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title Re-thinking urban design research - an interdisciplinary exploration at the interface of urban design and brain sciences using the Delphi technique.

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declaration Being a dissertation submitted to the faculty of The Built Environment as part of the requirements for the award of the MPlan City Planning at University College London: I declare that this dissertation is entirely my own work and that ideas, data and images, as well as direkt quotations, drawn from elsewhere are identified and referenced.

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The research for this dissertation started in the summer months of 2019 in more or less normal times, and was completed and written up around a year later in very a different world. Most of this dissertation has been written during the height of the COVID-19 pandemic. This has been (and still is) a strange time for all of us, and it is no exaggeration to say that writing a dissertation in complete lockdown is - to put it mildly - a unique experience. Therefore, I cannot thank enough all seven participants who made this research possible. I am sincerely grateful that all of you stayed on board until the end of the study, and helped me finish this dissertation.

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IV abstract

Urban design is an interdisciplinary and dynamic discipline with an increasing importance in our urban world. In recent years, the discipline has shown an heightened interest in gathering scientific evidence on how the urban built environment shapes human-beings. Disciplines that have been making significant progress in this area are brain sciences (psychology, cognitive science and neuroscience). There is a potential, strong link between urban design and brain sciences in regard to human-centred urban design. To investigate this link in practice, this dissertation explores how far it is possible that urban designers and brain scientists cooperate at the intersection of both fields to create more human-centred urban built environments. The dissertation has been utilising a ranking-type Delphi study to let participants who are from brain sciences and urban design, agree on a hypothetical research agenda for human-centred urban design research. We hypothesised that the higher the consensus the higher the cooperation potential for the two fields. Their consensus on the research agenda acts as a proxy that indicates if the two fields have the potential to cooperate. This is based on the assumption that pre-existing overlap of research topics is an effective parameter that indicates cooperation potential for both fields. The dissertation found that there was a slight consensus for the ranking exercise, although it was non-significant. However, in combination with supplementary data from the other rounds of the Delphi study, this indicates that cooperation potential is apparent, yet practical challenges remain (e.g. different methodology and research language). Also, there have been a range of limiting factors in regard to the Delphi method. Therefore, more research is needed to further explore the link between the two fields in practice and to establish a better knowledge base.

'If we allow discoveries in neuroscience and cognitive science to butt up against old philosophical problems […] we will see intuitions surprised and dogma routed'

(Patricia Churchland, as quoted in Zeisel (2006), p. 11)

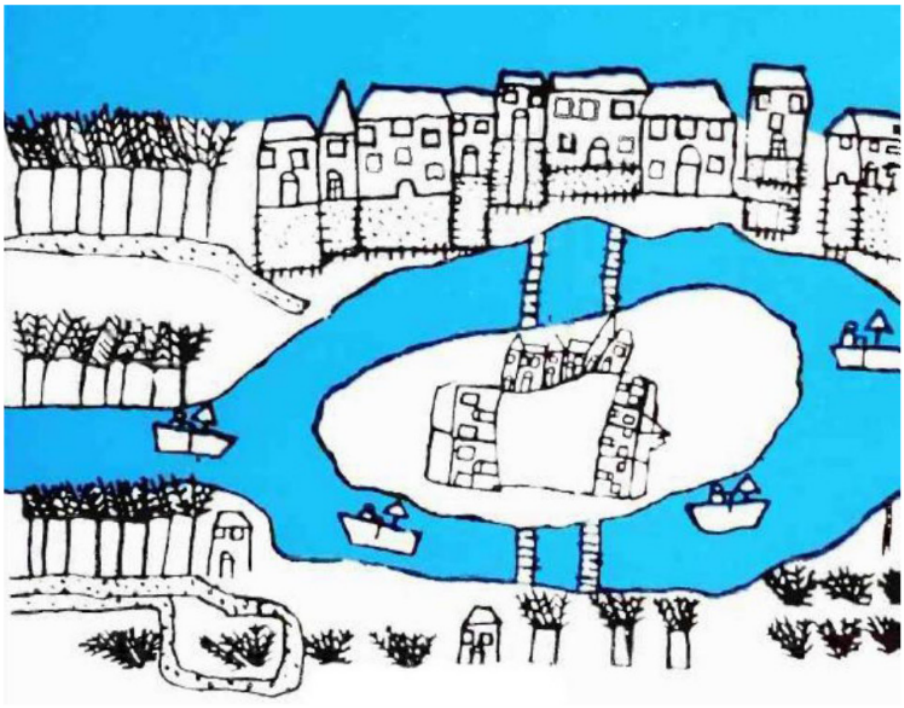


Figure 1.1: *Cover image of Kevin Lynch's 'The Image of the City'*

1 introduction

A definition of urban design

In 1956, the Dean of the Harvard Graduate School of Design, José Luis Sert, held an international conference to amalgamate evidence for a new definition of an emerging academic discipline: *urban design* (Krieger 2009). He defined urban design as "that part of city planning which deals with the physical form of the city" and its aim was "to find the common basis for the joint work of the architect, the landscape architect, and the city planner… Urban Design [being] wider than the scope of these three professions" (Sert 1956, p. 97). He concluded that urban design is practiced by all those, who are "urban-minded" (ibid.).

Sixty-two years later, urban design has evolved into a dynamic, independent and multifarious discipline beyond the scope of architecture, planning and landscape architecture. Urban design has become an integral part of the urban world - both to those who experience it and to those who practice it. A contemporary urban design definition provides the Urban Design Group (UDG) (2011):

> *"(Urban design) is the collaborative and multi-disciplinary process of shaping the physical setting for life in cities, towns and villages; the art of making places; design in an urban context. Urban design involves the design of buildings, groups of buildings, spaces and landscapes, and the establishment of frameworks and processes that facilitate successful development."*

This is by far not the only definition of urban design. A plethora of definitions with various types of emphases have been developed over the past 70 years. Some aim to encapsulate all elements urban design are concerned with, others focus on the physical realm or the process and purpose of design (Marshall & Çalişkan 2011). Yet, this also means that the field is *dynamic.* Urban design needs to reflect our fast-paced world otherwise it will not provide the solutions needed to improve our urban environments.

Hence, many ways of practising urban design exist. New paradigms emerge and supersede established ones gradually. To accommodate those changes, an integral part of any academic discipline should be to critically evaluate its current state and find solutions to improve it. Consequently, the motivation for this dissertation has been to investigate how urban design can be improved and adapted to current developments.

A new perspective - human-centred urban design

In the past years, there has been a growing debate about the scientific character of urban design. Marshall (2012) argues for example that seminal urban design theory are based on untested hypotheses or do not adhere to scientific standards. Similarily, Lampugnani (2012) calls for a new scientific revolution in urban design effectively incorporating scientific findings from other disciplines. Lastly, Batty (2013) advocates for a new science of cities which integrates urban design.

This work will adopt the same critical view and will argue that urban design could benefit from a more scientific approach. A controversial issue in urban design has always been whether it is an art or a science. Both views are valid, but this tension or indecision in the nature of urban design has meant that the discipline remained undecided about its scientific principles and has fallen short of its potential. Every academic discipline needs to uphold scientific standards and so must urban design. Therefore, this dissertation works under the assumption that urban design should strive to a be a science and therefore must live up to scientific principles.

To become more scientific, one solution is to learn from other disciplines and create synergies between urban design and those disciplines. Urban design has a rich tradition of applying and importing knowledge from other disciplines. For instance, in the early 20th century, advancements in public health have profoundly shaped basic city building principles in order to eradicate severe diseases from cities and increase its citizens' health. Other related disciplines are for example urban climatology or urban biogeography. Therefore, it seems legitimate to continue this practice and import scientific knowledge from other disciplines.

In this dissertation we will have a closer look at a discipline that has not yet often been associated with urban design: *brain sciences*. This field is actually comprised of three separate academic disciplines and their sub-disciplines: *psychology*, *cognitive science* and *neuroscience*. Psychology looks at the “science of mind and behaviour”, in a very broad sense (Merriam-Webster 2019a). Also looking at the mind side, cognitive science develops theories how human-beings perceive information, think and learn, but with an information-processing approach (Merriam-Webster 2019b). Neuroscience focuses on the “scientific study of the brain and nervous system” in a physical sense (Oxford Dictionary 2020). There are various sub-disciplines e.g. cognitive neuroscience, cognitive psychology and neuropsychology that combine different methods and theories.

One possible way to amalgamate urban design and brain sciences could be, for example, *human-centred urban design.* This term is not a set definition, but rather refers to our understanding of human needs and behaviours in the city and how we can design for those. Many scholars in urban design (e.g. Jane Jacobs and Jan Gehl amongst others) have argued that urban design needs to focus on *human-beings*. Buildings and the space between buildings should be designed in a way that it caters for human needs. Designing environments which focus on the human experience in the city have become a leading paradigm in recent years. From that perspective, one could argue that urban design ought to be a *human-centred discipline*, because urban designers put humans at the heart of our thinking about the city.

Brain sciences is also a *human-centred discipline*, because it investigates our mind and brain - it unravels what shapes human thinking and how the environment influences it. The key term here is *embodiment,* which is a crucial concept in brain sciences. Opposing the Cartesian view that our mind is separated from our body, embodiment theory has plausibly pointed out that there is a strong unity between ourselves, our body and even the environment - this is called *mind-body-environment paradigm* (Robinson 2015a). Our immediate environment influences our physical, emotional, mental and social well-being.

The issue with *human-centred urban design* research is that it only describes patterns of human behaviour in the city. This is comparable to measuring what comes out of a black box instead of understanding what happens inside. Brain sciences does the opposite: it aims to understand what happens within the black box and therefore tries to understand how individual experiences and behaviours shape human patterns in the city. Therefore, brain sciences could help us to get a more complete picture of how we interact with our environments.

The start of a new symbiosis?

University College London (UCL) is home to one of the most prestigious brain science faculties in the world. Nobel prize winner neuroscientist John O'Keefe - known for his research on place cells - has conducted research there, as well as neuroscientist Eleanor Maguire famous for her experiments on spatial cognition. One of the best built environment faculties in the world - the Bartlett - is in walking distance to the brain science research labs. Yet, a student at the Bartlett would typically never hear about the ground-breaking work that is being done across the street.

Typically means that there are exceptions and this dissertation got its inspiration from already existing work at the intersection of urban design and brain science. There are a few publications which provide practical insights for organisations to understand how humans interact with the built environment (Camargo et al. 2018). Also, there are PhD programmes that bring researchers and students from brain sciences and the built environment together to learn to understand how humans experience the world (Ecological Brain 2020). There are specialised research labs, where the impact of urban design on human psychology is studied (Urban Realities Laboratory 2020). An important milestone has also been the Minding Design symposium (2012) which brought leading neuroscientists and architects to the same table (Robinson & Pallasmaa 2015).

There has been a good deal of research in the past decade that investigates how our brain experiences the city, however most of this stems from brain science research with no or litte contribution from urban design. Essential introductory books at the intersection of urban design and brain sciences are Bernheimer (2017), Ellard (2015), Goldhagen (2017), Sussman & Hollander (2015), Mallgrave (2011, 2013), Pallasmaa (2012), Robinson & Pallasmaa (2015). This dissertation tries to tie in with the work of these authors with the general target that urban design contributes more to this research and with the underlying motivation to further explore the potential link between the two fields in practice.

Aim

As previously outlined, there is a strong potential link between urban design and brain sciences in relation to human-centred urban design, which serves as the common denominator between the two fields. Therefore, this dissertation wants to explore the question how far it is possible that urban designers and brain scientists can cooperate at the intersection of both fields to create more human-centered urban built environments. The dissertation's hypothesis is that there is a strong theoretical link between the fields when it comes to human-centred urban design and therefore potential for cooperation should also exist in practice. To investigate this claim we will utilise a ranking-type Delphi study. We let participants, who are either from brain sciences or urban design, agree on a hypothetical research agenda for human-centred urban design research. During the process, consensus between the participants will be measured. The higher the consensus the higher the cooperation potential for the two fields. Their consensus on the research agenda will act as a proxy that indicates if the two fields have the potential to cooperate. This is based on the assumption that pre-existing overlap of research topics is an effective parameter that indicates cooperation potential for both fields. Due to the time-consuming and resource-intensive requirements of a full Delphi study, this study has been set up as a pilot study.

Structure

Chapter 2 will give a brief introduction to urban design and brain sciences and draw a theoretical link between the two. In chapter 3, research question and aim, as well as the research objectives are introduced. This will be followed by chapter 4, research design, which will explain the Delphi study and how the method has been applied to the research objectives. Chapter 5 will describe how the data for the different rounds of the Delphi study was collected. Then the results of the study will be presented and discussed, as well as limitations and sources of errors demonstrated (Chapter 6). Lastly, a reflective conclusion will highlight how the dissertation's findings relate to our initial assertions (Chapter 7).

2 context

2.1 the evolution of urban design

Urban design's inter-disciplinary origins

Sert's 'being urban-minded' might seem like a loose description for what constitutes an urban designer. But he makes a point: even before the emergence of urban design as an academic discipline in the Western context, urban-minded people have been engaged with the creation of the physical form of the city[1].

The creation of ancient cities has typically not been guided by a professional urban designer in a way as we would define the role today, yet there have been sophisticated and intentionally designed cities throughout the world[2]. Only during the Renaissance and Baroque periods in Europe a new kind of professional city building would emerge bringing about change to city-making with new rules of visual order, perspectives and conceptions of space (Bacon 1976, Knox 2011).

Figure 2.1: *Pope Sixtus' urban plan for Rome (1588)*

Since then, urban designers came from a wide range of professions: *Pope Sixtus* re-shaped the urban layout of sixteenth-century Rome; *Baron Haussmann* (civil servant) was in charge of the massive overhaul of central Paris (Krieger 2009). Even classic urban design figures of the 19th and 20th century had an interdisciplinary background: *Ebenezer Howard* (1898) (economist) with his idea of garden cities as a way to integrate town and country living; *Camillo Sitte* (1898) (art historian), who called for an 'artistic renaissance' in city-making focusing on the human scale and on the other end of the spectrum, *Le Corbusier* (1987) (architect) with his utopian, modernist ideas, that would transform post-war Europe's built environment entirely.

1 see Çatalhöyük 7000 BC (Childe 1950, Mellaart 1967),
2 see Kin-Sai (Marco Polo 1299), Constantinople (Ibn Battuta 1354), Tenochtitlán (Bernal Diaz del Castillo 1521)

So even before the term 'urban design' was used more frequently the 1950s, the discipline already existed in a way through means of doing city-making throughout history (Cuthbert 2003). Therefore, contemporary urban design is rooted in a rich and interdisciplinary history that defines the field till today. As Carmona puts it, “urban design is (…) a mongrel discipline, that draws its legitimizing theories from diverse intellectual roots” (Carmona 2013, p. 2).

Urban design - science vs. art?

Urban design has seen a rising significance as an academic field and profession in the past decades (Madanipour 2006). There is a growing number of publications that describe the practice of urban design[1] (e.g. Banerjee & Loukaitou-Sideris 2011, Brown et al. 2014, Carmona 2010, Knox 2011, Knox & Ozolins 2001, Shane 2011, Watson 2003 et al.). Within a relatively short time span, urban design has evolved into a diverse field comprising an assemblage of different disciplines, methodologies, practices and theories (Cuthbert 2007, Inam 2002)[2]. The rising significance of urban design has also fuelled the debate about a definition of urban design (Krieger 2009, Rowley 1994, Schurch 1999).

Various scholars have attempted to categorise urban design theories systematically. Cuthbert (2007) for example undertook a systematic literature review of forty classic texts in urban design, from which he created three major 'theory categories'[3]: 1. reflective-descriptive synthesis urban design in the past 2. specific perspectives on urban-design related topics 3. primary urban design theory. Other scholars proposed slightly different definition categories: substantial, procedural and normative theories (see Faludi 1973, Marshall 2012, Taylor 1980). Yet, despite the attempts to structure and synthesise urban design theory, Cuthbert (2003, p. 177) comments that urban design theory remains “anarchistic, disjointed, dependent and cultish”.

A simple and effective framework is provided by Vernez-Moudon (1992). She argues that urban design has never resolved the problem whether it is an art or a science and that it has always drifted between a *normative-prescriptive* ('what should be') and a *substantive-descriptive* ('what is and why') approach (see Figure 2.2). Those two poles are opposite conceptual (ibid.).

1 for a comprehensive list see Krieger (2013)
2 a complete overview over the evolution of urban design theory is provided by Cuthbert (2007)
3 for the categories and the full list see Cuthbert (2003, p. 11)

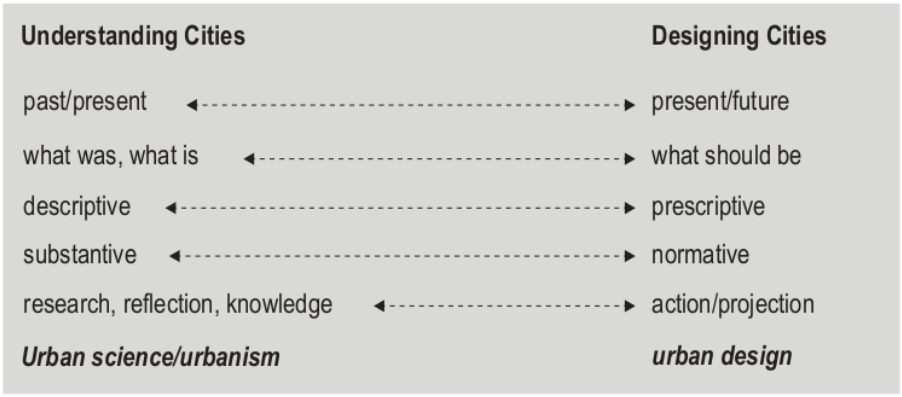


Figure 2.2: *Substantive-descriptive vs. normative-prescriptive approach (based on Moudon Vernez-Moudon 1992)*

The 'science' of urban design

Vernez-Moudon's analysis falls in line with what many other scholars argue: that urban design theories mainly consist of normative theories with little scientific merit. Cuthbert (2007) for example criticises, that many theories are scientifically true, yet they are only trivially correct in a sense that they show low levels of refutability after Karl Poppers philosophy of science[1]. He adds that, “as propositions they are useless in establishing a theoretical domain of any real content” (ibid., p. 12).

Furthermore, Vernez-Moudon (1992, p. 334) points out “that many normative theories use research to justify or substantiate a priori beliefs", when, in fact the reverse should take place, and research results should be interpreted to develop theories”. This exemplifies the serious scientific limitations of normative theories.

Marshall (2012) refers to urban design as a *pseudo-science* as often-cited and influential urban design theories lack robust, scientific grounding. He proves this claim by scrutinizing four major contributions to urban design theory (Alexander, Lynch, Cullen and Jacobs) by testing the scientific soundness of each hypothesis. He finds that the different hypotheses were to some extent not properly verified and that the basic scientific principle of systematic scrutiny has failed (ibid.). Cuthbert (2007, p. 178) describes this issue as followed: “Urban design is self-referential and is neither informed by, nor committed to, any external authority in intellectual terms”. Marshall (2012, p. 264) concludes that urban design is based on a “foundation of untested hypotheses”.

To sum up, we can argue that urban design needs to pay more attention to the substantive side of research. For urban design to become more scientific, Marshall (2012) proposes to either import knowledge from other disciplines or urban design develops own scientific theories. Furthermore, normative theories and scientific research need to be clearly separated from each other during the research process (Vernez-Moudon 1992).

1 For more information on scientific principles see Popper (1958)

2.2 human-centred urban design

A different urban design paradigm

In 1987, *Allan Jacobs* and *Donald Appleyard* wrote an urban design manifesto that offered an alternative to the modernist urban design paradigm of the 60s and 70s. It revealed how modernist planning led to the dehumanization of the built environment and a neglection of urban life (Larice & Macdonald 2007). They proposed principles such as liveable streets and neighbourhoods, and an increased focus on public space.

Even before, *Jane Jacobs* (1961) exposed how the physical form can influence people's lives. She criticised how post-war modernist policies neglected the local context in which people were living at that time. One must gather empirical knowledge about the local context first to better understand people's social lives before changes are made to the urban structure.

Jacobs was influenced in her position by urbanist *William H. Whyte* (1980), who observed people's behaviour in public spaces to understand which urban design elements attracted people or chased them away (Goldhagen 2017).

This observational work has been extended by *Jan Gehl* in the past two decades. His work focuses on identifying the urban elements that create a human-scaled experience of the city (Gehl 2010, 2011). In his observational studies he investigated, for example, the effects of facades onto people and how they provide an important link between large and small urban scale (Gehl 2006).

From human patterns to individual experiences

Figure 2.3: *Observing people as a method*

Jacobs, Whyte and Gehl's observational work highlights how the built environment shapes *human patterns* in the city. Urban environments are actually complex and chaotic systems with a myriad of *individual actions* happening simultaneously (Batty 2012). This makes it difficult to understand cities in their entirety (Batty 1980, Rittel & Webber 1973). However, many chaotic actions performed collectively create regular patterns (Galton 1889). Observational methods can reveal patterns of behaviour in chaotic urban systems. Yet, they fail to address the *individual level* or how we as individuals experience the built environment (Goldhagen 2017).

One of the first scholars investigating individual human experiences in the city was *Kevin Lynch* (1960). He argued that cities have a public image collectively held by its citizens. Lynch put those images in five different categories: landmarks, edges, paths, nodes and districts. People use those five elements to create an internal cognitive map of a city for navigational purposes. Lynch's work is one of the most influential urban design theories to date, although it has been criticised that his elements were not based on any scientific evidence, but rather on a priori beliefs (see Marshall 2012).

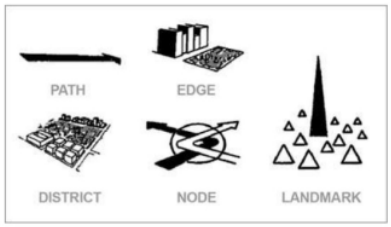


Figure 2.4: *Lynch's five elements*

Later, *Christopher Alexander* (1977) researched individuals and their living environments. He and his colleagues attempted to build up a database of timeless entities ('patterns') to form a universal human 'pattern language' of the built environment.

Probably closest to a scientific approach was *Amos Rappoport's* work (1977). He investigated people's perception of the city and how urban form shapes people. In his work he especially examined the correlation between urban configurations and human behaviour or satisfaction.

Recently, urban designers started gathering evidence from other disciplines to reveal how the built environment interacts with our minds. *Charles Montgomery* (2013) for example proposes that cities should be designed based on the premise that they increase people's happiness and well-being.

Daniele Quercia (2014) uses digital techniques (crowdsourcing) to capture what people think about places. He for example applied this method to identify the most emotionally pleasant routes in central London (ibid.).

Another approach is place value research spearheaded by *Matthew Carmona* (2019). He defines place value as "the diverse forms of value generated as a consequence of how places are shaped" (ibid, p. 3). Places are shaped through by a range of factors e.g. health, society and economy, which are affected by place and vice versa.

In the next section we will explore how human-centred urban design is the link between urban design and brain sciences.

What comes next?

Human-centred urban design is a collective term for the various attempts to explore the relationship between human-beings and the built environment and how to design for it.

Many urban design theories use observational and descriptive methods to describe *human patterns* in the city. Instead of merely *describing* patterns, we should focus on understanding what creates those patterns. A range of scholars have tried to examine people's *individual experiences* in cities by exploring this, for example, with psychological methods. Understanding this *individual level* might help to get a more complete picture of the urban environment.

In the past, there have been a few examples of urban design research at the individual level. Yet, this research has been done in a piecemeal kind of fashion, unsystematic and very often unscientific. Instead, urban design needs a research agenda, that does the opposite. One way to do this, is utilising the interdisciplinary support from other scientific disciplines (see Marshall 2012). The aim of such research agenda could be to better understand how we experience urban environments as individuals. Therefore, we need to go where our our senses and perceptions are processed - in different parts of our *brain* (see Figure 2.5).

In 2019, the Urban Design Group invited *Kate Jeffery* - a professor of behavioural neuroscience at UCL - to talk about Kevin Lynch's findings and how they relate to neuroscience research (Bartlett School of Planning 2019). Her lab investigates which environmental information cells use to form their map of space (UCL Department of Experimental Psychology 2020). Although Jefferey never heard of Lynch before, she confirmed that his findings were by majority in line with the scientific findings in the brain sciences community. Much of the work she referred to was done by a group of neuroscientists and Nobel prize winners around Edvard Moser, May-Britt Moser and John O'Keefe (as cited in Goldhagen 2017, Fyhn et al. 2004, Moser et al. 2008, 2014).

The next section will try to expose more links and outline how findings in brain sciences have paved the way for a new understanding of how we as human-beings experience the built environment.

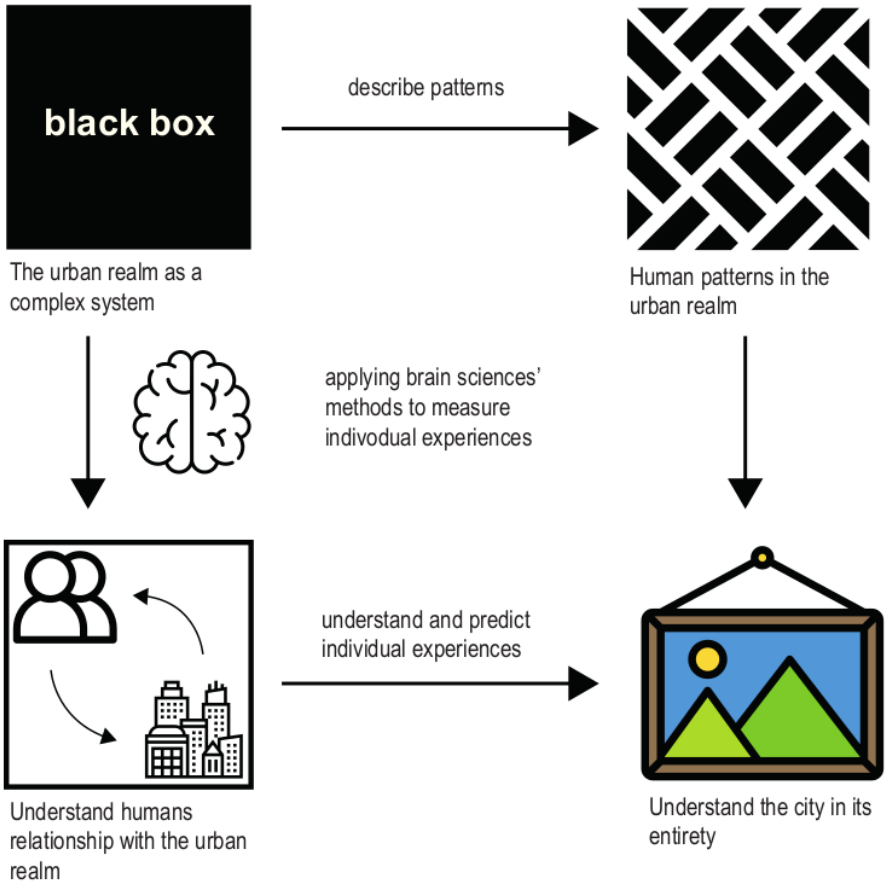


Figure 2.5: *Individual experiences vs. patterns*

2.3 brain sciences and urban design

A scientific revolution

Architectural history is rich in attempts to comprehend our individual experience of the built environment in an empathetic, sensual and perceptive manner (Mallgrave 2013, 2015). A famous example is the Garden City of Hellerau, where intellectuals - amongst them architects and urban designers like Ebenezer Howard & Le Corbusier - of the early 20th century gathered to partake in a musical and dance education program designed by Émile Jaques-Dalcroze (ibid.). The principles of the program were based on the hypothesis that the movements of the body need to be aligned with the neural activities of the brain, to induce a coordination between the mind, the brain and the muscles (Jaques-Dalcroze 1939). This was the precursor of our contemporary understanding of embodiment.

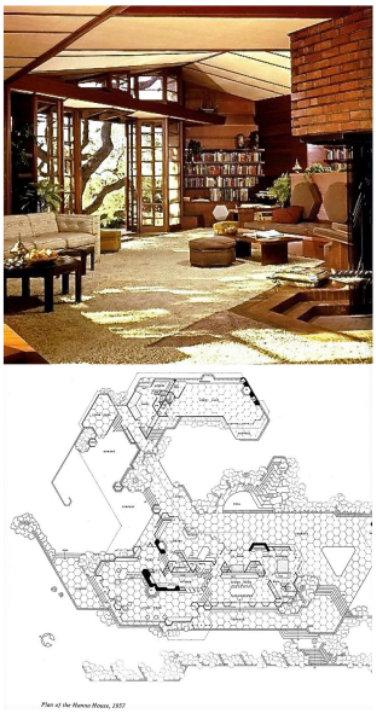


Figure 2.6: *Lloyds's Hanna House (1936) is based on a hexagonal grid to mimic natural forms*

This knowledge and spirit were lost as the result of two wars and was superseded by modernism in the post war era. Only a few architects continued to focus on embodied thinking and the application of cognitive science and neuroscience in the architectural world (Robinson 2015a): Frank Lloyd Wright and Richard Neutra (see Figure 2.6). Although much scientific progress has been made in those disciplines, "architects have remained surprisingly incurious or seem little moved by these events" (Mallgrave 2015, p. 18).

In the past decade, a multitude of experts have confirmed that the built and natural environment shapes our mental, physical, cultural and social world significantly and brain scientists are revolutionizing this knowledge (Robinson 2015a).

The notion of *embodiment* (Barsalou 2008, Hart 1996), meaning that our body inhabits our environment and this influences human cognition (*mind-body-environment*

paradigm) - as opposed to the *cartesian dualism* - has for example been empirically underpinned by the discovery of *mirror neurons* (as cited in Mallgrave 2013, Rizzolatti et al. 2004, 2006).

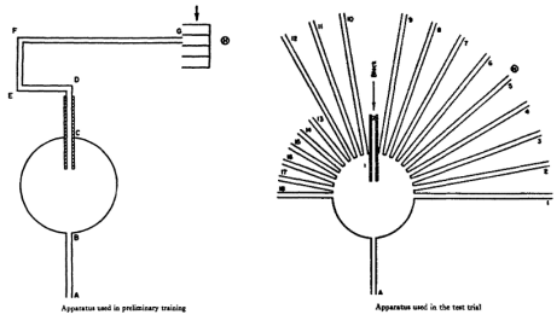


Figure 2.7: *Tolman's experiment with mice*

Advancements have also been made in our understanding of how *aesthetic experience*s are processed in the brain (Mallgrave 2013). Findings in *evolutionary biology* have shown that our perception of the environment is based on patterns developed over millions of years in the human brain. Lastly, the field of *spatial cognition* has contributed to better understand brain mechanisms involved in navigating through complex environments. The 1948 published paper 'Cognitive Maps in Rats and Men' by Tolman initiated a cascade of research in this field. His experiment with rats in mazes led him to the conclusion that animals form *mental maps* of their environment (Figure 2.7). Later, this was also found to be true for humans (O'Keefe & Nadel 1978).

Researchers have increasingly applied this knowledge to urban design research. A good example is *Colin Ellard's* research. In his Urban Realities lab at the University of Waterloo he investigates the impact of urban design on human psychology with, for example, virtual reality to test predictions about urban behaviour in simulations. Good introductions to this research provide Bernheimer (2017), Goldhagen (2017) and Ellard (2015).

The following section will give a more in-depth overview in the four areas *embodiment*, *neuroaesthetics*, *evolutionary biology* and s*patial cognition*.

Embodiment

As one of the first advocates of *embodiment theory,* Dewey (1934) argued that all living creatures are closely inter-connected with their environments. Johnson (2015, p. 35) describes this phenomenon as such that "the key to appreciating the central role of the aesthetic dimension for all human experience is recognising that everything important arises from the ongoing interactions of a living creature with its complex environments".

This idea has been elaborated by Barsalou (1999) and his *perceptual symbol system theory.* Human-beings create a meaning of an object by the possible experiences it affords to us. Those representations are multi-modal: visual, sensorimotor, gustatory, or olfactory (ibid.). For example, a bicycle not only contains a visual image of the bicycle, but also the experience of riding it (e.g. feeling the wind).

Figure 2.8: *National Aquatic Centre in Beijing, China. Bubbles as a metaphor for water?*

Barsalou's theory was essentially influenced by Gibson's idea of perceptual *affordances* (1979). Patterns and structures in the environment provide possibilities of experiences (*affordances)*, that interact with our body and mind. Seeing a cup will not only activate our visually perceptive areas of the brain. On a cognitive level a multi-sensory simulation of the cup and what we can do with the cup is taking place which is referred to as *embodied simulation* (Damasio 2000, 2010) or *schema* (Arbib 1989). On a neuronal level the simulation happens because *mirror neurons* (Gallese & Lakoff 2005) fire in certain areas of our brain. We experience a multi-sensory simulation of the action (picking up the cup) even though the physical action is not executed. Another kind of concept worth mentioning are *embodied metaphors* (Lakoff & Johnson 1980). Being a special kind of schema, metaphors create a multitude of associative and non-logical cognitions. They work in a way that familiar and concrete things we know are abstracted to convey other notions, feelings and ideas (Figure 2.8) (Goldhagen 2015).

Which implications does embodiment have for urban design? Most importantly, we need to acknowledge that our mind does not end with our brain. Our environment

shapes and defines our thinking (Pérez-Gómez 2015). When we visually see something, our brain activates a multitude of unconcious processes that ultimately influence our concious actions.

We tend to focus a lot on the concious aspects of the built environment - functionalism, technical details and the economical aspects of the built environment. Yet, architecture is also "constructed mental space" (Petäjä, personal communication with Pallasmaa 2015).

Hence, the built environment is a multi-sensory experience with a direct effect on our feelings (Niedenthal 2007, Niedenthal et al. 2005). The physical expression of those arousing emotions can be quantified by psychophysiological measures (Bach et al. 2016, Felber 2020). This allows us to draw conclusions about psychological processes. Common methods are electrocardiogram (ECG), measuring heart period and electrodermal activity measuring sweat production[1] (Felber 2020). Through embodied simulation those feelings can also be invoked in participants through virtual and augmented reality as described by Ellard (2015).

[1] certain paramaters indicate stress in participants

Neuroaesthetics

The origins of the scientific understanding of art go back to psycho-physicist *Gustav Fechner* (1860, 1876) who proposed the idea of *experimental aesthetic*s. In his experiments he calculated correlations between the value of a sensory stimulus and its psychological effects (ibid.). His works were very influential for the Gestalt theory and the Weimar Bauhaus. It also defined modern *neuroaesthetics* (see Mallgrave 2013). The aim of *neuroaesthetics* is to understand how artists tap into the fundamental properties of the (visual) brain.

It has been the desire of many other scholars to understand the difference between an ordinary visual experience and an aesthetic one. Zeki (1999) for example argues that the artist is an extension of the visual brain. There is a functional parallel between what the artist does (to us) and the visual brain does (for us). The artist works in accordance with the architecture of the visual brain and therefore artists seem to specialize in certain visual domains, producing super-stimuli for specific circuits.

Ramachandran and Hirstein (1999) were also investigating the question if the visual arts have universal rules and if they are linked to any neurological processes. Their (slightly ambiguous) argument was that firstly art is particularly pleasing because it represents an enhanced version of reality and secondly that it challenges our mind. They proposed eight laws of aesthetic experience which artists use to titillate the brain.

Kawabata & Zeki (2003) investigated the *neural correlates of beauty.* With their experiment they were able to identify certain areas in the brain (mostly related to pleasure) because they were activated when something was aesthetically pleasing.

Freedberg (art historian) and Gallese (neuroscientist) (2007) came up with the idea that the experience of art and architecture involves the mirror-neuron system that simulates actions, emotions and sensations (see also Umiltà et al. 2012). By looking at art or a sculpture we can read "the visible traces of the artist's creative gestures" (Freedberg & Gallese 2007, p. 199).

Although the theoretical based of those theories have been developed in relation to art, in recent years researchers have connected this to urban design research. As evidence suggests that our brain is tuned to certain patterns and forms (Mallgrave 2015), there is a patchwork of studies that have put this in relation to our built environment. For example, research has found that certain shapes - preferably round shapes rather

than sharp edges - our brain recognises faster because they are pleasant to us (Potter 1969). Furthermore, humans react to urban environments which are sharp, irregular and angled forms with discomfort and fear (Ghamari et al. 2014, Vartanian et al. 2011). Also, certain colours can create anxieties in us for example red (Sternberg 2009). Human-beings are also attuned to a set of compositional schemas called 'geons'. Those are basic geometric forms (e.g. a cube) that the brain can relatively easy and is independent of cultural settings (Biederman 2001).

evolutionary biology

Figure 2.9: *A savannah landscape*

Our pre-human, hominin ancestors appeared around 2 - 2.5 million years ago and homo sapiens 'only' about 315,000 years ago (Tattersall 2020). A fraction of this time (6000 years) we have lived in urban settlements, and an even shorter time in modern urban settlements (ca. 150 years). Much of our sense of aesthetics and responses to our environment seem to be rooted in our brains evolving over millennia (Sussman & Hollander 2015). Like every other being on earth, humans have a certain preference for their habitat (see Appleton 1975). This implies that if we understand human-beings in a more Darwinistic sense, we might also be able to adjust our urban environments to our actual, biological needs. Our brain is attuned to ancient and primal behaviours and "our perceptual systems are designed to register aspects of the external world that were important to our survival..." (Pinker 2013, p. 199). However, not everything can be simply explained by evolutionary psychology (Confer et al. 2010).

Yet for a range of areas clear substantive evidence has been found. For example, the idea of biophilia goes back to the biologist *E. O. Wilson* (1984) who was convinced that the environment of our hunter-gatherer ancestors (e.g. grassy plains with scattered trees) has transcribed into our DNA (Falk & Balling 2009). Statistically, human-beings gravitate to living environments, where they are on a height looking down, situated in a savanna-like terrain and close to a body of water (Kellert & Wilson 1993).

Nature deprived areas drain our cognitive resources more than natural environments ('attention restoration theory') (Kaplan & Kaplan 1989) and there is evidence that nature has a restorative effects on our body, even if it is only depicted on an image (Heerwagen 1990, Ulrich 2002).

The question is why natural elements have this effect on us. Some argue that our brain got attuned to a certain visual complexity that only natural elements like trees or a Romanesco broccoli provides, which is called fractal geometry (see Figure 2.10). Fractals are "repeating patterns of expanding symmetry, replicating the same form

Figure 2.10: *Fractal geometry in a Romanesco broccoli*

at different levels" (Bernheimer 2017, p. 119). Because our pre-modern world was dominated by fractal geometry, our brain prefers fractal geometry over straight lines and edges.

Research has also shown that people avoid walking in wide, open spaces and rather stick to the sides of the street (Kallai et al. 2007). This is referred to as thigmotaxis, which means 'wall-hugging'. In line with Appleton's human habitat selection theory, thigmotaxis can be explained by human-beings' urge "to see and not to be seen" in order to survive ('prospect refuge theory') (Ellard 2015, p.33).

Many of our aesthetic preferences are based on evolution. Although we are multi-sensory beings, our visual sense is still our most advanced (Kandel 2012). Our brain devotes large parts of its capacity to face recognition (ibid.) so that we even recognise faces in buildings ('pareidolia') (Chalup et al. 2010). Gehl (2010) argues that this is an important trait that makes human-scales public spaces successful.

spatial cognition

Spatial cognition describes our ability to receive and process information about our surroundings in order to understand and use space optimally (Burgess 2008, Jeffery 2019).

There is a strong link between our spatial cognition and certain parts of our brain. Maguire et al. (2000) for example found that there is a correlation between the size of certain parts of the hippocampus and navigational expertise as taxi drivers have slightly larger hippocampal structures than the average human-being.

Our brain has spatial cognition modes: *egocentric spatial cognition* - everything in relation to our body - and *allocentric spatial cognition* - everything relative to our outside world (Proulx et al. 2016). Another mode is the *learning of routes* (Hartley et al. 2003). In different situations people will make use of any one of those three navigation systems.

Another essential discovery were *place cells* (Moser et al. 2008, O'Keefe & Nadel 1978). Those cells are activated if someone is in a certain (geographic) position which then creates a cognitive map in our brains. In 1984, Ranck discovered *head direction cells*, which fire when a rat faces in a certain direction and can therefore act as a *cognitive compass.* Those cells constantly update their sense of direction through certain environmental features (landmarks)[1] and help our brain to orient itself in a three-dimensional environment (Jeffery et al. 1997). This has strong implications for our *sense of place.* Urban environments need to be designed in a way that one can easily establish a sense of place by landmarks and path integration (Jeffery 2019) (Figure 2.12).

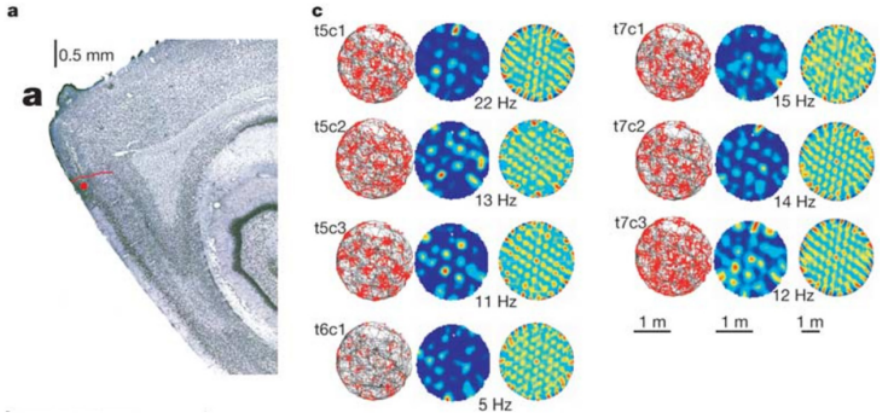


Figure 2.11: *Grid cells in rats*

1 The similarity to Lynch (1960) is striking

Hafting et al. (2015) discovered special cells for navigation which are arranged in triangular and hexagonal patterns (*grid cells)*. The layout of those cells suggests that spatial navigation in rodents works by triangulating their body with two other points (Goldhagen 2017).

In recent years, research has also shown that spatial cognition is connected to emotion processing systems. This allows our brain to detect and memorise unpleasant places (Chaaya, Battle & Johnson 2018). Our brain also associates positive feelings with places (De Lavilléon et al 2013). Curiosity, exploration and territoriality are all traits that are influenced by spatial cognition (Cipriani et al 2014, Kumaran et al. 2016). Research also suggests that our brain can switch in a threat-induced escape mode triggering a spatial cognition part based on rapid, instinctive decision-making (Evans et el. 2018). Because of the strong link between spatial cognition and emotions, design of spaces needs to be shaped in a way that they reduce spatial unease (Jeffery 2019).

In the future, research might make more use of new technologies to gather data from the internet. This has already been demonstrated by Dr Hugo Spiers and the app Sea Hero Quest, where millions of users play an online fishing game generating data about their spatial navigation capabilities (UCL 2020).

Figure 2.12: *Piccadily Circus - no path integration and landmarks makes it hard for the brain to navigate*

3 research question and objectives

Motivation

The underlying motivation for this dissertation is to investigate the strong potential link between *urban design* and *brain science,* that exists in theory, by further investigating this connection in practice[1]. As outlined earlier, brain science and urban design have a common denominator, which is *human-centred urban design*.

Urban design could benefit from brain sciences' scientific approach to better understand the human relationship with the built environment. There are existing research findings at the intersection of both field, however they need to be further disseminated and elaborated. The idea is to establish a permanent cooperation between the to fields and utilise synergies between them.

Research question

This dissertation wants to investigate following research question:

> *How far is it possible that urban designers and brain scientists could cooperate at the intersection of both fields to create more human-centred urban built environments?*

Hypothesis

This dissertation's hypothesis is that there is a strong link between the fields when it comes to human-centred urban design and a potential for cooperation between the two fields exists in practice.

1 The two terms are used as blanket terms and represent mere simplification for research purposes. In our case, 'brain sciences' is defined as 'psychology, cognitive science, cognitive neuroscience and neuroscience'. 'Urban design' is defined as 'urban design, urban planning, architecture and engineering'.

Aim

The aim of the dissertation will be to investigate if a potential for cooperation between the two fields exists in practice. The study will draw on the *Delphi technique* and will utilise a *ranking-type Delphi study.* In this method, a panel of brain science and urban designer researchers will be asked to agree on a hypothetical research agenda for human-centred urban design research. During the process, consensus between the participants will be measured. The higher the consensus the higher the potential for cooperation between the two fields.

The technique will not only allow us to meet the research aim, but also act as an exercise to bring the two disciplines to the same table. This in itself has the potential to stimulate cooperation between the two fields.

Research objectives

The study will be split in different parts providing us with different data. This data will be of value on its own, yet ultimately contributing to answering the research question.

Following research objectives have been agreed upon:

1. Identify research topics at the intersection of both fields
2. Measure consensus between the two fields ("cooperation potential")
3. Investigate how the fields perceive each other and if they see potential in cooperation

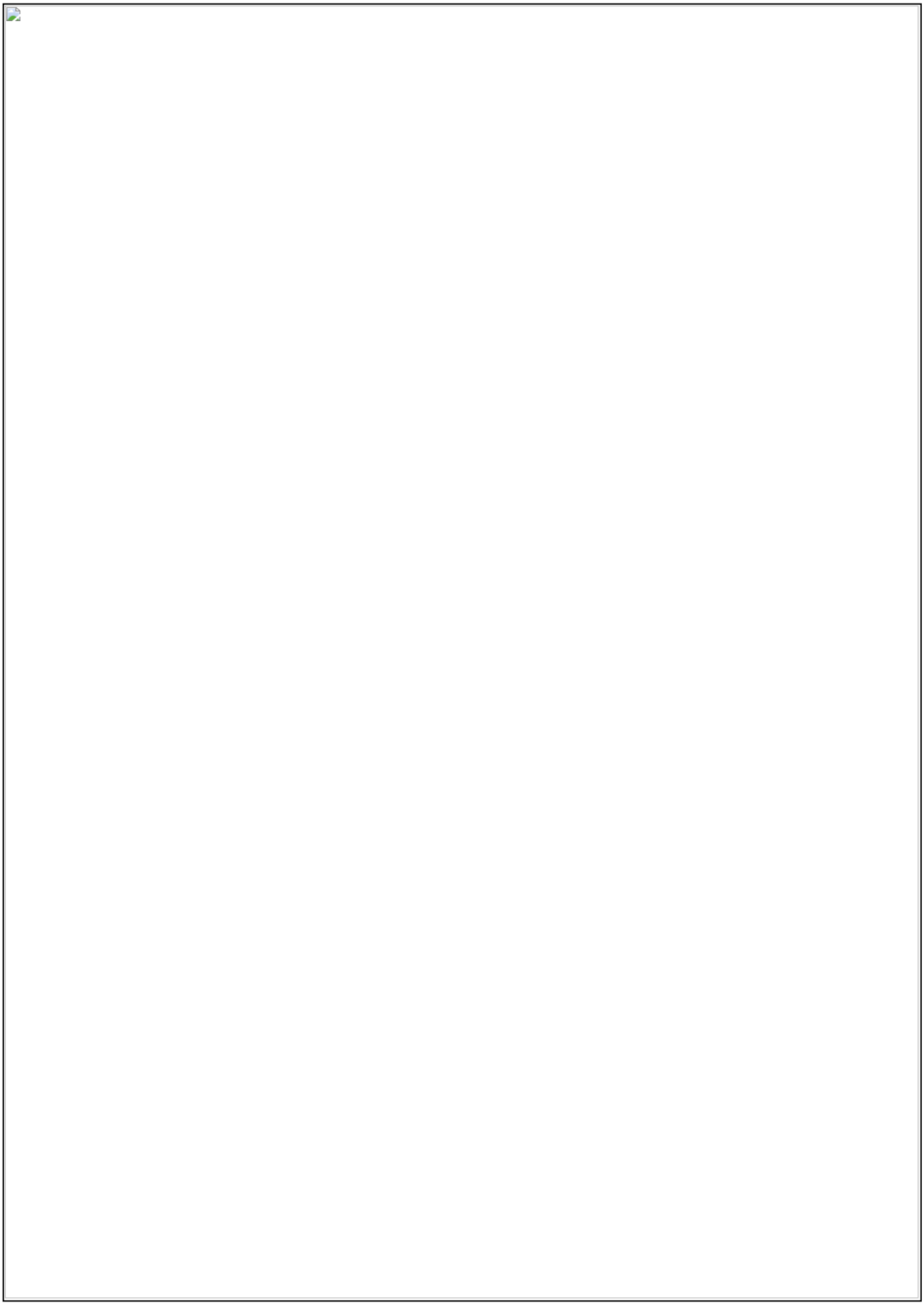
The details of the research objectives and how they translate into the research design, will be discussed in the next chapter.

Character of study

There is a range of existing methods to measure the potential of cooperation between two disciplines. Much of it falls under the category of measuring interdisciplinary research (based on Prager et al. 2015, Wang & Schneider 2018):

- scientometric approaches (mostly statistical methods)
- traditional surveys
- expert interviews

In this sense, the Delphi technique has not been much explored yet as a method to measure cooperation potential between two disciplines. As comparable studies have not been conducted yet, this study is exploratory in nature. Therefore, this study is set up as a pilot study. Hence, sample size is much reduced compared to other Delphi studies and the research design has been adjusted. This will also cater for the fact that a complete Delphi study would exceed the scope of a master's dissertation. Therefore, the results can only indicate trends.



Ranking-type delphi study

Ranking-type Delphi studies are commonly used to generate ideas from a knowledgeable pool of experts 'to explore areas where controversy, debate or a lack of clarity and to check if those experts can reach consensus for those ideas' (Iqbal & Pipon-Young 2009, p. 598). They have been developed to measure consent or diversity of opinions amongst a group (Schmidt 1997).

In this dissertation we will utilise the ranking-type Delphi technique to generate research topics amongst two homogenous group of brain scientists and urban designers in one panel.

The method seemed suitable for this dissertation because it is the most effective technique to measure consensus between participants' opinions. Furthermore, it produces multiple sets of data and utilises both qualitative (e.g. generating research topics) and quantitative methods (e.g. ranking research topics). The Delphi technique can also been used to measure convergence between two fields, which we will also be making use of in this dissertation (Jones 2002).

4.2 aim of study

The dissertation wants to investigate the question how far it is possible that urban designers and brain scientists cooperate at the intersection of both fields to create more human-centered urban design. The aim of the Delphi study is to compare their research topics generated during the task and measure consensus between them with Kendall's *W.*

For this research, a slightly modulated version of the ranking-type Delphi study will be used. The primary goal of the study will not be to reach consensus by multiple reiterated rounds in the end. It therefore is not an exercise where participants change their opinion by being exposed to other participants' arguments. Instead, we want to measure the *status quo* or rather how similar (or diverging) their research topics are and use this as a proxy that indicates if the two fields have the potential to cooperate. We assume that the pre-existing overlap of research topics is a good parameter for the capability of two research fields to cooperate.

In this study, they will rank a list of research topics generated by both urban designers and brain scientists, which will be based on following question:

> *Coming from your discipline (urban design or brain sciences), which (research) topics have most potential to create more human-centered built environments?*

The question has been crafted carefully to ensure that the study will produce the desired output. Figure 4.1 explains the reasoning behind the question:

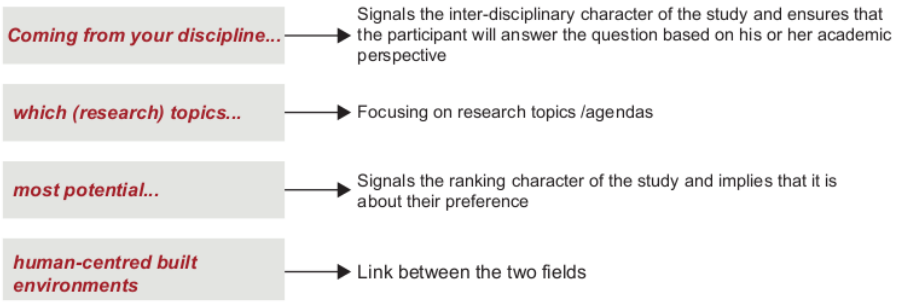


Figure 4.1: *The study question explained*

4.3 research design

This Delphi study uses previous studies as a point of reference. The general structure has partly been adopted from Okoli and Pawlowski (2004). For the statistical part, a ranking-type Delphi method by Schmidt (1997) has been utilised.

The reason why those reference studies have been chosen is that they resonate well with the desired research outputs and the method is suitable to produce the required results (especially output 1 & 2). However, a few steps have been modified to cater for output 3.

Figure 4.2 provides a general overview over the research design showing the research objectives, required outputs, the reference study and the Delphi study for this dissertation.

Furthermore, Figure 4.3 compares the dissertation's general research structure with the reference study in detail.

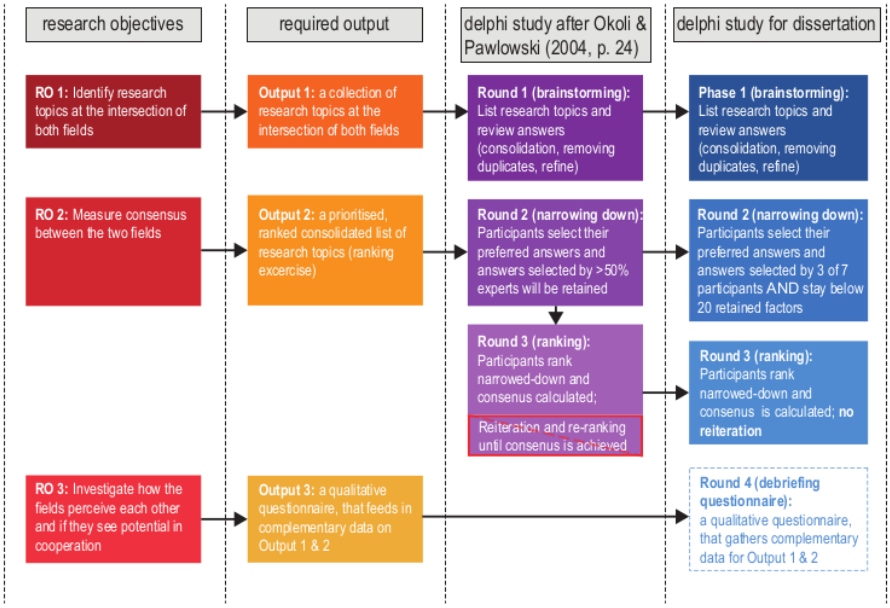


Figure 4.2: *Research design framework*

	Okoli & Pawlowski (2004)	Dissertation
Panel size	• 10 - 18 participants • multiple panels	• eight participants • one panel
Participant selection	• knowledge resource nomination worksheet (KRNW) helps to categorise the experts • ranks experts based on their qualification • invites experts via e-mail	• similar selection approach • candidates' database with qualifications • only researchers with PhD • invite experts via-email
Questionnaires	• sent by e-mail, fax or web	• sent by e-mail (pdf) and Google forms
Timeframe	• six questionnaires (15 mins each) over a period of 1-3 months	• five questionnaires (15 mins each) over a period of 3-5 months
Rounds	• *questionnaire 1:* experts list relevant factors • review/consolidation • *questionnaire 2:* experts validate consolidated list **Round 2 (Narrowing down):** • *questionnaire 3:* each expert selects ten factors on each list • retain factors selected by over 50% of experts **Round 3 (Ranking):** • experts rank factors on each of their panel's narrowed down lists • assess consensus (Kendall's *W*) • if no consensus is reached, share feedback and rank again	**Round 1 (Brainstorming):** • *same approach* **Round 2 (Narrowing down):** • *questionnaire 3:* each expert selects at least ten topics **on the same** list • retain topics selected by 3 of 7 experts **AND** stay below 20 retained topics **Round 3 (Ranking):** • experts rank topics on the consolidated list • assess consensus (Kendall's *W*) • no feedback / reiteration process **Round 4 (Debriefing):** • a qualitative debriefing questionnaire

Figure 4.3: *Comparison between Delphi methods*

5 data collection

5.1 research timeframe

The study has been taken place over a time period of 4.5 months from mid-January to end of May 2020. The data collection process has been split in six steps as shown on Figure 5.1 on a timeline:

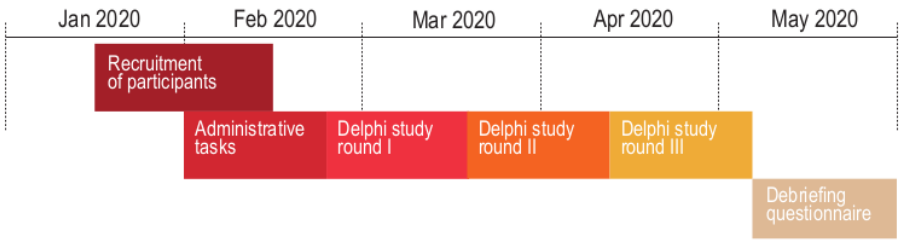
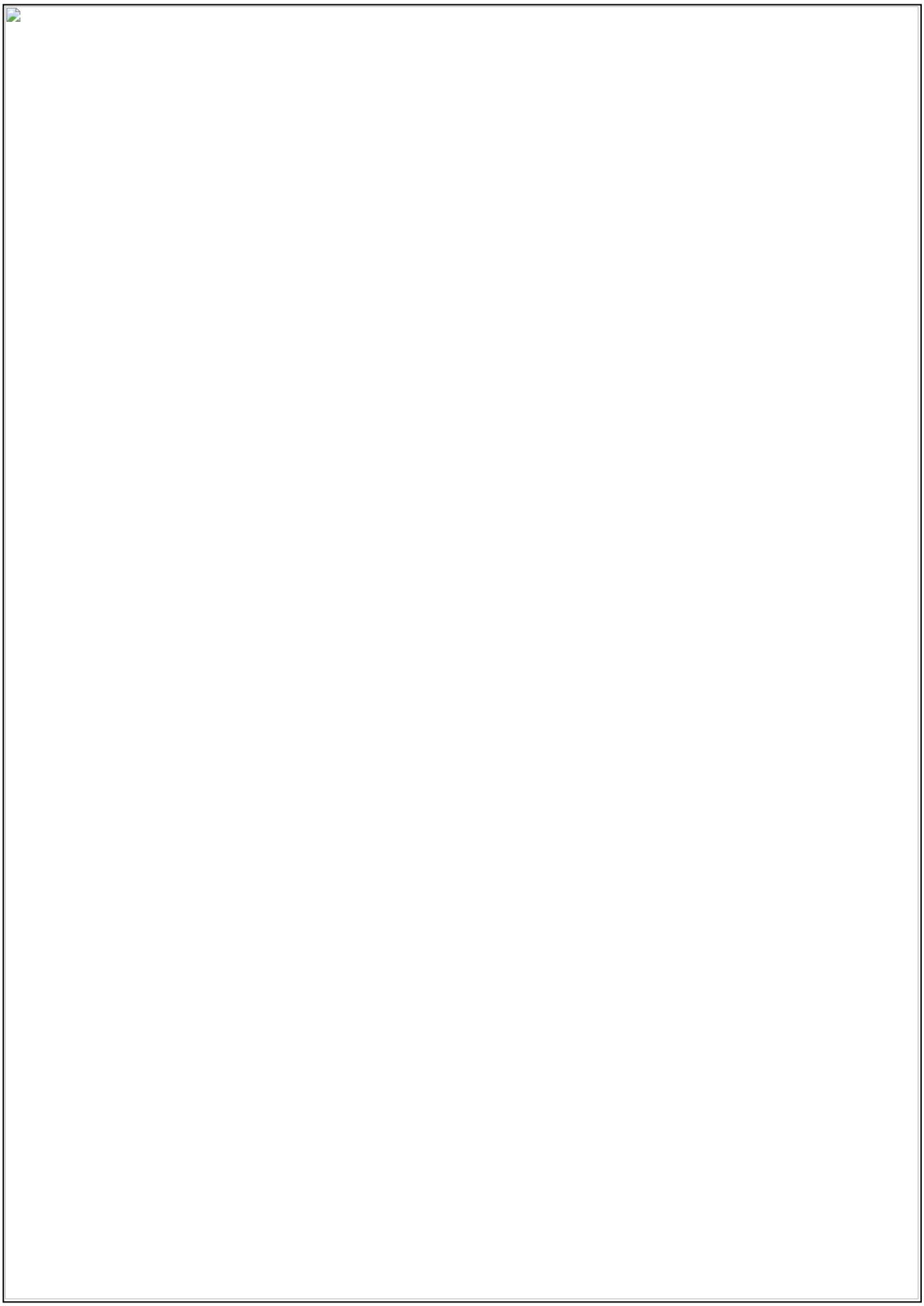


Figure 5.1: *Research timeframe*

Note on COVID 19

The majority of the research has been undertaken during the COVID-19 pandemic. Overall, the pandemic delayed the study around two to four weeks as participants were replying slower than usual. However, none of them dropped out and all seven participants gave formal consent to continue the study as usual. Therefore, the impact of the pandemic on the study was mild. This is due to the fact that all participants fulfilled their responsibilities dutifully despite the difficult situation and the fact that the study was fully online.



Identifying suitable candidates

Suitable candidates were identified based on following methods:

Method 1

Research institutes were identified based on their curriculum and research focus through online research. Some institutes were also picked because they were mentioned in research literature.

For **urban design**, following schools were considered:

- Bartlett School of Planning at University College London (UCL)
- Centre for Transport Studies at University College London (UCL)
- London School of Economics (LSE)
- Oxford Brookes University

For **brain sciences**, following schools were considered:

- Faculty of Brain Sciences at University College London (UCL)
- Max-Planck-Institute (MPI) for Human Cognitive and Brain Sciences in Leipzig, Germany
- Department of Psychology at University of Waterloo in Ontario, Canada

An e-mail was sent out to research lab staff, faculty offices or administrative staff to either share a generic e-mail with PhD students or to refer to PhD students to contact. Sometimes, online lists of current PhD projects also helped to identify suitable candidates. Unfortunately, the response rate for this approach was low.

Method 2

Therefore, a second approach was put in place, which utilised personal networks and referrals from other researchers. Already existing contacts in the wider UCL network and other professional contacts to other universities through acquaintances allowed to establish e-mail contact to suitable candidates. Personalised e-mails, sometimes with an introduction through another person, had the highest response rate.

Contacting via e-mail

If a candidate fulfilled all criteria, they were contacted via either one of the previously explained methods. Recipients were given a short description of the project and the title of the thesis. They were also given the time commitment and an overview of the study timeframe. Figure 5.3 provides an overview of the contacting process and response rates.

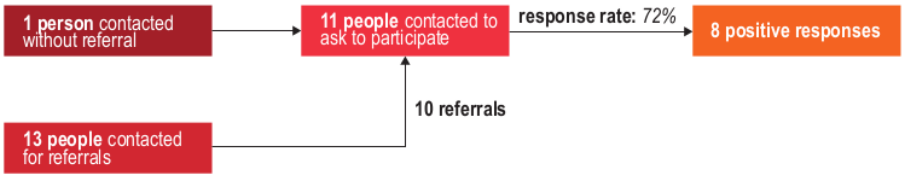


Figure 5.3: *Responses from contacted candidates*

5.3 administrative tasks

The aim of this step was to complete a range of administrative tasks before the actual study commenced. The following section will explain those in detail.

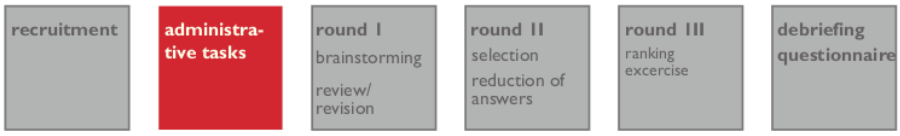


Figure 5.4: *Timeline - administrative tasks*

Participant information sheet

After candidates agreed to participate in the study via e-mail, a *participant information sheet* was sent to the participants which provided participants with all relevant information for the study (see Appendix A, Figure A.3).

Research consent form

Participants were asked to give formal consent to their participation in the study in the *research consent form* (see Appendix A, Figure A.4). The consent form reflected the points addressed in the participant information sheet but also elaborated on issues like data protection regulation and research ethics. All eight participants gave consent and returned a digitally signed version via e-mail.

Data protection regulation

Data protection impact assessment

A *Data Protection Impact Assessment (DPIA)* was conducted to identify data privacy risks and actions to mitigate those (see Appendix A, Figure A.2).

The research design for the study was constructed in a way so that it would strictly adhere to UCL Data Protection Rules and the General Data Protection Regulation (GDPR).

5.4 round I (brainstorming)

Round I consisted of two parts: the first part was the actual Delphi exercise (brainstorming) and second part was a revision task for the first exercise. At the end of this round, a list of 56 answers with accompanying descriptions was compiled.

Figure 5.5: *Timeline - round I*

Part 1: brainstorming excercise

Task description

The round I questionnaire was circulated amongst participants via e-mail. Each of them received an individual e-mail containing a link to a questionnaire on Google Forms (see Appendix A, Figure A.5).

This part introduced participants to the study and asked for the participants' personal information. A general description of the Delphi study was given, followed by a thematic introduction providing participants with the same basic knowledge. It introduced the characteristics of urban design and provided a definition of human-centred urban built environments. Then it explained briefly how brain science was connected to urban design, but in a very broad sense so participants would not understand the purpose of the study in detail.

This was followed by the actual task. Participants were given the following question:

> *Coming from your discipline (urban design or brain sciences), which (research) topics have most potential to create more human-centred built environments?*

Then, they were asked to answer the question as concise as possible. In a separate description they could support their answer with additional information. In total, eight answers needed to be given.

Submitted answers

Around half of the participants completed the study within the first two days. If nothing was submitted within a week from the first e-mail, a friendly reminder was sent out to the participants. One participant failed to submit his responses even after multiple reminders. This participant dropped out at a later point due to other commitments and therefore the overall group size was reduced to seven. This had implications for the rest of the study and will be discussed in the next chapters.

Part 2: review and revision

All submitted answers were transferred to a separate excel spreadsheet. In total, the participants submitted 56 research topics with 31 accompanying descriptions.

Then a step-by-step review process was undertaken by the researcher (see Figure 5.6):

1. Each topic and accompanying description were numbered and linked to participants
2. Possible duplicates[1] were identified and consolidated
3. Topics were put in different thematic groups for analysis purposes and to increase legibility
4. Sentences were refined if content was hard to understand or if the language was unclear/incorrect
5. Participants were asked to elaborate on their submitted topics or add further descriptions if the meaning was unclear

The length of the research topics varied, but not to an extent that they needed to be shortened significantly. The length of the accompanying descriptions however varied significantly, so that a condensed version of descriptions was offered to a few participants.

During the review process, interference was kept to a minimum and changes were only made if need be. For example, some answers could have been consolidated based on their similarity (duplicates), but their meaning still varied slightly. Hence, an information loss would have occurred. Therefore, topics that were similar sounds but different in meaning were kept.

1 a duplicate was defined as a sentence that conveyed a similar meaning

In some cases, specific terminology was used, but lacked sufficient explanation and therefore a few participants were asked to further elaborate on their descriptions or add new descriptions. In a few cases, answers were re-phrased to increase their readability.

Each participant received a copy of his or her (revised) research topics and descriptions. Participants then had the chance to comment on the proposed version and/or further elaborate and leave a statement. They also needed to give consent if they accepted the revised version as the final version. This document was sent back via-email. All changes were then incorporated in the final list for round II.

The final list comprised 56 research topics with 43 accompanying descriptions and 14 categories.

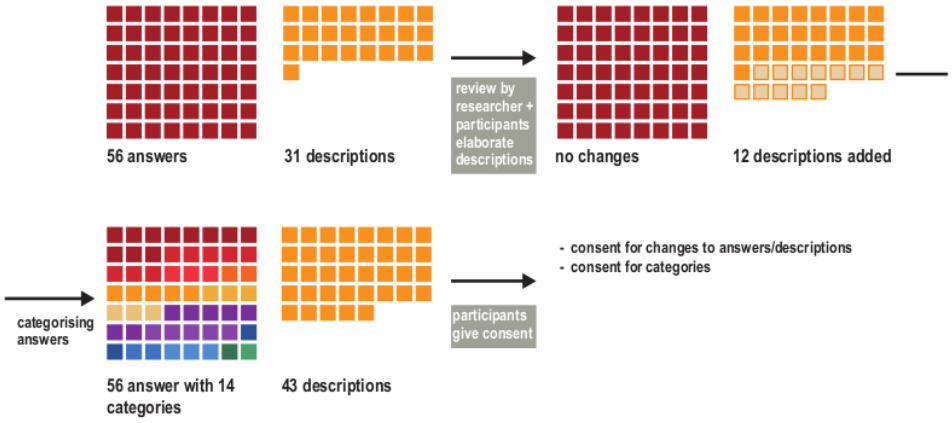


Figure 5.6: *Round 1 - reviewing process*

5.5 round II (consolidation)

In this round, participants had to select ten research topics from a list of 56. The aim for this round was to narrow down the list below 20 topics.

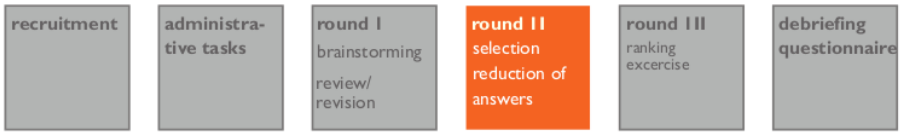


Figure 5.7: *Timeline - round II*

Task

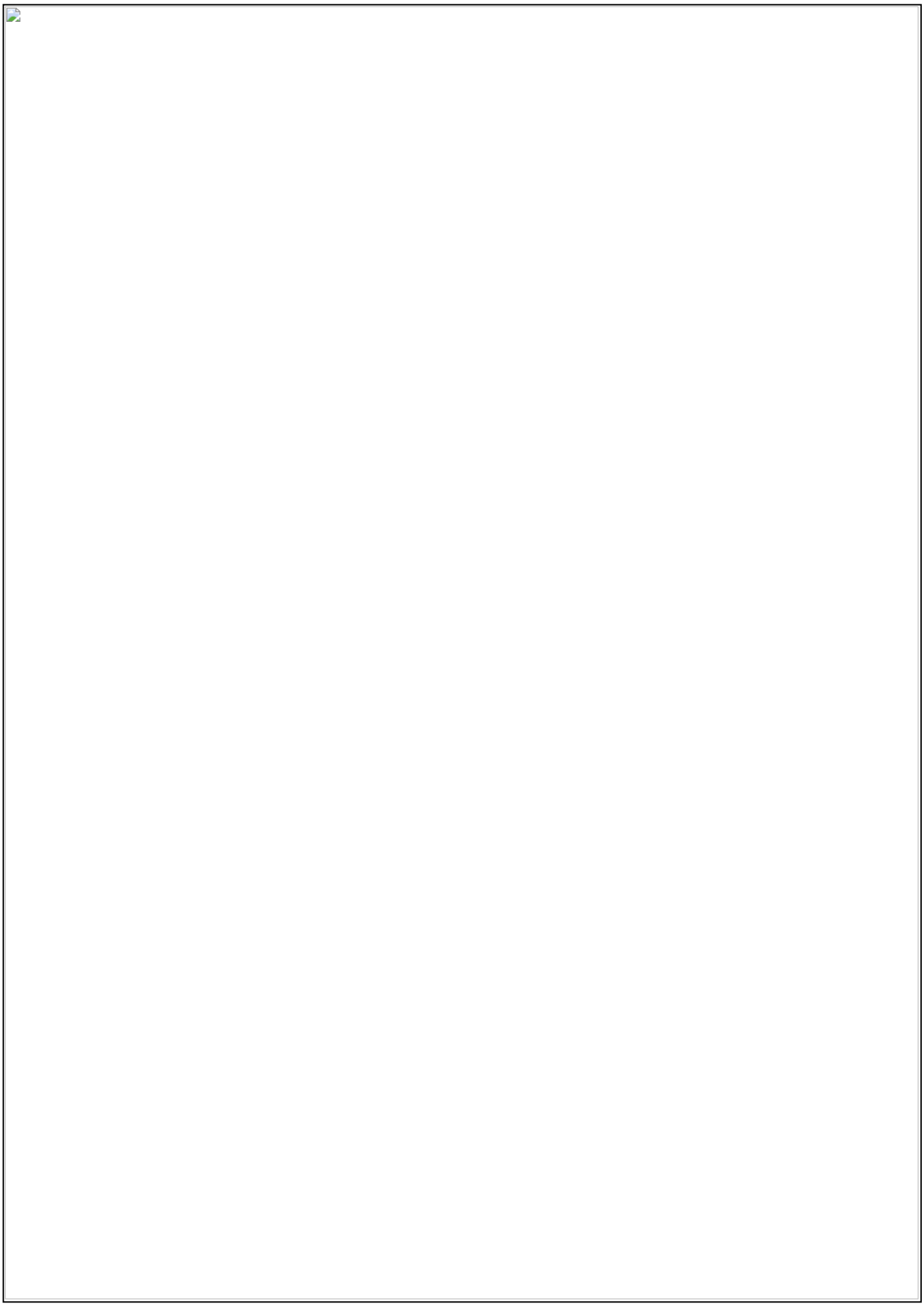
All revised topics and accompanying descriptions were merged into one comprehensive list. For legibility and analytial reasons, the answers were grouped into thematic categories. Those were meant to help participants navigate through the list when they were performing the task The final list was sent out to all seven participants via e-mail with accompanying instructions.

The instructions asked the participants to select their ten research topics from the list in relation to the research question (referred to as 'selection'). Ten selections seemed to make most sense as other studies followed this threshold too (for a discussion see Okoli & Pawlowski 2004).

The original task description and an exemplary list of answers can be found in Appendix A (Figure A.6).

Submitted answers

The majority of participants completed round II within a week. A friendly reminder was sent out to one participant. Generally, responses were slower this round as the COVID-19 situation started accelerating around this time. None of the participants experienced any issues, however one participant mentioned that the list of answers was too lengthy.



5.7 debriefing questionnaire

The debriefing questionnaire had two main purposes: firstly, participants could comment on the study. Secondly, the questionnaire allowed to gather further qualitative data which helped to put the results of the Delphi study in context.

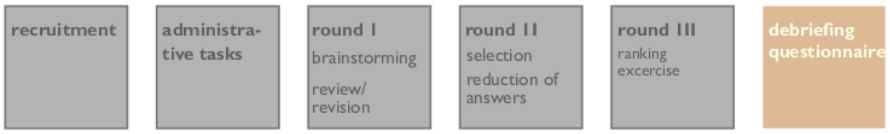


Figure 5.9: *Timeline - debriefing questionnaire*

Task

A Google forms questionnaire consisting of five questions was prepared and sent to each participant. At the end of the questionnaire a short section revealed the purpose of the study to the participants (Appendix A Figure A.8).

The debriefing questionnaire was not a formal part of the Delphi study and therefore it was voluntary to fill out the form.

Results

In total, 6 of 7 participants filled out the debriefing questionnaire. The results of this part will be presented and discussed in the next chapter.

6 discussion

In the following, research findings will be presented and discussed. In particular, we want to give an answer to the question in how far it is possible that urban designers and brain scientists cooperate at the intersection of both fields to create more human-centred urban built environments.

First, key findings of the study will be presented followed by a thorough discussion of said findings including sources of error and limitations. This chapter will follow the structure of the data collection chapter starting with round I and ending with the debriefing questionnaire.

6.1 presentation of data

round I (brainstorming)

In this section, results of round I (brainstorming) will be presented. The aim of this task was to brainstorm research topics. We will first look at the participants' profiles and then present a categorised list of 56 research topics.

participants' profiles

Six participants stated that they are currently working towards a PhD degree and one participant already obtained a PhD degree. On average, they have been enrolled in their PhD program for around three years. In total, three participants stated that they affiliate themselves with brain sciences (two cognitive neuroscientists and one psychologist). One participant had an academic background in both disciplines, but more experience in the built environment and was counted as an urban designer. The other three participants affiliated themselves with urban design (two urban planners and two urban designers).

When asked if they had any experience with the other field, one brain scientist said he was familiar with urban design, whereas the other two were unfamiliar (Ø 2.3, scale 1-5). Only one of them worked with urban designers before. The urban designers were on average very unfamiliar with brain sciences (Ø 1.7, scale 1-5): One urban designer was slightly familiar and two not at all. None of them worked with brain scientists before.

When asked about their area of research, five participants affirmed that their research was only connected to their discipline with no direct implications for the other discipline, but two participants mentioned that their area of research was connected to both.

brainstorming

A complete list of all submitted 56 research topics can be found in Appendix B Table A.1 - A.7. For legibility and analytical reasons, we will now be using the 14 thematic groups established by the researcher during the review process. This will help to get an overview of the breadth of research topics submitted by the participants. An explanation of the categories can be found in Appendix B Table A.8. The categories are as followed:

1. City & Cognition
2. New methods & methodologies
3. Wayfinding & spatial navigation
4. Inclusive Urban design
5. Understanding of place / place-making
6. Urban design & transport
7. Politics of urban design
8. Data & technology
9. Urban design & environment
10. Collaborative urban design
11. Urban morphology
12. Sustainable urban design
13. Urban design & temporality
14. Interdisciplinarity

Figure 6.1 shows the distribution of topics across categories and indicates which topics have been mentioned most. From this diagram we can deduce following: first, certain research topics are more often associated with human-centred urban design than others. Secondly, certain topics are mostly popular amongst urban designers, some others mostly amongst brain scientists. Third, despite those preferences, mixed categories are the most popular ones (e.g. city & cognition).

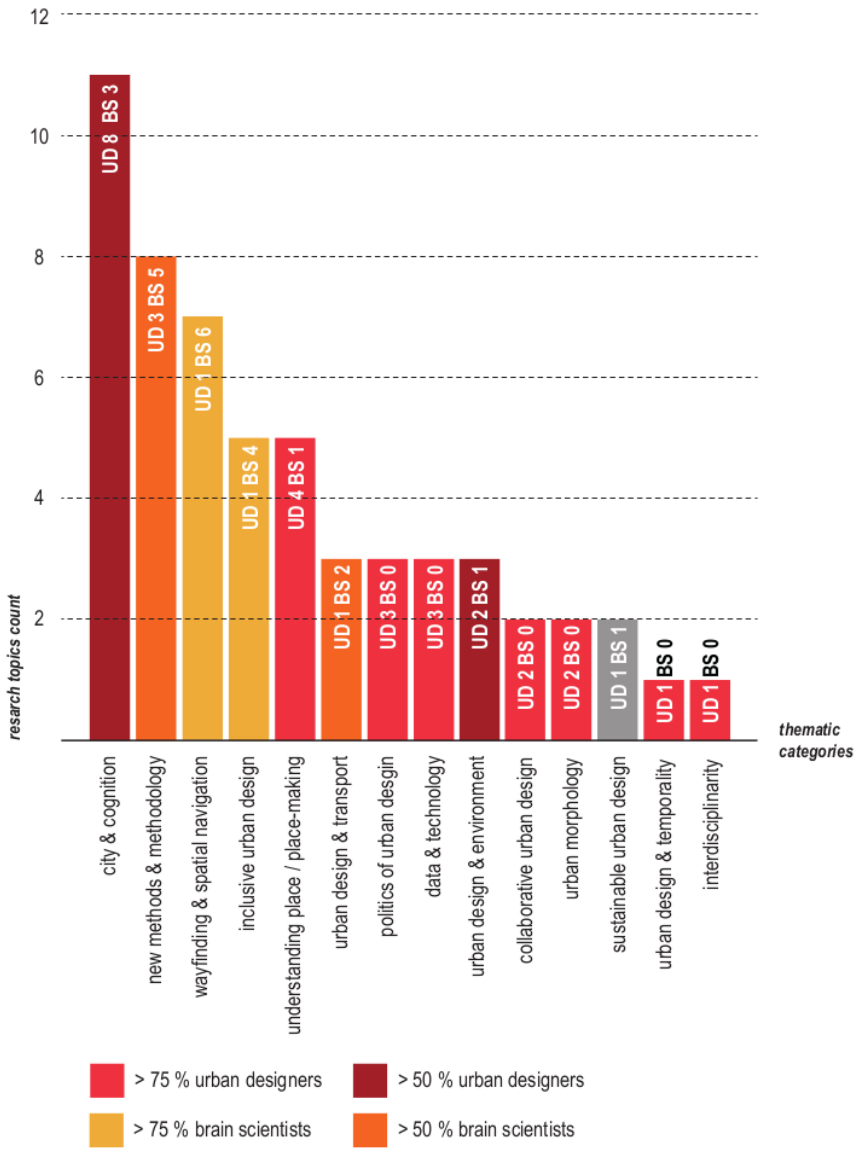


Figure 6.1: *Thematic categories histogram indicating selections by urban designers and brain scientists*

round II (consolidation)

In this section, results of round II will be presented. The aim of this round was to consolidate and condense the brainstormed list of research topics. We will first look at which threshold has been used for the consolidation and then present the retained topics

Setting the threshold

In total, 70 selections were submitted (10 selections per participant). The selections were reviewed and the number of selections per research topic counted. Figure 6.2 shows a histogram of the selection patterns.

The x-axis shows how many times a topic has been selected (for example all topics which have been selected once form the category 'selected once'). 'Topics' refer to the number of topics which have been selected in that range. 'Selections' refers to the total number of selections in one category.

For example, category three contains all the topics being selected three times. Those are eight in total and they make up for 24 selections.

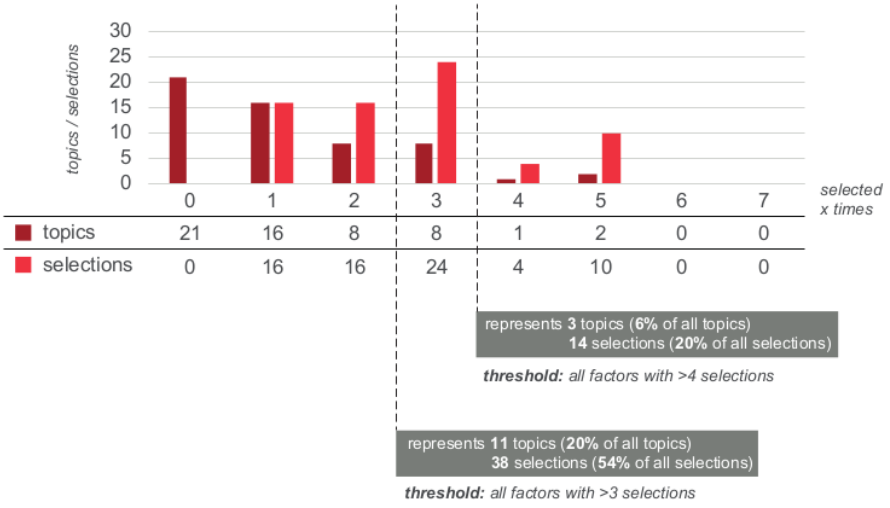


Figure 6.2: *Histogram of the distribution of selections and research topics*

A decision had to be made about where to set the threshold which would define the topics being retained for the next round. Schmidt (1997) indicates that the number of items on a narrowed down list should be limited to 20 or below and Okoli & Pawlowski

(2004) propose that only answers with a simple majority of selections should proceed to the next round. Those guidelines have been adopted for this study.

Since we have an uneven number of seven participants a simple majority would be 3.5 of 7 participants. Therefore, it had to be decided if three or four participants was the threshold.

There is significant clustering of selections around certain topics. If we drew a hypothetical line at all topics that have been selected >3 or >4 times, we would get following results (see grey boxes in Figure 6.2):

- **≥ 3 times selected:** 11 topics retained
- **≥ 4 times selected:** 3 topics retained

Therefore, the threshold was set to all topics that have been selected ≥ 3 times. Consequently, 11 topics made it to the next round (54% of all selections) and 45 topics were lost in the process (46% of all selections).

consolidated list

A complete list of the 11 consolidated research topics can be found in Appendix B: Table A.9. Figure 6.3 represents an illustration of this list. In total, eight topics were retained which have originally been submitted by urban designers and three which were proposed by brain scientists. Those topics represent 21 selections by urban designers and 17 by brain scientists.

Generally, the selection pattern is very mixed and there is no topic which has been exclusively selected by one field. The most popular topics are topics submitted by urban designers and have also been selected predominately by urban designers. Therefore, there is a slight urban design bias in the data.

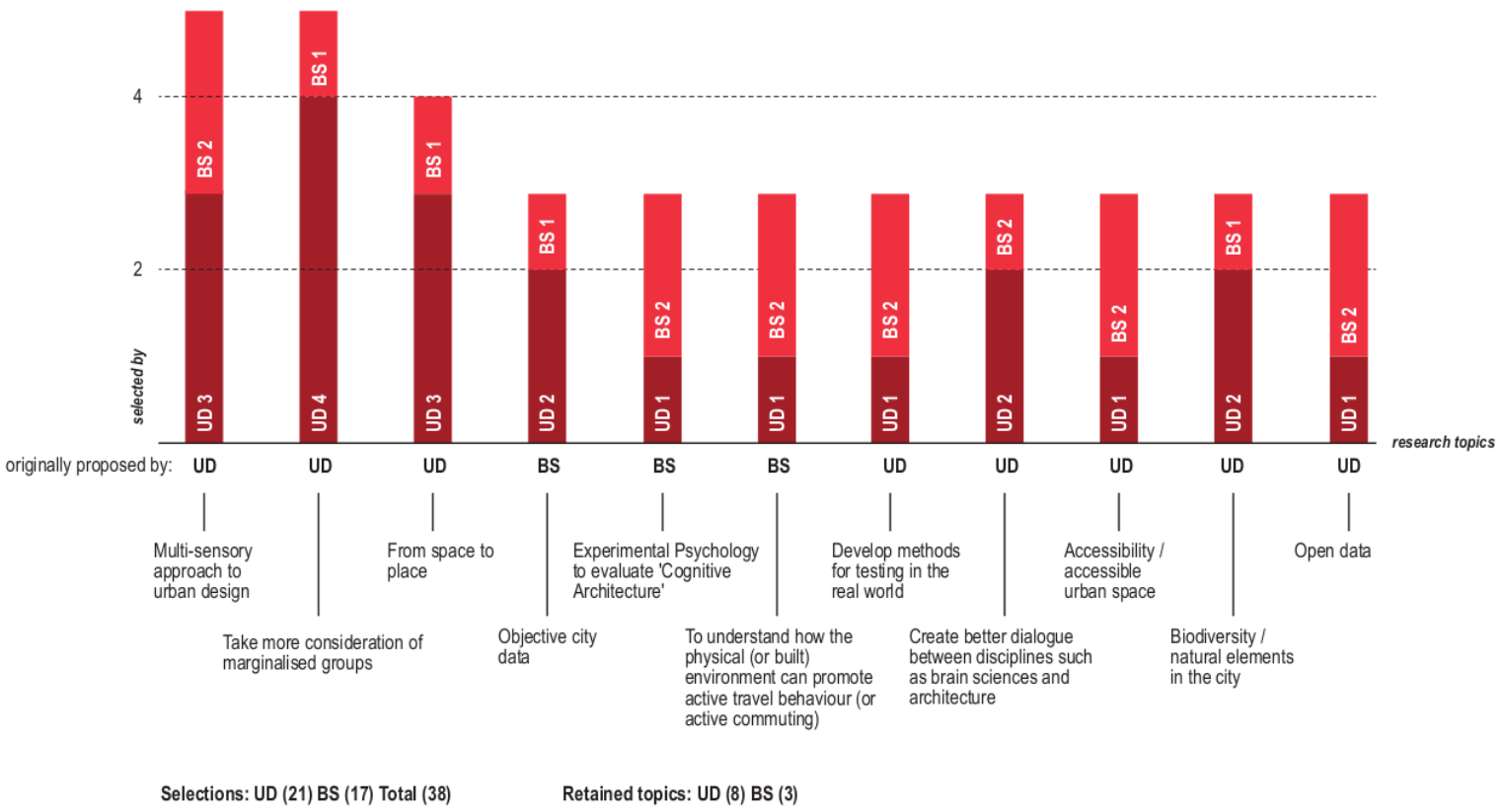


Figure 6.3: *Distribution of selection across retained research topics*

round III (ranking)

In this section, the results of round 3 (ranking) will be presented. The aim of this round was to let the participants rank the list of research topics and measure their consensus. We will first show how consensus has been calculated and then secondly examine the ranked list.

Kendall's *W*

Okoli & Pawlowski (2004) stress out that there are different metrics for measuring non-parametric rankings (for reference see Siegel & Castellan Jr. 1988, Bagdonavicius et al. 2011). The most common analysis method for ranking exercises in the context of Delphi studies is Kendall's Coefficient of Concordance (*W*) or Kendall's *W* (Schmidt 1997). Legendre (2005, p. 228) defines Kendall's *W* as "a measure of the agreement among several *p* judges who are assessing a given set of *n* objects".

p are the seven participants and *n* the eleven topics from round II. *W* indicates the level of agreement amongst *p*. *W* values can fall within the range of 0 – 1 with 0 indicating no agreement and 1 meaning full agreement.

W was calculated with following formula (from Siegel & Castellan 1988):

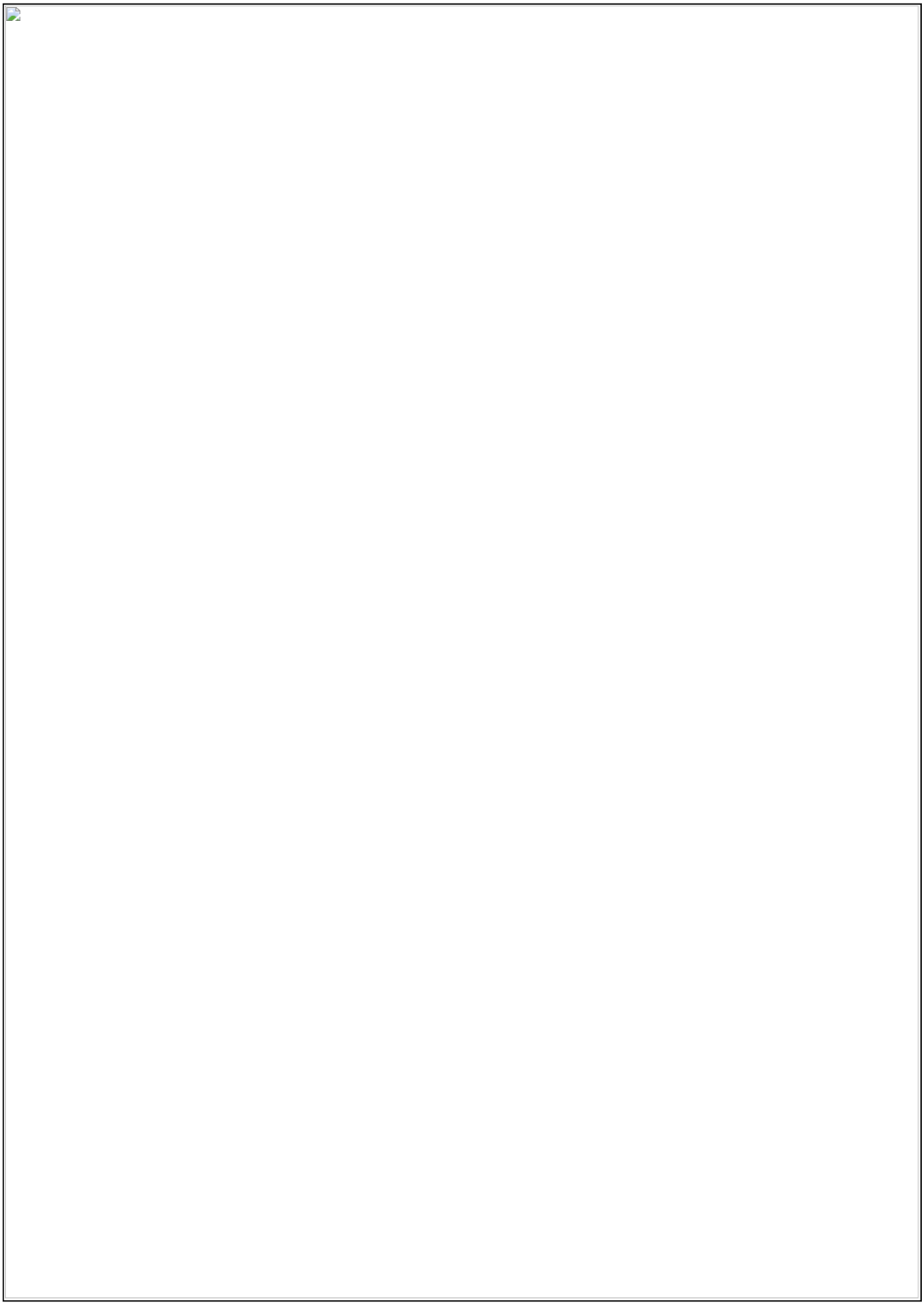
$$W = \frac{12S}{p^2(n^3 - n) - pT}$$

In a first step *S* in the numerator needed to be calculated with following formula:

$$S = \sum_{i=1}^{n} (R_i - \bar{R})$$

S is a sum-of-squares statistic over the row of sums of ranks R_i. $\bar{R}$ is the mean of the R_i values.

Next, *W* was calculated by inserting the calculated variables (*S*) and adding *p* and *n*. In our case *pT* is disregarded as this is a correction factor for tied ranks.



rank	topic	selected in round 2	originally proposed by	mean rank (UD)	mean rank (BS)	diff. BS/ UD	mean rank (all)	SD (all)
1	Take more consideration of marginalised groups	5x	UD	**2.75**	4.66	1.91	3.57	3.55
2	Accessibility / accessible urban space	3x	UD	**3.75**	4.66	0.91	4.14	3.02
3	From space to place	4x	UD	**3.25**	6	2.75	4.43	2.99
4	Multi-sensory approach to urban design	5x	UD	6	**5**	1	5.57	2.82
5	Biodiversity / natural elements in the city	3x	UD	5.25	7	1.75	6	2.29
6	Experimental Psychology to evaluate 'Cognitive Architecture'	3x	BS	6.75	**5.66**	1.09	6.29	3.81
7	Create better dialogue between disciplines such as brain sciences and architecture	3x	UD	**5.25**	8	2.75	6.43	3.15
8	To understand how the physical (or built) environment can promote active travel behaviour (or active commuting)	3x	BS	**4**	8.25	4.25	6.71	3.03
9	Develop methods for testing in the real world	3x	UD	8.25	**6.33**	1.92	7.43	3.35
10	Objective city data	3x	BS	8.25	**6.33**	1.92	7.43	3.30
11	Open data	3x	UD	**7.5**	8	0.5	7.71	2.05
		38/70	**UD 7 BS 4**	**5.54**	**6.35**	**1.88**	**5.97**	**3.03**

p value 0.24 **Kendall's W** 0.18

Table 6.1: *Final ranking*

debriefing questionnaire

In this section, key findings of the debriefing questionnaire will be presented. The aim of this round was to debrief the participants and also use the chance to further generate qualitative data for the study. Question 1 was disregarded as this was only a control question and did not contribute to answering the research question.

answers

All Likkert-scale questions were from 1 (not at all) to 5 (very much so).

Q2: Did the study change your perception of the other field? Please specify in how far the study changed your perception.

The average rating was 3.0 (SD= 0.9) indicating a slight change in the participants' perception. One brain scientist was positively surprised by the diversity of answers, which added to their understanding of urban design research agendas. However, another brain scientist argued that the language of both fields was very different making collaboration challenging. One urban designer found that brain sciences are more scientific and urban design/planning more outcome oriented.

Q3: Have you considered the other discipline to be part of your research before the study?

A majority of the participants considered the other discipline to be part of their research before the study (avg. rating= 3.66 SD= 1.0).

Q4: Would you consider working with the other discipline in the future?

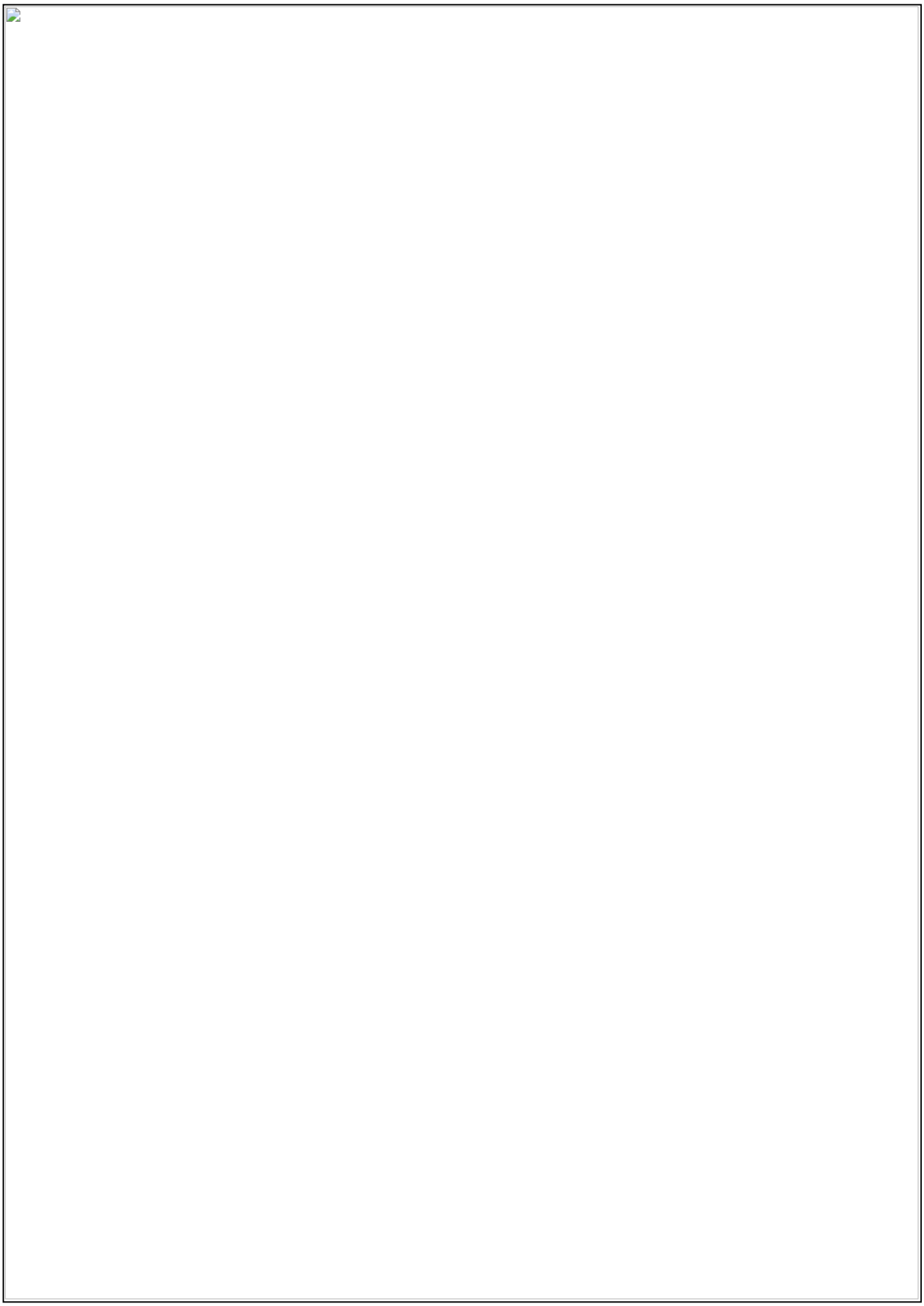
Participants were interested in future research collaboration. The value increased from the previous question indicating that their attitude towards cooperation changed (avg. rating= 4.33 SD= 0.52).

Q5: In how far is it possible that urban designers and brain scientists could cooperate at the intersection of their fields to create more human-centred urban built environments?

This was the actual research question of the dissertation. All participants generally agreed that cooperation between the two fields is possible, although brain scientists were generally a bit more cautious. One brain scientist mentioned that cooperation between the two fields could only happen at the conceptual stage but not beyond. Another one argued that cooperation would be desirable because it would help findings in brain sciences to have "an impact on society". Furthermore, one brain

scientist commented that the human brain is very complex and therefore it is difficult for brain sciences to give specific advice on practical issues. Different methodologies would further complicate things.

On the other hand, one urban designer was convinced that it only takes a few interested individuals seeing the value in cooperation and learning to speak a common language for collaboration to succeed. This goes hand in hand with another urban designer's opinion that the two fields have lots of "intersections in promoting better quality of spaces, for body and mind experiences". There are already existing collaborations and connections that only need further investment.



In round II (consolidation) the participants were able to agree on a list of eleven research topics, which reflected more than half of all selections. The selection patterns indicated slight overlapping as all research topics in that list were being selected by at least one researcher from either field. However, the selection pattern also showed that more topics and selections from urban designers were retained.

In the debriefing questionnaire the participants were generally optimistic about a collaboration between the two fields, yet they were sceptical of challenges in practice (e.g. different methodologies, research background and language)

In the following, we will have a closer look at the results of each research objective and link this knowledge back to the already existing literature.

Research objectives

Research objective I 'Identify research topics at the intersection of both fields'

Round I (brainstorming)

In light of the extensive data produced in round I, it seemed relevant to apply descriptive-statistical methods to the data to be able to identify convergence respectively thematic overlap between the two fields (Jones 2002). This will help us to get a quick, initial assessment of the results, although the analytical emphasis is on the next two rounds.

Generally, the 56 brainstormed research topics reflect a diversity of knowledge in regard to human-centred urban design and reflect current research topics as outlined in the context chapter. This shows that the participants have a good foundation of knowledge corresponding with current research. For example, often-mentioned brain science topics were embodiment (cat. city & cognition), applying new methods like VR (cat. new methods & methodologies) and spatial navigation (cat. navigation & wayfinding) (see Figure 6.1). For urban design, often-mentioned topics were place value (cat. place-making), accessibility (cat. politics of urban design) or inclusive design for different users (cat. inclusive urban design).

The top two most mentioned categories (cat. *city & cognition* and cat. *new methods & methodologies*) were mentioned by both fields. This suggests that disciplines have a sense for research topics at the intersection of both fields. Those topics are very similar to the interdisciplinary research we identified in the context chapter. The tenor of those topics reflects, for example, much of the research being done by Ellard (2015).

Yet, there are also some topics that seem to be exclusive to either field for example *collaborative urban design* (urban design) or *way-finding & spatial navigation* (Brain science). This is surprising as for example way-finding is also a central theme in urban design, but has not been mentioned much by urban designers in this study.

Still, the participants' top-mentioned categories gravitate towards topics which are of interest to both fields even though there is also a significant amount of exclusive urban design or brain science categories. This is not a factor that might hinder cooperation, but it rather indicates the fields' different research priorities.

Research objective II 'Measure consensus between the two fields'

Round II (consolidation)

Consolidation tasks are typically only a preliminary step for the ranking excercise, yet Delphi literature recommends applying descriptive-statistical analysis to this data (Okoli & Pawlowski 2004, w 2003). In our case, this helped to identify the two field's selection patterns indicating possible convergence.

In general, the selection patterns in Figure 6.3 suggest that there is an urban design bias in terms of how many topics were retained from last round. In total, eight topics which were originally proposed by urban designers and three topics from brain sciences were retained. Also, more selections from urban designers were retained (UD 21 / BS 17).

This is supported by the fact that many topics sound in tone much alike the typical urban design research as outlined in the context chapter (e.g. 'from space to place', 'marginalised groups'). However, this distinction can be sometimes misleading, because brain scientists also suggested topics that sounded and selected urban design specific topics ('active travel behaviour and built environment').

Comparing the lists from round I and II, it is apparent that strong brain science topics like embodiment and spatial navigation - which were considered particularly significant in the context chapter - were not retained, but disregarded. At this point, we can only guess why this was the case. Still, a few strong brain sciences topics have remained like 'experimental psychology' or 'objective city data'.

Yet, there are also topics that lie at the intersection of both fields or example 'multi-sensory urban design', 'develop methods in the real world' or 'natural elements', which is supported by the mixed selection pattern. Especially, in conjunction with the participants' descriptions it becomes clear that these topics represent issues that could well be addressed in both fields in an interdisciplinary way.

Round III (ranking)

This round deviated from the typical procedure of a Delphi study which sees a reiteration of the questionnaires when no consensus is reached (see Okoli & Pawlowski 2004, Schmidt 1997). However, no further rounds were carried out. The purpose of this dissertation was to measure their cooperation potential and therefore we were interested in their pre-reflective attitude towards certain topics - the status quo - rather than their change in opinion.

The ranking exercise did not produce significant results, yet the *W*-value 0.19 (p=0.24) indicates a slight trend towards consensus. Possible explanations for this result are following:

Firstly, the most obvious explanation is that participants from the two fields indeed have different views on what are important research topics for human-centred urban design. However, this stands in contrast with the good results from the previous round.

Secondly, the high standard deviation indicates that ratings for individual research topics show a very wide spread. Participants might have been strongly bound to their research expertise further amplified by the participants' heterogenous profile of the participant. However, we need to treat the standard deviation as an indicator for statistical variance with caution as it generally becomes less reliant with small sample sizes.

Lastly, we also need to critically re-evaluate if the ranking exercise can act as an indicator for cooperation potential. Research thrives on the fact that different fields of research coexist side by side. This stimulates the discourse and allows as many positions as possible to be included in order to describe reality. Hence, having not agreed on a ranking does not necessarily mean that there is no cooperation potential. Therefore, the previous round might actually be a better indicator for cooperation potential.

Despite all that, there are few topics, which show very clearly the thematic overlap between the two fields. This is for example true for 'multi-sensory urban design' (#4) which was selected and rated similar by both fields, or 'Experimental Psychology to evaluate 'Cognitive Architecture'' (#6). Those topics could be a great starting point for further, more in-depth research. They also resonate with current research as outlined in the context chapter.

Research objective III 'Investigate how the fields perceive each other and if they see potential in cooperation'

In general, the data obtained in the debriefing questionnaire was very helpful as it helped to put the results of the previous rounds in context. Therefore, it might make sense to attach a further, more detailed qualitative questionnaire to a future follow-up study (as recommended by Skumolski et al. 2007).

The results of Q2 indicate that the study did not have a significant impact on the two fields and their perception of the other field. A reason might be that the exercise made them realise how different the language and the research methods of the two fields are as commented by a few participants. This suggests that there are practical challenges which might hinder cooperation in the future, although the participants are generally positive about the potential of collaboration and have even considered the other discipline to be part of their research before (Q3).

This is supported by the results of Q4, that clearly indicate that the majority of participants is interested in future cooperation. It is also interesting that agreement went up from the previous question (Q3) showing that even participants who might not have considered cooperation in the past might do this in the future.

Above-mentioned points also resonated in the answers of Q5 (collaboration in theory vs. practical issues). Furthermore, it seems that brain scientists were a bit more cautious as they stated that collaboration could happen only in specific cases. The overall tenor of this question was that collaboration was desirable, but in practice not (yet) feasible. Urban designers on the other hand were much more enthusiastic. However, this give the impression that they are not equally aware of the practical challenges that such a collaboration might impose on them. Interestingly, the wording of brain scientist's answers imply that they think of urban design as the practical and applied field with an "impact on society", whereas they perceive their field as more theoretical. Those issues could be investigated in possible follow-up studies that utilises qualitative methods.

6.3 sources of errors

Uneven group sizes

In round I, one brain scientist dropped out due to other commitments which is not uncommon for Delphi studies (Donohoe & Needham 2009). As seeking for a replacement would have delayed the study by multiple weeks, it was continued with four urban designers and three brain scientists only. This had a major impact on the results of the study as the data was skewed towards urban designers.

Small sample size

Although Delphi studies are flexible in terms of sample sizes - between 10 to 100 participants depending on the research design - the sample size for this study was too little for significant results (see Okoli & Pawlowski 2004). Small sample sizes decrease statistical power and increase the margin of error. Furthermore, there is the difficulty of generalising the results to a wider audience (Hartman & Jugdev 1998). Also, the high standard deviation in the final ranking can be a result of a small sample. Although other methods might have been more manageable, this method still seemed like the most fitting as the purpose of this study was to explore the Delphi method for future application.

Selection of participants

To reflect the diversity of research disciplines involved both in urban design and brain sciences research, participant selection guidelines were kept broad. Eventually, this led to a heterogenous participants profile consisting of many research disciplines. This is not an issue per se as Delphi studies should not be too homogenous, because there is the danger that the data will be biased towards one opinion. Yet, if too heterogenous, this makes it difficult to research consent (Iqbal & Pipon-Young 2009). The heterogenous research profile might have been the reason why the ranking exercise was not significant due to the many individual research interests. Ideally, the two groups could have been more homogenous.

Participants' classification

One participant was difficult to classify as brain scientist or urban designer, because her research background was in both fields. It was decided that the early career weighted more than the current career. Due to the small sample size and the fact that her results were in the final list multiple times, this decision had a strong impact on the results. A different classification would have drawn a different overall picture.

6.4 limitations

Methodological limitations

Delphi studies have been criticised by a few scholars (Fink-Hafner et al. 2019). They mention, for example, the uneven spread of expertise amongst participants or the participants' specific research agenda (Hsu & Sandford 2007). Furthermore, much of the success of this technique is based on the researcher's evaluation (Donohoe & Needham 2009).

Above-mentioned points were also noticed in this study. The expertise amongst the participants was very diverse. For round I, this was positive as many different research topics were mentioned. However, in later rounds the differences amongst participants became increasingly apparent.

To get the 'right' expertise, the participant selection must be undertaken carefully based on the researcher's evaluation. However, this will automatically create researcher's bias although selection of participants should actually be as unbiased as possible. In that sense the Delphi method seems ambiguous (Sackman 1974).

Therefore, Delphi studies are particularly susceptible to researcher bias as a high degree of editorial license is needed. This was especially true for the selection process, as participants were researched and contacted based on the researcher's prior knowledge. Furthermore, in round I and II the researcher needed to review and synthesise research topics based on which thematic categories were created. Although this step was validated by the participants, a bias cannot be ruled out.

Category error

Another problem is the inherent category error in the design of the study. By asking the participants to come up with topics for a human-centred urban environment, the question itself is directly linked to urban design, but not to brain sciences. That means that the participants came from different starting conditions with the urban designers having an advantage. This limitation lies within the nature of the research question and therefore seemed reasonable.

7 reflective conclusion

This dissertation was motivated by the desire to further investigate the strong potential link between urban design and brain sciences in relation to human-centred urban design in practice. Human-centred urban design means that we prioritise our human needs and behaviours in the city and cater for them with appropriate design. Eventually, brain sciences - psychology, cognitive science and neuroscience - could help to make urban design more scientific and human-centred.

The aim of this dissertation was to explore in how far it is possible that urban designers and brain scientists cooperate at the intersection of both fields to create more human-centred urban built environments. During the course of this work it should have become clearer that a strong potential link between urban design and brain sciences exists - at least in theory.

This dissertation set out to further explore the practical side of this link by bringing the two fields to the same table. This was done with the Delphi technique: the two fields would need to agree on a hypothetical research agenda for human-centred urban design. During the exercise, consensus between participants was measured which would indicate their potential for cooperation.

The findings of this study only partially support the assertation that there is potential for cooperation between the two fields in practice. The ranking exercise hasn't produced any significant results, although the other rounds suggest that overlap in some areas of research occurs and cooperation potential is apparent. However, those findings should be treated with caution as there were a range of limiting factors (e.g. the small sample size).

One conclusion of this work is that it is one thing to draw a link between two disciplines in theory and another to do that in practice. Although the ranking results in this dissertation were not significant, future research with other methods might be able to establish this link in practice.

Implications for future research

As we learned, a central point of this dissertation was that research at the intersection of brain science and urban design is still relatively unexplored. Hence, there are extensive opportunities for future research. In the following, we want to focus on possibilities for new research which have arisen during the course of this dissertation and which are directly connected to this study.

The dissertation has experienced a range of limitations in regard to sample size, selection process and research design. Therefore, it would be useful to carry out a follow-up Delphi study with an increased sample size. The literature recommends at least ten participants, although more would be ideal (for examples with a larger sample size, see Linstone & Turoff 2002).

Also, a more randomised selection process could reduce researchers' bias in the selection process. A pre-selection would still be undertaken by the researcher, but the selection of this selected group of candidates would be randomised (see Delbecq et al. 1975). Follow-up studies could also differentiate between different disciplines instead of using generalisations (e.g. psychology, cognitive science & neuroscience instead of brain sciences).

The literature review has also highlighted the need for a more detailed and systemic understanding of research efforts at the intersection of both fields. Therefore, a systematic literature review of the various fields and their research efforts both in urban design and brain sciences would be useful (see Weaver et al. 2002). Besides, one could also analyse existing older research papers which already utilised similar research thinking as investigated in this dissertation but have been 'forgotten' (e.g. environmental psychology in the 1960/70s) (see Van Raan 2004).

The debriefing questionnaire in this dissertation has also revealed the importance of qualitative data. This kind of data, collected for example through interviews, often provides a more in-depth picture than other methods. Therefore, cooperation potential could also be explored by utilising research methods like expert interviews and traditional surveys (see Bogner et al. 2009).

As mentioned earlier, one option to explore interdisciplinarity are scientometric methods e.g. measuring how often certain research is published in which categories of papers. This could be an interesting quantitative approach to better understanding the two fields, however, the problem with this method is that it requires an already established corpus of existing literature (Wang & Schneider 2018).

Lastly, in the debriefing questionnaire a few participants mentioned barriers for successful cooperation between the two fields were language (e.g. terminology used). Hence, it could be useful to investigate how the two different fields make use of certain terms or how the two fields differ in their language used (Narraway et al. 2020).

implications for practice

Although this field of research is yet much to be explored, it might still be worth discussing a few implications for practice. We will do this with reference to the findings of this study.

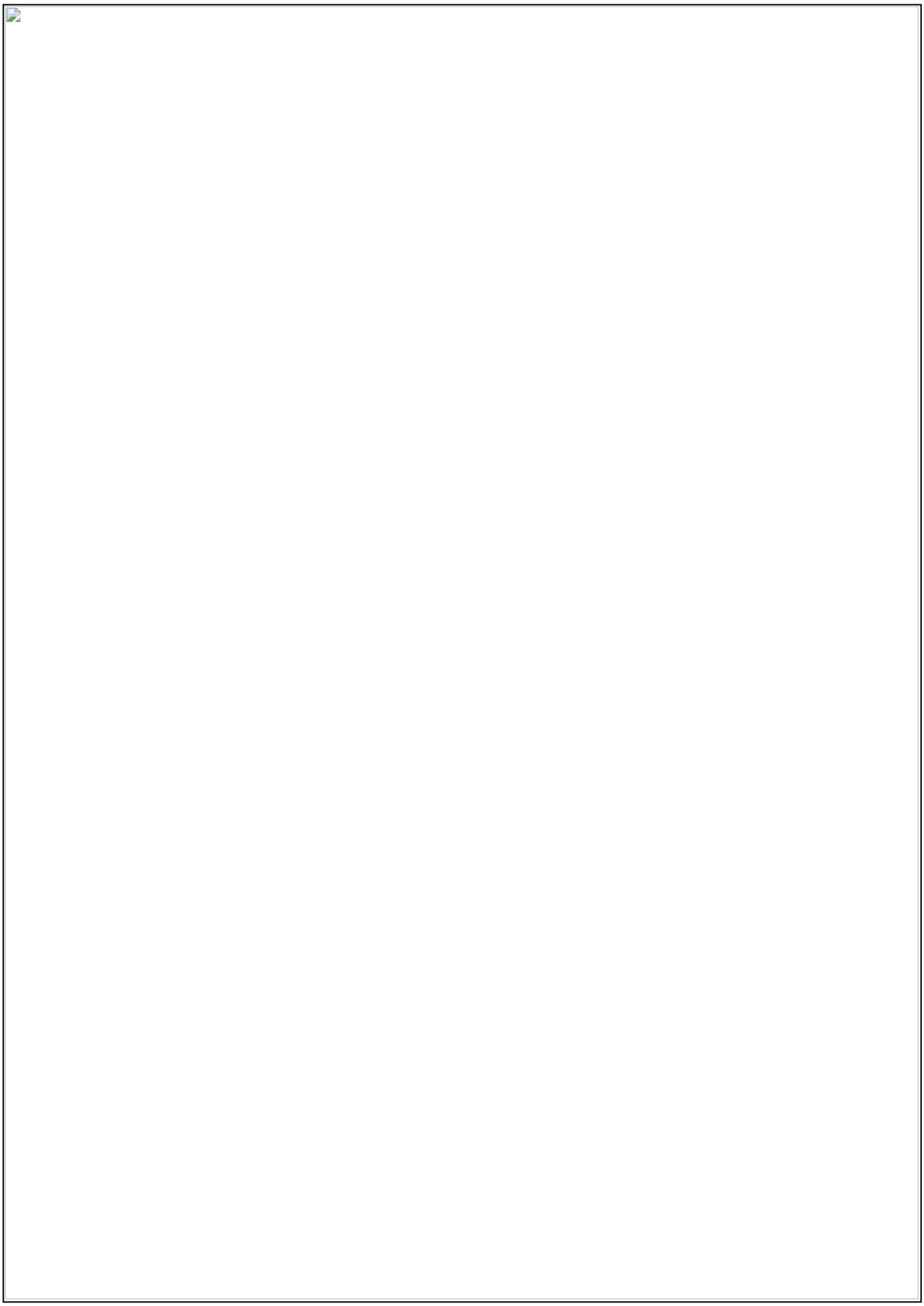
Human-beings have specific and sensitive needs when it comes to our environment. Urban environments ignoring those needs, will most likely have a negative impact on our mental and physical well-being. We are just beginning to understand those needs.

Besides better understanding those, a key challenge will also be to ensure that research will find its way to the decision-makers, who are in charge of producing large parts of our built environment: real estate developers, construction firms, local planning authorities and private architectural and planning firms (see Goldhagen 2017). Yet, this change will not happen overnight and will require many intermediate steps.

First, we need to re-think urban design research as proposed in this dissertation. As an interdisciplinary discipline we might be able to utilise knowledge from other disciplines - in our case brain sciences - but also focus on the strength of existing knowledge in urban design. A good example for a topic that could combine the best of the two worlds is *multi-sensory urban design.* This topic has been equally selected by both research fields in all rounds.

Secondly, this scientific research should then find its way to local planning authorities responsible for city planning and urban design. In the UK context, this would be Local Planning Authorities (LPAs) or Regional Planning bodies like the Greater London Authority (GLA). This could help to strengthen the evidence base for planning regulation and design codes. For example, one of the topics on the final list was *objective city data.* This topic refers to the notion that urban design should produce specific behaviours, not metaphors. Many of our designs do not serve the purpose they were intended to, but rather work with abstract ideas (metaphors), which often serve other purposes (e.g. representation of power) than actually producing places with high value. Evidence-based policies could help to decipher these metaphors, reduce their impact and steer it towards purposeful design for people's actual needs.

Thirdly, the construction industry, real-estate sector and landlords must adapt too. As Goldhagen (2017) discusses in her book, these groups are often left out in the debate about human-centred design, although they have a large impact on our built environment. In the UK, almost half of all new homes are built by just ten companies



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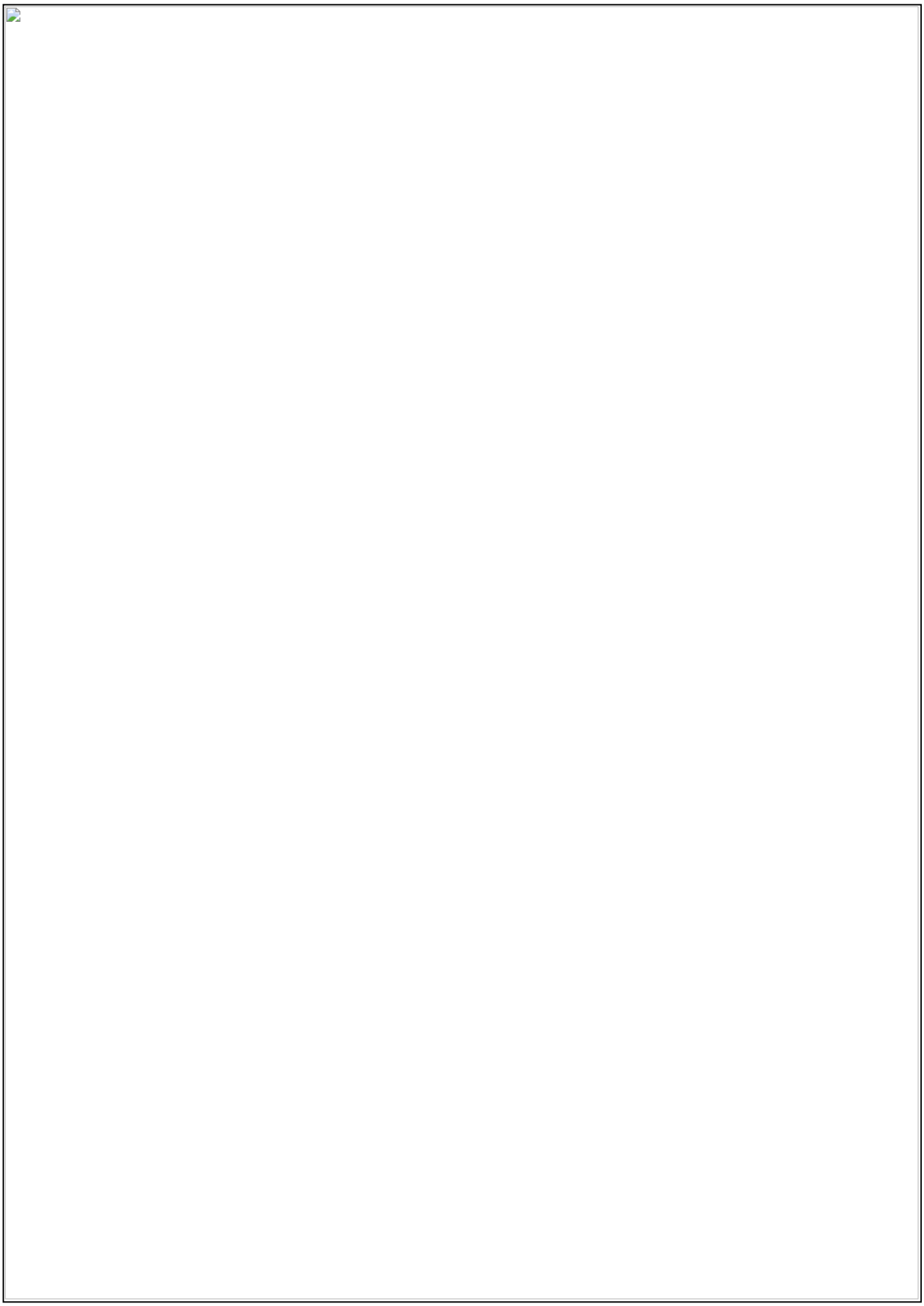

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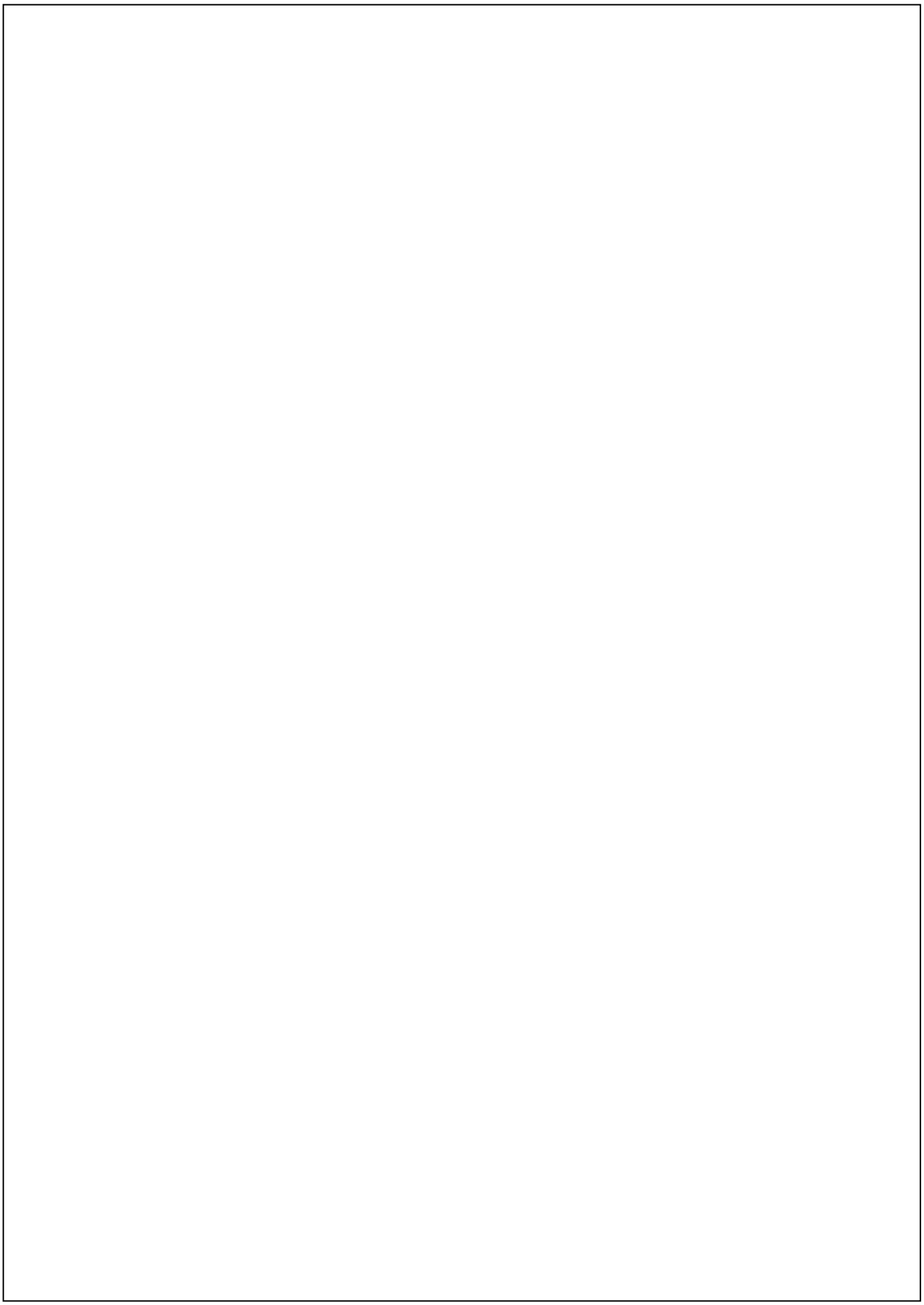

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Figure 2.5: Created by author

Figure 2.6: Pinterest / Smoore (2020). *Hannah/Honeycombe House, FLW, 1937, Stanford, CA*. Available at: https://bit.ly/2Vh0DsB [Accessed 1st July 2020].

Figure 2.7: Tolman, E. C. (1948) Cognitive Maps in Rats and Men. *Psychological Review,* 55 (4), pp. 189 - 208.

Figure 2.8: Architravel (2019) *Beijing National Aquatics Centre (Water Cube)* [Online]. Available at: https://www.architravel.com/project/beijing-national-aquatics-centre-water-cube/ [Accessed 1st July 2020].

Figure 2.9: Clode, D. (2018) *Mara trees. A classic scene in the Masai Mara in Kenya, with dry grass and Balanites aegyptica trees*. Available at: https://bit.ly/3eH4kiV [Accessed: 28 June 2020)

Figure 2.10: Pinterest (2020) *Head of a Romanesco broccoli*. Available at: https://bit.ly/2AgopO8 [Accessed: 28 June 2020)

Figure 2.11: Hafting, T., Fyhn, M., Molden, S., Moser, M.-B., Moser E. I. (2005) Microstructure of a Spatial Map in the Entorhinal Cortex. *Nature* [Online], 463 (7052), pp. 801 - 806. Available: https://10.1038/nature03721 [Accessed: 29 June 2020].

Figure 2.12: 9gag (2020) *A cut-out view from 1928 showing the workings of Piccadilly Circus tube station on the London Underground system* [Online]. Available at: https://9gag.com/gag/aXjyZPg [Accessed 1st July 2020].

Figure 4.1: created by author

Figure 4.2: created by author, partly based on Okoli, C., Pawlowski, S. D. (2004) The Delphi Method as a Research Tool: an Example, Design Considerations and Applications. *Information & Management* [Online], 42 (2004), pp. 15 - 29. Available at: doi.org/10.1016/j.im.2003.11.002 [Accessed 9 June 2020].

Figure 4.3: created by author, partly based on Okoli, C., Pawlowski, S. D. (2004) The Delphi Method as a Research Tool: an Example, Design Considerations and Applications. *Information & Management* [Online], 42 (2004), pp. 15 - 29. Available at: doi.org/10.1016/j.im.2003.11.002 [Accessed 9 June 2020].

Figure 5.1: created by author

Figure 5.2: created by author

Figure 5.3: created by author

Figure 5.4: created by author

Figure 5.5: created by author

Figure 5.6: created by author

Figure 5.7: created by author

Figure 5.8: created by author

Figure 5.9: created by author

Figure 6.1: created by author

Figure 6.2: created by author

Figure 6.3: created by author

Figure I.1: UCL (2020) Risk Assessment Form Field / Location Work. Available at: https://www.ucl.ac.uk/safety-services/a-z/risk-assessment/risk-assessment-form.pdf [Accessed: 22 July 2020].

Figure I.2: created by author

Figure I.3: created by author

Figure I.4: created by author

Figure I.5: created by author

Figure I.6: created by author

Figure I.7: created by author

Figure I.8: created by author

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Table I.1: created by author

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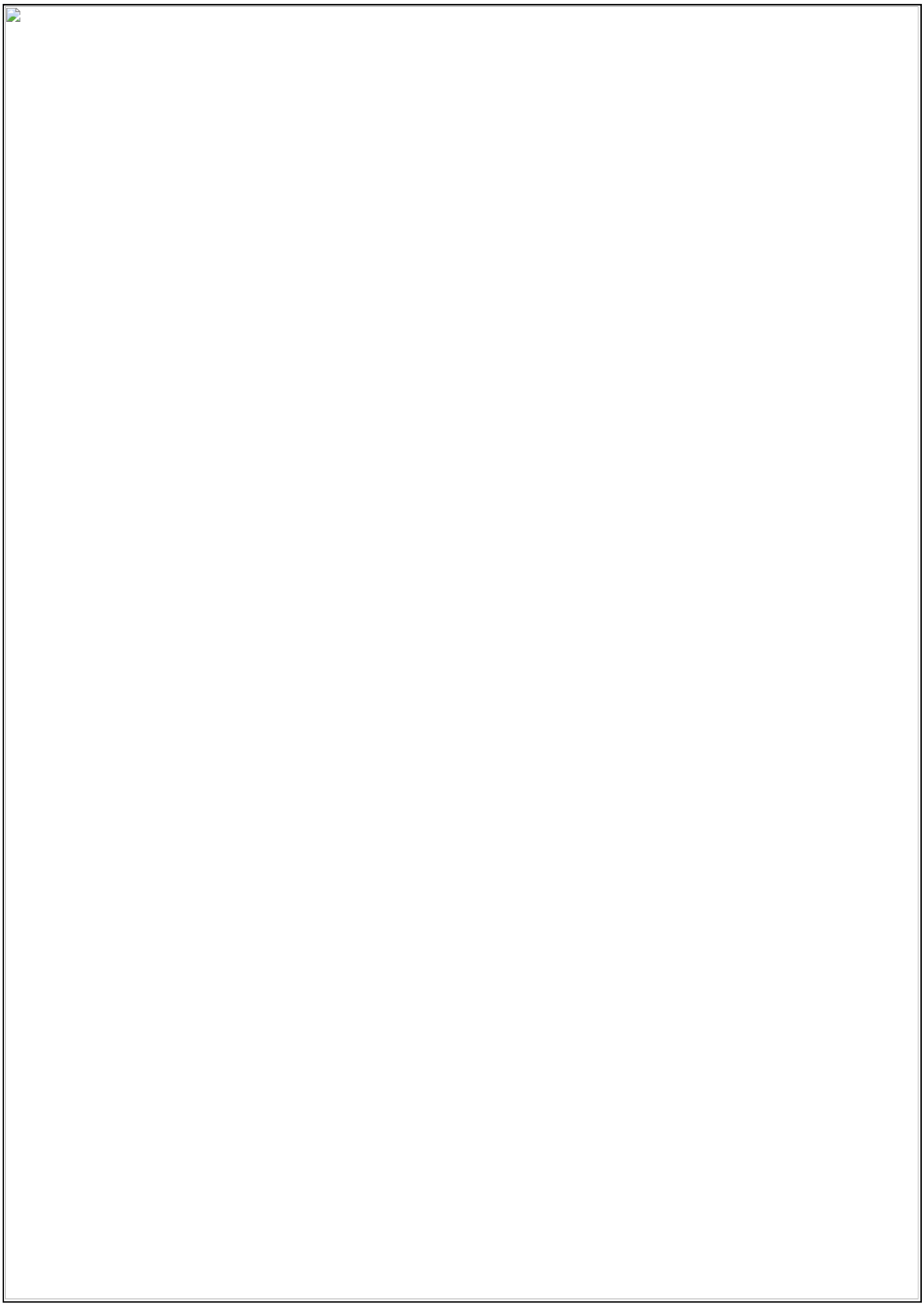
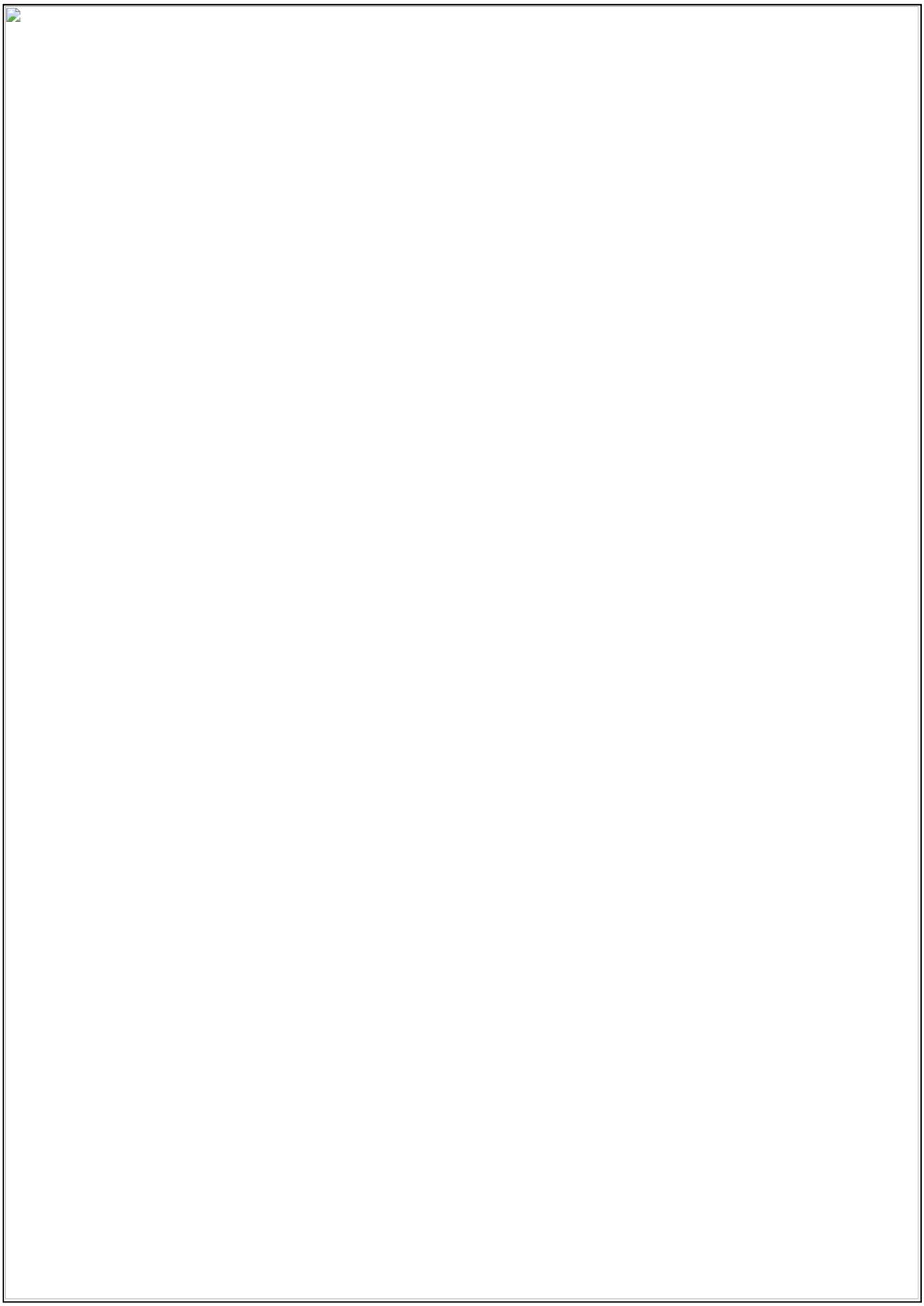




ILL HEALTH	The possibility of ill health always represents a safety hazard. Use space below to identify and assess any risks associated with this Hazard.
e.g. accident, illness, personal attack, special personal considerations or vulnerabilities.	Examples of risk: injury, asthma, allergies. Is the risk high / medium / low? Based on my medical condition: low; there has also been a low risk of getting COVID-19 as I followed social distancing rules and remained home almost at all times. The risk for participants was also low, however additional consent was acquired from them during the pandemic if they were willing to continue the study, which they fully agreed to.

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	an appropriate number of trained first-aiders and first aid kits are present on the field trip
☐	all participants have had the necessary inoculations/ carry appropriate prophylactics
☐	participants have been advised of the physical demands of the trip and are deemed to be physically suited
☐	participants have been adequate advice on harmful plants, animals and substances they may encounter
☐	participants who require medication have advised the leader of this and carry sufficient medication for their needs
☒	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

Participants have been advised about the risks on their health in regard to the study. Especially, in terms of COVID-19, they were asked if their were willing to continue the study during the pandemic or if it was too much of a burden.

TRANSPORT	Will transport be required	NO	X	Move to next hazard
		YES		Use space below to identify and assess any risks
e.g. hired vehicles	Examples of risk: accidents arising from lack of maintenance, suitability or training Is the risk high / medium / low? no public transport will be used for study purposes			

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	only public transport will be used
☐	the vehicle will be hired from a reputable supplier
☐	transport must be properly maintained in compliance with relevant national regulations
☐	drivers comply with UCL Policy on Drivers http://www.ucl.ac.uk/hr/docs/college_drivers.php
☐	drivers have been trained and hold the appropriate licence
☐	there will be more than one driver to prevent driver/operator fatigue, and there will be adequate rest periods
☐	sufficient spare parts carried to meet foreseeable emergencies
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

DEALING WITH THE PUBLIC	Will people be dealing with public	Yes	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. interviews, observing	Examples of risk: personal attack, causing offence, being misinterpreted. Is the risk high / medium / low? The study will be conducted with seven participants, however there will be no personal contact		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	all participants are trained in interviewing techniques
☐	interviews are contracted out to a third party
☐	advice and support from local groups has been sought
☐	participants do not wear clothes that might cause offence or attract unwanted attention
☐	interviews are conducted at neutral locations or where neither party could be at risk
☒	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

Participants have been instructed about the Delphi technique

WORKING ON OR NEAR WATER	Will people work on or near water?	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. rivers, marshland, sea.	Examples of risk: drowning, malaria, hepatitis A, parasites. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	lone working on or near water will not be allowed
☐	coastguard information is understood; all work takes place outside those times when tides could prove a threat
☐	all participants are competent swimmers
☐	participants always wear adequate protective equipment, e.g. buoyancy aids, wellingtons
☐	boat is operated by a competent person
☐	all boats are equipped with an alternative means of propulsion e.g. oars
☐	participants have received any appropriate inoculations
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

MANUAL HANDLING (MH)	Do MH activities take place?	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. lifting, carrying, moving large or heavy equipment, physical unsuitability for the task.	Examples of risk: strain, cuts, broken bones. Is the risk high / medium / low?		

CONTROL MEASURES	Indicate which procedures are in place to control the identified risk
☐	the departmental written Arrangement for MH is followed
☐	the supervisor has attended a MH risk assessment course
☐	all tasks are within reasonable limits, persons physically unsuited to the MH task are prohibited from such activities
☐	all persons performing MH tasks are adequately trained
☐	equipment components will be assembled on site
☐	any MH task outside the competence of staff will be done by contractors
☐	OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

SUBSTANCES	Will participants work with substances	No	If 'No' move to next hazard If 'Yes' use space below to identify and assess any risks
e.g. plants, chemical, biohazard, waste	Examples of risk: ill health - poisoning, infection, illness, burns, cuts. Is the risk high / medium / low?		

CONTROL MEASURES — **Indicate which procedures are in place to control the identified risk**

- ☐ the departmental written Arrangements for dealing with hazardous substances and waste are followed
- ☐ all participants are given information, training and protective equipment for hazardous substances they may encounter
- ☐ participants who have allergies have advised the leader of this and carry sufficient medication for their needs
- ☐ waste is disposed of in a responsible manner
- ☐ suitable containers are provided for hazardous waste
- ☐ OTHER CONTROL MEASURES: please specify any other control measures you have implemented:

OTHER HAZARDS	Have you identified any other hazards?	Yes	If 'No' move to next section If 'Yes' use space below to identify and assess any risks
i.e. any other hazards must be noted and assessed here.	Hazard: COVID-19 Risk: is the risk **low**		

The COVID-19 pandemic had a mild effect on the study. Additional consent was acquired from participants, if there were able to deal with the extra burden. All of them agreed. Participants were in regular contact with the resarcher. No participant seemed to have been infected with COVID-19 during the study.

CONTROL MEASURES — **Give details of control measures in place to control the identified risks**

following UK & German government guidance, as well as UCL guidance

Have you identified any risks that are not adequately controlled?		
	NO ☒	**Move to Declaration**
	YES ☐	**Use space below to identify the risk and what action was taken**

Is this project subject to the UCL requirements on the ethics of Non-NHS Human Research? No

If yes, please state your Project ID Number

For more information, please refer to: http://ethics.grad.ucl.ac.uk/

DECLARATION — The work will be reassessed whenever there is a significant change and at least annually. Those participating in the work have read the assessment.

Select the appropriate statement:

- ☒ I the undersigned have assessed the activity and associated risks and declare that there is no significant residual risk
- ☒ I the undersigned have assessed the activity and associated risks and declare that the risk will be controlled by the method(s) listed above

NAME OF SUPERVISOR Stephen Marshall

Stephen Marshall

SIGNATURE OF SUPERVISOR DATE 15 July 2020

Figure A.1: *Fieldwork risk assessment*

UCL data protection impact assessment (DPIA)

Step 1 – DPIA team			
	Name	Job Title	Email Address (as contact point for future privacy concerns)
Principal Investigator owning DPIA	Florian Mayer	Graduate student	florian.mayer.18@ucl.ac.uk
Third Part(y/ies) assisting with DPIA (if any)	-	-	-
Step 2 – Research summary			
Project Name	Master thesis MPlan City Planning		
Department /entity	UCL Bartlett School of Planning		
Date	10/02/2020		
Step 3 – Identify the need for a DPIA			
Describe the purpose/aims of the research. In your description set out the benefits to: i. UCL ii. individuals iii. the wider public	I am conducting a delphi study involving eight PhD students. The research is at the interface of urban design and brain sciences. The aim of the study is to understand how urban designers and brain scientists could better collaborate in the future. Benefits to UCL: contribution to research with master's thesis; benefits to individuals and the wider public: ultimately, better understanding of the built environment and therefore creating higher quality built environment		
Please explain: - the role of personal data in the project; - the risks to privacy there are in your project (please list), and - why the processing of personal data is necessary and proportional for the purposes of your project.	For the delphi study, experts have been identified based on their academic background and qualifications. It is important to understand which participant is an urban designer and which is a brain scientist. All personal data will be anonymised. In the thesis participants will be referred to as Urban Designer X or Brain Scientist X, because it is important to understand which academic background they have. However, nobody will be able to identify participants based on those attributes. The PI is the only person that will be able to identify participants based on those attributes. All personal data is securely stored on an Excel spreadsheet on a password-protected computer. Additionally, the folder with the sensitive information will be		
Step 4 - Please describe the information flows. If this is described in another document, please attach it to this DPIA			
Information Flows: means the collection, retention, use, transfer and deletion – i.e. all types of data processing as part of the project's lifecycle - of personal data should be described here. 'Transfers' would include emails between the team members. If information is sent outside the EU/EEA, you should state that here. It would also be helpful to produce and refer to a flow diagram or another way of explaining data flows.	Collection: Personal information has been collected through online search and compiled in a excel spreadsheet. Based on this information participants have been contacted per email to ask for participation in the study. Participants will be asked to fill out a form on Google forms where they will be providing personal information. Retention: Personal information has been saved on a encypted excel spreadsheet. The speadsheat is saved on a password-protected windows computer. Once personal information has been entered on Google forms, personal information will also be saved on Google servers. Use: Collected personal information will only be used to determine the academic background of each participant. The academic background is important for the analysis. Transfer: Transfer of data will very likely not be happening because there is only one person working on the project.		

Step 5 – What steps or controls are you taking to minimise risks to privacy? **Please tick**			
a. Risks to individual privacy are minimal	☑	j. Special category personal data is not used	☑
b. Personal data is pseudonymised	☑	k. Randomisation	☐
c. Encryption of data at rest, i.e. when stored	☑	l. Participant opt out at any stage of the research	☑
d. Encryption used in transfers	☐		
e. Total number of participants is less than 50	☑	m. Personal data kept in the EEA	☑
f. Information compliance training for staff has been completed - data protection, information security, FOI	☐	n. Research is not used to make decisions directly affecting individuals	☑
		o. De-identification	☐
g. Hashing or salting employed	☐	p. Short retention limits	☐
h. Adherence to privacy by design principles	☑	q. Restricted access controls	☑
i. Probalistic risk management	☐	r. Other (please specify)	

Step 6 – What steps have you taken to make sure the research is as accurate as possible and there are minimal unintended consequences? Please tick			
a. data management plan in place	☑	d. this study builds on a pilot study	☐
b. data management plan is peer reviewed	☐	e. an extension to a previous similar	☐
c. PI experience levels - no experience;	☐	study registered by DPO,	☐
some experience;	☑	if there is, please provide the number	☐
very experienced	☐		

Step 7 – How have you assessed what participants will think of the research? What have you done to address concerns raised? Please tick			
a. pilot project ☑	b. use of focus group ☐	c. information sheet/consent form ☑	d. experience drawn from previous study ☐

Step 8 – For the controls/steps specified in Step 5, who will make sure the controls are put in place? Please tick		
a. PI ☑	b. Head of School ☐	c. other body (please specify)

Figure A.2: *Data Impact Assessment template for research*

* the

Another way to look at the urban habitat is through the lenses of brain scientists involving the disciplines psychology, cognitive science, neuroscience and cognitive neuroscience. The history of the relationship between brain sciences and the study of cities goes back to the 1950s, when Tolman published his influential paper on "Cognitive Maps in Rats and Men" coined the term *cognitive map*[2]. Nowadays, there is a plethora of research investigating how our brain experiences the city[3].

The aim of this study is to explore the interface of urban design and brain sciences. This study acts as a trial for future studies in this area of research.

For the success of the study, it is important that the exact details will be withheld from the participants till their involvement is over.

The duration of the project will be 2-3 months.

3. Why have I been chosen?

Participants for this study have been selected based on following criteria:

- **Level of education:** PhD, working towards a PhD or having been enrolled in a PhD programme
- **Academic background:** Architecture, urban design, urban planning or engineering OR psychology, cognitive science, neuroscience or cognitive neuroscience.
- **Research institutes:** The number of participants from the same research institute was restricted to two in order to promote a diversity of research perspectives.
- **Interests:** The participant should show an interest in inter-disciplinary research and should understand the purpose of the study.

In total, eight participants have been selected for the study. Six participants work towards a PhD and two participants hold a PhD. Participants come from a total of five different research institutes.

4. Do I have to take part?

It is up to you to decide whether or not to take part. If you do decide to take part you will be given this '**detailed participant information sheet'** to keep and you will be asked to sign a '**research consent form'**, which is provided in another document. You can withdraw at any time without giving a reason. If you decide to withdraw you will be asked what you wish to happen to the data you have provided up to that point.

---

[2] TOLMAN, E. C. 1948. Cognitive Maps in Rats and Men. *The Psychological Review,* 55, 189 - 207.

[3]

5. What will happen to me if I take part?

If you decide to take part in the study, you will be participating in a Delphi study and you will be part of a group of experts. In general, a Delphi study can be characterised as a method for structuring a group communication process to that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem. Typically, a Delphi study consists of different rounds. Each round you will be asked to perform another task. The first round typically involves some sort of feedback of individual contributions of information and knowledge. The second and third round provide opportunities to revise views and assess the group judgment or view. Every contribution is anonymous, and the other participants won't be able to see who is contributing what.

The total time commitment is approximately 60-

7. What are the possible benefits of taking part?

Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will help shape future research. Participants might get inspiration for future research work from the study.

8. What if something goes wrong?

In case a complaint needs to be made (e.g. treatment during the research process has been unfair or something serious occurred during or following the participation in the study) feel free to contact the principal researcher at any point or alternatively, please contact the supervisor of the thesis Prof Stephen Marshall, s.marshall@ucl.ac.uk, University College London, 5th Floor, Central House, 14 Upper Woburn Place, London, WC1H 0NN.

If you feel your that your complaint has not been handled to your satisfaction, you can also contact the Chair of the UCL Research Ethics Committee – ethics@ucl.ac.uk.

9. Will my taking part in this project be kept confidential?

All the information that will be collected about you during the course of the research will be kept strictly **confidential**. Data will be saved securely and with high security standards. You won't be able to be identified in any ensuing reports or publications. Participants will be pseudonymised if they are referred to in the study (e.g. Urban Designer I, Brain Scientist II). Data protection standards are in line with UCL Data Protection Standards and a Data Protection Impact Assessment (DPIA) has been undertaken. They are also compliant with General Data Protection Regulation (GDPR). The study will make use of Google Forms. Generally, Google Forms are GDPR compliant. A separate data protection consent form will ask for consent from the participants to collect their personal data.

10. Limits to confidentiality

Confidentiality will be respected subject to legal constraints and professional guidelines.

11. Use of deception

Research designs often require that the full intent of the study won't be explained prior to participation (as indicated under point 2 *project purpose*). Although the general nature of the tasks that you will be asked to perform have been described, the full intent of the study will not be explained to you until after the completion of the study.

12. What will happen to the results of the research project?

The results of the research will be used as part of the analysis of the master's thesis. The results will be read by a supervisor and a secondary supervisor. If the thesis achieves a 'distinction' mark, it will be published by the Bartlett School of Planning and will be available through the UCL Library Catalogue as a hard-print version. A digital version of the thesis will also be sent to all participants once it has been submitted.

As stated earlier, participants won't be identified in any report or later publication.

It is very unlikely, that data collected during the course of the project might be used for additional or subsequent research. Although the study is structured in a way, that a follow-up study could repeat the study with a higher number of participants, at this point nothing like that is planned.

However, in case the data is needed at a later point, UCL data retention guidelines suggest a ten-year period in which the data needs to be stored securely.

13. Local Data Protection Privacy Notice

The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk

This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice:

For participants in research studies, click here

The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices.

The categories of personal data used will be as follows:

Name
Current research institute
Research discipline
Area of research
Topic of PhD

The lawful basis that would be used to process your *personal data* will be performance of a task in the public interest.

LONDON'S GLOBAL UNIVERSITY

UCL

Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this, and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

14. Contact for further information

For further information you can always seek contact via e-mail either through florian.mayer.18@ucl.ac.uk (for research-related questions) or my supervisor on s.marshall@ucl.ac.uk (for complaints and other issues).

You will be provided a digital copy of the information sheet. It would be highly appreciated if participants could sign a research consent form and could send it back at your earliest convenience.

Thank you for reading this information sheet and for considering to take part in this research study.

F. Mayer

London, 11/02/2020

Figure A.3: *Participant information sheet*

Research consent form

CONSENT FORM FOR PhD CANDIDATES AND PhD HOLDERS IN RESEARCH STUDIES

Please complete this form after you have read the 'Detailed Participant Information Sheet', which was sent as a separate document.

Title of Study: "Re-thinking urban design research - an inter-disciplinary exploration at the interface of urban design and brain sciences using the Delphi-method"

Department: UCL Bartlett School of Planning

Name and Contact Details of the Researcher(s): Florian Mayer, MPlan City Planning, e-mail: florian.mayer.18@ucl.ac.uk

Name and Contact Details of Supervisor: Prof Stephen Marshall, Professor of Urban Morphology and Urban Design, e-mail: s.marshall@ucl.ac.uk

Name and Contact Details of the UCL Data Protection Officer: Alex Potts, e-mail: a.potts@ucl.ac.uk

This study has been approved by the UCL Research Ethics Committee: Project ID number: not applicable*

Thank you for considering taking part in this research. The accompanying **'Detailed Participant Information Sheet'** should have provided a sufficient overview over the study. If you have any questions arising from the **'Detailed Participant Information Sheet'** or explanation already given to you via e-mail, please ask before you decide whether to join in. You will be given a digital copy of this **'Research Consent Form'** to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box below I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes mean that I DO NOT consent to that part of the study. I understand that by not giving consent for any one element that I may be deemed ineligible for the study.

* the study does not require ethical approval through UCL REC, because it falls under exemption category 4: "Research involving the use of non-sensitive, completely anonymous educational tests, survey and interview procedures when the participants are not defined as "vulnerable" and participation will not induce undue psychological stress or anxiety". More information under https://ethics.grad.ucl.ac.uk/exemptions.php.

Figure A.4: *Research consent form*

Round I (brainstorming)

Task description & questionnaire

You have been invited to participate in a Delphi study with the research title: "Re-thinking urban design research - an inter-disciplinary exploration at the interface of urban design and brain sciences using the Delphi-method".

In the following, you will be guided through the study step-by-step. Please read the instructions carefully and take your time doing the task.

This should approximately take between 20-30 minutes.

Before you start, please enter your 'Unique Participant Identifier' (UPI), which was sent to you individually in a separate e-mail.
*Required

1. Please provide your UPI: *

Before we start...

The following section will focus on your academic backgound. Please answer the questions as detailed as possible. Please read the questions carefully.

Academic qualification

2. What is your academic qualification regarding your PhD? *

Mark only one oval.

- ◯ I obtained a PhD degree *Skip to question 3*
- ◯ I work towards a PhD degree *Skip to question 4*
- ◯ Other *Skip to question 5*

Skip to question 6

Duration of PhD program

3. How long were you enrolled in the PhD programme? *

Mark only one oval.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ >5

Skip to question 6

Time spent in PhD program

4. How long have you been in enrolled in the PhD programme? *

Mark only one oval.

- ◯ 0
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ >5

Skip to question 6

Time spent in PhD program

5. How long were you enrolled in the PhD programme?

Mark only one oval.

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ >5

Skip to question 6

Current research institute

6. Please state the name of your current research institute. If not applicable, please leave blank.

_____

Research discipline

7. What is your research discipline? *

Please choose an option from below. If you have an interdisciplinary research background, please choose the discipline, which has most influenced your current research.

Mark only one oval.

- ◯ Psychology *Skip to question 8*
- ◯ Cognitive Science *Skip to question 8*
- ◯ Neuroscience *Skip to question 8*
- ◯ Cognitive Neuroscience *Skip to question 8*
- ◯ Architecture *Skip to question 10*

- Urban Design *Skip to question 10*
- Urban Planning *Skip to question 10*
- Engineering *Skip to question 10*

Interdisciplinary knowledge

8. How familiar are you with urban design? *

Mark only one oval.

	1	2	3	4	5	
not very well						very well

9. Have you worked with urban designers before? *

Tick all that apply.

- [ ] Yes
- [ ] No

Skip to question 12

Interdisciplinary knowledge

10. How familiar are you with brain sciences? *

Mark only one oval.

	1	2	3	4	5	
not very well						very well

11. Have you worked with brain scientists before? *

Tick all that apply.

- [ ] Yes
- [ ] No

Skip to question 12

Your research

12. What is/was your area of research? *

13. What is/was the topic of your PhD?

The Delphi Study - General Information

Thank you for providing your information in the previous section. We will begin with the Delphi study now.

General information

You are part of a group of experts. The other experts are either brain scientists or urban designers.

The Delphi study consists of three rounds. This is round 1 of 3.

The first round involves individual contributions of information and knowledge from the participants. This is a simple brainstorming task.

You will be given one question, which you have to answer by yourself on the next pages. Those answers will form the basis for the next rounds. Every contribution is anonymous, and the other participants won't be able to identify what you were contributing.

In the following, we will start with round 1 of 3.

Thematic introduction

Introduction

Please read the following introductory text carefully and give attention to every detail:

In recent years, urban design has evolved into a diverse field comprising an assemblage of different disciplines, methodologies, practices and theories. We're living in an increasingly urbanised world. Cities provide habitats for more than half of the world's population. This creates opportunities, but also severe challenges. Urban design can help to address those challenges and shape a better urban habitat.

In past years, urban designers have more and more focused on the human experience of urban design in the city. This human-centred design has been advocated by many scholars and has become very influential within the urban design community. Building for the human scale follows the credo: the urban environment is a human habitat and therefore we need to build for human-beings. The better we understand the human experience of the urban environment, the better we can cater for human needs in the city.

Another way to look at the urban habitat is through the lenses of brain scientists. In the context of this study, brain sciences represent the disciplines psychology, cognitive science, neuroscience and cognitive neuroscience. The history of the relationship between brain sciences and the study of cities goes back to the 1950s. Since then, new research has paved the way for a better understanding of the relationship between the brain and the urban environment. New technologies like brain imaging (e.g. fMRI), psycho-physiological methods (e.g. galvanic skin response as predictor for stress) and behavioural methods allow researchers to get deeper insights in how our brain responds to the built environment. Nowadays, there is a plethora of research investigating how our brain experiences the city.

In the next section, we will start with the first task. Please take your time and think carefully about your responses.

Round 1

Instructions

On the following page you will be given one question. Your task will be to anwer the question. In total you will be asked to give eight answers. One answer represents one factor. In the end you should have a list of eight factors, that are most important to you.

Each answer should be as concise as possible and no longer than one sentence. However, you will have the chance to provide a separate description to support your answer. Please make use of this separate description when you think your answer needs further explanation.

A factor could look like this: Better understanding of colour and its impact on the perception of space. A further explanation could look like that: "By perception, I mean [explanation]." (This example is absolutely generic and has no connection to any research).

Furthermore, the way you order your factors determines their importance. Answer 1 is your most important choice, whereas answer 8 is your least important. Please think about the order before you start answering, because it might be hard to reshuffle them afterwards.

Please use simple language and be aware of the fact that not all participants might be familiar with certain terms. Try to avoid expert language wherever possible. If we use expert language, please make sure to explain what you mean briefly.

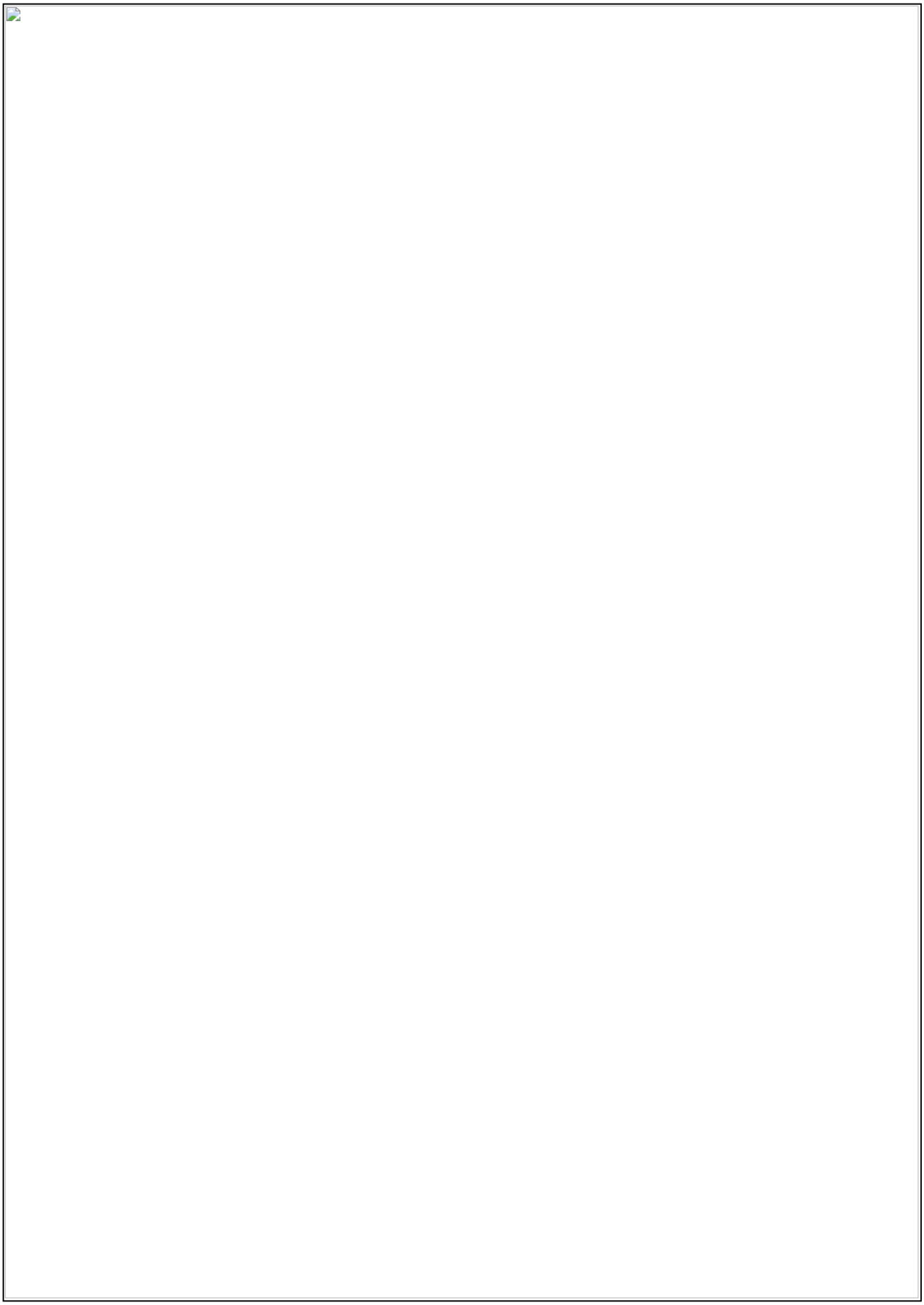
When you are done with all answers, please submit the form.

Round I

Please answer following question:

Coming from your discipline (urban design or brain sciences), which (research) topics have most potential to create more human-centered urban built environments?

Figure A.5: *Questionnaire round I*



Round III (ranking)

task description & consolidated list for ranking

Thank you for participating in round 2 of the Delphi study. **We now proceed to round 3**. Please read the instructions carefully and take your time doing the task. It should take approximately 10-15 minutes.

In the last round, you chose **10 answers** from a list of **56 answers**. Your entries have been reviewed and a list of **11 answers** has been collated. Those 11 answers represent all answers that have been selected by **three or more participants** in the last round and account all together for the **majority of submitted selections**.

Essentially, round 3 is a **'ranking' exercise**, where you are asked to rank the remaining 11 answers. In the following you will find your **instructions**:

- Go through the list carefully and consider every answer.
- Please **rank the answers** based on their relevance regarding the initial research question: *"Coming from your discipline (urban design or brain sciences), which (research) topics have most potential to create more human-centred urban built environments?"*
- Ranking means that every answer needs to be assigned a rank between **1** and **11**. **1** is your **preferred choice**, **11** your **least preferred choice.**
- To rank an answer, please write the relevant rank in the box on the right-hand side of the sheet. Please make sure that there are no **duplicates** and **double-check** before submitting.

Note: Some of you might find it easier to do the ranking exercise because the majority of their selections from the previous task have made it into this list. If you are in a position, where you need to re-consider answers you haven't prioritised before, make sure you do this to the best of your knowledge. Even if it may be difficult to rank unfamiliar answers, please make sure you rank them.

Reduced list of answers for ranking exercise (3 or more times selected)

Factor	Description	Rank
Take more consideration of marginalised groups - don't just design around the prototypical man. Consider homelessness, disabilities etc. i.e. prioritise inclusive design	-	
Open data	The backlash against the control of the smart city by a handful of firms, and the subsequent policy push towards citizen centred data sovereignty is key to the human city. People need to have control of their data for a series of reasons, but also to enable small players to provide services.	
To understand how the physical (or built) environment can promote active travel behaviour (or active commuting)	The term 'active travel behaviour (or active commuting)' refers to physical activity as a means of transport and very often in combination with public transport.	
Biodiversity / natural elements in the city	Humans are indistinguishable from nature, the idea of flora and fauna as something 'other' needs to be recalibrated to support the largescale rewilding of our cities to reinforce how humanity is part of a wider ecosystem. The wellbeing and mental health benefits of exposure to nature- even in urban environments-is something that is increasingly understood as a core element of planning.	
Multi-sensory approach to urban design	An approach or method within urban design that includes more than the visual senses. It should include the analysis of how people experience public space through vision, hearing, smelling and tasting	
From space to place	Understand what make space users understand and use the space, what makes people be more attached to some places than others, feeling about space are here considered	
Objective city data	Cities and spaces should be designed to produce specific behaviours, not metaphors. That is to say, if a coffee shop is designed beautifully with bespoke renderings with handsome young people in business suits starting the next Facebook, it should also perform that behaviour once it is designed. Too often you see architects overpromise what their designs can do. Often their promises take advantage of current cultural insecurities around things like status, wealth and health. Some of these outcomes have objective metrics that can be used to track success. Well thought out objective data gathering would help evaluate the success of designs.	
Accessibility / accessible urban space	Tied to both movement and interactivity is the concept of accessibility. Being human, surely must mean that the city is accessible for all, and this impacts the way places are designed to include the needs of the most vulnerable users as well as the governance practices that form an unseen layer of the city. The feel or noise of a defines its accessibility as much as whether it is privately managed - in this way both defensive architecture and a decree outlawing informal settlements are two sides of the same coin. Without accessibility to services and places, your city creates opposite of a human space: alienation.	
Develop methods for testing in the real world	It'll be important to find ways to test the effects of different urban design strategies in the real world (i.e. outside the lab), or to find a way to bring the 'real world' into the lab. Essentially, to have as ecologically valid research and experimentation as possible, because the questions we're interested in are rooted in real world environments and situation	

Objective city data	Cities and spaces should be designed to produce specific behaviours, not metaphors. That is to say, if a coffee shop is designed beautifully with bespoke renderings with handsome young people in business suits starting the next Facebook, it should also perform that behaviour once it is designed. Too often you see architects overpromise what their designs can do. Often their promises take advantage of current cultural insecurities around things like status, wealth and health. Some of these outcomes have objective metrics that can be used to track success. Well thought out objective data gathering would help evaluate the success of designs.	
Accessibility / accessible urban space	Tied to both movement and interactivity is the concept of accessibility. Being human, surely must mean that the city is accessible for all, and this impacts the way places are designed to include the needs of the most vulnerable users as well as the governance practices that form an unseen layer of the city. The feel or noise of a defines its accessibility as much as whether it is privately managed - in this way both defensive architecture and a decree outlawing informal settlements are two sides of the same coin. Without accessibility to services and places, your city creates opposite of a human space: alienation.	
Develop methods for testing in the real world	It'll be important to find ways to test the effects of different urban design strategies in the real world (i.e. outside the lab), or to find a way to bring the 'real world' into the lab. Essentially, to have as ecologically valid research and experimentation as possible, because the questions we're interested in are rooted in real world environments and situation	

Figure A.7: *Round III - task description and final list*

Debriefing questionnaire

Questionnaire

Thank you all for participating in the delphi study.

In the following, I kindly ask you to fill out a debriefing questionnaire. This questionnaire will allow you to comment on the methodology and provide feedback about the study.

Before you start, please enter your 'Unique Participant Identifier' (UPI), which was sent to you individually in a separate e-mail.
*Required

1. Please provide your UPI: *

Question 1

2. What do you think was the purpose of the study?

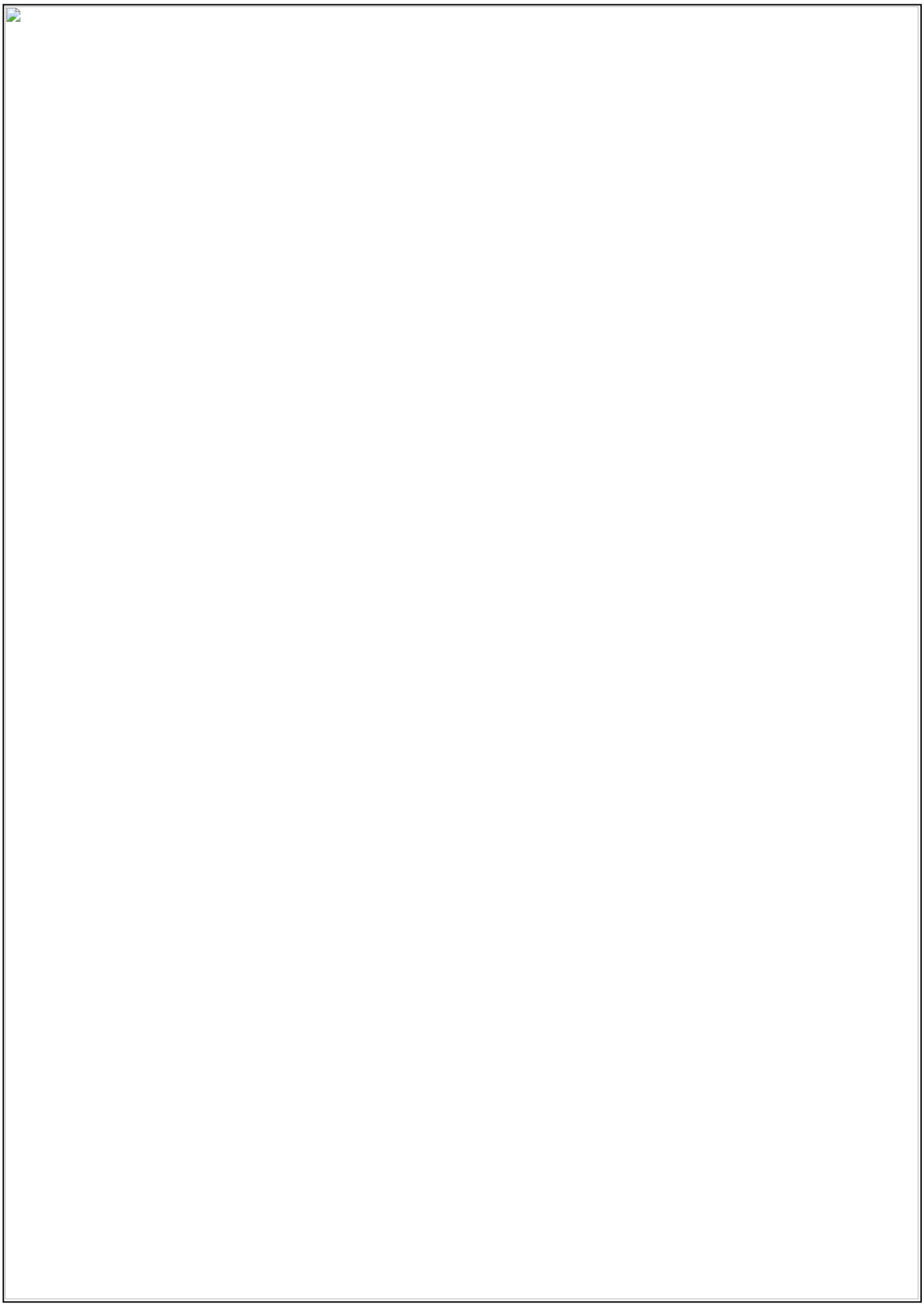
Question 2

3. Did the study change your perception of the other field?

Mark only one oval.

	1	2	3	4	5	
Not at all	◯	◯	◯	◯	◯	Very much so

4. Please specify in how far the study changed your perception.



Purpose of study

This study has been carried out to give answers to the question if brain scientists and urban designers could cooperate at the intersection of their fields to create more human-centred urban built environments.

In recent years research done at the intersection of both fields has steadily grown. However, the "awareness" of each other's research, topics and general agenda is still relatively low. Therefore this study had three overall aims:

1. Stimulating research cooperation by bringing together different experts of the two fields. The Delphi study acted in a way as a 'platform' and a case study how communication and cooperation between the fields can be fostered and measured.

2. Exploring a range of topics (in regard to human-centred built environments) that could be derived from this excercise, the Delphi study, involving the two fields.

3. Measuring if there is consensus between the two fields. If there is consensus this could indicate that there is common ground for further cooperation.

There are a range of limitations due to the scope of this master's thesis. Due to the relatively small group size, it is not expected that the results will produce significant results, but nevertheless indicate trends. The aim of this study has always been to be explorative and to be a starting point for possible future studies. A strong focus will be put on the discussion of the research method.

The study has produced interesting results so far and I am more than happy to share them after I submitted the master thesis.

Comments

Do you have any further general comments about the study?

Thank you!

And I just wanted to say thank you again! I am very grateful that all of you have stayed onboard till the end and helped me finish the study. I know this has been a very challenging time for all of us and that's why I am more than happy that we made this work. All of you have spent your free time on this without any reimbursement and that's just incredible and I don't take this for granted. I wished I had the chance to meet you personally at some point and talk about the study and your research.

I wish you all the best in your future endeavours.

Florian

Figure A.8: *Debriefing questionnaire*

A.A Appendix B: presentation of data

Round I (brainstorming)

Results BS 2

	code	participant's original answer	revised answer by researcher	final revised answer
answer 1	1	Metaphor	Metaphorical meanings of space and architecture	Metaphorical meanings of space and architecture
description		Metaphor refers to a secondary meaning to a tangible object. Space and architecture are tangible, yet the metaphorical meaning of space in architecture seems to, with regards to humans, be prioritized by designers and consumers of design, rather than the embodied, pre-reflective, experience of architecture.	x	Metaphor refers to a secondary meaning to a tangible object. Space and architecture are tangible, yet the metaphorical meaning of space in architecture seems to, with regards to humans, be prioritized by designers and consumers of design, rather than the embodied, pre-reflective, experience of architecture.
category		**CITY & COGNITION**		
answer 2	2	Embodied Cognition	x	Embodied Cognition
description		Embodied cognition is the idea that our cognition is deeply dependent on the state of the body and its "situatedness". Research from cognitive neuroscience is demonstrated strong links between the "world we live in" and our resulting cognitive abilities. The more we understand the strength of these relationships, the more sensitive we may be to designing "supportive" embodied experiences.	**Comment:** how does this relate to the urban built environment more specifically?	Embodied cognition is a theory that claims our cognition is deeply dependent on the state of the body and its relation to the environment. Under this theory, Architects, therefore, not only design for behaviour but also mental states. For example, some religious sites are designed to invoke "awe", some health centres are designed to "calm", and some neighbourhoods are designed for "happiness". Understanding the nature and strengths of relationships between buildings, the body, and cognition is a promising research track.
category		**CITY & COGNITION**		
answer 3	3	Pre-reflective architecture	x	Pre-reflective architecture
description		Pre-reflective architecture refers to architecture that acts on the human condition prior to metaphor (i.e., prior to cognitive appraisal). This type of architecture is considered more "universal", in that it affects aspects of the human condition that are personality and culture independent. Examples are texture, colour, proprioception, movement.	x	Pre-reflective architecture refers to architecture that acts on the human condition prior to metaphor (i.e., prior to cognitive appraisal). This type of architecture is considered more "universal", in that it affects aspects of the human condition that are personality and culture independent. Examples are texture, colour, proprioception, movement.
category		**CITY & COGNITION**		
answer 4	4	Objective city data	x	Objective city data
description		Cities and spaces should be designed to produce specific behaviours, not metaphors. That is to say, if a coffee shop is designed beautifully with bespoke renderings with handsome young people in business suits starting the next Facebook, it should also perform that behaviour once it is designed. Too often you see architects overpromise what their designs can do. Often their promises take advantage of current cultural insecurities around things like status, wealth and health. Some of these outcomes have objective metrics that can be used to track success. Well thought out objective data gathering would help evaluate the success of designs.	x	Cities and spaces should be designed to produce specific behaviours, not metaphors. That is to say, if a coffee shop is designed beautifully with bespoke renderings with handsome young people in business suits starting the next Facebook, it should also perform that behaviour once it is designed. Too often you see architects overpromise what their designs can do. Often their promises take advantage of current cultural insecurities around things like status, wealth and health. Some of these outcomes have objective metrics that can be used to track success. Well thought out objective data gathering would help evaluate the success of designs.
category		**DATA & TECHNOLOGY**		
answer 5	5	Experimental Psychology to Evaluate 'Cognitive' Architecture	x	Experimental Psychology to Evaluate 'Cognitive' Architecture

Results BS4

	code	participant's original answer	revised answer by researcher	final revised answer
answer 1	17	Better understanding of how we perceive and find our ways in compartmentalised environment	x	Better understanding of how we perceive and find our ways in compartmentalised environment
description		Compartmentalised environment means the space with multiple floors, multiple rooms (typical of urban design, in contrast to natural environment)	The term 'compartmentalised environment' refers to spaces with multiple floors and multiple rooms (typical of man-made built environments in contrast to natural environments)	The term 'compartmentalised environment' refers to spaces with multiple floors and multiple rooms (typical of man-made built environments in contrast to natural environments)
category		**WAYFINDING/SPATIAL NAVIGATION**		
answer 2	18	Ergonomic ways of creating/arranging space vertically	x	Ergonomic ways of creating/arranging space vertically
description		The typical multilevel building can cause confusion for each floor	To move through a building vertically with multiple levels is a very different setting to the environments we are typically in. Therefore, the typical multilevel building can cause confusion for our brain. The term 'ergonomic' in this context refers to a way of building that reduces this confusion to a minimum	To move through a building vertically with multiple levels is a very different setting to the environments we are typically in. Therefore, the typical multilevel building can cause confusion for our brain. The term 'ergonomic' in this context refers to a way of building that reduces this confusion to a minimum
category		**WAYFINDING/SPATIAL NAVIGATION**		
answer 3	19	How aging affects the navigation/spatial memory in urban environment	How aging affects the navigation/spatial memory in urban environments	How aging affects the navigation/spatial memory in urban environments
description		x	x	x
category		**WAYFINDING/SPATIAL NAVIGATION**		
answer 4	20	Considering cultural differences in perceiving space and wayfinding	x	Considering cultural differences in perceiving space and wayfinding
description		x	x	x
category		**WAYFINDING/SPATIAL NAVIGATION**		
answer 5	21	Applying social science/brain science to create optimal space for social activity?	x	Applying social science/brain science to create optimal space for social activity
description		x	**Comment:** add description	Social space refers to space both within and outside the building, which is used for social acticity (e.g. meeting room, a corridor that promotes the exchange of idea and thoughts, courtyard)
category		**UNDERSTANDING OF PLACE / PLACE-MAKING**		
answer 6	22	Design the urban environment that can stimulate human's natural wayfinding behaviour and related cognitive functions	Design urban environments that can stimulate human's natural wayfinding behaviour and related cognitive functions	Design urban environments that can stimulate human's natural wayfinding behaviour and related cognitive functions
description		x	x	There is a concern that people lose their natural wayfinding ability and related cognitive function (e.g. hippocampus-related) in the stereotypical urban environment and over-reliance on GPS device.
category		**WAYFINDING / SPATIAL NAVIGATION**		
answer 7	23	Applying virtual reality (VR) or augmented reality (AR) for urban planning	x	Applying virtual reality (VR) or augmented reality (AR) for urban planning
description		x	**Comment:** pleae elaborate	I meant architects can use VR and AR when they design the building or environment in order to simulate and predict how people would feel and interact with the environment. Probably they can make some experiment with a group of participants.
category		**NEW METHODS & METHODOLOGIES**		
answer 8	24	Considering gender differences in space perception and navigation	x	Considering gender differences in space perception and navigation
description		No description	x	x
category		**WAYFINDING / SPATIAL NAVIGATION**		

Table A.3: *Round I - participant BS4 results*

Results UD2

	code	participant's original answer	revised answer by researcher	final revised answer
answer 1	33	Building a better understanding of the behavioural and cognitive influences of air quality.	x	Building a better understanding of the behavioural and cognitive influences of air quality.
description		x	x	x
category		CITY & COGNITION		
answer 2	34	Building a better understanding of the behavioural and cognitive influences of nature.	x	Building a better understanding of the behavioural and cognitive influences of nature.
description		x	x	x
category		CITY & COGNITION		
answer 3	35	Building a better understanding of the behavioural and cognitive influences of aesthetics.	x	Building a better understanding of the behavioural and cognitive influences of aesthetics.
description		No description	x	x
category		CITY & COGNITION		
answer 4	36	Develop methods for testing in the real world.	x	Develop methods for testing in the real world.
description		No description	Further explanation needed?	It'll be important to find ways to test the effects of different urban design strategies in the real world (i.e. outside the lab), or to find a way to bring the 'real world' into the lab. Essentially, to have as ecologically valid research and experimentation as possible, because the questions we're interested in are rooted in real world environments and situations.
category		NEW METHODS & METHODOLOGIES		
answer 5	37	Create better dialogue between disciplines such as brain sciences and architecture - utilise each others' methodologies and paradigms/fill in each others' gaps.	x	Create better dialogue between disciplines such as brain sciences and architecture - utilise each others' methodologies and paradigms/fill in each others' gaps.
description		No description	x	x
category		INTERDISCIPLINARITY		
answer 6	38	Take more consideration of marginalised groups - don't just design around the prototypical man. Consider homelessness, disabilities etc. i.e. prioritise inclusive design.	x	Take more consideration of marginalised groups - don't just design around the prototypical man. Consider homelessness, disabilities etc. i.e. prioritise inclusive design.
description		No description	x	x
category		INCLUSIVE URBAN DESIGN		
answer 7	39	Develop methodologies to better understand fluid, subjective human qualities such as emotions.	x	Develop methodologies to better understand fluid, subjective human qualities such as emotions.
description		No description	x	x
category		NEW METHODS & METHODOLOGIES		
answer 8	40	Better understanding of building scale aspects such as room size, ceiling height etc.	x	Better understanding of building scale aspects such as room size, ceiling height etc.
description		No description	x	x
category		URBAN MORPHOLOGY		

Table A.5: *Round I - participant UD2 results*

Results UD3

	code	participant's original answer	revised answer by researcher	final revised answer
answer 1	41	Interactivity	Places for human interactivity	Places for human interactivity
description		Places that enable people to interact passively or actively are key to the human-scale city. Humanity surely is about the interplay between the individual and society, so the role of third spaces and active streetscapes is key to enable this.	x	Places that enable people to interact passively or actively are key to the human-scale city. Humanity surely is about the interplay between the individual and society, so the role of third spaces and active streetscapes is key to enable this.
category		**UNDERSTANDING OF PLACE / PLACE-MAKING**		
answer 2	42	Healthy movement	x	Healthy movement
description		The way we navigate through space is a fundamental part of (urban) life. Some modes can isolate you and damage your health while others enable your body to be used fully, the latter it would seem would be more akin to a human scale city - walking + cycling through this optic would be considered more human than ordering a curry via Deliveroo.	x	The way we navigate through space is a fundamental part of (urban) life. Some modes can isolate you and damage your health while others enable your body to be used fully, the latter it would seem would be more akin to a human scale city - walking + cycling through this optic would be considered more human than ordering a curry via Deliveroo.
category		**URBAN DESIGN & TRANSPORT**		
answer 3	43	Accessibility	Accessibility / accessible urban space	Accessibility / accessible urban space
description		Tied to both movement and interactivity is the concept of accessibility. Being human, surely must mean that the city is accessible for all, and this impacts the way places are designed to include the needs of the most vulnerable users as well as the governance practices that form an unseen layer of the city. The feel or noise of a defines its accessibility as much as whether it is privately managed - in this way both defensive architecture and a decree outlawing informal settlements are two sides of the same coin. Without accessibility to services and places, your city creates opposite of a human space: alienation.	x	Tied to both movement and interactivity is the concept of accessibility. Being human, surely must mean that the city is accessible for all, and this impacts the way places are designed to include the needs of the most vulnerable users as well as the governance practices that form an unseen layer of the city. The feel or noise of a defines its accessibility as much as whether it is privately managed - in this way both defensive architecture and a decree outlawing informal settlements are two sides of the same coin. Without accessibility to services and places, your city creates opposite of a human space: alienation.
category		**POLITICS OF URBAN DESIGN**		
answer 4	44	Biodiversity	Biodiversity / natural elements in the city	Biodiversity / natural elements in the city
description		Humans are indistinguishable from nature, the idea of flora and fauna as something 'other' needs to be recalibrated to support the largescale rewilding of our cities to reinforce how humanity is part of a wider ecosystem. The wellbeing and mental health benefits of exposure to nature- even in urban environments-is something that is increasingly understood as a core element of planning.		Humans are indistinguishable from nature, the idea of flora and fauna as something 'other' needs to be recalibrated to support the largescale rewilding of our cities to reinforce how humanity is part of a wider ecosystem. The wellbeing and mental health benefits of exposure to nature- even in urban environments-is something that is increasingly understood as a core element of planning.
category		**URBAN DESIGN & ENVIRONMENT**		
answer 5	45	Playfulness	Playfulness / playful urban environments	Playfulness / playful urban environments
description		The idea of play has defined the relationship building underpinning the formation of human societies for centuries. Playful environments are more human ones, this can be inbuilt to streetscapes, public spaces, facades, building design, etc. A smile is one of our universals :-)	x	The idea of play has defined the relationship building underpinning the formation of human societies for centuries. Playful environments are more human ones, this can be inbuilt to streetscapes, public spaces, facades, building design, etc. A smile is one of our universals :-)
category		**CITY & COGNITION**		

answer 6	46	Circularity	x	Circularity
description		The extractive nature of our current economic practices is threatening our very humanity -- introducing more circularity in the way we manage and use our spaces, can help provide opportunities for people to flourish. This could impact our supply chains and externalities to reduce our emissions/ pollution so that our activities are not so noxious. Whether this is truly possible at a city scale remains to be seen.	x	The extractive nature of our current economic practices is threatening our very humanity -- introducing more circularity in the way we manage and use our spaces, can help provide opportunities for people to flourish. This could impact our supply chains and externalities to reduce our emissions/ pollution so that our activities are not so noxious. Whether this is truly possible at a city scale remains to be seen.
category		**SUSTAINABLE URBAN DESIGN**		
answer 7	47	Complementary technology	x	Complementary technology
description		Technology that complements our humanity rather than competes with it is key. For example, ride hailing distorts our idea of geography whereas map reading enhances it. We need to hamess tech that helps make us more intelligent and self-dependent, not more reliant on things we don't understand.	x	Technology that complements our humanity rather than competes with it is key. For example, ride hailing distorts our idea of geography whereas map reading enhances it. We need to hamess tech that helps make us more intelligent and self-dependent, not more reliant on things we don't understand.
category		**DATA & TECHNOLOGY**		
answer 8	48	Open data	x	Open data
description		The backlash against the control of the smart city by a handful of firms, and the subsequent policy push towards citizen centred data sovereignty is key to the human city. People need to have control of their data for a series of reasons, but also to enable small players to provide services.	x	The backlash against the control of the smart city by a handful of firms, and the subsequent policy push towards citizen centred data sovereignty is key to the human city. People need to have control of their data for a series of reasons, but also to enable small players to provide services.
category		**DATA & TECHNOLOGY**		

Table A.6: *Round I - participant UD3 results*

Results UD4

	code	participant's original answer	revised answer by researcher	final revised answer
answer 1	49	Research on people's perception of urban transformation	x	Research on people's perception of urban transformation
description		The important feature of transformation is its temporal element; The urban experience of people in a constantly changing urban environment	x	The important feature of transformation is its temporal element; The urban experience of people in a constantly changing urban environment
category		**URBAN DESIGN & TEMPORALITY**		
answer 2	50	Studying the sensual stimuli in the built environment that can cause distress	x	Studying the sensual stimuli in the built environment that can cause distress
description		These stimuli could involve all the human senses,	These stimuli could involve all human senses.	These stimuli could involve all human senses.
category		**CITY & COGNITION**		
answer 3	51	Studying the social distress caused by crowding	x	Studying the social distress caused by crowding
description		x	**Comment:** please provide a definiton for crowding	Crowding is a perceptual phenomenon referring to a subjective (commonly negative) evaluation of density for example when the available personal space is less than desired.
category		**CITY & COGNITION**		
answer 4	52	The issue of scale and its impact on creation of social bonds	The scale of human settlements and its impact on the creation of social bonds	The issue of scale and its impact on creation of social bonds
description		By scale I mean the scale of human settlements, How big, how dense?	The term 'scale of human settlements' refers to their dimension and density	The term 'scale of human settlements' refers to their dimension and density
category		**CITY & COGNITION**		
answer 5	53	Investigating the role of place in the built environment and the importance of being attached to the places that we live in, work and rest.	x	x
description		Place as a social construct not as a concept that can be created out of nowhere and through top-down initiatives	x	x
category		**UNDERSTANDING OF PLACE / PLACE-MAKING**		
answer 6	54	The role of financialization of the built environment, commodification of space, and prevalence of economic reasoning on human alienation in the cities.	x	The role of financialization of the built environment, commodification of space, and prevalence of economic reasoning on human alienation in the cities.
description		x	x	x
category		**POLITICS OF URBAN DESIGN**		
answer 7	55	The idea of Libertarian Municipalism by Bookchin which has a huge potential for an alternative way of creating cities that promote human participation and mutual aid.	x	The idea of Libertarian Municipalism by Bookchin which has a huge potential for an alternative way of creating cities that promote human participation and mutual aid.
description		x	**Comment:** please add a description	""Libertarian Municipalism constitutes the politics of social ecology, a revolutionary effort in which freedom is given institutional form in public assemblies that become decision-making bodies." (Bookchin, The Next Revolution, 2015;p. 96). Libertarian municipalism intends to create a situation in which the two powers—the municipal confederations and the nation-state—cannot coexist. Its supporters—Communalists—believe it to be the means to achieve a rational society, and its structure becomes the organization of society."
category		**POLITICS OF URBAN DESIGN**		
answer 8	56	Residents' empowerment through establishment of neighbourhood assemblies and increasing their involvement in decision-making and urban design processes;	x	Residents' empowerment through establishment of neighbourhood assemblies and increasing their involvement in decision-making and urban design processes;
description		A sort of multi-scalar governance pattern in which the local level is the main decision-making body and the highest level acts only as the coordinator.	x	A sort of multi-scalar governance pattern in which the local level is the main decision-making body and the highest level acts only as the coordinator.
category		**COLLABORATIVE URBAN DESIGN**		

Table A.7: *Round I - participant UD4 results*

Categorised list of brainstormed research topics

	group name	topics	description	includes for example
1	**City & cognition**	11	The relationship between the built environment and the brain and its underlying cognitive functions	Perception, senses, distress, embodiment and aesthetics
2	**New methods and methodologies**	8	New ways to measure how the urban environment interacts with our brain.	Virtual reality (VR) and artificial reality (AR), physiopsychological measurements and neuroimaging
3	**Wayfinding & spatial navigation**	7	How we orient ourselves in space and navigate through space	Navigation & wayfinding, walkability, spatial cognition and wayfinding.
4	**Inclusive urban design**	5	How to make urban design more inclusive for vulnerable groups of society	Special needs, health, well being and life satisfaction (in different social and age groups)
5	**Understanding of place / place-making**	5	Utilising place-making to create more human-centered places	Social activity in public spaces, human interactivity and place attachment.
6	**Urban design & transport**	3	How urban design can contribute to active transport and to healthier transport choices	Active transport & healthy movement.
7	**Politics of urban design**	3	The influence of politics on urban design and how this influences our use of space	Accessibility of different social groups to various spaces, financialization and privatisation.
8	**Data & technology**	3	Use of technology and data to improve urban design	Open data, objective data gathering and complementary use of technology
9	**Urban design & environment**	3	Natural elements in the city and their relationship with the built environment and human-beings	Biodiversity, environmental design and health & well-being
10	**Collaborative urban design**	2	How urban design is a collaborative process involving different actors in society	Collaborative methods and neighbourhood assemblies
11	**Urban morphology**	2	How urban morphology shapes space use	Importance of building layouts, residential densities and neighbourhood form.
12	**Sustainable urban design**	2	How sustainability can be incorporated in urban design.	Circularity
13	**Urban design & temporality**	1	The temporal component of urban transformation.	-
14	**Inter-disciplinarity**	1	How better dialogue between urban design and other disciplines can foster better urban design	-

Table A.8: *An overview of brainstormed research topics categorised in thematic groups and their distribution*

Round II (consolidation)

Consolidated list of research topics with distribution of selections

	topic	selected	originally proposed by	selected by UD	selected by BS
1	Multi-sensory approach to urban design	5x	UD	3	2
2	Take more consideration of marginalised groups - don't just design around the prototypical man. Consider homelessness, disabilities etc. i.e. prioritise inclusive design	5x	UD	4	1
3	From space to place	4x	UD	3	1
4	Objective city data	3x	BS	2	1
5	Experimental Psychology to evaluate 'Cognitive Architecture'	3x	BS	1	2
6	To understand how the physical (or built) environment can promote active travel behaviour (or active commuting)	3x	BS	1	2
7	Develop methods for testing in the real world	3x	UD	1	2
8	Create better dialogue between disciplines such as brain sciences and architecture - utilise each others' methodologies and paradigms/fill in each others' gaps.	3x	UD	2	1
9	Accessibility / accessible urban space	3x	UD	1	2
10	Biodiversity / natural elements in the city	3x	UD	2	1
11	Open data	3x	UD	1	2
		Total	UD 8 BS 3	21	17

Table A.9: *Consolidated list with distribution of selections*