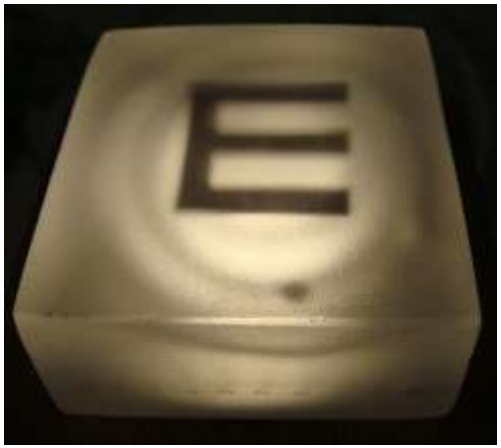


Figure 20: block ground to 200 grit on light box

The blocks were fully fused, although the edges of several sheets 'stuck' to the fibre paper, creating a ragged finish - although these were easy to grind after firing.

There was also some devitrification in particular on the block that had been fired on its own on the right hand side of the kiln, suggesting that it cooled more rapidly than the others. The controller for this kiln does not offer many ramps to control the rate of heating or cooling – a consideration for future firings.

The effect of light shining through the block after grinding but before polishing was interesting, creating a gentle, floating impression.

Figure 21: Blocks prepared for pick-up (left hand with edges left rough, right hand completely smooth), block on blowing iron before and after blowing

Two of these blocks were pre-heated in a toploading kiln to 550°c in preparation for encapsulation in hot glass. The front and back of both were ground, then sandblasted using 200 grit.

The glassblowing technician James Devereux then prepared a blowing iron with a small square-shaped open 'punty' and picked up the pieces from the kiln. I picked up the first piece with a glove and placed it on the iron, which resulted in large cracks on the front and back of the piece. These were reheated and apparently healed up without losing the glass.

James picked up the second piece directly and, although a small crack appeared when he introduced the block to the glory hole, this also healed up completely. Once hot, James blew a bubble into the base and as it rose through the block, the central layer of print was pressed upwards: the print retained its integrity but perfectly expressed the movement of the glass.

Figure 22: overview and detail of the block

Route 2: 'Leaves'

As an alternative to the pre-fused 'block' described above, individual flat tiles of printed glass were pre-heated to 550°C. James blew a cylinder or 'post' of clear glass and I pressed the printed tiles into the edges. Several tiles broke from contact with the gloves or tweezers in the first attempts, demonstrating the importance of planning the sequence and position of elements for pick up beforehand.

James heated the piece until the panels were both fully fused to the central cylinder and to each other in a reasonably regular pattern, creating loops with large voids between.

He then gathered over this form, leaving the glass in its organic shape. Again, the print retained its integrity and density but expressed the movement of the glass. Of particular interest is the way the prints seem to 'float' around the inner forms, suggesting that the two surfaces of each tile are pulled away from each other under the pressure of surrounding glass in motion.

The forms were then cut and polished to create a simple 'block' form with voids through which the printed elements emerged.

4/ Inclusions through casting

1. Context

The tests described above suggested that the transfer print flows with the glass during the making process, effectively tracing the fluid qualities of the material. The pick-up technique described above allows considerable control over the positioning of the elements and the degree of distortion.

2. Objective

In this context, the main objective of this test was to explore the more organic flowing effects that might be generated by casting the elements rather than placing them onto the blowing iron. I also used this test to see whether printing with copper oxide powder would produce a coloured effect – an approach suggested by the historical research into decorative techniques.

3. Process

Gaffer casting glass was used as it reliably casts into complex forms and is less likely to devitrify than the furnace glass. This was pre-cast into four flat billets so that I could layer the prints between the blocks without leaving one of the faces exposed.

Figure 23: Cast piece overview and detail

Transfers were screen-printed in the usual way, replacing black pigment with copper oxide. The prints were placed onto the pre-cast billets then stacked into a plaster mould. The piece was fired using the Gaffer recommended cycle for an object of this size in a front loading kiln:

a) Ramp 1: 75°c to 600°c, 1 hour hold
b) Ramp 2: 125°c to 866°c hour hold
c) Ramp 3: Afap to 440°c, 4 hour hold
d) Ramp 4: 5°c per hour to 390°c
e) Ramp 5: 12°c per hour to 340°c

The piece was allowed to rest for 24 hours before demolding, cutting and polishing.

4. Results

- The prints did flow with and through the material in a very suggestive way. However, although the print kept its integrity and density, the graphics stretched to the point where they were no longer legible – a problem for the Eye Hospital project. The copper oxide developed through the firing process to a luminous blue colour that cast coloured shadows within the piece.

5/ Coloured effects from glaze materials

1. Context

The tests so far had confirmed that the fluid or ductile qualities of the glass could effectively be expressed by encapsulating printed elements using variations on a basic 'pick-up' technique.

Attention then turned to the issue of transparency. While black pigments are obviously opaque, the bright transparent blue produced by the copper oxide and the golden colours created by the silver leaf in the borosilicate tests suggested that the materials used for colouring glazes may generate a rich, organic palette.

Through the historical research, reference to Dr Heike Brachlow's thesis and in conversation with members of the ceramics team, I identified number of minerals with the potential to produce transparent coloured effects.

2. Objectives

The objective of this experiment was to see whether selected minerals could reliably produce transparent coloured effects when encapsulated in glass.

3. Process

The first stage was to identify minerals likely to flux within the temperature range of the glass processes that I am investigating: kiln formed glass from 620^{o} to 760^{o}c, and hot glass, between 900^{o} and 1200^{o}c. I consulted colleagues and tutors as well as books from the library in order to narrow the selection. For the float glass test, I cut six small squares of bullseye tecta glass 5x5cm, and a further six rectangles of 2.5x5cm. I sieved a layer of the mineral onto the square, then covered one-half of the square with the rectangle in order to identify the reaction in a reducing atmosphere (i.e. covered so that no oxygen could reach the surface). The minerals used were:

1. rutile
2. yellow iron oxide
3. copper carbonate
4. manganese carbonate
5. vanadium pentoxide
6. cobalt carbonate
7. cobalt oxide
8. crocus martis

Figure 24: Sections of clear glass cylinder painted with minerals before encapsulation

These were then placed in a test kiln (kiln 19) and fired with the recommended 'full fuse' cycle given by Bullseye in their Technical Notes handbook for this thickness of glass:

a) Ramp 1: 125°c per hour to 600°c
b) Ramp 2: afap to 720°c
c) Ramp 3: 10 minute hold
d) Ramp 4: afap to 440°c
e) Ramp 5: 10 minute hold
f) Ramp 6: 10°c per hour to 390°c
g) end

The hot glass technician James Devereux blew a cylinder of clear glass that I cut into rings. Onto these, I painted a solution of the oxides above mixed at 5% with the alkaline flux. These were allowed to dry overnight before pre-heating in the toploader to 550°c. James picked up each section on a small bubble of clear glass and heated this until the surface was glossy in order to be sure that the coating was fully fused onto the piece before gathering and forming into a simple ball, then cracked off and left to anneal. These were simply ground to remove rough edges.

Figure 25: float glass samples after firing

4. Results

The results of the float glass tests are to the left. The yellow iron oxide, cobalt oxide and crocus martis failed to bond to the surface and washed off in the uncovered areas. The copper carbonate and cobalt carbonate both generated large bubbles in the covered area, but the copper carbonate was the only sample that changed colour.

Although a number of other materials and approaches could be explored, this is a complex field and the next series of experiments explore the effects produced by standard commercially-available materials.

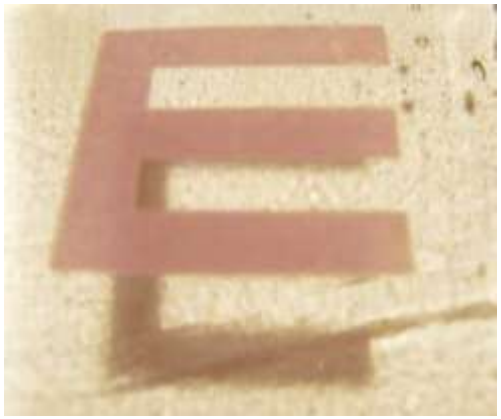


Figure 26: transfer print ('pink' pigment) fired onto Bullseye Tecta panel

Figure 27: vessels blown with Gaffer glass rod[5]

6/ Coloured effects from commercial colour products

1. Context

The experiments described above defined the territory for the next series of investigations: to work with standard coloured materials designed for hot glass applications. I had noticed that the commercially-available pigments for printing produced an opaque result (cast a dark grey shadow), but the solid 'bar' or coloured rod used in glass blowing generated bright transparent hues. This suggested the form of the material (powder or solid rod) defined the degree of transparency.

2. Objective

To test this hypothesis, I designed a series of experiments to compare the transparent qualities generated by solid coloured bar in three forms:

- finely-ground powder
- coarse frit
- solid cast form

[5] From www.justglassonline.com, accessed 23 September 2013

Figure 28: Blown 'eggshell' of hot glass rod ground in ball mil, painted transfer before and after encapsulation, detail to show shadow colour

A/ Finely ground powder

Process

The senior glass technician Anthony Harris blew an 'egg' or thin-walled sphere of pure rod colour. This was then ground to fine powder in ball mill and mixed with water-based medium to create a paste and painted onto transfer paper in order to create a thick layer of colour.

Covercoat was then applied and allowed to dry in the normal way before application to an 'embryo' or bubble of clear glass. This embryo carrying the transfers was heated to 550^{o}c in toploader then picked up, heated until fully melted into the surface of the embryo then encapsulated. Once cool, the form was cut to focus on the area with the image and the edges polished.

Result

In reflected light, the resulting image was bright and sharp, with an interesting tonal effect given by the different thicknesses. The resulting image cast a shadow that was substantially more 'colourful' than those created by commercial enamels, but still not fully transparent.

Figure 29: Sieving china clay onto the shelf as a release: Sieved glass frit print (coarse green frit on left, white powder and copper oxide on the right): Covering the print with china clay to 'seal'.

B/ Coarse frit

Process

This test built directly on the work of my colleague Dr Steve Royston Brown, who generously gave me guidance and materials, including a screen to save time.

The first stage was to prepare the kiln shelf by sieving china clay across the whole area to make sure that the prints would not stick to the shelf.

The next stage was to prepare the prints: A coarse-meshed screen had been prepared with an adhesive plastic sheet, from which areas had been cut out to expose sections of mesh so that when frit was sieved over the screen, it passed though those areas and fell onto the kiln shelf to create a simple pattern. In order to contrast different sizes of material, I used a coarse glass frit and a copper oxide powder. In a final stage before firing, china clay was sieved across the whole area in order to make sure that the details of the print stayed in place during the firing process. The shelf was then fired in a front loading kiln using the following cycle:

a) Ramp 1: 350ºc/hour to 760 ºc
b) Ramp 2: 30 minute soak
c) Ramp 3: end.

Figure 30: Print after firing detail, bottom and top, showing marks of china clay where the sieve was in contact with the shelf, leaving a subtle pattern.

Results

The basic system seems to work well, including the use of china clay powder as a release and the firing cycle.

However, the white powder/ copper oxide version was too fragile to be lifted from the kiln shelf. The version using coarse green frit, while still extremely fragile, gave some exciting results. In addition, when heated and picked up onto furnace glass, the final result opaque and dull, which may be due to the substantial residue of plaster that had become embedded in the glass as a result of the firing process. The fine edges of the print 'curled up' when heated, creating a blurred outline and uneven texture.

Figure 31: Result after pick up

Figure 32: Rhino class, December 2009: Wax prepared for casting in plaster: Resin model positive, silicon mould negative, wax positive

C/ Solid cast forms

Process

This approach was suggested by German 'prunts' or press-moulded bosses that were applied to glass vessels while hot to introduce a tactile decorative dimension. The aim was to consider the potential to create bright, transparent images using solid coloured rod. A one-day course in the 3d modelling software Rhino gave me the tools to translate graphics into simple three-dimensional forms, the starting point for this process. The Rhino file was exported in preparation for rapid prototyping. In order to prepare the object for printing from this programme, there are three steps to follow:

- toolbar / 'mesh', then select 'from NURBS object' from drop down and adjust for resolution / density of mesh
- click on object and choose mesh (not polysurface)
- from toolbar / 'file', select export object and choose '.stl' format = sterolithography

The file was printed in resin by the Rapidform team and the edges ground to 400 grit to remove the ridges. This resin object was then then cast in silicon. This was then cast in wax as shown.

Figure 33: Casts before firing

The first batch of tests shown to the left from top left to bottom, then top right to bottom

1. 28g kugler yellow blowing rod, small pieces *
2. 35g kugler yellow blowing rod, larger pieces *
3. 28g kugler forest green blowing rod, transparent
4. 19g kugler sea green blowing rod
5. 26g gaffer rhubarb casting, large chunks
6. 24g gaffer rhubarb casting, small chunks
7. 36g gaffer clear casting, medium chunks
8. 25g borosilicate (NS-SFO2955 borocolour red exotic frit size s) *
9. 25g borosilicate rod with prints broken into pieces *
10. 25g furnace glass with prints (hand printed)

These were then fired in a front loading with the following cycle

a) Ramp 1: 30% to 600^{o}c, 1 hour hold
b) Ramp 2: 30% to 866^{o}c, 3 hour hold
c) end

Figure 34: Casts after firing and Kugler yellow, forest green and gaffer rhubarb after demolding

Those marked with a * did not fully cast. All except the borosilicate rod pieces and the furnace glass were refired (the mould for the borosilicate and furnace glass had broken down and could not be reused). I prepared a second sample of the furnace glass with a printed tile, this time standing the print up into the mould rather than lying across the top as the first sample.

These were refired in a front loading test kiln with the following cycle:

a) Ramp 1: 30% to 600°c, 3 hours soak
b) Ramp 2: 30% to 900°c, 3 hours soak
c) end

Initial casting tests proved problematic as rod tended to 'strike' (become opaque) or did not cast fully into the mold. After a series of tests, I was able to determine a reliable firing cycle:

a) Ramp 1: 150°c to 600°c, 30 minute soak
b) Ramp 2: AFAP to 920°c, 1 hour soak
c) end

No annealing stage was needed as the pieces were thin and would be picked up again.

Figure 35: Kugler Sea Green blowing rod relief print on embryo and encapsulated.

Figure 36: Result showing soft edges, coloured shadow and grey bubbles

The resulting cast was then sawn and ground to 2mm sliver, pre-heated to 550°c in the toploader, picked up on the end of a clear bubble and encapsulated in clear glass. This was blown slightly until the colour was transparent but the image retained its integrity before the sphere was broken off, placed into the annealing oven. When cold, the sphere was cut using the crack off machine.

Result

This approach generated bright, clear coloured shadows, but very soft edges.

There may be potential to explore options for cold working these slivers to get fine edges or use modulation of depth to create density / tone.

I also noted the bubbles, which seem 'bright' or white in reflected light but cast dark shadow in transmitted light.

7. Colour mixing

1. Context

The previous test indicated that a thin sliver of solid colour produces a bright transparent pattern. However, the edges of this pattern were soft and the corners caught bubbles which generated dark shadows. In addition, the process of casting and grinding the slice was time-consuming and wasteful. However, I realised that the same effect could be achieved through the 'flashed glass' approach used in architectural glass and the graal technique: a clear base layer is overlaid with a thin flashing or layer of colour. Areas of the coloured layer are then etched away, leaving a pattern 'floating' on the clear glass base.

2. Objective

The objective of this series of experiments was to build on this knowledge to explore options for basic colour mixing, building on the results of these simple masking and etching techniques to experiment with UV-sensitive half-tone stencils. These provided the tools for the second series in this section, combining the transparent coloured effects with the fluid qualities of the encapsulation techniques discussed earlier. The last test integrates coloured and printed elements.

Figure 37: Preparation and results showing the colour blending effect from simple panels

Figure 38: Various masking and etching techniques

3. Process

A/ Basic colour mixing

The first tests simply refined the process for producing flashed glass panels, blowing cylinders with a thin layer of colour, cutting and slumping these to make a series of tiles that were picked up on in the end of a clear bubble, encapsulated, blown and cut into simple bowl forms using the crack off machine.

Having confirmed that the mixing effects were similar to patches of transparent film, these experiments progressed to explore a range of masking and etching techniques such as sandblasting, acid etching and engraving with a dremmel.

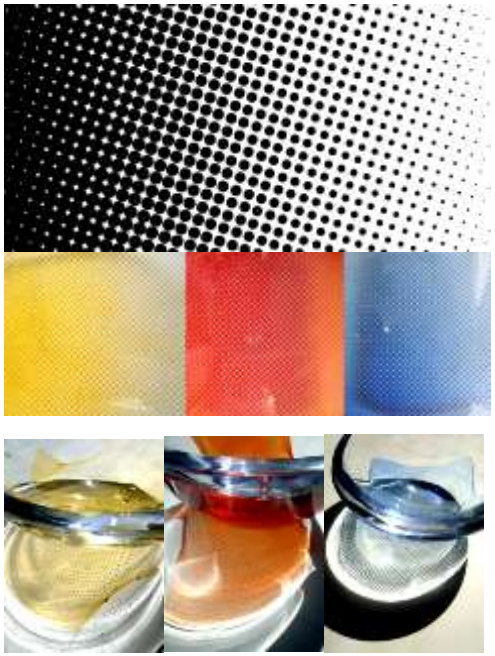


Figure 39: Halftone matrix progression: sandblasted yellow, red and blue panels: panels after encapsulation in hot glass bowls.

B/ Halftone matrix

Rudimentary experiments using the dremmel tool to remove points or dots of colour suggested that using a more structured dot matrix would produce a distinct graduation from 'light to dark'. UV-sensitive resist film (AFP 6mm from Crystal Galleries[6]) was exposed using a halftone dot matrix graduating from 100% to 0% (as shown to the left), then sandblasted to remove the coloured layer of glass in the exposed areas, shown here.

Three elements (cobalt blue, wine red and lemon yellow) were pre-heated and picked up on separate clear bubbles before adding a gather of clear glass then blown to make three dishes that would 'stack' to see how the 'order' of the colours affected the visual effect both internally and in terms of the projection. The bowls themselves were too thick and the forms did not 'sit' inside each other, so the interactive quality was not as successful hoped. However, the half tone patterns cast by the dishes suggested a textile weave texture. I also noted the impact of thickness of the overlays in the colour effect: the red was so much stronger than the blue or the yellow that the colours did not produce the optical combining effect (red + yellow = orange).

[6] www.crystalgalleries.co.uk

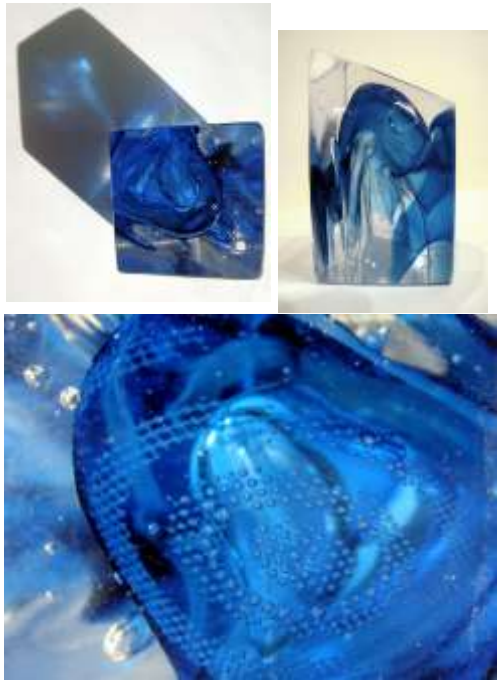


Figure 40: finished block from side, top and detail

C/ Combining transparent coloured effects with flow of encapsulation

Building on these results, this experiment returned to the original graphic devices (grid, concentric circles and block 'E') to see whether this 'flashing' technique would produce transparent, fluid detailed patterns. A cylinder blown from copper blue gaffer rod and clear glass with 2mm wall thickness was cut and slumped into flat squares. Sandblast resist film (AFP 6mm from Crystal Galleries – see website address above) was exposed, applied then sandblasted. This element was then pre-heated and loosely picked up on a clear bubble before adding a gather of clear glass, allowing the encapsulated element to 'flow' rather than being pressed down onto the bubble as in the previous experiments. The resulting form was cut and polished to make a simple block form.

Results

The fine lines of the grid with small numbers were not robust enough to survive the prolonged sandblasting required to break through the coloured layer. However, I noticed that the halftone pattern collected tiny bubbles, creating a subtle textured effect.

Figure 41: Finished block side and top views

D/ Combining two colours

Panels with sandblast patterns were prepared from a second cylinder blown with wine red rod. Two elements (copper blue and wine red) were pre-heated and loosely picked up on a clear bubble, allowing them to fold and float freely before adding a gather of clear glass and shaping to a cylinder.

The resulting form was cut and polished to make a simple block.

Results

The colours and the images retain their integrity, despite considerable movement: they do not 'mix' like watercolours. However, the colours do mix visually inside the object cast a multi-coloured shadow.

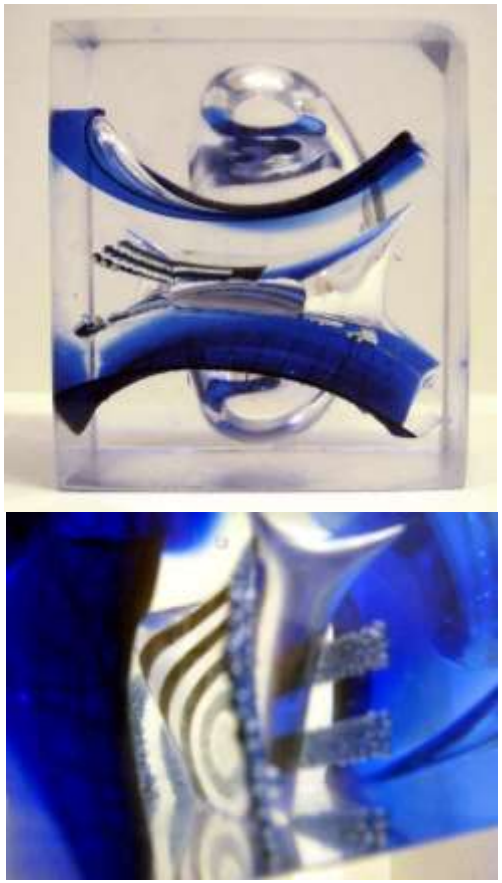


Figure 42: Thick panels with copper transfer print overview and detail

E/ Combining coloured panels and transfer prints

The clear 'carrier' layer provides a second surface for printed elements. While a thin panel appears as a single 'skin' with no distance between the coloured and clear surfaces, the clear side of a thicker panel, when encapsulated, appears as a completely independent structure within the object.

In this test, two thick panels (5mm thick) of furnace glass with a layer of blue colour were used as a base for transfer prints made using copper oxide. These were pre-heated in the toploader, picked up and encapsulated. The glass was left 'free form' (not shaped using a block or paper) to retain the graphic effect of the coloured glass panels within the glass. This form was then cut and ground into a simple block.

Results

Thick panels of glass offer an alternative to the fluid folding of the thinner pieces explored earlier. The internal forms and the prints remain completely stable, retaining a strong graphic quality. The bubbles caught by these rigid elements generate interesting reflections.

8/ Refining tonal effects

1. Context

The starting point for this work was the observation that even very light textures or marks on elements prepared for encapsulation caught bubbles when these were in direct contact with the hot glass, resisted repeated heating and did not change size or position, even after encapsulation. Of particular interest was the way that these bubbles appeared bright or light in reflected light, but cast grey shadows in projection - when lit from behind.

In addition, while tests using UV-sensitive sandblast resists had amply demonstrated the potential to create finely detailed images and half tone patterns, they are expensive and extremely fragile, breaking down very swiftly, especially when removing areas of colour which necessitates lengthy exposure to high pressure sand blasting. For this reason, while presenting obvious limitations in terms of the types of images that could be created because of the nature of the tracing process, laser cutting self-adhesive plastic seemed to offer the potential to prepare robust, affordable sand blast resists relatively swiftly.

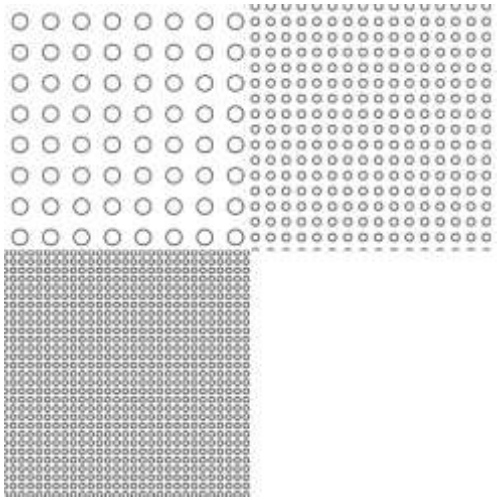


Figure 43: 5mm, 2.5mm and 1.8mm circles in halftone array for laser cutting

Figure 44: Comparison of sandblasted elements before encapsulation (5mm, 2.5mm and 1.8mm diameter circles)

2. Objective

The objective was to create a dense, even matrix of bubbles or tone. For this reason, efforts focused on achieving the smallest possible diameter of hole and the closest possible spacing between them while retaining sufficient strength in the plastic to resist the sand blasting process.

3. Process

A. Defining the matrix

In order to compare the visual effect, a single black plate was blown, then sawn into sections. Each was sandblasted with a different matrix, then encapsulated using the same method.

The size of dot and the spacing between the dots was reduced to the point where the plastic started to break down in the course of the laser cutting process. Several different types of plastic were tested for strength. However, flexibility and resistance to the laser cutting process were also factors ('super tough' products sold for flooring for example) were not flexible enough to cope with the curved surfaces of the plates).

Figure 45: Comparison of sandblasted elements after encapsulation (5mm, 2.5mm and 1.8mm circles)

Figure 46: Comparison of sandblasted elements after encapsulation (5mm, 2.5mm and 1.8mm circles) from top

Figure 47: Comparison of sandblasted elements after encapsulation (5mm, 2.5mm and 1.8mm circles) from side

Focus 'own-brand' self-adhesive plastic sold for diy applications such as shelf and window covering provided the best result, while basic 'diy' grade sold through local hardware stores was acceptable. Ryman's stationery-grade was not substantial enough to withstand sandblasting and distorted significantly in the process.

Additional observations

Several other issues became apparent in the course of this research. The first was the critical importance of achieving a clean, even dot matrix. Any imperfections resulted in the bubbles running together. Another important factor in achieving a clean, regular result was the level surface of the original element: when the surface was very uneven or ridged, additional bubbles were caught.

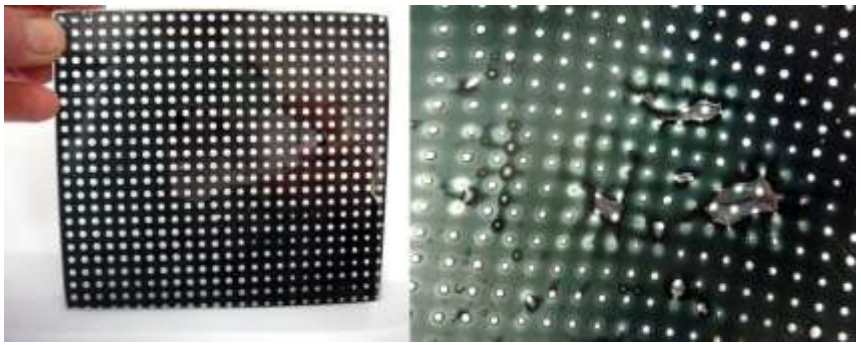


Figure 48: Illustration of uneven surface and poor final result

Figure 49: Illustration showing sample with black breaking up from overblowing and not overblown

Figure 50: Panel before encapsulation

The type of colour used also made a major difference to the effect: the lustre black originally chosen for its density broke up when blown or stretched creating interesting organic but potentially distracting effects.

B. Impact of sandblasting depth

This test was designed to see whether the depth of sandblasting affected the size of bubbles and the overall visual effect

A clear panel of glass was prepared with laser cut plastic and sandblasted to two depths: one very light and the other deep (to the point where the plastic started to break down). This was then encapsulated and blown using the standard process.

Figure 51: Clear dish from top, shadow and detail

Figure 52: Effect of blowing on bubble size

Result

The depth of sandblasting had no visible effect: the main factor on visual effect was the location of the bubble within the piece. A more important factor appeared to be the extent to which the piece was manipulated: when blown, the bubbles stretched.

Figure 53: Impact of location within the piece on bubble size

9. Refining coloured effects

1. Context

The tests described above suggested the critical importance of controlling the thickness of coloured layer to allow detailed sandblasting while giving a vibrant colour effect: if the layer is too thick, the resist breaks down before the colour has been removed, while if it is too thin, the coloured effect is too faint after encapsulation, especially if the form is then blown. We had also noted the difficulty of predicting the coloured effects from the printed coloured charts or from the shards or 'confetti' catalogue provided by the suppliers.

2. Objective

This series of tests sought to refine our understanding of these parameters, considering a number of alternative approaches to producing and evaluating detailed transparent coloured patterns in the glass. They can be divided into three themes:

A. Preparing coloured elements for encapsulation

B. Subtractive techniques – where material is removed e.g. etching or woodcut

C. Additive techniques – where material is added e.g. transfer prints

Figure 54: Colour tests

A. Preparing coloured elements

A series of tests were carried out to confirm the optimum quantity of coloured bar for selected hues from the Gaffer and Kugler ranges, working with a specific form in order to compare results. We chose to work with a standard mold-blown jar form that was then cut down to create an open cup. This approach made it possible to see the effect of colours in combination with each other by stacking the cups together.

This information was then used to calibrate the amount of colour bar needed for specific sizes of plates. Although there is some variation due to factors such as the heat of the furnace glass and the number of times the piece is reheated, for consistency, all subsequent tests used 25g for 13cm diameter plates, 50g for 17cm diameter and 75g for 22cm diameter.

In the course of this process, we also identified the need to keep the plates free of dust and shelf texture during the pre-heating phase that could last for many hours. Placing each element on a 3mm steel plate that was then stacked in the kiln separated by short kiln props proved to be an effective solution.

Figure 55: Original element and result showing effect of contact with hot glass and on the outer surface

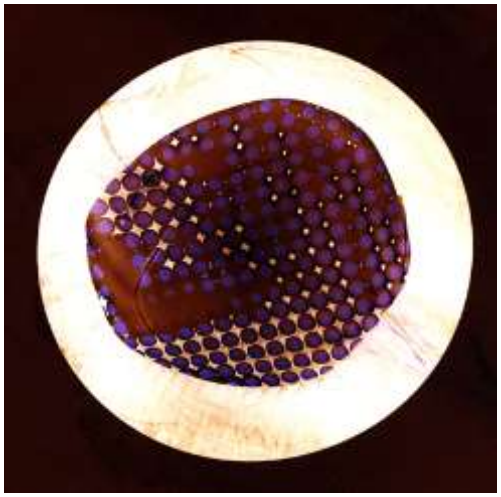


Figure 56: Colour photogram of encapsulation with bubbles, purple colour (complement of yellow) indicating generation of transparent shadows

B/ Subtractive techniques

i) Positive image produced by UV sandblast resist

Plates were blown using Gaffer daffodil yellow bar, then prepared using a UV-sensitive sandblast resist matrix exposed to a high-density stencil generated through the Epson inkjet printer. The UV sandblast resist permits the production of a 'positive' image (a 'dot' rather than a 'hole')

The sandblasted elements were preheated in the top loader using a slow cycle to ensure the elements did not crack: 50^{o}c per hour to 530^{o}c, then the temperature increased to 550^{o}c just before pick-up.

Two options were tested – the first with the coloured surface in contact with the hot glass captured a matrix of bubbles, while the second, with the coloured surface on the outside did not.

While I had chosen yellow because of its luminous qualities, it was proving hard to judge whether the coloured effects were in fact transparent. Colour photograms provided a reliable measure: when the shadow appeared purple (the complementary colour to yellow), this indicated a transparent shadow.

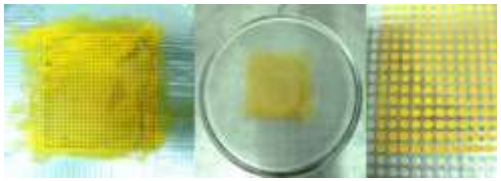


Figure 57: Preparation of the plate: areas masked with gaffer tape in order to leave some areas clean for comparison, overview of the plate, detail

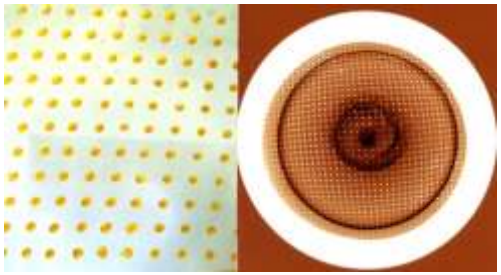


Figure 58: Detail of result and colour photogram showing the dots as opaque elements

Figure 59: Preparation of blue and red plate

ii) Positive image produced by inlaid pigment

Another option for producing a 'positive' image is to sandblast a 'hole' using the cheaper and more robust laser cut stencil and fill it with colour – in this case, a mixture of coloured enamel powder and printing medium into the spaces.

The result was a perfectly even array of coloured dots, but the photogram confirms that the effect is opaque and not transparent as the light was blocked by the pigmented areas.

This raised the question of whether the opaque effect could be due to the pigment remaining as a powder and not being fully melted.

In order to test this, two plates were prepared by sandblasting, then pressing powdered pigments again mixed with water-based printing medium. Two different colours (Kugler Lapis Lazuli powder and Kugler Cherry Red powder) were chosen in order to test whether the effect was due to the yellow pigment of the first test, yellow being considered a relatively 'hard' colour.

Figure 60: Unfired and pre-fired plate after encapsulation: Two bowls placed together

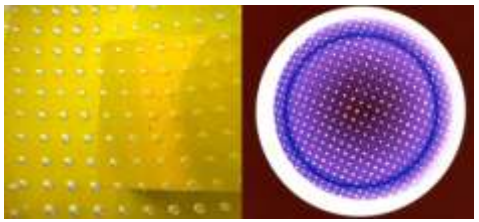


Figure 61: Section of sandblast encapsulated plate and photogram

One plate was fired before encapsulation and the other was not. The only apparent difference was that the coloured dots in the pre-fired matrix appeared to have distorted or shrunk slightly, giving a more uneven effect without noticeably improving transparency.

It was interesting to note the optical effects generated by placing the two objects together to create a closed form.

iii) Negative image – sandblast resist

As discussed, the laser-cut stencil produces a 'hole' rather than a 'dot'. In this variant, a laser-cut sandblast resist was applied to a plate made with Gaffer daffodil bar to create a matrix of clear holes. This was then encapsulated with the holes in contact with the hot glass. The result shown here alongside the colour photogram, demonstrates that this approach generates coloured shadows

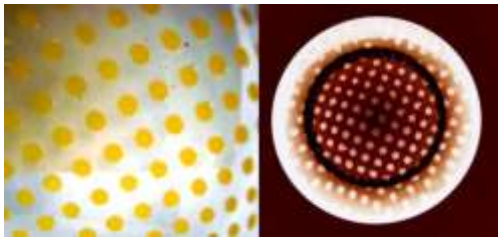


Figure 62: Detail of screen printed transfer after encapsulation and colour photogram

Figure 63: Gaffer Wine Red and Kugler Steel Blue elements before encapsulation and result after encapsulation

Figure 64: Encapsulated Gaffer Cherry Red, Gaffer Wine Red and Kugler Daffodil elements

C/ Additive techniques - transfer prints

Traditional screen printed transfers are the obvious alternative – colour is added to the surface of the glass. The result, shown here, was a bright, sharp pattern, but as the photogram illustrates, the shadows are opaque, not transparent.

D/ Colour mixing

A brief investigation built on this information, to consider colour mixing effects achieved by encapsulating different coloured elements sandblasted with the same matrix. Elements were pre-heated in the top loader as above. A clear bubble was blown and the first element picked up from the top loader. This was heated and encapsulated with a thin gather of hot glass. The second element was then picked up from the top loader, heated and then encapsulated before final shaping.

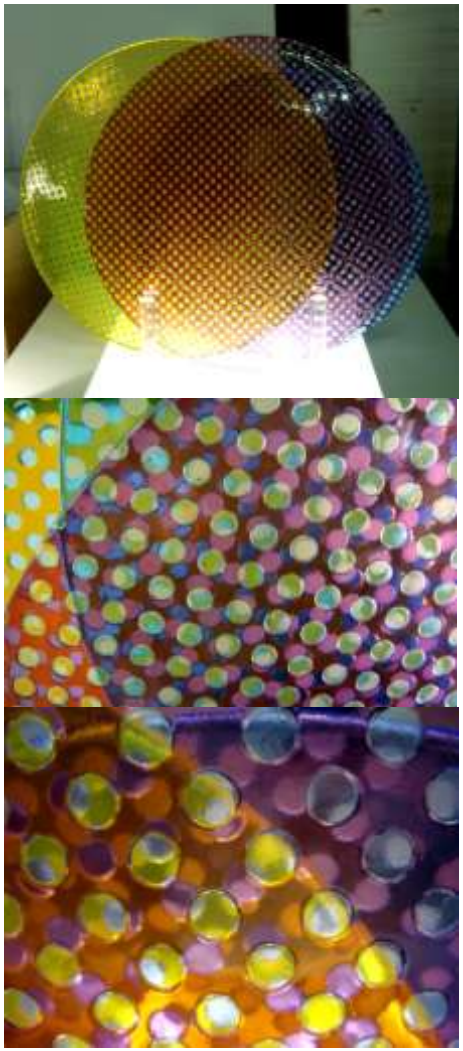


Figure 65: Plates with halftone matrix

This exploration raised the question of the effects would be generated by simply sandblasting the plates without encapsulation. However, the sandblasting process creates a 'cloudy' texture which blocks the light and stops the colour mixing.

In this test, a yellow, magenta and cyan plate were each sandblasted with the same halftone matrix, then placed in a kiln to 'fire polish', or remove the texture.

However, as the glass softens to the point where the texture is removed, it also begins to take on the texture of the shelf or surface on which it is placed.

While these pieces were too large, the ideal solution would be to fire polish in the glory hole – eliminating the shelf texture and offering greater control over the heat.

10. Exploring optical effects

1. Context

Previous experiments had shown that indentations or voids on the surface of an object prepared for encapsulation results in the creation of a bubble which, when seen in reflected light appears bright or light against a dark background, but casts dark grey shadows when lit from behind. These tests had also indicated that a regular matrix of bubbles, when encapsulated, reflected the flow of the material in the making process and unusual optical effects as layers of bubbles appear to interact with each other.

2. Objective

In this context, three groups of tests were carried out and described here:

a) Single matrix within vessel and torus forms to consider expression of movement
b) Double matrix within vessel form to consider expression of depth
c) Triple matrix within vessel form to consider potential to register matrices at different levels within the same piece.

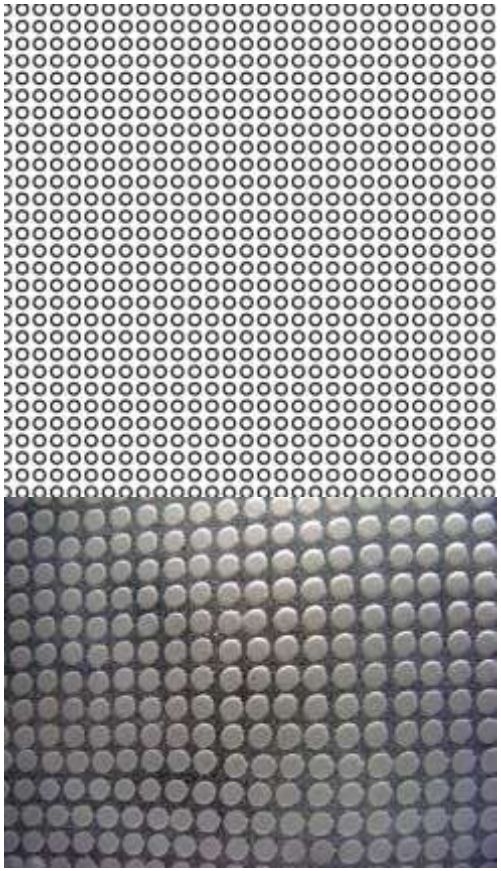


Figure 66: Circle cutting file and detail of plate after sandblasting

3. Process

Clear blown plates were prepared with a matrix of sandblast indentations, working with the size and spacing identified through earlier tests. These were then placed on steel plates spaced with kiln props for pre-heating in the top loader. Experience over a number of sessions highlighted the importance of the pre-heating cycle: when heated too swiftly (faster than 80°c per hour), the plates tended to crack, while too slow (50°c per hour to pick-up temperature, 540°c), they tended to stick to the steel. The optimum firing cycle in the toploader in the RCA hot shop was found to be: 70°c per hour to 400°c, then as fast as possible to 520°c, hold until ready to pick up, then as fast as possible to 545°c.

Sandblast resists laser-cut from self-adhesive plastic were significantly more robust than those created using the UV-sensitive resist. However, some laser-cut resists appeared to be 'burnt' and became brittle, possibly due to lack of calibration between jobs run on the machine. Initial experiments suggest that resists cut on the Creation brand 'P-Cut' machine (using a mechanical process and a blade) were the most solid of all. However, the laser and blade-cut resists pose obvious limitations in terms of the design or image that can be produced.

Figure 67: Torus form overviews and details

a) Single matrix within vessel and torus forms to consider expression of movement

These tests built on the observation that the encapsulated bubbles appeared bright in reflected light and cast shadows when lit from behind. In addition, the presence of the regular matrix of bubbles marked the movement of the glass in the course of the blowing process. In addition, the optical qualities of the glass create an impression of movement as the viewer moves around the object.

In the first test, a clear plate (diameter 16cm) prepared with a sandblast matrix, was picked up on a bubble, then encapsulated to create a cone-shaped form. This was then cut and polished.

In a second test, after encapsulation, a graphite post was pressed into the end of the form to create an impression. The movement of the glass was shown by the change in the matrix pattern.

Figure 68: Double matrix from side, base and detail

Figure 69: Triple matrix from side and detail

b) **Double matrix vessel form to consider expression of depth**

Building on the experience of the tests above, the next experiments were designed to explore the impression of depth created by the matrix. Two plates (13cm and 16cm diameter) were prepared, pre-heated and encapsulated.

This result raised the question whether it might be possible to register the matrices to control the optical effects and potentially create three and four-dimensional images.

c) Triple matrix within vessel form to consider potential to register matrices at different levels within the same piece.

In this experiment, three plates (13, 16 and 21cm diameters) were prepared with the standard matrix and encapsulated. Attempts were made to register the plates by marking the steel plates and the blowing iron so that the direction of the dots would be the same. However, while we had some success, the inevitable movement of the glass in the gathering and shaping process resulted in too much distortion to be able to reliably create an image.

This led to a re-evaluation of the process and the decision to develop a new technique, building up the layers through a series of separate sessions in the hot shop. This made it possible to register elements in sequence with little or no distortion.

Figure 70: Map showing location of Bucholtz, Nordheide[7]

Figure 71: Map showing location of Grunstadt, Pfaltz[8]

[7] Map data © GeoBasis-DE/BKG (2009) Google maps
[8] ibid

2. Interview with Ingeborg Wilding on her late husband Ludwig Wilding

Introduction

These notes were made in conversation with Ingeborg Wilding, Ludwig Wilding's widow, during a visit to their home in Bucholtz near Hamburg, from 24 to 25 July 2013.

Family / background

Ludwig was born on the 19th of May 1927 in Grünstadt / Pfalz, a small town in the south west of Germany on the edge of the Rhineland.

Ludwig was fourth of five children: the eldest sister died aged 11, survived by a second sister, a brother three years his senior and a younger twin sister. He admired his older brother and was very fond of his mother but beyond the usual annual gatherings, it does not seem to have been an especially close-knit family.

His father, also a catholic, worked as a salesman of bedroom-furniture for a manufacturing company. The family was considered middle class and owned one of the first private cars in Grünstadt.

Ludwig was called to the war at the age of 16 but was not sent to the front line, thanks to a doctor in the military hospital who had treated Ludwig for angina. At the end of the war, Ludwig made his way home across the countryside, living rough and begging for over a month, arriving on the day of his 18th birthday. During the war their house was occupied by the French army for a long time.

The suicide of the Jewish couple who lived door to the Wildings features as another strong memory from this time. The windows of the two houses were very close and Ludwig spoke of seeing the couple who had gassed themselves in their kitchen. The town had one of the largest Jewish populations in the region, decimated during the Second World War.

Ludwig was a talented musician, playing stringed instruments in a jazz band as a young man However, he decided not to pursue a musical career as he was wanted to be able to work late into his life and was worried that his hands would lose dexterity in old age.

Ludwig's father was keen that his son should have a steady income and wanted him to be an art teacher. But Ludwig wanted the freedom to make his own work. It was agreed that his father would pay for his education up to the value of teacher training and then Ludwig would make his own way.

Figure 72: Willi Baumeister at the Stuttgart Academy, 1947-8[9]

[9] http://www.willi-baumeister.org/index.php?getlang=en&menuid=29&reporeid=351&template= accessed 05/12/2013

Figure 73: Willi Baumeister in his studio in 1955 at work on the painting *ARU 5*[10]

Figure 74: Ludwig Wilding. 1949. *Abstrakte landschaft* (Abstract landscape)[11]

[10] http://www.willi-baumeister.org/index.php?getlang=en&menuid=29&reporeid=224&template= accessed 05/12/2013

[11] Wilding, Ludwig, Hoffmann, Tobias, and Bauer, Ines. 2007. *Ludwig Wilding:Visuelle Phänomene*. Köln: Wienand. p29

Training and influences

At that time, the painter Willi Baumeister[12] was teaching in Stuttgart and Ludwig determined to train with him. His initial applications were rejected but following two years studying art history at the University of Mainz (1948-50) Ludwig approached Willi directly and was accepted.

Ludwig studied in in Stuttgart between 1950 and 1953, developing approaches to structuring, modulating and distributing surfaces that would be recurring themes throughout his life. On graduation, Ludwig worked for a German textile company (1955 – 1967) winning prizes for his designs and travelling to trade fairs to meet clients and research new ideas. He continued to paint in his spare time, exploring figuration and colour, although little work from that period survives.

[12] Willi Baumeister, artist (1889-1955)

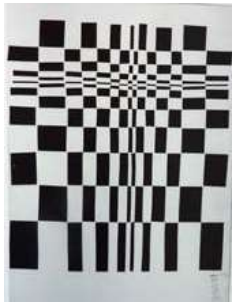


Figure 75: Ludwig Wilding. 1951, Schachbrettvariation (Chequerboard variation)[13]

Figure 76: Ludwig Wilding. 1960. *Objekt mit scheinbewegung mit progressiven winkel-anordnumgen* (Object with illusory movement with progressive chevron formation)[14]

[13] Wilding, Ludwig. 1987. *Ludwig Wilding: Retrospektive, 1949-1987: Pfalzgalerie Kaiserslautern, 25.10. bis 29.11.1987, Städtische Galerie Lüdenscheid, 4.3. bis 3.4.1988, Ulmer Museum, 22.5. bis 26.6.1988*. Kaiserslautern: Die Pfalzgalerie. p27

[14] Ibid p79

Figurative to abstract

One of Ludwig's directors encouraged him to go to see museums and galleries in the cities where they were staying and on a trip to Paris, Ludwig took some of his paintings to see if there might be a chance of showing his work there.

However, he felt that other artists exploring the same themes were achieving better results and that there was no point carrying on in the same vein.

Ludwig told the story of sitting on a bench in a school yard in Paris and recalling Baumeister's advice that an artist needs to find a field where no one else is working and make that their own. He decided to abandon his paintings. Realising a connection between the threads of his textile designs and the effects that he had been achieving with simple lines to suggest angled planes on flat surfaces, he decided to pursue that avenue, seeking to emulate the quality of 'filling the room' that he found so inspiring in Baumeister's work.

This led to a series of experiments, first with hand-drawn and then with ruled lines to create optical interference patterns. By 1957, he was working entirely in black and white and geometric parallels had almost completely replaced free-drawn marks

Figure 77: Ludwig Wilding. 1963. *Objekt mit scheinbewegung "augenmotiv"* (Object with illusory movement, 'eye motif')[15]

Figure 78: Ludwig Wilding, 1964. Designs of the early small-format multiples.[16]

He became fascinated by the emergence of new structures from combinations of fine gratings and grids, refining techniques for generating precise grids and controlling the effects of movement and depth. Over the following years, he experimented with new transparent materials, graduations and rotations in two and three-dimensional works, exploring every possible combination of moiré interference effects: speed and direction, parallel and concentric, and with modular and continuous 'all over' compositions.

While still working as a textile designer, Ludwig participated in a series of exhibitions held under the Nouvelle Tendances in Zagreb (1963)[17] and in Paris (1964)[18]. He was also in touch with emerging community who became known as 'op artists' in New York (1965) including painters such as Bridget Riley. These encounters led to experiments with printmaking techniques and the development of the first three-dimensional objects using string and glass.

[15] Ibid p61
[16] Wilding, Ludwig. 1973. *Räumliche irrationen: optische interferenzen perspecivische täuschungen.* Cologne, Germany: Kölnischer Kunstverein. P10

[17] *Nove Tendencije* exhibition series, 1961-1973 Galeria Suvremene Umjetnosti in Zagreb, now the Museu Suvremeni Umjetnosti (Museum of Modern Art) in Zagreb http://www.msu.hr/

[18] *Novelle Tendances* exhibition, Musée des Arts Décoratifs, Paris. Wilding, Ludwig. 1987. *Ludwig Wilding: Retrospektive, 1949-1987: Pfalzgalerie Kaiserslautern, 25.10. bis 29.11.1987, Städtische Galerie Lüdenscheid, 4.3. bis 3.4.1988, Ulmer Museum, 22.5. bis 26.6.1988*. Kaiserslautern: Die Pfalzgalerie. p237

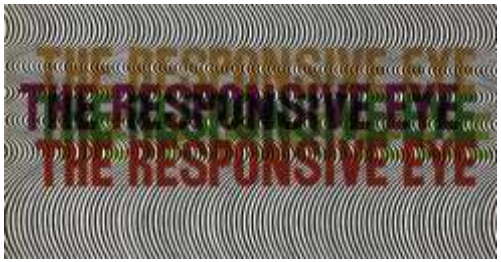


Figure 79: *The Responsive Eye* exhibition catalogue cover (1965)[19]

Figure 80: Larry Aldrich[20]

In 1963, Ludwig produced the first of his celebrated 'eye' interference patterns using white lines on black background and black superimposed on white.

The first multiples were produced in 1964: a series of circular prints of optical interference patterns. This practice of producing multiples, often in editions of 100, continued throughout his career, complemented the one-off pieces designated 'originals'. All the works were numbered with a simple system combining the size of the work and its place in the sequence of production.

The Responsive Eye exhibition in New York in 1965 could be seen as a milestone in Ludwig's career, presenting his work on the international stage for the first time – and bringing the op art aesthetic to a new audience.

[19] Seitz, William C. 1965. *The Responsive Eye*. N.Y: Museum of Modern Art, in collaboration with the City Art Museum of St. Louis [and others)

[20] Larry Aldridge, a New York industrialist, printed one of Bridget Riley's designs as dress-making fabric, controversially without asking her permission, Notes from interview between Larry Aldridge and Paul Cummings, *Oral history interview with Larry Aldrich, 1972 Apr. 25-June 10, Archives of American Art, Smithsonian Institution.* Image from http://greg.org/archive/2010/08/27/the_trendmaking_eye.html accessed 27 July 2013, copyright greg allen & greg.org, 2001-2013.

Figure 81: Visitor to the *Responsive Eye* Exhibition, MOMA, New York, still from *Eye on New York* television programme recorded for CBS by Mike Wallace[21]

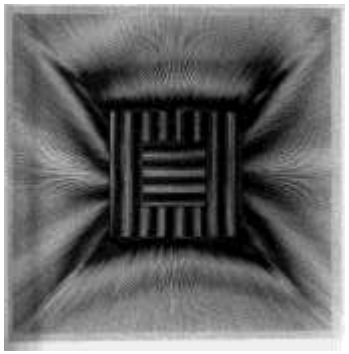


Figure 82: Ludwig Wilding, 1969, *Objekt mit scheinbewegung kreise quadrat im quadrat SINGLE L1* (object with illusory movement, square surrounding square SINGLE L1) (1969)[22]

Parallel themes

From this point, Wilding developed a number of themes in parallel, following Baumeister's advice that, whenever a line of enquiry seems to have reached a limit or an impasse, the artist should stop and explore a parallel approach before returning to the first. The catalogue of the Retrospective exhibition that toured a number of galleries in Germany between October 1987 and 1988 is divided into four distinct chapters, the first dedicated to early works, the others presenting works exploring three distinct themes all dated from the same period:

- Objects with illusory movement and three-dimensional overlays
- Stereoscopic pictures and objects 'pictures and objects for two eyes'
- Anaglyph pictures, paradoxical forms and spatial collages

[21] For copies of this broadcast, please see http://www.youtube.com/watch?v=XSVQqJo0Pmk

[22] Wilding, Ludwig. 1987. *Ludwig Wilding: Retrospektive, 1949-1987: Pfalzgalerie Kaiserslautern, 25.10. bis 29.11.1987, Städtische Galerie Lüdenscheid, 4.3. bis 3.4.1988, Ulmer Museum, 22.5. bis 26.6.1988*. Kaiserslautern: Die Pfalzgalerie. p97

Figure 83: Ludwig Wilding. 2002. *Objekt mit paradoxem körper PAR 4403* (Object with paradoxical forms PAR 4403) [23]

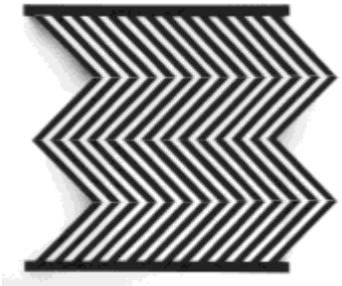


Figure 84: Ludwig Wilding. 1998. *Anamorphose ANAM 2804* (Anamorphosis ANAM 2804) [24]

This series also includes an investigation of the role of the external form of the work: a series of small-scale works which are essentially cut out shapes generating strong depth and movement cues through curved or stepped black and white lines

Alongside these themes, three others are significant:

Stereoscopic effects

Wilding started to develop a series of red-green prints for viewing with red-green glasses to create stereoscopic illusions, beginning discussions with a German Television production company to explore these effects in broadcast media. But the early promise of the collaboration was not fulfilled and was not pursued.

Figure 85: Front cover of the catalogue *Ludwig Wilding, Bilder für zwei augen* (Pictures for two eyes) held at the Schoeller Gallery, Dusseldorf in September 1982. Photograph by Ingeborg Wilding

[23] Wilding, Ludwig, Hoffmann, Tobias, and Bauer, Ines. 2007. *Ludwig Wilding: Visuelle Phänomene*. Köln: Wienand. p209
[24] Ibid p201

Figure 86: Ludwig Wilding. 2004. *wechsel-falt-objekt FAZO 5502* (changing multiple object *FAZO 5502*)[25].

Figure 87: Ludwig Wilding *No title* (1990), Photocopy on paper and board[26]

Colour

After over 50 years working as an artist, in 2004, Ludwig embarked on a series of pieces exploring colour, choosing distinctive bright neon papers and transparent sheets combined with black and built into small layered structures in which the colours appear to flip and extend in unexpected ways. However, this was a brief excursion in a journey that was almost entirely explored through the simplicity and freedom of black and white.

Fractals

Produced by photocopying, enlarging, reducing and cutting, photocopying and editing again, Wilding began producing these pieces in the 1980's. In the foreword to the catalogue 'kunst = traum = illusion = täuschung' produced for an exhibition at the Renate Kammer gallery in Hamburg in 2012, Wilding's essay published in the catalogue for this show indicates that this new theme represented an important step or jump in the development of his practice, relating the mysterious unrepeating and unrepeatable patterns generated by this industrial process to the 'wonderful gospels of the middle ages'[27].

[25] Ibid p226
[26] Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding

[27] Wilding, Ludwig. 2012. *Ludwig Wilding: kunst = traum = illusion = täuschung ; 4. November bis 2. Dezember 2012, Galerie Renate Kammer, Hamburg*. Hamburg: Galerie Renate Kammer.p6

Figure 88: Ludwig Wilding. 1990. *No title.* [28]

Figure 89: Ludwig Wilding.*1990. No title*.[29]

Paper collages: Although best-known for his use of transparent overlays, Wilding also developed a body of work layering strips of printed paper. Ingeborg explained that Ludwig never threw anything away and that, during a brief period of depression in the early 1990's, began to use scraps of discarded prints to create compositions that combined lines and text.

Figure 90: Ludwig Wilding. 1984. *räumlich collage RC709* (spatial collage RC709) [30]

[28] Photocopy on paper. Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding
[29] Detail (ibid)

[30] Wilding, Ludwig, Hoffmann, Tobias, and Bauer, Ines. 2007. *Ludwig Wilding: visuelle Phänomene*. Köln: Wienand. p217

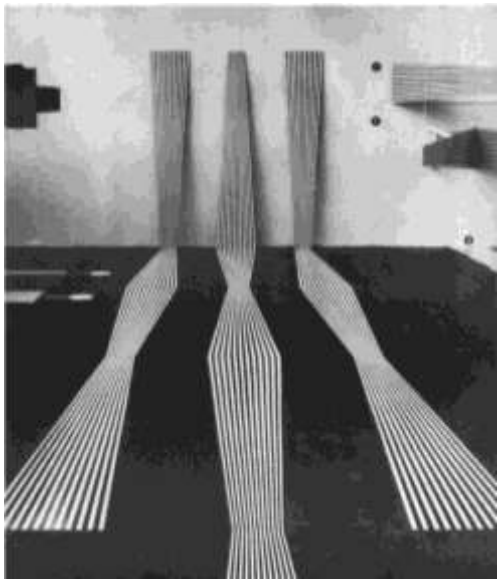


Figure 91: Ludwig Wilding. *Installation* (1973) [31]

[31] Wilding, Ludwig. 1973. *Räumliche irrationen: optische interferenzen perspecivische täuschungen.* Cologne, Germany: Kölnischer Kunstverein. p57

Beyond the frame

In 1972 and 1973, Wilding produced the only two installation-based exhibitions of his career[32], setting up a series of panels painted with parallel black and white lines configured to create illusions of space when seen from a particular angle.

With these notable exceptions, Ludwig preferred to explore his ideas through small-scale, wall-based framed works: the vast majority measure between 28 and 150 cm and almost all are square. He preferred to arrange a series of frames around the walls of dedicated room but to treat each as a piece that the viewer could take home and enjoy in its own right rather than relying on the collective impact of an installation.

This seems to have been largely a pragmatic decision as the cost of materials, and the logistics of making, storing and transporting the work were important considerations.

This practical attitude may have been a reason that Ludwig never made work for installation outside: it was simply never asked for. However, as Ingeborg pointed out, when he had an idea Ludwig usually pursued it. This is borne out by the multitude of experiments that pack the shelves of the Wilding's home, many of which were simply tests to see whether something would work or not.

[32] Ibid, p15

Figure 92: View of shelves in the Wilding home, 2013[33]

Technique

Wilding developed his ideas through trial and observation, believing strongly that knowledge emerged through the process of making the work and that the benchmark was the strength of the effects first hand. Ingeborg was often the litmus test of success, frequently called upon to give her opinion on a new idea or technique.

However, once Ludwig had mastered the combination of line and angle to generate a given composition and rhythm, he would give a detailed specification to a printer and a framer to produce the multiples, described earlier. The original works he produced himself.

He embraced new technology and was inspired by its patterns, taking polaroid photographs of the linear structure of the television image, using the photocopier to generate the 'fractal' designs or to experiment with scale.

[33] Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding

Figure 93: Ludwig Wilding, detail of work showing the effect of ridged Perspex panel overlay.[34]

Figure 94: Ludwig Wilding, detail of open-sided box frame construction. [35]

He chose Perspex to frame most of the work as it is lighter and more robust than glass and explored the interference effects generated by ridged acrylic. Perspex also made it easier to build the distinctive 'open-sided' box frames that allowed more light into the work where Ludwig judged that necessary.

Art and science

Wilding's work was a source of fascination for psychologists interested in perception of space and was featured in a number of books and articles on the subject of moiré interference effects such as those published by Nick Wade,[36] and Lothar Spillman.[37] He saw himself as a scientist also, observing the effects of small changes in the variables of his essential vocabulary of line and simple forms with the constant aim of creating spaces that appear to be set free from the surface of the work by the slightest movement of the viewer.

[34] Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding

[35] ibid
[36] Wade, Nicholas J. 1982. *The art and science of visual illusions*. London: Routledge & Kegan Paul.
[37] Spillmann L, 1993, *The perception of movement and depth in moiré patterns. Perception* **22**(3) 287 – 308

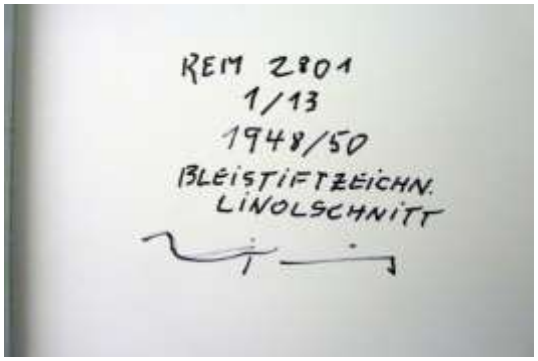


Figure 95: Ludwig Wilding signature. Photograph of the reverse of an early work[38]

This systematic approach is also suggested by the detailed diagrams included in the earlier catalogues explaining the effects and how they are achieved. The titles of the works are also completely factual: 'single z83 1970 with parallel stripes' being a typical example. The image here is of the signature on the reverse of an early work. The note 'REM' indicating a remake, the number indicating its size, position in the series and technique (pencil drawing lino cut)

The overlap between his approach and research into visual perception led to lifelong friendships with scientists such as Nick Wade and Lothar Spillmann. Wilding and fellow artist Wolfgang Kiwus along with Wade, and their wives set up an experimental process for producing art works as a collective to play with traditional ideas of authorship: a design may be started by one member of the group, altered by the next, further changed by the third and finished by the fourth. The names of the art works were a simple combination of the first letters of each name, the order of these letters signalling the sequence of intervention[39].

[38] Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding

[39] see http://www.wawiki.com,

Figure 96: Views of the terrace of the Wilding home in Buchholz[40]

Home life

From 1967 to 1992, Ludwig taught at the Hochschule für bildende Künst (Academy of Fine Arts) in Hamburg[41], establishing a foundation programme along the lines of the Bauhaus to offer a thorough grounding in technical drawing, colour theory etc. His teaching style was also inspired by Baumeister who was a man of few words. Willi's silence implied disapproval, while a brief positive comment was as much encouragement as could be hoped for. Ludwig told the story of standing behind Baumeister while he looked at a new piece of work and being torn between a deep respect for his judgement and the desire to punch him (in order to get rid of an admired "father-figure")

Ludwig met Ingeborg in 1968. They married in 1970 and moved to Hamburg in the same year. In the early days, they were housed in the art school, living in a space divided from the class room by wooden walls built by Ludwig, along with simple furniture – a table, bed and stools, also built by hand. A picture emerges of an intense and exclusive relationship in which Ingeborg was Ludwig's constant companion, aide and confidante, living and working together for over 40 years.

[40] Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding.

[41] http://www.hfbk-hamburg.de/en/

Figure 97: Ludwig Wilding at the Cologne Arts Association exhibition in Cologne in 1973[42]

Ingeborg describes a powerful and single-minded yet sensitive man, determined to preserve his freedom and follow his own path, with not much interest in the social scene or the more esoteric and spectacular approaches that were being played out in the art world during his long career. She describes many examples of his care to encourage more reserved students and the quiet ways in which he showed his gratitude for her support, particularly in the annual gifts of a work that was always signed with a humorous or affectionate note. Ludwig had simple, frugal tastes in food and material possessions and was a man of habit, choosing to go to the same places to eat and to stay and to sit on the secluded terrace in Bucholz with Ingeborg, to enjoy the sun.

He was happiest at home with all the materials and equipment he needed to work. Perhaps as many men who had been through the war, Ludwig was not especially interested in health and fitness and did not play sports or seek out exercise. As a young man, he played tennis and enjoyed skating, foil-fencing and gliding. While Ludwig never again played music himself, he liked to be surrounded by sound, with the television and radio always in the background - as well as his cigarettes and a glass of whiskey. Always busy, every journey was built around an exhibition or research. Although he was not a religious man, a visit to the church was always his first port of call when visiting a new town, followed by the market square.

[42] Wilding, Ludwig. 2012. *Ludwig Wilding: kunst = traum = illusion = täuschung ; 4. November bis 2. Dezember 2012, Galerie Renate Kammer, Hamburg*. Hamburg: Galerie Renate Kammer p56

Figure 98: Ludwig Wilding in his studio[43]

Figure 99: Ludwig Wilding. 2009. *Last drawings*[44]

He was often so preoccupied that he had trouble concentrating while driving and after several car accidents, Ingeborg took care of all the logistics, financial and domestic arrangements.

In the last two years of his life, Ludwig Wilding was confined to a wheel chair and started to lose his sight but continued to work, creating powerful continuous line drawings with a marker pen onto simple A4 sheets of white paper that often included the outlines of faces. Ingeborg suggests that these motifs were chosen because that was what he could still see. These were reversed on the photocopier. the two symmetrical patterns placed on a convex curved surface.

On his 80th birthday, Ludwig and Ingeborg established the Wilding Foundation, commissioning the construction of a dedicated museum and archive in Ingoldstadt in partnership with the Konkrete Kunst Museum[45].

[43] Wilding, Ludwig, Hoffmann, Tobias, and Bauer, Ines. 2007. *Ludwig Wilding: visuelle Phänomene*. Köln: Wienand. pp243-4

[44] Photograph taken by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding.

[45] See http://words.mkki.de/

Figure 100: Ludwig Wilding's grave near Bucholtz,[46]

On his death, Ludwig was buried in a quiet graveyard near Buchholz. His funeral was a quiet and simple event attended by close friends, family and colleagues. The gravestone is a natural stone that Ingeborg found in a farm near a spot where she and Ludwig had spent an hour enjoying the sunshine during the months before he died.

On Ingeborg's death, the rights to Ludwig's publications and writings will pass to the Germanische Nationalmuseum in Nürnberg[47].

[46] Photograph by Shelley James, 2013, reproduced with kind permission of Ingeborg Wilding.

[47] See http://www.gnm.de/

Figure 101: Patrick Hughes in his London studio[48]

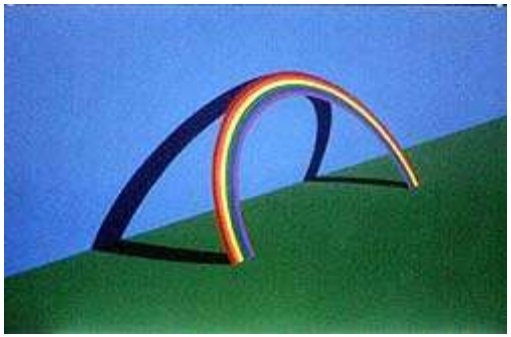


Figure 102: Patrick Hughes. 1979. *Leaning on a Landscape*[49]

[48] Photograph by Shelley James 2012 reproduction by kind permission of Patrick Hughes

[49] http://en.wikipedia.org/wiki/File:Leaningrainbow.jpg

1/ Notes from conversation with the artist Patrick Hughes in his London studio, Friday 14th December 2012

Born in Birmingham in 1939, the artist Patrick Hughes has developed his own distinctive painting style and an international reputation for his 'Reverspective' structures inspired by visual illusions. Alongside his own creative work, Hughes is also a teacher and writer. One of his earliest books, *Vicious Circles and Infinity: A Panoply of Paradoxes*[50] discusses his particular attitude to linguistic and visual riddles. The third edition of the monograph *Perverspectives*, published in 2011 and written by the American art critic John Slyce, offers a valuable overview of Patrick's past influences and current interests[51].

Hughes's early works, created in a variety of media could be described as graphic explorations of optical paradoxes. His 'rainbow period' from the early 1970's to the late 1980's explored this theme though a series of rainbows placed in paradoxical or impossible situations: stuffed into letterboxes, casting shadows on walls, arranged in vases, slung on shirt hangers, and standing in for phalluses emerging from men's zippers for example.

[50] Hughes, Patrick, and Brecht, George. 1975. *Vicious circles and infinity: a panoply of paradoxes*. Garden City, N.Y.: Doubleday.

[51] Slyce, John, and Patrick Hughes. 2011. *Patrick Hughes: Perverspective*. London: Flowers.

Figure 103: Patrick Hughes. 2007. Vanishing Venice[52]

Introduced following a lecture by Patrick at the Courtauld Institute in November 2012[53], he kindly offered to welcome me at his studio in London[54].

Patrick's studio is an impressively practical and professional space, with separate, well-equipped rooms dedicated to the construction, preparation, storage and painting of the work. Over a number of years, Patrick has refined the materials and tools needed to achieve the precise edges and angles that are key to the impact of the work. Digital technology is used to plan the layout, but each panel is then traced and hand-painted by a team of artists.

The introduction of these scanning and printing techniques has enabled more complex designs, most recently, those inspired by Venetian architecture. While the technology may have altered the types of imagery and the way it is deployed, the central principle of inviting the viewer to participate in the experience of visual paradox could be considered a trademark of Patrick's work. He described the shift from his early painting and printmaking practice to the current three-dimensional wall pieces as 'the difference between telling and showing'.

[52] Https://en.wikipedia.org/wiki/File:Vanishing-venice.jpg accessed 05/12/2013

[53] Patrick Hughes lecture 'Material Insights' lecture. http://eastwingx.wordpress.com/tag/patrick-hughes/
[54] Patrick Hughes studio, 72 Great Eastern Street, London EC2A 3JL

He went on to point out that this disorientation is characteristic of the surrealist attitude with which he identifies strongly: an exposure or heightening of the essential strangeness of what is considered 'real'. From a fascinating and wide-ranging conversation, a couple of points relevant to this project are noted here:

- On the origin of the 'reverspective' effect itself: Patrick described perception of verticals as a constant, natural and inevitable result of gravity. In contrast, perception of the horizontal planes, the ground, the horizon and the sky, are projections, subjective reflections of the physical and psychological location of the viewer. Conflicts between horizontal cues in different parts of the image generates confusion between the eye and the body, which the brain resolves by creating paradoxical spaces that appear to shift with the viewer.

- Noting the increasing choice of sky as a 'natural ceiling' and the water as the perfect 'ground' for Patrick's extraordinary floating spaces, we discussed one of the works in progress that was displayed upside down for ease of painting. As this composition contained very few cues to orientation, beyond fragments of a mountain range seen through a window - which could be 'read' as a decorative mural - this interior had a particularly surreal quality.

- On the question of scale: while he has made a piece that is 30m long, Patrick does not aspire to make monumental or architectural-scale work, rejecting the implications of power and control where the work 'overpowers' or 'dwarfs' the viewer and emphasising his interest in the 'human scale'.
- On the question of 'wall' vs. 'plinth': Patrick felt that presentation on a wall offers the most compelling effect. In particular, when the pieces are presented without borders, the spaces can appear to lie behind the wall itself.
- Patrick mentioned a number of scientists with whom he has collaborated, including Semir Zeki, Colin Blakemore, and Thomas Papathomas

3. Classification of types of image, interview with Professor Nick Wade, March 2013

Introduction

Nick Wade is Emeritus Professor in the School of Psychology at the University of Dundee. His current research covers three main topics:

- The representation of space and motion in human vision.
- The history of research in visual science
- The relationship between visual science and visual art

He is involved in a number of collaborations with international instututions including Prof. S. Finger, Washington University, St. Louis; Dr. B. Lingelbach, University of Aalen; Prof. H. Ono, York University, Canada; and Prof. Marco Piccolino, University of Ferrara.

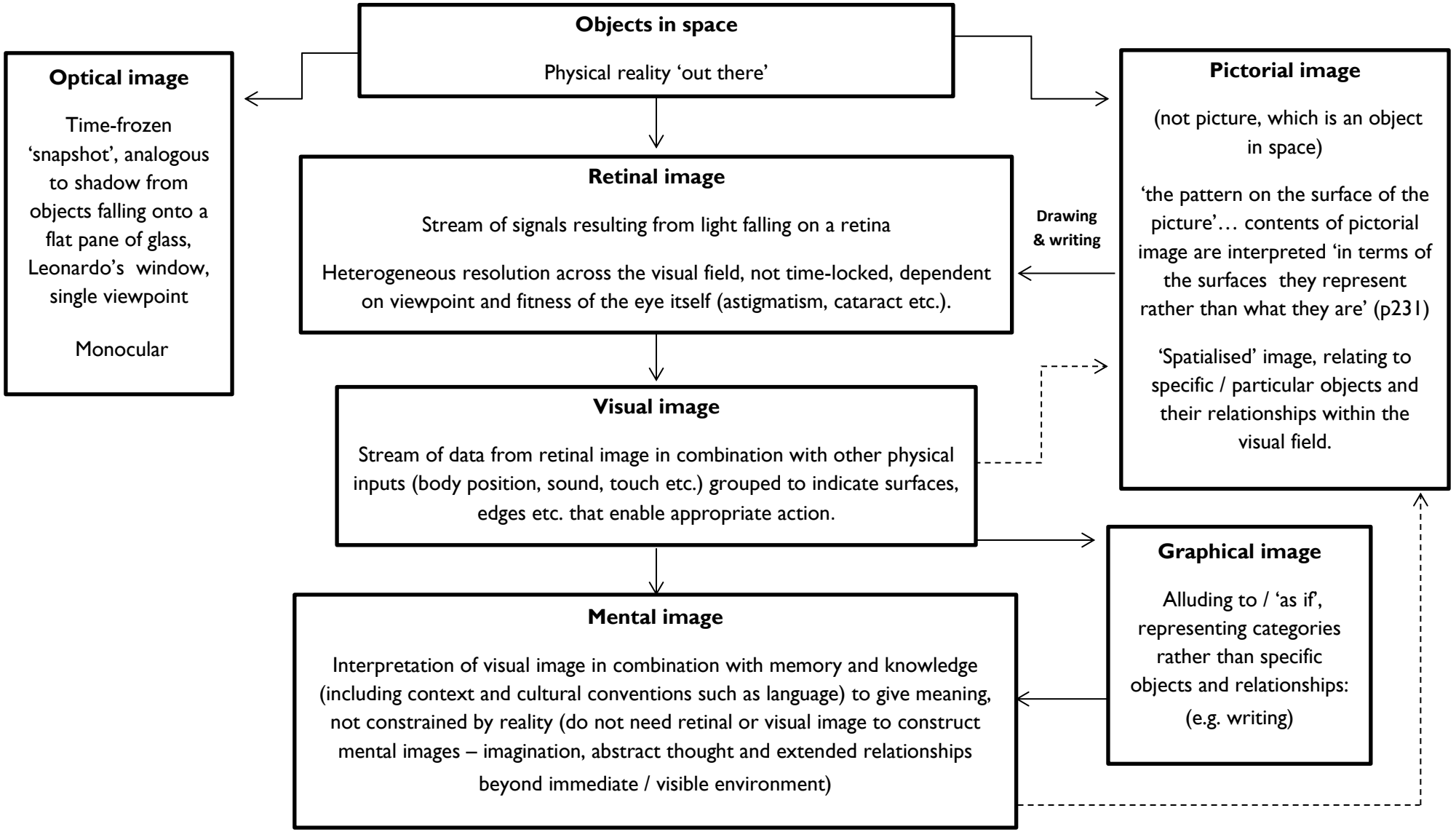
Although a number of Nick's writings and presentations have informed this project, this note focuses on the framework for a classification of different types of images presented in his book *Visual Allusions: Pictures of Perception.*[55] This structure, annotated following an extended interview with Nick Wade in March 2013 is on the following page.

[55] Wade, Nicholas J. 1990. *Visual Allusions: Pictures of Perception*. Hove: Erlbaum.

1. Classification of types of image, interview with Professor Nick Wade, March 2013

Stalking the illusion: print in glass.

Shelley James. PhD by practice, Ceramics and Glass, Royal College of Art. Submitted December 2013



4. Interview with Professor Brian Rogers at the European Conference on Visual Perception, Bremen, Germany, August 2013

Introduction

Professor Brian Rogers is a Professor of Experimental Psychology, and Fellow and Tutor in Psychology, at Pembroke College, University of Oxford. His main field of research is vision and visual perception in humans, and he also works in the fields of computational vision, oculomotor systems and perceptual theory. His current research interests include motion parallax, cyclovergence, stereoscopic vision, perception and representation of surface orientation and curvature, the role of optic flow in heading judgments and the maintenance of balance.

These notes are an edited transcript of a conversation between Brian and myself following a controversial presentation on definitions of illusion that he made at an informal gathering of psychologists and artists at a research centre near Aalen in South Eastern Germany known as 'Bernt's Barn' after its founder and director Professor Bernt Lingelbach.

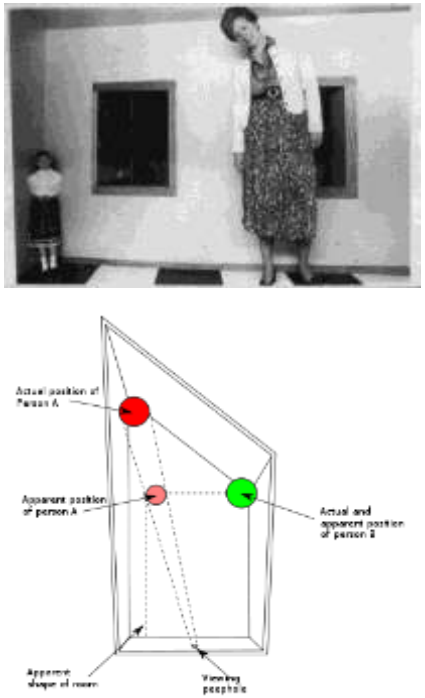


Figure 104: Ames Room illusion demonstration[56] and explanation[57]

[56] University of Maryland Physics department resources http://www.physics.umd.edu/deptinfo/facilities/lecdem/services/avmats/slides/thumbs.php?title=O4

Illusions and veridical perception

Brian proposes that there is no meaningful dividing line between what is known as 'veridical' perception, where our perception corresponds directly with some description of the input to the visual system, and illusory perception, where it does not.

The Ames room and similar demonstrations show that using the “outside world” as a description of the input is inappropriate (i.e. that the Ames room is actually trapezoidal). In these cases, a more appropriate description of the “input” would seem to be the “information available”.

However, defining “information” is not straightforward. For example, what is information for one species is not the information for another species. Or, colour information for a trichromatic observer is not the same as information for a dichromatic observer. Hence, it seems to me that an appropriate description of the information is actually a description of how the particular visual system works. If this is the case, then all our perceptions are limited by the particular ways our perception mechanisms work including things like thresholds, non-linearities and, of course, metameric colours.

[57] Ames Room illustration by Alex Valvanis http://en.wikipedia.org/wiki/File:Ames_room.svg

In the past, some of these perceptual effects have been categorised as illusions and others as simply how the system works. Brian does see how this can be justified. These discrepancies should, rather, be understood in terms of a process of arbitration, or resolution of conflicts between different types of information (brightness, border, movement, texture for example).

With respect to cue-conflict situations, Brian's argument is that it doesn't make sense to say that because our perception is consistent with ONE of the cues in the situation (e.g. the perspective in the Ames room rather than the height of familiar objects (people), the situation is illusory. He points to a number of phenomena that arise purely from the physiology of the system itself, such as lightness and contrast (doubling the strength of the signal does not result in a doubling of the perceived brightness) and metamers (where the system fails to distinguish between two objects).

But, in his view, ALL of our perceptions depend on the particular characteristics of the underlying (physiological) mechanisms. In this context, he points out that many of the phenomena currently termed illusions should more accurately be described as limitations of the system, or as conflicts - exposing the strength of one set of cues relative to another.

Brian also suggests a flaw in the models that describe visual perception in terms of a cycle of 'hypothesis, test, learn, change' as he considers that there is little or no evidence that that the visual system does actually alter predictions based on experience. No, of course our perceptual mechanisms change with experience in a general sense (including light and dark adaptation). Brian prefers to see these changes as changing the weights or strength of synapses in the underlying mechanisms rather than the laying down of “memories” or “knowledge”.

However, he does suggest that 'active looking', where the visual system can be attuned to seek out relevant information to perform a particular task or navigate an unfamiliar environment represents a different class of gaze, in which the default hierarchies between cues may be challenged.

1. Notes from study day: Mondrian, Nicholson and 20th Century Abstraction at the Cortauld Institute Research Forum, 3 March 2012

These notes were taken during a one-day conference held to coincide with an exhibition of Mondrian and Nicholson's work in Somerset House.

Presentation by Lee Beard on Ben Nicholson (1894 – 1982) and Piet Mondrian (1872 – 1944)

Lee reviewed the ideas underlying Nicholson's work: Nicholson believed that the work of the artist is to use visible, material reality to reveal an underlying invisible that lies just beneath the surface: the role of art is to reveal another divine reality or infinity, to 'uncover a new, enduring world' (perhaps in the face of flux / turmoil of war). His relief work can be seen in this context as an investigation of the location of the surface or the plane where different dimensions of reality might exist and interact. The choice of white for the relief pieces relates to idea of purity, unity, divinity, perfection.

Figure 105: Ben Nicholson *White relief sculpture version 1,* plaster on wooden base (1936)[58]

Figure 106: Ben Nicholson, Bromide print by Humphrey Spender[59] c 1935,[60]

58

https://www.tate.org.uk/art/artworks/nicholson-1936-white-relief-sculpture-version-1-t07274
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Although the work was not figurative, Ben asserted that his approach arose from an abstraction of the natural world: it did 'come from somewhere'. Ben was an active member of the Christian Science Church and considered that man is a reflection of god.

Lee continued with a description of Nicholson's life, drawing a picture of a talented, but self-absorbed and insecure man. His first wife, Winfred Nicholson[61] who was a painter in her own right was a constant support and welcoming hostess during Nicholson's early years in Cumbria.

They moved to London and Ben started a relationship with Barbara Hepworth[62] when they worked in the same space in Hampstead, eventually leaving Winifred to marry Barbara in 1938. They move together from London to St Ives, where he struggled with Barbara's growing success. He met and married the German photographer, Felicitas Volger[63], moving to New York. Following their divorce in 1977, he returned to the UK, settling near Cambridge where he died in 1982.

[59] © National Portrait Gallery, London http://www.npg.org.uk/collections/search/portrait/mw04671/Ben-Nicholson
[60] Humphrey Spender, photographer, artist and designer (1910-2005)
[61] Winifred Nicholson, painter (1893-1981)
[62] Barbara Hepworth, sculptor (1903-1975)
[63] Felicitas Volger, photographer (1922-2006)

Figure 107: Piet Mondrian. 1911. *Evolution Triptych*[64]

Figure 108: Piet Mondrian. 1914, *Composition in oval, Tableau III*[65]

[64] Online resources, Radford University, http://www.radford.edu/rbarris/art428/MondriananddeStijl.html

Piet Mondrian (1872-1944)

Lee's presentation continued with a discussion of Mondrian's life. While quiet and reserved, he had a reputation for being present at all the openings and performances and keenly aware of trends and new ideas. After period in London (1938 to 40), he went to live in New York, where he developed a passionate for jazz: Theolonius Monk's music was the inspiration for the *Boogy Woogy* series of paintings. Mondrian's early work was figurative and heavily influenced by his interest in Theosophy. His *Evolution* triptych of 1911,which he later rejected as 'embarrassing' can be seen a watershed in his career as within two years, his work was completely abstract and resolutely modernist, becoming an active member of the de Stijl group founded by his fellow Dutchman Theodore van Doesbourg[66] in 1930.

Mondrian considered that space is created through the movement of the eye across the canvas. Exploration of space in terms of time and rhythm – inspired by Einstein's Theory of General Relativity and the fourth dimension or the link between space and time. Traditional analysis of Mondrian's work is in terms of a search for equilibrium but Beard

[65] ibid
[66] Theodore van Doesbourg, painter (1883-1931)

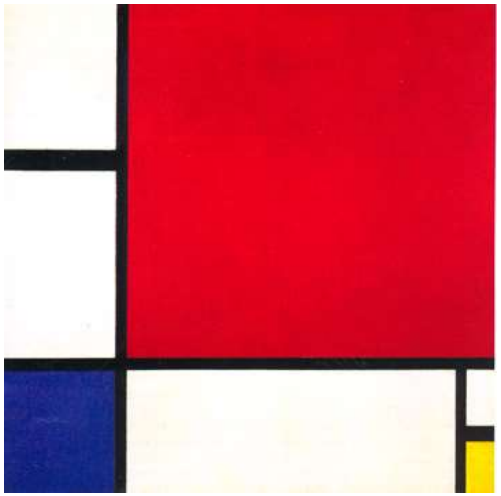

Figure 109: Piet Mondrian 1930, *Composition with Red, Blue and Yellow*[67]

suggested that it can also be seen as chaotic, full of movement, expanding from the canvas. Mondrian's work shows a particular interest in the edge, the margin: colours often placed around the edges. Paintings can be seen as an exploration of the individual within a network or ecology, not alone / singular, perhaps an interesting contrast with Nicholson's work which is much more self-contained.

Mondrian's aesthetic was often described as systematic, 'pinched', cold. But he asserted that as an artist all his work came from his engagement with the world, considering that the artist's work is to transpose their experience to create poetic, universal reality. Mondrian was fascinated by the power of memory, the retained image and the metaphysical notion of reincarnation – he was influenced by new scientific theories of mind that suggested that memories are the result of vibrations in the brain. He experimented with 'concentrated looking' (staring at a scene to generate after-image): many of his compositions exploit the Herman grid effect to generate additional coloured areas. Seeing the work in real life at the exhibition at the Courtauld Institute[68], I was struck by a sense of a subtle material making process –layering of paint, incision of the black lines, slight sheen of varnish used in the final coat of black and the subtle use of the edges of the canvas (colour continuing, black ending and vice versa).

[67] http://www.wikipaintings.org/en/piet-mondrian/composition-with-red-blue-and-yellow-1930

[68] Mondrian and Nicholson In Parallel, February-May 2012 http://www.courtauld.ac.uk/GALLERY/exhibitions/2012/mondrian-nicholson/index.shtml

2. Notes from International Institute for Research in Glass Conference: 'Working with light as a means of interaction between space and mind', National Glass Centre, Sunderland 17 to 18 May 2012

Attendance supported by the Research Office at the RCA

Introduction

The conference was a rare opportunity to meet a number of the leading figures in architectural glass from the UK, the USA, Russia and the Czech Republic and to hear them speak about their work. These notes give a brief outline of the presentations of particular relevance to the development of this project.

Figure 110: Judith Schaechter. 2004. *Dream of the Fisherman's Wife* [69]

Figure 111: Algirdas Dovydenas. 1999-2000 detail of panels from the Franciscan monastery at the Hill of Crosses in Lithuania.

Judith Schaechter

This celebrated stained glass artist from Philadelpia proposes that the idealised physical and metaphysical qualities of light are only fully realised when placed in direct relationship with the ugly and the dark. This was illustrated was illustrated with an extraordinary sequence of images and quotes from Suchet to Sartre. She gave a brief presentation of her own work the following day, demonstrating the relationship between these ideas and an intensely personal engagement with the material of glass, and the powerful creative statements that emerge from that dialogue.

Algirdas Dovydenas (b1944)

Considered the 'godfather' of Lithuanian stained glass, is work is characterised by subtle, moving and understated narratives placed in isolated shrines and massive modernist cathedrals, many lost for many months of the year in deep snow. Of particular relevance to my work was the use of subtle disturbances in the transparency of the glass created by slumping a pane of glass onto a plaster panel engraved with drawings.

[69] http://www.judithschaechter.com/Home.html

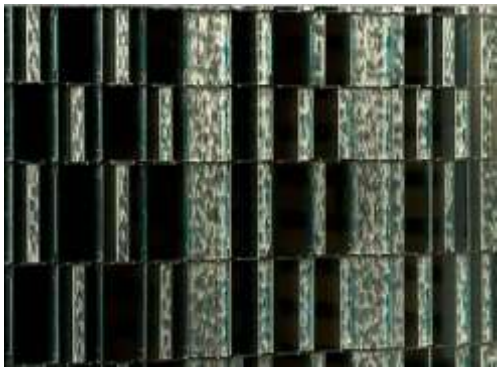

Figure 112: Alex Beleschenko commission for St John's College Oxford[70]

Figure 113: Carrie Fertig, 2010. Homing, Flameworked glass. 2010, 600 cm x 500 cm x 560 cm. © Carrie Fertig

Alex Beleschenko

One of the most successful artists in British contemporary architectural glass , describes the process of inspiration, creative development and production in terms of the definition of a 'code' or vocabulary for a piece that arises from a dialogue with the site, the architect and the client. Of particular relevance to my work is his approach to layering different levels of transparency on the front and back of the glass to create a range of tonal effects that shift depending on the perspective of the viewer.

Carrie Fertig

This Scottish artist is principally a lampworking specialist but increasingly suspends or installs multiple elements that expand to occupy space in an unusual way.

[70] http://www.beleschenko.co.uk/

Figure 114: Dana Zamenicnikova, *Conversation with a dog*[71]

Figure 115: Marian Karel . 1991. *Pyramid*[72]

Dana Zamenicnikova

An influential figure in contemporary glass from Prague, Dana uses simple float glass, painted, printed, etched and occasionally slumped, to explore permeability and the layered relationships between self and the other. She approaches the glass as a two-dimensional surface, then installs it in three dimensions.

Marian Karel

Again, using the simplest means –great panes of float glass bent metal, tensioned wire and, occasionally, Corning silicon-based glue, he creates subtle optical illusions of space within a space, many of them on a massive scale. Marian then led an informal discussion of his practice, showing us how he built several of the pieces.

[71] http://www.zamecnikova.cz.html

[72] Artforum http://www.gallery.cz/gallery/en/Vystava/1999_04/Ramec_V.html

Figure 116: Vanessa Cutler, 2006. *Spinal wave*[73]

Figure 117: Geoffrey Mann, 2008, *Dogfight*, subsurface etching in optical glass[74]

Figure 118: Glass staircase at The Apple Store, Boston. MA. Architect Bohlen Cywinski, Engineer Tim McFarlane

Vanessa Cutler

Vanessa Cutler uses waterjet cutting to produce complex interlocking geometric forms with float glass that is then kiln formed to introduce organic qualities.

Geoffrey Mann

This artist captures fleeting phenomena such as moth flights or curling smoke and translates this into digital files that are then used for sub-surface etching inside blocks of clear glass and Perspex.

Tim McFarlane

An international authority on engineering projects involving glass, Tim has been instrumental in altering attitudes among manufacturers and clients including Apple and New York City.

[73] http://www.vanessacutler.co.uk
[74] http://www.mrmann.co.uk/