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White Space and Digital Remediation of Design Practice in Architecture: A Case Study of Frank O. Gehry

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Abstract

The digitalisation of architecture has intensified the entanglement of digital materiality and design practice due to the process of remediation, which comprises both conceptual and organisational processes. The analysis of remediation demonstrates the ways in which advanced technology enables architects to explore white spaces, defined as the open-ended, unmapped, in-between, and not yet realised territories of conceptual, organisational and physical spaces. Consequently, the process of remediation changes both design practices and the experience of physical spaces. This paper investigates the case of a leading architect, Frank O. Gehry, who has pioneered the digital remediation of architecture. The premise of this paper is that sociomaterial entanglement is an experience idiosyncratic to individual architects, who can escape the determinism of digital materiality by developing their unique digital tools. This paper also stresses the importance of power relations for the construction of digital materiality, which, in turn, influences design practices and innovation in architecture.

Keywords

White space, remediation, sociomateriality, digital architecture, Frank Gehry

Introduction

The digitalisation of architecture has intensified the entanglement of digital materiality and design practice (Lemonier & Migayrou, 2014; Yoo et al., 2006, 2012). Pioneering architects have developed advanced technologies through the process of remediation which comprises both conceptual and organisational dimensions (Bolter & Gromala, 2005; Goldberger, 2015). This paper investigates the concept of 'white space', which refers to an open-ended, unmapped, in-between, and not yet realised territory of conceptual, organisational and physical space. Within an organisational context, the literature on white space addresses the effects of openness, temporality and spatiality on creativity and innovation without fully exposing the role of technology as a catalyst for the exploration of white spaces (Connellan, 2013; Johnson, 2010; Maletz & Nohria, 2001; O'Doherty et al., 2013).

White space is a powerful concept which can enrich the field of information systems, providing insight into the role of advanced technology in terms of conceptualising new ideas, enabling new organisational forms, and linking digital materiality with physical spaces (Boland et al., 2008; Yoo et al., 2006, 2012). By locating the concept of white space within the literature of sociomateriality (Orlikowski, 2010; Scott & Orlikowski, 2014; Leonardi & Barley, 2008), this paper scrutinises the ways in which technology enables designers to explore conceptual, organisational and physical white spaces.

The context of this study is the field of architecture, which has changed radically due to digitalisation (Spiller, 2008; Tilson et al., 2010). The ongoing process of digitalisation was initiated in the late 1980s, causing a significant shift in architectural design, challenging the dominant architectural style and construction methods which used mainly to reproduce standardised, frequently rectangular forms (Mitchell, 2004). The digital revolution in architecture has left no office untouched, accelerating the design process and enabling a new

curvilinear architectural language (Glynn & Shafiei, 2009). Technology has also transformed architectural firms, which have become open, agile and collaborative (McNeill, 2009).

The paper participates in an ongoing dialogue within sociomaterial scholarship, shedding light on the relationship between the material and social in the context of digital architecture (Cecez-Kecmanovic et al., 2014). According to Orlikowski (2007:1437), the social and material are ontologically integrated, privileging neither humans nor technologies, but "instead, the social and the material are inextricably related – there is no social that is not also material, and no material that is not also social". Hence, in the digital age, design practices, which include conceptual, technological and organising processes (Swann, 2002; Yoo et al., 2006), form a "sociomaterial entanglement", as "meaning and matter" are inseparable (Scott & Orlikowski, 2014:873). Specifically, it is particularly difficult to separate the material from the social, because digital materiality empowers the exploration of white space by enabling more affordances in creative and organisational practices, while allowing more agents to negotiate the meaning of spaces during and after their construction (Fayard & Weeks, 2014).

Although sociomateriality echoes radical changes in digital architecture, it remains relatively neutral regarding the role of agents in the adoption and development of digital tools (Leonardi & Barley, 2008). It is unclear whether technologically-induced organisational change in digital architecture is privileged by material or social practices (Knorr-Cetina & Mulkay, 1983; Woolgar, 1988). This study of digital architecture informs the literature of sociomateriality (Cecez-Kecmanovic et al., 2014), providing evidence of the ways in which leading architects construct unique sociomaterial entanglements through design practices that drive technological evolution and establish their power positions in the field (Balogun et al., 2014; Mutch, 2013). While the role of technologies in enabling new organisational forms has previously been investigated in the context of architecture (Boland et al., 2008; Boland et al., 2007, Yoo et al.,

2006), this paper scrutinises the ways in which leading architects overcome the constraints of digital materiality by developing unique digital tools which result from the blend of traditional and digital media within their design practices (Bolter & Gromala, 2005).

This paper integrates sociomateriality with the concept of 'remediation', which focuses on the ways in which new media forms emerge from older ones (Bolter & Gromala, 2005). New media forms in design practices emerge based on the dual logic of remediation. Specifically, the logic of transparency has led architects to adapt new media to improve the material conditions of practices, which refer to communicating information with greater accuracy, clarity and efficiency. Based on the logic of reflectivity, architects have developed new media to explore white spaces by enhancing affordances in conceptual and organisational processes resulting from their interaction with customised digital tools (Fayard & Weeks, 2014). As new media oscillate between transparency and reflectivity, pioneers in digital architecture engage with technologies in idiosyncratic ways to fulfil their architectural visions and business aspirations. Through the process of remediation, architects enact a constitutive entanglement (Scott & Orlikowski, 2014), and as a result, explore conceptual, organisational and physical white space.

The empirical context of this paper is a historical case study of the architect Frank O. Gehry, which exemplifies his pioneering of the digitisation of architecture (Goldberger, 2015). Gehry inaugurated the use of digital tools in the late 1980s, while launching a digital infrastructure which integrated all the links in the construction chain within a single organisation (Boland et al., 2007). Gehry's relationship with technology is crucial because his practices explore the conceptual and organisational white space which connects IT infrastructure with physical spaces. The case of Gehry demonstrates a power shift in the construction industry, as the digital model has enabled the architect to build a strong identity in the field (Gal et al., 2014), replacing the engineer as a leading authority in construction (Kolarevic, 2003).

Part Two of the paper reviews the digital remediation of architecture, and Part Three defines conceptual, organisational and physical white space. Part Four delineates the research methods of this study, while Part Five comprises the case study of Gehry. In the discussion, key lessons for the literature of sociomateriality are addressed, based on the findings of the case study, while the Conclusion addresses the contributions and future research implications for white space.

2. Digital Remediation of Design Practice in Architecture

2.1. The digitalisation of architecture

Digital architecture is a paradigm shift that refers to the evolution of architectural design from the standardised forms of the 'industrial era' into the complex and computer-aided designs of the 'information age' (Mitchell, 2004). During this period, architects have started to explore unmapped territories of creativity as a result of engaging with technology. In general, digitalisation has revolutionised architectural practice: by influencing architectural thinking and style based on the enhanced qualities of digital tools; by reorganising architectural firms, which are more open and collaborative than the past; and by enriching architectural research through studying the experience of users in physical spaces (Kolarevic, 2003; Spiller, 2008).

Inaugurated in the late 1980s, digital architecture has enhanced, and in some cases replaced, traditional design tools, such as sketches, drawings or models (Kolarevic, 2003). The digital era has revolutionised the expressive repertoire of architects, realising a new architectural style based on curvilinear forms, known also as 'blobby' or 'non-Euclidean' architecture, which previously was impossible or too time-consuming to build (Kolarevic, 2003; Mitchell, 2004). In addition, computational media facilitate data-driven architectural research, enhancing architects' analysis of complex flows of movement in space, sustainability and the performance of buildings (Oxman, 2008).

In the 1990s, many offices put all their efforts into keeping up with the ongoing process of digitalisation, mostly adopting standardised packages such as 2-D computer-aided design (CAD). However, some more visionary architects saw digital technologies as an opportunity to reinvent their design practices. Digitalisation enables architects to overcome structural constraints, bypassing previous sequential processes, which mean that their work is restricted to providing plans, while engineers and constructors determine which designs can be built and how (Kolarevic, 2003). This paradigm shift in architectural design has altered organisational dynamics in architectural offices, returning power and control to architects, while including more agents in the design process (Harris, 1996, 1997; Kolarevic, 2003).

Advanced technology supports architectural offices, by providing 'digital infrastructure': "basic information technologies and organizational structures, along with the related services and facilities necessary for an enterprise or industry to function" (Tilson et al., 2010:748). Architectural offices operate in a global environment, in which advances in ICT enable collaboration and integration within dispersed networks. Large architectural firms can operate as flexible project-based organisations (Yoo et al., 2006), adjusting their digital infrastructures so that they can be "shared, unbounded, heterogeneous, open, and evolving sociotechnical systems comprising an installed base of diverse information technology capabilities and their user, operations, and design communities" (Tilson et al., 2010:748).

Digital technologies enable architects to incorporate greater complexity, creating buildings and spaces which are symbolic and functional, while opening up a wider range of possibilities through an open-ended design process that reflects on the experience of physical spaces (Harry et. al, 2008). Architectural narratives of the digital age avoid purely functionalistic approaches, as architectural language does not aim to express meaning, but to construct "meaning through the ordering of spaces and social relationships" (Psarra, 2009:2).

2.2. Digital remediation of architectural design

Digital architecture entails conceptual, technological and organisational processes which feed into specific 'design practices' (Swann, 2002; Yoo et al., 2006). Swann (2002) defines the design practice as an ongoing process that is initiated through problem research and analysis, and then proceeds with creative synthesis and materialisation of design ideas. As a practice, architecture consists of conceptualisation, as the response of architectural thinking and vision to a given problem, and the organisation of architectural design that includes the structures and processes which facilitate creative synthesis and production (Swann, 2002; Yoo et al., 2006).

Design practices in digital architecture imply the development of unique digital tools. Since the beginning of the digital era, architects have been concerned with the use of standard software packages which would constrain the creativity and expressive repertoire of architects (Mitchell, in Kolarevic 2003). Pioneering architects have developed unique versions of software, extending their idiosyncratic design practices into the digital sphere (Kolarevic, 2003). Frank Gehry, for instance, develops his architectural thinking by converting sketches and models into design information with 3-D representation technologies (Lindsey, 2001). Zaha Hadid created new ideas through the use of drawings which are converted into information by open-source software, while Peter Eisenman has developed a software package, designing by interacting with it (Galofaro, 1999; Schumacher, 2004).

This phenomenon of developing new media forms from older ones is known in the literature of human-computer interaction as 'remediation' (Bolter, 2007; Bolter & Grusin, 1999; Bolter & Gromala, 2005). According to the theory of remediation, designers develop new digital tools which imitate the representation of previous media forms but are enhanced with new digital qualities. Therefore, remediation analyses a process of media evolution, incorporating cultural and technological drivers which give rise to new media qualities.

These qualities are captured by the dual logic of remediation (see Table 1 below), as new media forms improve the design process by communicating information more accurately and efficiently (the logic of transparency), while triggering new possibilities for creativity through interaction with the software (the logic of reflectivity). Although new media forms tend to imitate previous ones in terms of representation, they introduce both transparency and reflectivity to varying degrees, a process described as 'oscillation' (Bolter & Gromala, 2005).

TABLE 1 ABOUT HERE

Remediation enables open-ended creative exploration, rather than the adoption and use of digital media in architectural design. The 'logic of transparency' articulates how digital media deliver information to users with clarity, accuracy and efficiency. Digital tools are an interface, which is metaphorically viewed as a *'window'* that allows designers to virtually simulate reality by looking through it. Virtual reality and video games are examples of transparent interfaces, especially when user experiences attempt to imitate reality (Bolter & Gromala, 2005). In architecture, transparency enables 'virtual representations' of buildings and spaces which facilitate communication of architectural ideas and information between clients, designers, fabricators, contractors and engineers (Norman & Tilder, 2003).

Transparency is based on the computational power of new digital tools that accurately translate design information into data. Architects call this process 'parametric design', as all design elements are digitised parameters which are manipulated and stored into a single platform (Wong, 2010). Parametric design feeds into the 'digital fabrication' and 'mass customisation' of building components or mouldings, supporting complex built structures without dramatically increasing the costs of production (Kolarevic, 2001; Kolarevic, 2003).

In contrast, the 'logic of reflectivity' facilitates design practice, as designers interact with digital tools (Bolter & Gromala, 2005). Reflectivity invites users to look at the interface as a

'mirror' and create by interacting with it. Open-source software is an example of a reflective interface that enables users to create a desired experience by customising it. While transparency epitomises technological evolution driven by the computing community, reflectivity stresses the role of users, including digital artists and designers, in developing technology to enrich and express their cultural practices (Swann, 2002). Closely related to reflectivity is the notion of 'affordance', as users discover new possibilities for cultural, social and technological practices in interaction with technology (Bolter & Gromala, 2005; Fayard & Weeks, 2014).

Transparency stresses materiality, providing a perspective on digital architecture as determined by digital tools. In contrast, reflectivity emphasises human agency, and, more specifically, cultural practice in terms of technological evolution. However, the dual logic of remediation manifests that digital design is transparent and reflective, similar to the way in which the social is entangled with the material (Orlikowski, 2007). Remediation is a useful analytical lens through which to understand both the relationship between the social and material in digital architecture in general, and also, more specifically, within the design practice of each architect, which varies based on the degree of 'oscillation': the extent to which a designer builds a design process that relies more on the transparent or reflective qualities of the medium (Bolter & Gromala, 2005). Oscillation explains the plurality of approaches, as architects may develop digital tools or blend analogue and digital techniques (Celani & Vaz, 2012).

Remediation has implications for conceptualisation and organisation when it exists within a design practice (Bolter & Gromala, 2005; Swann, 2002). This is because the use of digital tools and their contribution to new architectural languages rely on the ways in which architectural firms select and deploy such tools, organising their practices around them. Ultimately, these approaches influence the ways in which architects envisage and create the experience of physical spaces.

3. White Space in Digital Architecture

The dual logic of remediation demonstrates that designers develop technologies in order to enhance efficiency of design, while also enriching creativity as a process of interaction with digital tools. While transparency epitomises advancement in digital technology, reflectivity allows the possibility of using technologies in unique ways which were not envisaged before. Digital remediation in architecture is a particularly interesting phenomenon to investigate because it is where creative and business practices intersect.

In the digital age, technology is a catalyst for the exploration of new ideas, facilitating the organisation of architectural firms in terms of flexible network structures (Yoo et al., 2006; Yoo et al., 2012). The digitalisation of architecture provides advanced methods with which to study the spatial experience of users based on rigorous data analysis (Spiller, 2008). This section addresses the ways in which architects use technologies in order to explore conceptual, organisational and physical white spaces.

3.1. Conceptual white space

The introduction of digital tools in architectural design has altered architects' perception of 'epistemic objects' of design that move from drawings, sketches and models into digital applications (Ewenstein & Whyte, 2009). Epistemic objects contribute to conceptual development because of their ability to embed and communicate design knowledge, being at once sites of creative exploration and visual representations "characterized by a 'lack' or incompleteness that precipitates unfolding" (Ewenstein & Whyte, 2009:26). Epistemic objects are sources of information and inspiration, being 'in between' the conditions of 'stable-in flux; abstract-concrete; used within or across practices" (Ewenstein & Whyte, 2009:26). This "process of exploratory, projective reflection" enables the exploration of novel designs, taking place in interaction with digital tools (Ewenstein & Whyte, 2009:22).

Da Costa Meyer (2009) makes a critical distinction between the role of sketches and drawings in the design process of architecture. He claims that "finished plans, sections, and elevations, traced on paper with ruler and compass and pruned of all personal references, differ significantly from the open-ended capriciousness of the sketch, still subject to change and development" (Da Costa Meyer, 2009:16); and argues for the power of an open and unfinished structure, as sketches enhance imagination and creativity in an ongoing 'back-and-forth' process that empowers improvisation.

Architectural design is influenced by the exploration of digital media in the creative process. The exploration of white space enables an inimitable creative process, as architects engage in a process of 'permanent extendibility' of computational media using open-source software (Manovich, 2007). Architects expand digital tools by adding new features, and often blending them with traditional design tools, which lead to new ideas within the design process which could not be envisioned previously (Bolter & Gromala, 2005; Manovich, 2007).

3.2. Organisational white space

From an organisational perspective, white space represents an unoccupied territory which transcends the formal strategy, purpose and structure of a firm, as "managers who operate in these unchartered seas are often the ones more successful at driving innovation, incubating new businesses, and finding new markets" (Maletz & Nohria, 2001:103). In contradistinction, the 'organisational black space' includes all opportunities that are formally targeted and rely on the current spectrum of skills and knowledge (Maletz & Nohria, 2001). Furthermore, the organisational white space encompasses entrepreneurial dynamics when firms develop new organisational structures in order to discover or create new markets (Johnson, 2010).

The organisational white space signifies a radical way of organising architectural practice. The inclusion of more agents in the design process nurtures architectural thinking within an

orchestrated process of collective intelligence (Jenkins, 2004; Wigley, 2007; Yoo et al., 2012). Therefore, exploring white spaces provides new opportunities to include more voices in the design process, often generating design paradigms, such as Building Information Management (BIM), a new organisational form that includes more agents in design, unifying the objectives of all parts of the construction chain in a single digital infrastructure (Ambrose, 2012).

3.3. Physical white space

Digital architecture attempts to blur the boundaries between the designer and user, revealing the ways in which technology assists the experience of users in physical spaces (Swann, 2002). 'Space' refers to the "physical space with its social and psychological dimensions, a dynamic conception which accommodates at the same time constant change and embeddedness, and that can only be understood in monitoring the way space is being made and remade, at the intersection of the development processes and everyday life" (Madanipour, 1996:331). White space represents 'constant change' as a quality of space, and as a driving force that leads places to be reshaped and remade. The notion of space refers to our homes, offices, places in transit, private and public spaces. Being in 'constant change' means that users can assign and reassign the use and meaning of space (Gieryn, 2000).

Kirsh (2001:113) claims that "much of architecture is about boundaries: defining space and movement by the thoughtful design of walls, enclosures and openings". Although architects assign particular functions and meanings to spaces (Harry et al., 2008), the complex and opportunistic behaviour of people means that they use them as 'activity spaces' in unexpected ways which could never be envisioned (Kirsh, 2001:114). For this reason, architects deliver some empty or white spaces so that they can be adapted and turned into places by users at the post-construction stage. In the 'new office paradigm', organisations encourage employees to express their identity by assigning meaning to physical spaces (Beyes & Steyaert, 2011).

The exploration of physical white spaces is evident in performative actions that give particular functions and meanings to spaces in a given time and context. These performative actions shift space, conceived as abstract geometries (distance, direction, size, shape, volume) to 'place-making', which takes "material form and cultural interpretation … filled up by people, practices, objects, and representations" (Gieryn, 2000:465). Skateboarders, for instance, 'occupy' spaces carrying a cultural identity which is imposed on those spaces at the post-construction stage (Borden, 2001:12; see Table 2 below).

TABLE 2 ABOUT HERE

White spaces are unmapped because they constantly appear and disappear, as people perform space, enacting a personal and spatial identity (Beyes and Steyaert, 2011, 2013; O'Doherty et al., 2013). 'White space' literally means 'a new space', but white as a colour may have different meanings across institutional contexts (prison-identity-less; university-authority and freedom; church-purity; Western parliament buildings-power and stability), thus reproducing hierarchies and power relations (Connellan, 2013). White spaces are 'negative spaces' which have 'nothing' in them, but allow for "unseen action" (Connellan, 2013: 1547). Nevertheless, white spaces differ from 'empty spaces', which are "first and foremost empty of *meaning*" (Bauman, 2000:103).

Henfridsson et al. (2014:27) note a temporal difference between digital design and the actual outcome of the design process, as "firms successively freeze design specifications before production and therefore only allow limited windows of functionality design and redesign". Architects reduce the temporal difference between digital designs and outcomes by allowing users to explore white spaces (Henfridsson et al., 2014; Maletz & Nohria, 2001). White space is consequently a conceptual tool, an organisational condition and a quality of physical spaces. It is first and foremost a design principle energised by digital technologies.

4. Research Design and Method

4.1. Sociomaterial entanglement in digital architecture

This research investigates the effect of advanced technologies on the exploration of white spaces in digital architecture. Due to its gradual digitalisation in the last twenty-five years, the field of architecture provides an exemplar case of technology-driven organisational change. The purpose of this study is to demystify the relationship between technology and design practice, which in the language of sociomateriality refers to the tension between materiality and human agency. This study subscribes to the inseparability position in sociomateriality theory (Cecez-Kecmanovic et al., 2014), assuming that "reality is the entanglement of matter and meaning produced in practice within specific phenomena" (Scott & Orlikowski, 2014:878).

Rather than promoting the analytical separation of the social from the material, treating them as 'different things' (Leonardi, 2011; Mutch, 2013), the inseparability position facilitates the purpose of this research, which is to scrutinise the cultural, social and business triggers of technologically driven organisational change in architecture (Orlikowski, 2007). The problem with separating the material from the social refers to the ontology of white space, which, as an open process, does not allow technology to be clearly distinguished as a bounded object from design practice (Ewenstein & Whyte, 2009; Scott & Orlikowski, 2014). Large architectural firms in the digital age also operate as project-based organisations, with performative, temporal and spatial characteristics, and technological development may trigger organisational change for all firms involved in the construction chain (Yoo et al., 2006). In our endeavour to connect IT architecture with physical architecture, we subscribe to practice-based views on sociomateriality (Barad, 2003; 2007; Orlikowski, 2007; 2010; Scott & Orlikowski, 2013; 2014), according to which "material arrangements are important in terms of spaces and configuration of objects within spaces" (Cecez-Kecmanovic et al., 2014:815).

However, the material and the social are not in a neutral relationship, as power conditions and identity have an important influence on sociomaterial entanglement (Balogun et al., 2014; Gal et al., 2014; Mutch, 2013). Indeed, in digital architecture, the material is an integral part of the social (Orlikowski, 2007). But at the same time, the social is entangled with creativity to provide unique versions of the material at the level of both tools and outcome, influencing in turn the organisation of architectural firms and the design of spaces.

4.2. Empirical context

This paper argues that sociomaterial entanglement is unique in the case of each architect, and for this reason the empirical context of this study is the case of the leading architect Frank O. Gehry. This research comprises a single historical case study of Gehry based on secondary data (Benbasat et al., 1987; Myers, 1997; Stake, 1995), to reveal the ways in which advanced technology leads to the exploration of conceptual, organisational and physical white spaces.

The organisation 'Frank Gehry Partners' is the unit of analysis chosen in order to analyse the actions and limitations that result from Gehry's design practices (Benbasat et al., 1987). This research has collected data from Gehry's interviews with scholars (Isenberg, 2009; Weick, 2003), and discussions with architects (Foster, 1999), together with texts that analyse Gehry's creative (Da Costa Meyer, 2009; Goldberger, 2015; Johnson & Lewis, 2007; Mathewson, 2007) and digital practices (Lemonier & Migayrou, 2014; Lindsey, 2001). Additional sources include Boland and his colleagues (2008, 2007), who collaborated directly with Gehry in the creation of the Peter B. Lewis Building in Cleveland (2002); Yoo et al. (2006), as information systems and organisation scholars who have studied the design practices of Gehry; Kolarevic (2003), as an academic architect; and Giovannini (2004), as an architecture critic (see Table 3 below).

TABLE 3 ABOUT HERE

These sources of secondary data provide rich information about the phenomena investigated, which refer to the early period of digital architecture, when technologies reorganised the architectural firm of Gehry (Lindsey, 2001). The purpose of this research is to scrutinise the role of technology in exploring conceptual, organisational and physical white space, and therefore, the case study is organised around these three analytical themes (Walsham, 1995).

Within-case analysis is the method employed to analyse the data, comparing the findings of the case study with key aspects of theory (Yin, 1994). Data analysis takes place throughout the process of narrative writing, matching evidence of Gehry's design practice with the three types of white space investigated. The discussion part then directly engages with the research question, while maintaining a relatively open structure that allows lessons for the literature of IS to be addressed. The choice of studying a single case provides rich information about Gehry's architectural firm, which is large and established (McNeill, 2009). This case study deliberately has no rigid boundaries, and its structure unfolds in such a way as to show how digitalisation opens up design practice both technically and organisationally (Yin, 1994). However, the findings may not apply to smaller firms which adopt standardised software packages (Yoo et al., 2006).

In terms of external validity, the findings of this research cannot be generalised beyond the context of this study, as each architect constructs a unique sociomaterial entanglement (Denzin & Lincoln, 1994). However, internal validity compensates for the lack of external validity by providing an analytical path with which to investigate the effect of digitalisation on the exploration of white space. Our analysis of remediation, and its impact on the exploration of white space could be used to replicate the findings of this research or to analyse the cases of other designers who engage with digital tools. Finally, the reliability of this research is ensured by using diverse and multiple sources of secondary data (Denzin & Lincoln, 1994).

5. The Digital Architecture of Frank O. Gehry

Frank Owen Gehry (1929-) began his career as an architect in 1962, and his work has been strongly linked with the style of deconstructivism (Bonta, 1996:8). In the late 1980s, Gehry's office started experimenting with newly available digital tools (Saggio, in Lindsey, 1999:5). His office soon went 'paperless', delivering in 1992 in Barcelona the first entirely digital project, using drawings at no stage of the construction process (Kolarevic, 2003:60). Since then, Gehry has completed many outstanding buildings that define the field of digital architecture, such as the Guggenheim Museum in Bilbao (1997); the Peter B. Lewis Building in Cleveland (2002); Walt Disney Concert Hall in Los Angeles (2004); the Stata Building in MIT (2004); the renovation of Art Gallery Ontario (2008); the Beekman Tower/8 Spruce Street (2011) in New York; and more recently the Louis Vuitton Foundation (2014) in Paris (Goldberger, 2015; Lemonier & Migayrou, 2014; Mathewson, 2007).

Inspired by his architectural vision, Gehry developed a new architectural language based on software development and the use of 3-D representation techniques that source information by scanning physical models (Boland et al., 2008; Boland et al., 2007; Yoo et al., 2006). Gehry uses digital technologies to explore unmapped territories when conceptualising and organising architectural projects, creating buildings which in turn can be explored by their inhabitants and users.

5.1. Exploring conceptual white spaces

'Abstracted organic shapes' (Giovannini, 2004) and 'bricolage' (Weick, 2003) characterise Gehry's early works, such as the Fishdance restaurant in Kobe (Japan, 1987) and El Peix, the fish-shaped pavilion in Barcelona (Spain, 1992). His digital architecture is epitomised by the creation of the Guggenheim Museum Bilbao (1991-1997) and the Disney Concert Hall (1999-2003). The Guggenheim Museum Bilbao highlights architecture as public installation art,

introducing a new architectural language manifested in non-Euclidian and 'blobby' forms (Johnson & Lewis, 2007; Kolarevic, 2001, 2003; Lemonier & Migayrou, 2014). The Disney Concert Hall is "the site of invention" for Gehry's digital architecture, as the building is characterised by a "rich series of curvilinear structures that have repositioned the art of architecture and raised the bar of the discipline" (Giovannini, 2004:94).

Gehry's projects start from an abstract idea –'a dream', as he calls it – and develop through various raw models and sketches that capture multiple versions of the same 'dream', which are then translated into digital renderings (Boland et al., 2008). This is a remarkably fluid method, in which architectural thinking is developed in sketches and models as an ongoing recursive process of "organizing a vision and implementing a design" (Weick, 2003:95).

Although Gehry Partners has been radical in introducing digital practices to architecture, Gehry himself rarely uses computers as design tools, because:

> "[A computer] dries out the ideas, it takes all the juice out. The computer graphics is [*sic*] really impediment to me. And it's painful when you look at the computer screen, you see that image which is like a dried out version of what you're thinking, you have to hold the dream image in your mind while you're manipulating the thing on the screen which is horrible, and it's very hard, it's excruciatingly painful to carry this image which you're looking at a bad image" (Gehry, 2003, in da Costa Meyer, 2009:68-71).

Architectural projects start and remain "liquid for long before they crystallize" (Boland et al., 2008:18). This is because 'liquid' is considered to be a stage of constant development and evolution of ideas, which are in flux before 'crystallising' into the final version. This means that the main design challenge for Gehry is to maintain the 'fluidity' of a project in order to include many voices without 'crystallising' the design too early in the process (Boland et al., 2008:18). Reflecting on Gehry's practices, Weick (2003:95) questions whether the 'dream' stage is really "a singular vision that can only be compromised as more and more people get

involved with it? Or is the dream actually a collective vision that becomes more vivid, explicit, and rich as it engages the sentiments of many?" Although Gehry develops architectural solutions "as an active dialogue with forces outside the studio and especially clients" (Lindsey, 1999:5), he recognises that this process can overpower the initial 'dream' (Gehry, in Friedman, 1999:44). Gehry's architectural vision aims to keep the 'dream' alive throughout the process, while also incorporating collective approaches to each project.

Gehry uses multiple models at different scales to explore people's reactions and their cognitive and emotional human experiences. He engages with clients in a process of mutual sense-making, rather than making decisions about the design problem himself (Boland et al., 2008; Weick, 2003). While a common vocabulary facilitates communication at this stage of the design process, Gehry avoids labelling particular solutions to prevent conceptual crystallisation (Weick, 1999). Human experience, sense-making and discourse are therefore significant factors that prevent early crystallisation.

After a process of constant development, "the final design is a bricolage of fragments from different models as well as a unity" (Weick, 2003:95), and the final synthesis thus includes options adapted in the design process, while also sustaining the initial architectural vision and origin (Weick, 2003:96). In this way, Gehry generates an 'organisational bricolage', by redesigning teams in unique ways, "bringing specialized actors and artefacts together in novel ways that respond to particular conditions and requirements of each project" (Boland et al., 2008:18).

5.2. Remediation of Gehry's digital architecture

Digital technologies have a role in Gehry's work, translating his sketches and models into design information, as precise documents for contractors (Sorkin, 2002:30). As Da Costa Meyer (2009:53) states, "[B]y ensuring that every form, however complex, can be built to

specification, the computer has revolutionized Gehry's architectural practice, and possibly his sketches as well. No longer bound by the need to instruct and inform, his fantasies can soar into the unknown and the unconventional." In this way, technologies allow Gehry to explore conceptual white spaces, realising imaginative designs which were hard to build before the advent of digital tools.

Sketches are used to construct physical models, and once a final synthesis is complete, each physical model is translated into a digital version (Lindsey, 1999:65). The digitisation of physical models takes place through the use of a "digitizer that produces lines and curves corresponding to points on the model", by "locating the extreme boundary points of the model and then tracing the edges of major curves", or by the "tracing of a grid superimposed on the model" (Lindsey, 1999:65). Other techniques include the CAT scan (computer axial tomography), which was used for the design of Disney Concert Hall (Lindsey, 1999:66). Once the curves are defined, the role of the software is to close the form and generate the final design information (Lindsey, 1999).

Gehry's use of technology empowers a new organisational form that has revolutionised architectural design. Using Computer-Aided Three-dimensional Interactive Application (CATIA) software[1] for the first time at the Disney Concert Hall, his office pioneered the use of a digital model as the "single source of design and construction information", linking "architects, engineers, contractors and fabricators" within a horizontal organisation (Kolarevic, 2003:59). Through CATIA, Gehry entered "a curvilinear world without suffering prohibitive costs … to make otherwise unbuildable forms possible" (Giovannini, 2004:96).

More specifically, Gehry's office emerges as a new organisational form derived from the interdependent collaboration of human and digital agents (Child & McGrath, 2001; Figure 1).

[1] CATIA is "the design and manufacturing software used mainly in the aerospace industry" (Kolarevic, 2003:59).

Gehry's creative and organisational practices provide an exemplary case of remediation, as the CATIA model digitises design information, which has been created through the use of analogue media, such as sketches and models (Bolter & Gromala, 2005; Kolarevic, 2003). As a result of the accurate and clear information provided by the CATIA software, the diverse parts of the construction process can be coordinated and made to collaborate efficiently with each other.

However, the CATIA model emerges as a structure that implements Gehry's digital design strategy, revealing the concentration of power as a consequence of remediation (Bolter & Gromala, 2005; Child & McGrath, 2001; Boland et al., 2007). The CATIA software consolidates the design information within a single platform, allowing the architect to control the entire design process. Therefore, the exploration of white space within the organising process of Gehry's architectural office reflects the reassembly of the boundaries, responsibilities and power of the architectural firm within the construction process, placing the architect at the centre of attention and authority (Kolarevic, 2003).

FIGURE 1 ABOUT HERE

Remediation, in combination with the CATIA model, has an indirect effect on Gehry's creative activity, saving time for creative exploration of conceptual white spaces, as operational stages take place more effectively and over shorter periods of time. The digital model influences Gehry's decisions concerning organisational design, allowing him to experiment more with white space, by importing new sources of knowledge and permitting clients to influence the actual design process to a greater extent. Consequently, a digital design strategy has an indirect impact on the creative process, determining the distribution of resources dedicated to exploring conceptual white spaces (Bolter & Gromala, 2005).

According to Boland et al. (2008:11), Gehry's architectural practice includes "innovations in crafts, fabrication, engineering, technology use, project management, and organization

strategies". Gehry's innovation is fundamentally expressed through his 'design attitude' "as a thorough, ongoing expectation that each project is a new opportunity to create something remarkable, and to do it in a way that has never been done before", as well as a "question and search for new methods, materials, and new ways of organizing" (Boland et al., 2008:13).

His designs often nurture a path-creating process that encourages contractors to innovate. Gehry's digital architecture has triggered 'wakes of innovation' in the construction chain which has had to respond with novel solutions imposed by his radical designs (Boland et al., 2007). For the construction of the Peter B. Lewis Building in Cleveland, Ohio, contractors, such as "the structural engineering firm invented a new method for designing a steel roof with dramatically curved surfaces" (Boland et al., 2007:631). Similarly, "the drywall contractor invented multiple patentable ways to frame undulating wall surfaces, and began a new line of business, consulting on high-profile construction projects", among others (Boland et al., 2007:631). In other words, Gehry projects imposed problems that required solutions, which were then diffused to the wider construction industry (Boland et al., 2007).

5.3. Exploring organisational white spaces

The CATIA model is a vehicle used to overcome legal barriers that restrict architectural practice (Kolarevic, 2003). According to the American Institute of Architects, "the architect will not have control over or charge of and will not be responsible for construction of means, methods, techniques, sequences or procedures" (Kolarevic, 2003:58). Hence, the role of architects is restricted in providing designs to the succeeding parts of the construction chain.

To overcome these legal barriers, Gehry Partners has developed a new organisational structure, a 'hybrid system', in which all aspects of the design, fabrication and construction, as well as "an owner-contracted consulting firm [that] provides digital modelling services in CATIA to all members of the design and construction team", operate under Gehry's organisation

(Kolarevic, 2003:60). All aspects of construction therefore keep their liabilities within the boundaries of current legal status (Kolarevic, 2003:61). However, this new organisational form of digital architecture serves only 'design-build firms' that comprise architects and contractors under a common owner, "representing a single legal entity and a single point of responsibility", where the owner-contracted consulting firm has the role of 'data manager' (Kolarevic, 2003:61).

"The master CATIA model is the 'single source of information' for the design of the building and becomes a legal part of the contract document", allowing "the architect to become a coordinator of information between various groups involved in the construction of the building" (Lindsey, 1999:87). The digital model reduces the transaction costs of each function within the firm, as the architect takes control over the construction process, which is "important when there is interdependence among architecture, engineering and construction" (Weick, 2003:95). Gehry emphatically states that "control is back where it belongs, in the hands of the architect as master builder" (Friedman, 1999:18). Such a concentration of power may increase the architect's rewards, but it may also increase risk, which is otherwise spread among the different parts of the construction process (Kolarevic, 2003:60-61).

The CATIA model represents the 'crystal' state, as the purpose of the digital model is to translate Gehry's sketches and models into design information. Although the CATIA model claims horizontality in the construction chain, the process reveals that power is concentrated in the hands of Gehry as a 'master-builder', who is the first and last voice in each project (Kolarevic, 2003). Although transparency enables Gehry to create and establish a digital model which carries out operational activities, the actual creative process and the exploration of white spaces take place using analogue/non-digital media, such as models or sketches (Da Costa Meyer, 2009). Gehry has progressively developed CATIA software, which currently takes the

form of services provided to other architectural offices, setting in this way a standard for digital architecture:

> "Gehry Technologies (GT) provides technology and services to owners, developers, architects, engineers, general contractors, fabricators and other building industry professionals internationally. GT engages directly with clients to increase creativity and control; reduce project risks, costs and completion times; and improve processes and decisions through collaboration, project visibility and information access. GT develops and sells Digital Project™, a suite of comprehensive 3D building information modelling (BIM) and management tools"[2].

5.4. Exploring physical white spaces

The Guggenheim Museum Bilbao was the commission that permanently changed Gehry's life (Isenberg, 2009:133). The new museum contributed to the local economy as a successful urban regeneration project, producing what is known as the 'Bilbao Effect' (Goldberger, 2015; Isenberg, 2009). The Guggenheim Museum Bilbao includes a series of innovations that refer to the site of the building, the use of exterior materials (titanium), and the spectacular design of the exterior (Gehry, in Isenberg, 2009). According to Gehry, an important design innovation of this building is the arrangement of the interior galleries:

> "It was a sort of an antidote to the Metropolitan Museum syndrome, where you go in, get lost, and you're there for a few hours with no relief. I like the idea of going to a museum, seeing a section at it, then coming back to the centre. You could branch out again, as well as be able to go in a continuous fashion around the central space. In this case, I also wanted to have the central space open to the city so that whenever you came back to that central space, you had different views of the city of Bilbao around you. It made the experience interactive and seeing art interacting with the city made sense to me. The city is a living thing, and the art is inspired by living. It's a kind of interrelated." (Gehry, in Isenberg, 2009:138).

[2] http://www.gehrytechnologies.com/index.php?option=com_content&task=view&id=24&Itemid=200

This project reveals ‘space’ to be the key unit of architectural research, as Gehry’s aim is always to balance interior with exterior design, spaces with volumes, atmosphere with the material, conceived “in a fluid, continuous movement” (Lindsey, 1999:6). For this reason, Gehry has developed a creative process that focuses on space as a way of studying architectural solutions “in order to create an active dialogue with the forces outside the studio and especially the clients” (Lindsey, 1999:5). Gehry says of participation that:

> “The design evolves in a process in which they [the design teams] participate. They can watch it evolving and they know they’re part of it. You know, I don’t sit in a room and design a building and then say, “This is it, client”. It evolves from the inside out. So I have developed a way of working with the staff that allows me to delegate, which is one of the hardest things for somebody to do who has a single-minded design language. I don’t keep the creative process private. I think there are people who guard their privacy in their creative work, who go somewhere along and think it through and come back with it” (Gehry, in Isenberg, 2009:169).

Gehry conceptualises the unfinished as a quality of physical spaces. Realising “that buildings left unfinished were at their most powerful”, he wants “to sustain that sense all the way to the finished building” (Giovannini, 2004:95). The Ray and Maria Stata Centre at MIT is intended to look permanently unfinished, as a metaphor for freedom of research which can inspire the unconventional thinking of researchers, while also including unspecified social spaces that trigger social activity and connect the users of that community (Campbell, 2004; Mathewson, 2007). The design of the Stata Centre was a process of exposing the creative process to almost all users of the Centre, who were able to critique it and make recommendations:

> “We also created a website which the 400 students, 250 faculty, and the administration – about 700 people altogether – could access. I knew it was risky, and in hindsight I think it was *really* risky, but we did it. We would constantly refill the website with pictures of the models, and all kinds of we were thinking about that related to the project. I said, “We’re going to let it all hang out for you, and you guys can respond. Here’s my e-mail address.” And I got some hateful e-mail for a while” (Gehry, in Isenberg, 2009:179).

In a context such as a research centre, the exploration of white spaces is related to the creativity of the users, as they engage with 'knowledge exchange' or 'social talk', reinforcing "connections, trust and a culture of collaboration" in organisational and social life (Mumford, 2001:100). This process of involving users in the design process has had positive effects, as Gehry states:

> "It took about a year or so. But because they were involved and were able to say these things to me, I think they became believers. With the size of the models that we've prepared, they've also been able to see what we're doing that way. We've taken them inside with Web cameras, so they can understand the space. We've made mock-ups of their offices in Cambridge, in a warehouse, so they can go in and sit at desks in offices like they're going to get, and criticize the furniture. They've already done that, and we've made modifications. It's a process I really love. I enjoy the people part of it, probably as much as I do the design." (Gehry, in Isenberg, 2009:180).

Through these processes, Gehry has achieved something he calls 'functional', a "building that does all the things we want from our buildings", meeting requirements "for current and future programs, for cultural characteristics of the organization, for efficiency of operation, for being a good neighbour, for the context and scale of the environment, and for the feelings and emotional reactions to living in or visiting the structure" (Boland et al., 2008:15).

The 'liquid' process of Gehry's creative practice occurs during the early stages of design, when digitalisation 'crystallises' the final design and generates the design information. On the one hand, Gehry acts as a leader of the creative process, combining his architectural vision with collective voices and novel ways of organising activity. On the other hand, he is a 'master builder' who materialises that crystal design, acting as a single source of information which controls the construction chain. But for Gehry, design is mostly "a continuing battle between freezing the thing and losing the dream, and keeping the dream but losing the common ground that stirs others to make the dream happen" (Weick, 2003:95).

6. The Unique Sociomaterial Entanglement of the Design Practice of Frank Gehry

The case of Frank Gehry provides rich insights into the role of advanced technologies in design practice. Leading architects, such as Gehry, develop digital tools in order to overcome the constraints of technological determinism (Orlikowski, 1992). These tools form the basis for their digital design strategies. Specifically, Gehry's idiosyncratic engagement with remediation aims mainly to enhance the quality of transparency, increasing efficiency in linking design information to visualisation, fabrication and construction. Nevertheless, oscillation (a greater emphasis on transparency or reflectivity) is a matter of strategic choice for each architect who engages with digital technologies in the design practice. Gehry consciously recalibrates his activities and recursively modifies conceptual and organisational processes by imposing remediation upon himself and his organisation. As a result of this remediation he explores conceptual, organisational and physical white spaces (see Table 4 below).

TABLE 4 ABOUT HERE

Based on evidence from the design field of digital architecture, this research contributes to sociomateriality theory by delineating how the process of remediation leads to the construction of a unique sociomaterial entanglement, which in turn advances the exploration of conceptual, organisational and physical white spaces. Hence, it responds to criticisms of the inseparability position as not being "specific about technology", while neglecting "the social context in which practices are situated, which renders it difficult for analyses to take full account of factors such as power" (Mutch, 2013:32). By focusing on the interaction of architects with technologies, this paper shows that the inseparability position is viable through a process of remediation that connects agency with material practices while situating the analysis within a technological and socio-cultural context in which power relations are played out (Bolter & Gromala, 2005).

In contrast to the inseparability ('entanglement') position which scrutinises relationships between the technological and the social (Orlikowski, 2007; Scott & Orlikowski, 2014), the separability position aims to extend the existing socio-technical systems theory, according to which the social and the material should be "held apart for the purpose of exploring their interplay" (Mutch, 2013: 29). With an emphasis on design practices, scholars advocating for the separability position propose 'sociomaterial imbrication' as an alternative to 'sociomaterial entanglement' (Bratteteig & Verne, 2012). Imbrications "can be undone and remade" as "social and material agencies are seen to retain their distinctive form despite the fact that they depend on one another for the production and perpetuation of sociomaterial practices" (Leonardi & Rodriguez-Lluesma, 2012:79). Nevertheless, remediation is a hybrid cultural *and* technological practice in which meaning and matter are inseparable; and as the case of Gehry illustrates, it leads to the creation of a novel architectural style based on new ways of organisation (Bolter & Gromala, 2005; Scott & Orlikowski, 2014).

The ontological position of inseparability is a precondition for perceiving and exploring white space through the process of remediation (Bolter & Gromala, 2005; Orlikowski, 2007). Although "materialism has acquired the stigma of determinism" (Leonardi & Barley, 2008: 163), digital materiality enables creative and organisational affordances within the design practice (Fayard & Weeks, 2014). The analysis of remediation explains the ways in which sociomaterial entanglements are enacted, scrutinising the relationship between the material conditions of transparency and the agential qualities of reflectivity (Bolter & Gromala, 2005; Orlikowski, 2007). In the case of Gehry, the materiality of transparency is manifested by the use of the CATIA model which accelerates and coordinates design and construction (Yoo et al., 2006). However, digital materiality is not necessarily deterministic (Leonardi, 2011), but it can also support the agential quality of reflectivity, allowing architects to invest more time and include more voices in the design process (Fayard & Weeks, 2014).

The role of agency is crucial in the construction of digital materiality, an argument which is developed in the literature of agential realism, according to which a constitutive entanglement is enacted based on performative actions (Barad, 2003; Scott & Orlikowski, 2013). Architects enact a unique sociomaterial entanglement by developing digital design strategies which allow the exploration of white spaces, once the material and social are constitutively entangled (Bolter & Gromala, 2005). The agential quality of reflectivity defines the digital design strategy of a firm. For instance, Gehry reflects on the conditions of materiality which include technology as an impediment, participatory structures as eroding the initial idea or labelling solutions as causing conceptual crystallisation (Weick, 1999). However, these strategic choices are not produced by separating the material from the social, but are made in practice and in a performative manner while exploring white spaces (Feldman & Orlikowski, 2011). Hence, reflectivity encapsulates an 'agential cut', as architects need to be aware of the conditions of materiality in order to manipulate them and enact a desired experience (Barad, 2003; 2007).

The position of inseparability provides an explanation of the 'star architect' phenomenon in the digital era, highlighting the technological, business and cultural context (O'Neill, 2009). As meaning and matter are inseparable within a sociomaterial entanglement (Scott & Orlikowski, 2014), digital materiality contributes to the creation of meaning as a distinguished architectural style which forms the professional identity of Gehry (Gal et al., 2014). Digital materiality also influences matter, as his form-free sketches and models cannot be realised without the CATIA model which empowers the exploration of organisational white space as an ongoing process of integrating a collaborative network of agents and firms in design and construction (Boland et al., 2007; Yoo et al., 2006). However, this process of 'organisation designing' does not necessarily lead to the distribution of power across a collaborative network. Therefore, the power conditions within a sociomaterial entanglement should be examined more closely.

Although the inseparability position does not privilege either the social or material (Orlikowski, 2007), the case of Gehry shows that a sociomaterial entanglement is not neutral (Balogun et al., 2014), but enacts a power position for the architect. Specifically, his chief motivation for launching the CATIA model was to regain control by overcoming legal barriers that previously restricted the authority of architects in construction (Kolarevic, 2003). Hence, the CATIA model is an exemplar case of a new organisational form, resulting from media convergence which changes the power structure within construction, shifting power from constructors to the architect, who remains the first and last voice in the design process (Jenkins, 2004; Kolarevic, 2003; Yoo et al., 2012). This constitutive entanglement, initiated by the need to concentrate power in the design process by controlling data, has established Gehry's reputation and fame in the field as a pioneer in digital architecture, while supporting the international expansion of his firm based on the strategy of vertical integration (Glaister, 2009; Kolarevic, 2003; McNeill, 2009). Consequently, the power conditions shape a sociomaterial entanglement enabling path-dependencies which are also governed by human and social interests (Thomas, 1994).

A sociomaterial entanglement does not necessarily represent a harmonious balance, but may enclose tension between the architect as an authoritative 'icon' who masters the design process (McNeill, 2009; Yoo et al., 2006), and the architect as an orchestrator of participation, who develops technologies and practices in order to include diverse voices and communities in the processes of the conceptualisation, organisation and meaning-creation of spaces. White space is illustrated by the example of the Ray and Maria Stata Centre at MIT, which was conceptualised digitally based on diverse voices within the design process. This example reveals white space as a principle for democratising design, but the sociomaterial entanglement of Gehry Partners was fuelled by its power position as a large and resourceful firm, which can afford to invest in advanced technology in order to explore conceptual, organisational and physical white space.

7. Conclusion

This paper contributes to sociomateriality theory by inserting remediation as a feature of the inseparability position, which connects agency and materiality within a unique sociomaterial entanglement (Orlikowski, 2007). Based on evidence from the field of digital architecture, this paper responds to criticisms from the separability position, according to which constitutive entanglements appear to lack a focus on materiality and temporality, being both decontextualised and neutral (Leonardi & Barley, 2008; Leonardi, 2013; Mutch, 2013). Taking into account the philosophical ramifications of inseparability and separability positions which have been addressed more fully in the literature of agential realism and critical realism respectively (Leonardi, 2013; Mutch, 2013; Orlikowski, 2007), we argue that the inseparability position is appropriate for the analysis of design practice, being a trigger for technological and organisational change within the context of innovation-driven firms (Yoo et al., 2006).

The sociomaterial practice of remediation demonstrates that the inseparability position is viable and provides an analytical framework to study agential cuts in design practice (Barad, 2003). For Gehry, transparency sheds light on technology, organisational structure and discourse as the material conditions of design practice; while reflectivity addresses the ways in which he develops new media from previous creative practices to overcome the constraints of determinism (Weick, 1999). Remediation is a sociomaterial practice and not an imbrication (Leonardi, 2013), because transparency influences reflectivity even if material conditions are put aside; and reflectivity enacts the performative exploration of white space (Orlikowski, 2007). Remediation addresses the issue of temporality (Mutch, 2013), as a greater emphasis on transparency or reflectivity (‘oscillation’) predates materiality or creativity respectively (Bolter & Gromala, 2005). Each project unfolds as a path-creating process in which ideas, technology and organisational forms ‘become’ throughout the design process (Boland et al., 2007).

Although the findings from the case of Gehry cannot be generalised, the analysis of remediation provides a methodological framework for the study of sociomateriality. A thorough investigation of white space in design practice requires sociomaterial entanglement as a unit of analysis and remediation as an analytical framework. Although the social and material are inseparable in practice (Orlikowski, 2007), the agential cut draws a line between the events and researcher's 'reflexivity' (Alvesson & Sköldberg, 2000). A reflexive methodology facilitates the study of the inseparability position, shifting emphasis from following a rigid case study protocol to performing case study research in a more open and self-critical spirit, identifying key themes that drive the transformational use of technology in organisations (Alvesson & Sköldberg 2000). In this research, placing the analysis within the context of Gehry's firm has enabled power to emerge as a key theme of the sociomaterial entanglement (Balogun et al., 2014), revealing tensions between creativity and control, while exposing path-dependencies which have established the legacy of the architect within the field of architecture.

More broadly, digital tools facilitate conceptualisation, as the interactive qualities of media enable new affordances. Gehry enacts white space as a design strategy, leaving some empty territories in which technological, creative and organisational practices arise. This is also a consequence of the evolution of material conditions within and beyond a single industry, which evolve in interaction with people, in turn fuelling creative practices. Nevertheless, many organisations discover white space as a result of technological change beyond their boundaries, which necessitates their convergence with the practices of more powerful firms (Boland et al., 2007). Therefore, more research is required to understand power relations and conflict, as creativity does not always result from harmonious processes, but from renegotiation, which forms the basis for innovation. While this research investigates a large architectural firm, which can afford to invest in advanced technologies to explore white space, the concept of imbrication may also be suitable for smaller firms which adopt standardised packages (Leonardi, 2013).

This research contributes to the literature of white space by scrutinising the concept from the viewpoint of technology, while defining conceptual, organisational and physical white space. As firms increasingly open their boundaries in order to innovate (Chesbrough & Appleyard, 2007), future research could examine the ways in which remediation facilitates co-creation, enabling firms to explore white spaces. For instance, the toy manufacturer LEGO has developed a digital platform in which users can co-design products (Frow et al., 2015; Hienerth et al., 2014). A future study should investigate the ways in which firms strategically develop technologies, such as social media, in order to facilitate co-creation and open innovation by augmenting the conceptual white spaces to include users in the design process.

Future research could investigate the ways in which remediation sets the conditions for the exploration of organisational white spaces. The process of remediation enables firms to explore organisational white spaces, as the boundaries between the internal and external environment continue to blur. Advanced technologies empower Gehry's architectural firm to explore white space while overcoming legal barriers, which restrict the role of architects in providing plans. This type of organisational white space is also found in the sharing economy, in which firms such as Uber or Airbnb reassemble their boundaries in order to overcome legal barriers and create value in collaboration with their users as service providers (Botsman & Rogers, 2010).

Future research could focus on investigating physical white spaces within organisations. The 'new office paradigm' in the context of high-technology firms could be ideal for the study of physical white space, investigating how firms such as Google design organisational spaces whose meaning can be reassigned by employees within a process of empowerment (Beyes & Steyaert, 2011; Zhang et al., 2008). Finally, a future study of physical white space could focus on the design of smart environments, embarking on remediation to analyse the performative experience of users in interaction with spatially embedded media (Atzori et al., 2014).

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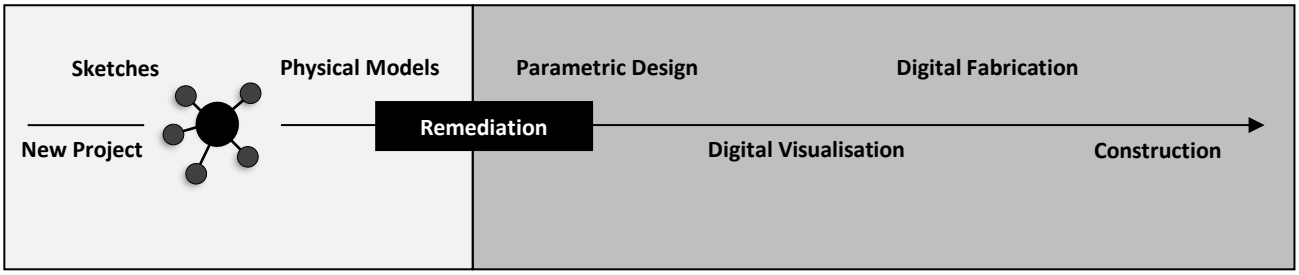
Figure 1: Frank Gehry's conceptualisation (fluid state) and CATIA Model (crystal state)



Source: the authors

Table 1: The dual logic of remediation

	Logic of Transparency	**Logic of Reflectivity**
Goal	Information delivery	Compelling experience
Metaphor	Interface as window	Interface as mirror
Response by user	Look through interface	Look at interface
General examples	Virtual reality, video games	Open-source software, interactive art
Role in digital architecture	Coordinating creativity	Enabling creativity

Source: Developed based on Bolter and Gromala, 2005, p.67

Table 2: Summary of literature concerning the concept of 'white space'

Elements of White Space	Authors	Examples
Conceptual White Spaces		
'Epistemic objects' facilitate communication of ideas and collaboration in the design process	Ewenstein & Whyte, 2009	Drawings, models
Design tools offer infinite possibilities for creativity due to their 'unfinished' nature	Da Costa Meyer, 2009	Unfinished sketches
'Permanent extendibility' of digital tools leads to new ideas which could not be imagined	Manovich, 2007	Open-source software
Organisational White Spaces		
'Organisational white space' goes beyond the formal structure and strategy of a firm enabling creativity	Maletz & Nohria, 2001	Agile organisations
'White spaces' refer to new segments of the market which are discovered or created	Johnson, 2010	New market creation
Flexible organisational structures include more agents in the design process	Wigley, 2007	Network structures
Physical White Spaces		
Meaning and function of 'activity spaces' derives from the opportunistic behaviour of people	Kirsh, 2001	New office paradigm
Performative actions of people construct the identity and meaning of 'places'	Gieryn, 2000	Skaters & public space
White space as 'negative space' that has 'nothing' in it, but allows for unseen actions.	Connellan, 2013	Universities, churches

Source: the authors

Table 3: The sources of secondary data and their relationship with the case study's themes

Authors	Field	Focus	Case Study Themes
Boland et al. (2008)	IS/Organisation	Organising Process	**Conceptual White Space**
Da Costa Meyer (2009)	Architecture	Epistemic Objects	
Johnson & Lewis (2007)	Architecture	Architectural Critic	
Lemonier & Migayrou (2014)	Architecture	Conceptualisation	
Lindsey (2001)	Architecture	Digital Design	
Weick (2003)	Organisation Studies	Conceptualisation	
Boland et al. (2007)	IS/Organisation	Innovation Diffusion	**Organisational White Space**
Friedman (1999)	Architecture	Digital Technology	
Gehry & Forster (1999)	Architecture	Gehry's Interview	
Isenberg (2009)	Architecture	Gehry's Interview	
Kolarevic (2003)	Architecture	Digital Technology	
McNeill (2009)	Architecture	Architectural Firms	
Yoo et al. (2006)	IS/Organisation	Organisation	
Bonta (1996)	Architecture	Technology	**Physical White Space**
Campell (2004)	Architecture	Architectural Critic	
Giovannini (2004)	Architecture	Architectural Critic	
Goldberger (2015)	Architecture	Technology	
Mathewson (2007)	Architecture	Architectural Critic	

Source: the authors

Table 4: Summary of white spaces identified in Gehry's creative practice

Types of spaces	**Transparency** 'Effectiveness, clarity and accuracy in design'	**Reflectivity** 'Design as a compelling experience'
Conceptual Space	Digital tools accelerate the implementation of architectural ideas ('crystal stage'), facilitating the creation of more complex forms. *i.e. Boland et al., (2008); Lindsay (2001)*	Based on the efficiency of digital tools, Gehry can afford to spend more time in the conceptual ('fluid stage') stage of projects. *i.e. Da Costa Meyer (2009); Weick (2003)*
Organisational Space	The CATIA model integrates all parts of the construction into a horizontal organisation that overcomes legal barriers, shifting power back in the hands of the architect. *i.e. Friedman (1999); Kolarevic (2003)*	Digital tools enhance the organisational white space, as they enable Gehry to include more participants and voices within a more collaborative and flexible design process. *i.e. Yoo et al. (2006); Boland et al. (2007)*
Physical Spaces	Digital technologies empower a distinctive architectural style, which is associated with the research and identity of Gehry as designer. *i.e. Goldberger (2015); Mathewson (2007)*	Gehry's choice to leave some spaces 'unfinished' allows users to explore them as white spaces at a post-construction stage. *i.e. Giovannini (2004); Isenberg (2009)*

Source: the authors