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RETHINKING MUSEUM SPACE

Interaction between Spatial Layout Design and Digital Sensory Environments

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ABSTRACT

Over the past decade, there has been a growing awareness of architectural and spatial design in the functioning of museums and the creation of distinctive visitor experiences. This issue has itself become more complex as digital technologies offer new potentials to mediate between museum content and visitors, and in particular technologies which have the capacity to amplify senses and facilitate interactive, whole body, immersive and sensorial experience. The paper will explore for the first time the role of spatial layout in the sensory environments created through digital media in museums. Among the key questions raised are: how are they integrated into the museum itinerary spatially and conceptually? In what kind of spaces are they installed and how do they relate to them? Are they arranged so as to exploit key spatial properties? We investigate these questions initially through the identification and review of existing experimental projects, and then through the in-depth study of examples of the museum work of two well-established creative studios which combine architecture and interaction: Jason Bruges Studio and United Visual Artists. The analysis is based, on the one hand, on interviews with the designers involved in their creation and, on the other, on syntactic concepts and techniques. By looking in parallel at the work of the two studios, from their first installations until now, and through syntactic analysis, we unravel the way these projects become integrated in the museum, both in literal terms (spatial positioning) and in metaphorical (curatorial practice). The analysis shows that as these works become with time more symbolic, they also become less intrinsically spatial and their experience less dependent on movement. More interestingly, it brings to surface aspects of the design of digital sensory environments which have a *relation of correspondence* with syntactic properties, such as *integration*, and *types of space*. Having shown that space plays a key but variable role, the paper ends by proposing a model for the spatial understanding of these novel technology-mediated experiences and for rethinking museum space.

KEYWORDS

digital environments; museum spatial layout; interaction design; configurational analysis; space types

1. INTRODUCTION

Over the past decade, there has been a growing awareness of architectural and spatial design in the functioning of museums and the creation of distinctive visitor experiences. This issue has itself become more complex as digital technologies offer new potentials to mediate between museum content and visitors, and in particular technologies which have the capacity to amplify senses and facilitate interactive, whole body, immersive and sensorial experience. The paper will explore for the first time the role of spatial layout in the sensory environments created through digital media in museums. The aim is to contribute to a spatial understanding of their embedding in museum settings since they constitute curatorial challenges, in the sense that the exhibit is multimodal and there is no established knowledge about its arrangement or precedents to learn from. So key questions raised are: how are digital sensory environments integrated into the museum itinerary spatially and conceptually? In what kind of spaces are they installed and how do they relate to them? Are they arranged so as to exploit key spatial properties?

Here we present the first part of ongoing research in a field that is developing rapidly, though it is still largely underexplored from an architectural-spatial and museological-curatorial points of view. More precisely, we seek to investigate these key questions through examples of the museum work of two well-established creative studios: Jason Bruges Studio and United Visual Artists (UVA). After a discussion, in the first part of the paper, of the background and context of these digitally mediated experiences, including an identification and review of existing experimental projects of interest in this context, we focus, in the second, empirical part, on the analysis of the main case studies. The analysis is based, on the one hand, on interviews with the designers involved in their creation and, on the other, on syntactic concepts and techniques. By looking in parallel at the work of the two studios, from their first commissions in 2005 until now, and through syntactic analysis, we unravel the way they become integrated in the museum, both in literal terms (spatial positioning) and in metaphorical (curatorial practice). The comparative analysis brings to light a key shift from the playful digital experience which is independent of the museum narrative, to the informative which accompanies other exhibits and communicates semantic information. More interestingly from a syntactic point of view, it shows that as works become more symbolic, they also become less intrinsically spatial and the creation of experience less dependent on movement. The paper argues that, in our sample, aspects of the design of digital sensory environments have a *relation of correspondence* with syntactic properties, such as *integration*, and *types of space*, and relates these underlying correspondences to space syntax theory. Having shown that space plays a key but variable role, the paper ends by proposing a model for the spatial understanding of these novel technology-mediated experiences and for re-thinking museum space.

2. BACKGROUND AND CONTEXT

Since 2000, technologies, situated and mobile, have become part of most museum displays, not only as interpretative tools – for example, interactive touch-screen kiosks accompanying objects, or multimedia guides on portable devices – but as the exhibit and the key experience itself, for example by offering immersive and embodied mediated interactions. Emerging technologies tend to be creatively embraced by museums open to experimentation and exploring new possibilities. The fast growing area of tangible and embodied digital interaction, for example, has opened up new ways of mediating between visitor and content by breaking away from the screen, and developing instead more physical ways of interacting with computing (Hornecker, 2011). A wide range of systems based on embodied interaction, full body movement and tangible manipulation, are now designed in museums, at scales ranging from tangible interactions to immersive experiences. To cite just a few indicative examples in the increasingly growing range of projects: in 'The Hague and the Atlantic Wall' exhibition (2015) in Museon, The Hague (part of the meSch project – see below), an additional layer of narrative content was proposed by the use of 'smart objects' – that is, crafted reproductions of original objects related to the exhibition and embedded with digital content – that were activated by visitors when placed on hotspots; in an innovative installation based on gestural recognition, visitors to the UCL Petrie Museum (2012), manipulated 3D replicas of objects from

the museum collections through body movement in an Augmented Reality environment (Fatah gen. Schieck and Moutinho, 2012); at a different scale, in the Museum of the Palazzo Valentini, Rome (2010), which is not a purpose-built museum, but an archaeological site, technologies (virtual reconstructions, graphics and videos) are used to recreate the site's architectural and social past; in the Rockheim, in Trondheim (2010), the national museum of popular music of Norway, visitors engage with museum content through interactive and immersive exhibits, ranging from touch screens to motion-sensing interaction and whole body movement; while a series of connected immersive sensory environments and interactive experiences evolve in real-time through visitor presence and participation, in the Future World, Art Science Museum, recently (2016) opened in Singapore.

The attempt to better understand the design of digitally mediated experiences, their functioning and their effects on museum visits, is reflected in an expanding body of literature in different fields, in particular human-computer interaction (HCI) and interaction design, and museum studies. Among the key issues raised we could distinguish indicatively: how technologies are used to represent culture and promote cultural heritage (see MeLa–European Museums in an age of migrations, and RICHES–Renewal, Innovation and Change: Heritage and European Society); how they influence the ways in which visitors examine and experience exhibits (e.g. vom Lehn and Heath, 2005), allow personalised storytelling experiences (e.g. CHESS–Cultural Heritage Experiences through Socio-personal interactions and Storytelling), and enable co-designing by developers as well as stake-holders (e.g. Material EncounterS with Cultural Heritage–meSch); how they affect the social dimensions of the visit (Jafari, Taheri and vom Lehn, 2013); what kind of usability issues and behaviour patterns they generate (e.g. Clarke and Hornecker, 2013), including evoking shyness in visitors (Scott et al., 2013); how visitors engage with digital content, 'how interactivity as a medium produces meaning' (Edmonds, 2006), 'how the audience interacts with it', and 'the experience and the degree of participant's engagement' (Edmonds, 2010).

Interactive digital installations in museums and galleries are also increasingly discussed in the literature (see for example Bullivant 2006; 2007). But so far little research has been done in bringing together knowledge of digital interaction and museology by looking at both from a spatial point of view[1]. Yet the problem of space is seen as a key parameter in the creation of the experience as well as its understanding. It is argued, for example, that the spatial dimension has an essential role in 'the meaning-producing capacity of computer-based interactivity'. 'The generation of meaning' [lies], it has been suggested, not just in interactivity in an abstract sense but in situated interactivity', and so 'the site of exhibition can be seen... not as an auxiliary space for understanding certain aspects of an artwork, such as its social or practical implementation, but the central site for interactive art research' (Edmonds, 2006, p.312). Research has also demonstrated that certain spatial characteristics of accessibility and visibility are more likely to bring visitors into contact, and perhaps engage them, more than others (Kortek and Grønbæk, 2008, p.616).

3. METHODOLOGY, KEY CONCEPTS AND TERMS

Reflecting this situation, we are interested in investigating the role of spatial layout in digital interaction through the first hand study of what we will call *digital sensory environments* in museums. This is not among the more commonly used terms, which include *responsive environments or responsive installations* (Bullivant, 2007, p.37), *interactive spatial multimedia* (Kortek and Grønbæk, 2008) or *spatial interactive works* (Bullivant, 2007, p.35). But using this term we seek to emphasise the idea of environments which both 'inspire our sensory perceptions' and are created through digital media. The 'Poème Électronique' along with the Philipps pavilion, designed by Le Corbusier and Iannis Xenakis, for the Expo '58, Brussels, has been held to be their historical precedent in modern times: 'the first electronic-spatial environment to combine architecture, film, light and music to a total experience made to

1 In contrast, the spatial environment's role is explicitly discussed in media architecture literature (see for example Daalsgaard, Halskov and Nielsen, 2008; Dalton, Marshall and Dalton, 2010; Behrens, Fatah gen. Schieck and Brumby, 2015).

function in time and space' (Lopez, 2001). The digital sensory environments discussed in the paper are designed by two London-based studios, Jason Bruges Studio and United Visual Artists (UVA). The analysis is based initially on semi-structured interviews with Jason Bruges and Alexandros Tsolakis, Head of Design and Development, UVA, combined with research in relevant literature and documentation of projects, and, in some cases, first hand study of the works. This is then followed by spatial analysis. We use the syntactic concepts of *integration, axiality* and *visibility* as qualitative measures to describe the configurational properties of digital sensory environments and provide a theoretical framework for spatial interpretation. This is coupled with the representation of the museum layouts as schematic graphs in order to make clear their positioning in the global spatial organization, and with space type analysis. By distinguishing spaces as four types (a-, b-, c- or d-spaces) in terms of how they are connected to the layout of which they form part (Hillier 1996), we capture key properties of spaces, which, as it will be shown, relate positively to aspects of the design of digital sensory environments.

Before moving to the presentation of the cases studies, a clarification of two additional key terms as used in the paper for proposing a taxonomy of the case studies (see below and Table 1) is needed. As often argued (Manovitch, 2001, p.71; Haque, 2007), 'interactive' is a 'too broad concept', and used in different ways, so here we employ *attributes of interactivity* – the notions of *Dynamic, Interactive, Participatory, Communicative and Performative* – proposed by Caldwell and Foth (2014) as characteristics of media architecture, and 'understood as qualities that can occur in parallel or alongside one another'. We also adopt the concept of *interaction styles*, and in particular, movement, touch, or none, proposed by Dalsgaard, Halskov and Nielsen (2008).

4. DESCRIPTION OF CASES

The case studies are presented in chronological order and their key features, which form the background for the comparative analysis that will follow, are summarized in Table 1.

	PROJECT	INTERACTION DESIGNERS	DATE	MUSEUM	LOCATION	SPACE TYPE	VISUAL RELATIONS	AXIAL RELATIONS	ATTRIBUTES OF INTERACTIVITY	INTERACTION STYLES	CONCEPTUAL RELATION TO MUSEUM NARRATIVE
1	Dotty Duveen	JASON BRUGES STUDIO	2005	Tate Britain, London	circulation axis	d	multidimen-sional & open visibility	in the centre of two main axes	Dynamic Interactive Participatory	touch	independent playful experience
2	Monolith	UVA	2005	Victoria & Albert Museum, London	outdoor	c	open visibility	on the main axis	Dynamic Interactive Performative	body movement	independent playful experience
3	Volume	UVA	2006	Victoria & Albert Museum, London	outdoor	c	open visibility	on the main axis	Dynamic Interactive Performative	body movement	independent playful experience
4	Mirror Mirror	JASON BRUGES STUDIO	2009	Victoria & Albert Museum, London	outdoor	c	open visibility	on the main axis	Dynamic Interactive Performative	body movement	independent playful experience
5	High Arctic	UVA	2011	National Maritime Museum, Greenwich	gallery space	a	visual insulation	no strong axial links	Dynamic Interactive Communicative	body movement, UV torch	independent, communicating climate change awareness
6	Momentum	UVA	2014	Curve Gallery, Barbican, London	gallery space	c	visual insulation	no strong axial links	Dynamic Communicative	none	independent, inspired by the concept of time
7	Our time	UVA	2016	MONA, Hobart	gallery space	a	visual insulation	no strong axial links	Dynamic Communicative	none	independent, inspired by the concept of time
8	The Great Animal Orchestra	UVA	2016	Fondation Cartier, Paris	gallery space	a	visual insulation	no strong axial links	Dynamic Communicative	none	informative experience part of the museum narrative
9	Scent Constellation	JASON BRUGES STUDIO	2016	Le Grand Musée du Parfum, Paris	gallery space	a	visual insulation	no strong axial links	Dynamic Communicative	none	informative experience part of the museum narrative

Table 1 - Taxonomy of our main case studies, the museum work of Jason Bruges Studio and United Visual Artists, summarizing their key features

4.1 'DOTTY DUVEEN'

One of the earliest cases is the temporary installation 'Dotty Duveen' (Figure 1a) designed by Jason Bruges Studio for Tate Britain: an array of 40 wands, each two meters high, with a glowing sphere at the top that turned on only when the rods were touched and bent. It was installed in the central space (Sackler Octagon) of the Duveen Galleries. A second part of the installation involved tracking the interaction throughout the day. The resulting video provided an overview of the different movements occurring within this open circulation space. The design intention was, on the one hand, to engage visitors to touch these 'moving playful objects' and, on the other, to interrogate the space from above, seeing 'how the space changed', and how the 'landscape of objects' shaped visitors' movements and interactions as well as their interrelationships with other visitors interacting with the objects.
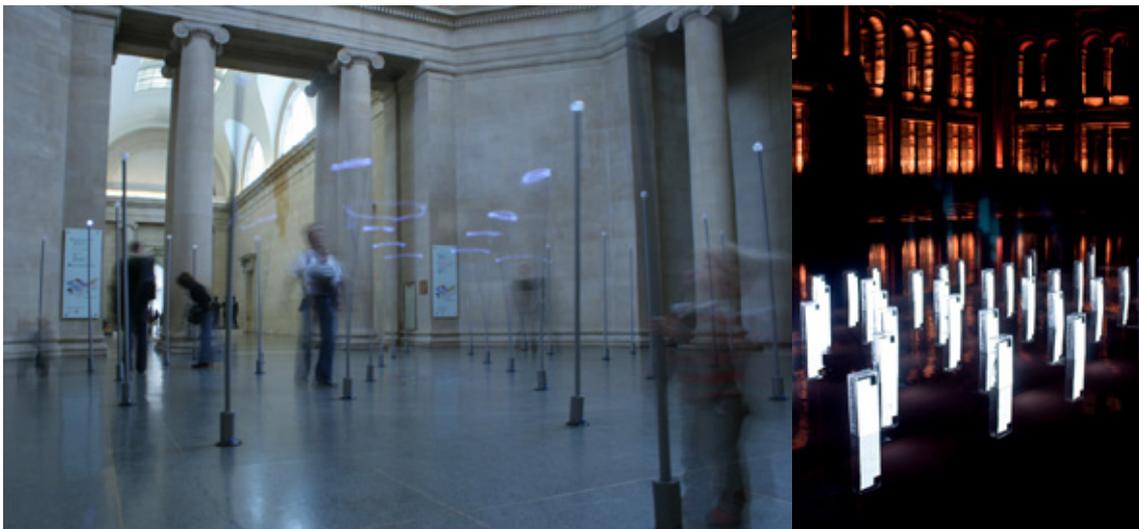

Figure 1 - 'Dotty Duveen' (2005) (a), and 'Mirror Mirror' (2009) (b), ©Jason Bruges Studio

4.2 'MONOLITH'

In 2005 United Visual Artists designed 'Monolith' (Figure 2a) in the John Madejski garden of the Victoria and Albert Museum: a single block of LEDs (3 m. high), showing soothing colours and playing calming sounds. The pattern changed as visitors approached the installation, with the colour and sounds becoming louder and harsher. The simplicity and minimalism of its design was intended to create a contrast with the complexity of its visual background, the baroque museum building.

4.3 'VOLUME'

A year later, United Visual Artists created a larger installation, 'Volume' (Figure 2b), for the same space. It took the form of a grid of 48 luminous, sound-emitting columns (2.5m high) that responded to visitors' movement, creating a series of audio-visual experiences. It was positioned in the centre of the garden and visitors could walk through this 'sculpture of light and sound', while lack of movement deactivated it. The whole configuration of columns and people was analysed by a digital camera with its own image-processing computer, placed high up in the courtyard, and complex emergent patterns were generated depending on the individual's path through the installation, as well as on the movements of people co-present around him or her.

4.4 'MIRROR MIRROR'

In the same space, the John Madejski garden, Jason Bruges Studio designed 'Mirror Mirror' (Figure 1b), as part of the 2009 exhibition 'Decode: Digital Design Sensations', showing the latest developments in digital and interactive design, from small screen-based graphics to

large-scale installations. Works were organized in three themes – 'Code as Raw Material', 'Interactivity' and 'The Network' – reminders of their characteristics, with 'Mirror Mirror' being part of the 'Interactivity' theme. A group of light panels, each containing a camera, were disposed in the pond of the garden, 'in a pseudo-random arrangement' (Jason Bruges, as cited in Victoria and Albert Museum, 2009), giving the impression of floating on the water. At a global level, the work was installed on the central axis of the building, so that it could be seen from the entrance through the museum shop. At the local scale of the garden, the panels were laid out so that each panel would see a different part, so as to give 'a complete view of the whole space but fragmented across the different nodes'. The camera recorded movement, 'giving back the visitor a different media visual feedback', also reflected on the surface of the water. Thus the animated images created multiple reflections, becoming an expression of its design concept, of digital narcissism and the individual's relationship with space, water and others.

Figure 2 - 'Monolith' (2005) (a), and 'Volume' (2006) (b), ©United Visual Artists

4.5 'HIGH ARCTIC'

To inaugurate the new Sammy Ofer Wing, and a new kind of exhibition, the National Maritime Museum, London, presented in 2011 the 'High Arctic' exhibition (Figure 3), designed by United Visual Artists. The exhibition was an immersive, responsive environment that filled an entire 820 square metre open space. It used a combination of sound (both soundscape music and voices), light in a dark environment, animations and 3000 sculptural 'glaciers' of different height, each representing a real glacier in Svalbard, to create a vast abstracted arctic landscape, set in 100 years in the future. As physical forms were integrated with digital projection, visitors were invited to explore the landscape using ultraviolet light torches, that allowed them to reveal hidden animations (for example, to activate the name of the glacier), to generate constantly shifting patterns of graphics and text on the floor that reacted to movement and interaction with the torch. An artificial horizon bordered the gallery as a seamless canvas of light, shifting in intensity and colour. An important part of the narrative were the voices of Arctic explorers and a commissioned poem about our relationship with the Arctic since the first explorers in the fourth century. The installation was conceived as a response to the UVA's founder Matt Clark trip to the archipelago of Svalbard (between mainland Norway and the North Pole), together with a group of scientists, poets, musicians and artists, organized in 2010 by the arts and climate science foundation Cape Farewell. The aim was to provoke awareness, through the engagement of artists, to issues of climate change and human impact to the arctic environment.

Figure 3 - 'High Arctic' (2011), ©United Visual Artists

4.6 'MOMENTUM'

The work 'Momentum' (Figure 4a) was created by United Visual Artists, in 2014, for the Curve Gallery of the Barbican Centre: an immersive installation carefully choreographing a sequence of light, sound and movement. The work continued a path set out by their previous work, 'Chorus' (2009), but it was redesigned to respond, both technically and conceptually, to the morphology of the tall and narrow space of the 90 metre long gallery. It consisted of a sequence of 12 pendulum-like elements (with changing white lamps), suspended from the ceiling, and swinging back and forth, sometimes moving in unexpected ways or even stopping, emitting sound and light and projecting shadows and planes of light across the walls and floor, in the completely dark gallery and misty atmosphere. 'The sound was individual to each pendulum, prepared and tuned to seamlessly resonate as they moved within the Curve' (Barbican, 2014). The arc shape of the gallery also inspired the theme of the work, the concept of time, and in particular the subjective experience of the passing of time, while the calming and contemplative environment created by the work (Brown, 2014) was intended to contrast with the surrounding urban environment and the hectic life in the City of London. It is of particular interest in our context that visitors' comments (in Twitter), after their visit, consistently refer to their individual experience linked to their emotions and memories (for example, 'Mesmerised and calmed by at points I was thinking about the sea...'; 'this is how my dreams feel sometimes repeating the day I just had), rather than the inherent qualities of the work. This has been related to the idea that 'the more abstract the space the more people create their own, imaginative environment'.

4.7 'OUR TIME'

A variation within the series of kinetic sculptures that began with 'Momentum' and the theme of time, is the larger-scale installation 'Our Time' (Figure 4b) that United Visual Artists created, in 2016, for the Museum of Old and New Art (MONA), in Hobart, initially presented in the context of an annual festival and then integrated into the museum collection. 'Our Time' was installed in a vast square space, and defined a physical environment where 21 suspended LED pendulums, arranged in a grid, swing, each to its own rhythm, activating light and sound. Like 'Momentum' it was designed to be 'a meditative, quiet piece but at the same time... very dramatic because of the sheer scale' ('Our Time').

Figure 4 - 'Momentum' (2014) (a), and 'Our Time' (2016) (b), ©United Visual Artists

4.8 'THE GREAT ANIMAL ORCHESTRA'

An installation that was a response to a specific exhibition theme was created by United Visual Artists for the Fondation Cartier, Paris, in 2016. 'The Great Animal Orchestra' (Figure 5) was part of the exhibition that devoted to the work of musician, bio-acoustician and scientist Bernie Krause, who had been recording animals, 'amassing a collection of more than 5,000 hours of sounds recordings of over 15,000 individual species in their natural habitats from all over the world' ('*The Great Animal Orchestra'*). The immersive installation gave a three-dimensional form to the recordings, through, among other things, soundscapes and spectrograms that created an abstract visual landscape and proposed an interpretation of the various locations and times of day that Krause made the original recordings, using two different kinds of spectrographic imaging. The work was installed in the basement space of the Fondation Cartier, with the left side showing 'a dance of horizontal lines occupying different frequency bands in real time as Krause's recordings play' (Barry, 2016), and the right, 'a more static 'recorded' image, like a print-out, from which one can grasp Krause's point: the high tweets of the pine siskin at 6khz will not be troubled by the 1khz call of the American crow, nor the even deeper howls of the eastern wolf'.

Figure 5 - 'The Great Animal Orchestra' (2016), ©United Visual Artists

4.9 'SCENT CONSTELLATION'

Also in 2016, the Jason Bruges Studio was invited to create a work in response to a display narrative. 'Scent Constellation' (Figure 6) is a permanent installation at Le Grand Musée du Parfum, in Paris, opened in December 2016 and located in a mansion. The museum display is organized in three sequences, on different floors, with the 'Scent Constellation' being part of the last sequence, 'The art of the perfumer', on the third floor. The work recreates the perfumer's organ and is intended to visualise the process of creating a scent. Five types of scent families are represented, and each generic recipe was represented as a constellation of light using white laser and mist, with corresponding sounds.
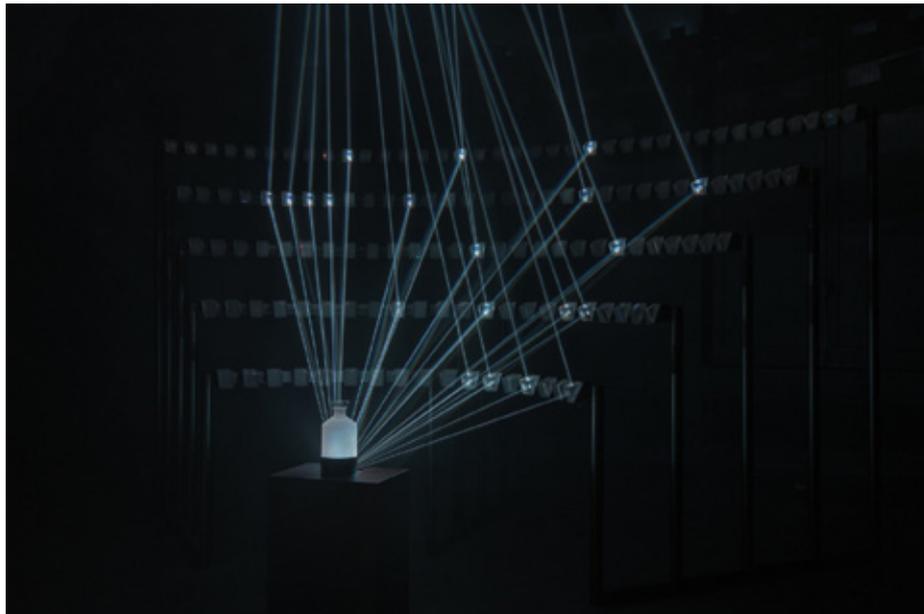

Figure 6 - 'Scent Constellation' (2016), ©Jason Bruges Studio

5. COMPARATIVE DISCUSSION

5.1 FROM A SPATIAL-SYNTACTIC POINT OF VIEW

If we first look at our cases comparatively from the point of view of their spatial arrangement in the museum setting, we find a variety of locations. More interestingly perhaps, we note a shift from movement and social spaces (main axis, garden), in the first examples, to the single and flexible open space for temporary exhibitions (Curve, Sammy Ofer Wing) and to the gallery spaces themselves (in the latest works, as in Le Grand Musée du Parfum).

This said, it is possible, on the basis of our sample, to distinguish three approaches in the way the majority of the cases take into account their spatial setting: *morphologically, visually* or *conceptually*. The morphological approach can be illustrated by 'Momentum' which works with the architecture, as light is projected on the walls and sound reflected off them. The predominantly visual approach is exemplified by the three works installed in the V&A garden. They create a play with the contrast of simplicity-complexity (see 4.2 above) and with the reflective qualities of the water, in particular 'Mirror, Mirror' which was designed so that through each mirror's orientation and placement the whole court is collectively covered. Finally, we find cases where space becomes a *conceptual* inspiration either for the design idea (e.g. relating the arc shape gallery with the sense of time in 'Momentum') or for broader metaphorical relations (e.g. linking the calm gallery space with the hectic urban environment, also in 'Momentum'). In the remaining cases, either space is treated as the neutral background for the works (as in 'The Great Animal Orchestra' and in the 'Scent Constellation') or the work itself creates the space for visitors to explore (as in 'High Arctic').
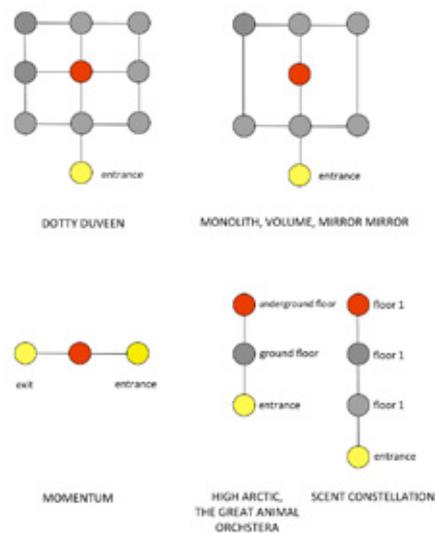
Figure 7 - The basic configurational properties of the case-study spaces are visualised in the form of schematic *graphs*

Space syntax concepts and techniques allow a deeper understanding of the configurational position of the works (see schematic *graphs* of layouts in Figure 7). The first four examples (1-4) are located in the centre or on the main axis of the museum, in strategic locations both in terms of spatial and visual links. The Sackler Octagon, in the middle of the Duveen Galleries, for example, is a d-space (offering route choice) and among the most highly integrated locations of Tate Britain (Figure 8a). The Madejski Garden is a well connected c-space (offering circulation but not choice) related to main rings of circulation in the V&A and on the main axis linking the museum entrance with the galleries. Intriguingly, the opposite is the case in the later examples. They tend to be created in a-spaces (dead-end spaces, without through movement) and found in relatively segregated locations in the layout. For example, the 'High Arctic' (5) and 'The Great Animal Orchestra' (8) are a-spaces on the underground floor of the museums. The 'Scent Constellation' (9) is on the third floor, in a space that essentially functions as an a-space since it constitutes the end of the display sequence. At first sight 'Momentum' seems to be an exception since the Curve Gallery that accommodated it is a c-space. However, the fact that it is an individual exhibition space, in a complex of spaces of different functions, gives it the separated nature of an a-space. In all these cases, the digital sensory environments are created in enclosed, 'black box' spaces which do not encourage visual relations with neighbouring spaces (compare the spiky visibility pattern of 'Dotty Duveen' in Figure 8a with the convex hierarchical pattern of the 'Scent Constellation' in 8b). It is worth noting that this emerging emphasis on a-spaces can be related to the findings of a previous syntactic study (Tzortzi and Hillier, 2016), which showed that this type of space is favoured for the display of performing arts collections because of its enclosed, static (rather than movement oriented) and immersive nature.
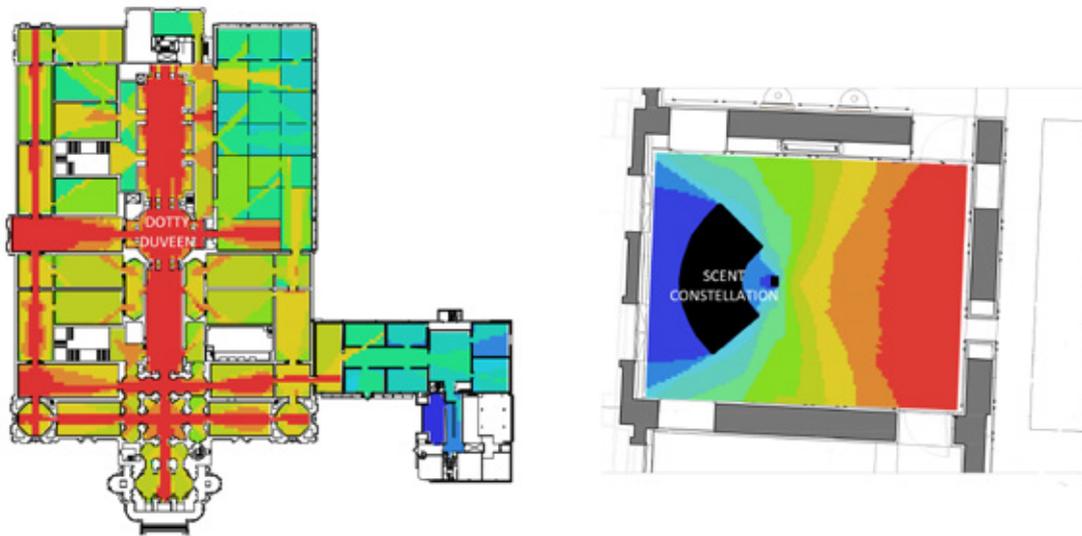
Figure 8 - Visual integration analysis of Tate Britain and the 'Scent Constellation' gallery (not to scale). It makes visually clear the contrast between the high visual integration of 'Dotty Duveen' in the former and the enclosed environment and hierarchical visibility pattern of the latter

5.2 FROM A MUSEOLOGICAL-CURATORIAL POINT OF VIEW

If we now consider our cases in terms of their conceptual relation with the museum display, we find that in the majority of cases (1-7), works are created independently of the museum narrative (e.g. 'Dotty Duveen', 'Volume', 'Momentum') and 'the source of meaning [lies] in situated action itself' (Edmonds, 2006, p.311). That is, meaning is created by exploring the sense of being there and is based on individual perception and experience. The works in the V&A garden, for example, invite visitors to explore an evolving composition of light and sound, shaping, through their movement, their individual experience. 'Momentum' and 'Our Time' also create spatial, visual and acoustic patterns that constitute meaning in themselves, but in this case independently of visitors' movement. 'High Arctic' marks a shift in the sense that it makes complex patterns that are meaningful in that they substitute for the museum objects.

Strikingly, a diametrically different approach is adopted by the more recent works in that they have a close relation to the dominant display narrative. Both the 'Scent Constellation' and the 'Great Animal Orchestra' are created to accompany other exhibits and support a pre-existing idea (the perfumer's organ) or data (Krause's recordings). So they become an integral part of the museum itinerary. Interestingly, in both cases the visitor experience is more 'static', compared to the previous cases, and the creation of meaning not dependent on movement.

5.3 FROM AN INTERACTION DESIGN POINT OF VIEW

If we finally focus on key aspects of the design of these digital sensory environments, we note that they all define a physical environment and create experiences where 'the proprioceptive, sensory, intellectual, aesthetic and social' are interrelated for the visitor (Levent and Pascual-Leone, 2014, p.xiii). The environments created are mainly visual and sonic spaces, in one case combined with tactile exploration. From the point of view of interactivity, and drawing on Caldwell and Foth's *attributes of interactivity* (see above), their quality in terms of how they are used could be described (see Table 1) as *Dynamic* (in all the cases), *Interactive* (1-5), *Performative* (that is, promoting performance from visitors, as in 'Volume' and 'Our Time') and *Communicative* (related to the transmission of semantic information, as the more recent cases 5-9).

If we focus on the *interaction styles*, visitors' movement (touching, moving or stopping) is critical in the earliest cases, and aims initially at an enjoyable experience (1-4) and later at a meaningful result (5). No interaction with visitors is 'required' in the more recent works (6-9) and the experience becomes with time less dependent on visitors' movement (compare e.g. cases 6-7 with 8-9). But, in spite of these differences, the works consistently, tend to create experiences which are immersive – to a higher or lesser degree – and amplify visitors' physical and sensory realities.

6. THE ROLE OF SPACE IN THE DIGITAL SENSORY ENVIRONMENTS IN MUSEUMS: A SYNTACTIC ARGUMENT

So both in spatial-syntactic and museological-curatorial terms (or in terms of integration into the museum itinerary spatially and conceptually), we find a range of case types which seem to have an evolutionary dimension, as shown in our two-dimensional model (Figure 9).
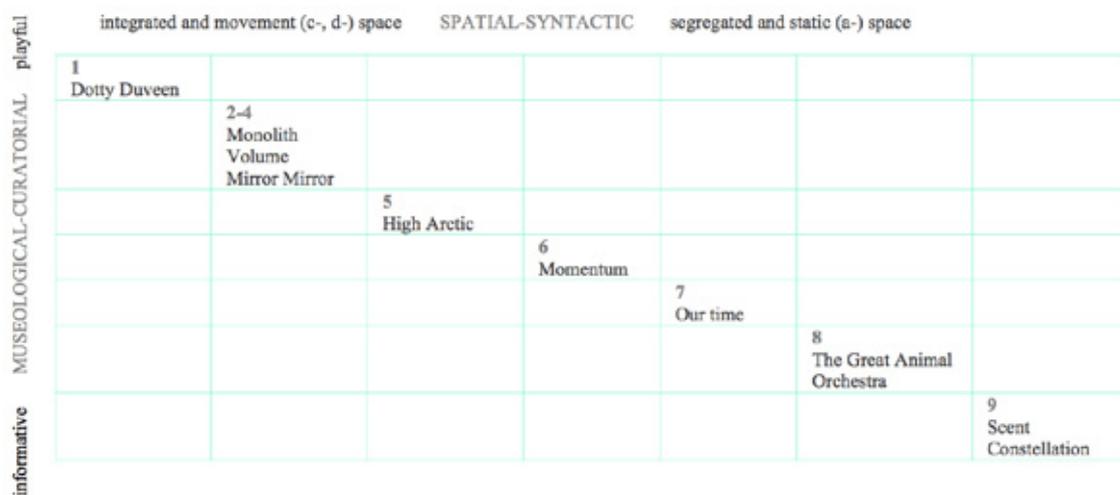

Figure 9 - The works of the sample on the spatial-syntactic and museological-curatorial model grid. In the spatial (horizontal) axis, the cases range from the 'integrated and d-spaces' to the 'segregated and a-spaces'. In the curatorial (vertical) axis, a playful or an informative experience are the two opposite poles of the continuum.

More specifically, it could be argued, looking at the cases chronologically, that we observe a series of shifts:

- from the playful to the informative experience, and from the primary embodied experience to that accompanied with an intellectual narrative;

- from the spatially independent digital sensory environment to the integrated into the museum itinerary;

- from the temporary installation to the installation that becomes part of a museum collection;

- from the weak design brief (designers are given a space to create an experience) to the strong brief (describing the message to be transmitted).

These arguments could perhaps be clarified by using the concepts, established by Basil Bernstein (1975), of 'classification' – meaning the strength of the boundaries between contents of knowledge – and 'framing' – the control of transmission from teacher to taught. In our context, 'strong classification' implies controlling the relations between exhibits to reflect pre-existing meanings, and 'framing' is strengthened through the control of spatial and visual relations connecting spaces[2]. In these senses, the shift from the playful to the informative is

2 For interpretations of the two concepts in syntactic literature, see for example Pradinuk, 1986; Zamani and Peponis, 2010.

a shift from weaker to stronger classification. This is accompanied by a shift from weaker to stronger framing which is expressed by syntactic properties. It is reflected both in the *types of space* (we move from the d-space to the c-space and then to the a-spaces) and the control of *visibility* (we pass from rich visual relations to visual insulation). It remains to be seen whether this shift from weak to strong classification and framing means closer involvement of designers with the creation of museum narratives and curators' greater dependence on these works to communicate intended meanings, and whether, in parallel, this might lead to less autonomy for the designers.

7. CONCLUDING REMARKS AND FUTURE DIRECTIONS

This study and analysis of the museum work of the two major creative studios, from their first installations in museums until today, contributes a significant finding about the role of spatial layout in the emerging design field of digital sensory environments. It suggests that space not only has a key role to play in our digital era, as acknowledged in the literature (see above), but that this may be a highly variable role.

More specifically, the analysis brings to light a relation between space, people and digital interaction, in the form of *correspondence* between spatial layout design and the design of digital sensory environments. Playful experiences are created in integrated locations and in movement spaces (d- or c-spaces in syntactic terms) which support and generate movement. Informative experiences are created in segregated (deep from the entrance or outside the main route) spaces and in particular in a-spaces, which, by being distant from through-movement, privilege a more static immersion. Playful experiences are to be enjoyed in themselves and not through any communication they offer, as is the case with the informative experiences. In the former, the visitor is active in creating patterns through movement interaction. In the latter, the visitor is receptive, and space, by controlling movement, supports that. These underlying correspondences can be related to findings of space syntax theory. For example, in domestic space we often find a distinction between spaces for everyday interaction and spaces for special occasions (see Hillier and Hanson, 1984). In simple terms, integrated spaces let things happen, while segregated spaces, where we find more order, are about defining things.

These observations about a development over time are of course related to the study of the museum work of the two studios. It will be interesting to follow future developments in the creation of digital sensory experiences in museums, taking this proposed model as a foundation and as a comparative framework for spatial understanding, of interest to all three fields of knowledge involved: museum studies (new curatorial challenges), and space syntax and human-computer Interaction (a new kind of findings relating spatial design and interaction design).

Taking a more distant view of our cases, It is clear that digital sensory environments can bring back the aura of the museum exhibit, by creating singular experiences that must be lived at that time and space. No less interesting are, in many cases, the ways they enhance the sense of shared space and collective experience, since it is about experiencing in individual ways but together, in the company of other visitors, who become part of the experience itself. Lastly, and spatially speaking, they invite us to rethink museum space, by augmenting physical space perceptually, replacing it, interacting with it, complementing it, in short, by adding through digital interaction a new richness of perception and embodiment.

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