

Designing Interactive Objects and Spaces for the Digital Public Space

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Abstract

The Internet is evolving, both in form and function, at a rate which is becoming increasingly difficult to match. Through constructs such as The Internet of Things, our consumption of digital information and knowledge is slowly moving away from being primarily consumed through screens to one in which we are generators of data by interacting with the objects and spaces which surrounds us. Thus, the Internet is no longer a space we visit but rather the space we live in and experience in our daily lives. The Digital Public Space, a concept based on the democratisation of privately held knowledge, is intrinsically connected to the notions of Internet, especially around its delivery and reach. Whilst the two are arguably separated by different social and political motivational aspirations as the internet evolves so must our consideration of the Digital Public Space.

The AHRC Creative Exchange research project was set to explore the myriad of potentials of the Digital Public Space from understanding, facilitation and creation of digital public spaces to privacy and ethical concerns. I approached this space by considering how our own physicality means that there will always be a tangible aspect to the consumption and production of digital information; a duality in existence which needs to be understood in order to design better experiences. In particular, I am concerned with the characteristics and particularities around the creation processes involved in the design of mixed-reality objects and spaces which might contribute to the Digital Public Space in the context imposed by the juxtaposition of the digital and the physical worlds.

Therefore, this research presents the methodological framework required for the understanding of such design processes with a clear focus on the interactions and affordances mixed-reality artefacts make use of in their designs. Through the exploration of five different research projects, resulting from collaborative design-led research, conducted in close partnership between academia and the creative industries, I extract, rationalise and present ideas, individually, in order to present research insights for the design and construction of mixed-reality artefacts. The key aspects of which are summarised in a set of guidelines, taking the shape of a manifesto, to serve prospective designers in the production of mixed-reality artefacts.

Declaration

I declare that, other than where the contribution of others is specified in the list below, that this thesis is entirely my own work and has not been submitted for the award of any other degree, either at Lancaster University or elsewhere.

Adrian Gradinar

The following chapters have sections that have been presented as research papers or chapters in books in earlier forms.

Research Design includes excerpts adapted and expanded from:

Coulton, P., Burnett, D., Gradinar, A., Gullick, D. and Murphy, E., 2014. Game design in an internet of things. Transactions of the Digital Games Research Association, 1(3).

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Designing for the dichotomy of immersion in location based games. Foundations of Digital Games 2015.

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Huck, J., Coulton, P., Gradinar, A. and Whyatt, D., 2015, April. Cartography, location-based gaming and the legibility of mixed reality spaces. In 23rd GIS Research UK Conference.

This paper can be found here: <http://eprints.lancs.ac.uk/72807/>

Paths of Desire includes excerpts adapted and expanded from:

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This paper can be found here: <http://dl.acm.org/citation.cfm?id=2892317>

Coulton, P., Huck, J., Gradinar, A. and Salinas, L., 2017. Mapping the beach beneath the street: digital cartography for the playable city. In *Playable Cities* (pp. 137-162). Springer Singapore.

This paper can be found here:

https://link.springer.com/chapter/10.1007/978-981-10-1962-3_7

Huck, J., Gradinar, A., Paul, C. and Salinas, L., 2016. Paths of desire: dynamic visual hierarchies to intentionally influence route decision. In *Proceedings of the 24th Annual GIS Research UK Conference*.

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The following is a list of other academic publications based on the projects I have collaboratively worked on during my doctoral candidate journey:

Simm, W, Ferrario, MA, Gradinar, A & Whittle, J 2014, Prototyping 'clasp': implications for designing digital technology for and with adults with autism. in DIS '14 Proceedings of the 2014 conference on Designing interactive systems. ACM, New York, pp. 345-354. DOI: 10.1145/2598510.2600880

Huck, J, Whyatt, D, Coulton, P & Gradinar, A 2014, Mapping traffic pollution exposure: the quantified self. in J Drummond (ed.), Proceedings of the GIS Research UK 22nd Annual Conference: The University of Glasgow 16th-18th April, 2014. vol. 1, Geomatic Group, University of Glasgow, Glasgow, pp. 243-251.

Lochrie, M, Gazzard, A, Gradinar, A & Coulton, P 2014, Mobilising Monopoly: game design, place and social values. in Proceedings of 9th International Conference on the Foundations of Digital Games. FDG 2014, the 9th International Conference on the Foundations of Digital Games, Ft. Lauderdale, United States, 3-7 April.

Tseklevs, E, Darby, A, Gradinar, AI & Smith, MT 2014, Exercising playfully: co-designing fun ways of keeping active in the park. in CHI PLAY '14 Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play. ACM, New York, pp. 447-448, the first ACM SIGCHI annual symposium, United Kingdom, 19-21 October. DOI: 10.1145/2658537.2661316

Tseklevs, E, Gradinar, A, Darby, A & Smith, M 2014, Active Parks: 'Phygital' urban games for sedentary and older people. in B Schouten, S Fedtke, M Schijven, M Vosmeer & A Gekker (eds), Games for Health 2014: Proceedings of the 4th conference on gaming and playful interaction in healthcare. Springer Fachmedien Wiesbaden, Wiesbaden, pp. 140-143. DOI: 10.1007/978-3-658-07141-7_19

Huck, J, Coulton, P, Gradinar, A, Powell, P, Roberts, J, Hudson-Smith, A, De-Jode, M & Mavros, P 2014, Designing for empathy in a church community. in AcademicMindTrek '14 Proceedings of the 18th International Academic MindTrek Conference: Media Business, Management, Content & Services. ACM, New York, pp. 249-251, Academic MindTrek Conference 2014, Tampere, Finland, 4-6 November. DOI: 10.1145/2676467.2676497

Coulton, P, Jacobs, R, Burnett, D, Gradinar, A, Watkins, M & Howarth, C 2014, Designing data driven persuasive games to address wicked problems such as climate change. in AcademicMindTrek '14 Proceedings of the 18th International Academic MindTrek Conference: Media Business, Management, Content & Services. ACM, New York, pp. 185-191, Academic MindTrek Conference 2014, Tampere, Finland, 4-6 November. DOI: 10.1145/2676467.2676487

Gazzard, A, Lochrie, M, Gradinar, A, Coulton, P, Burnett, D & Kershaw, D 2014, 'From the board to the streets: a case study of Local Property Trader' ToDIGRA, vol. 1, no. 3.

Tsekleves, E, Darby, A & Gradinar, A 2015, Urban design for promoting community public health: co-designing playful urban park experiences for promoting community public health. in 11th Design and Health World Congress and Exhibition. International Academy for Design and Health.

Darby, A, Tsekleves, E & Gradinar, A 2015, Co-designing playful interactions for public health in green spaces. in K Christer (ed.), Proceedings of the Third European Conference on Design4Health 2015. Sheffield Hallam University, Sheffield.

Simm, WA, Ferrario, MAFC, Gradinar, AI, Forshaw, S, Tavares, M, Smith, IC & Whittle, JND 2016, Anxiety and autism: towards personalized digital health. in CHI '16 Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems. ACM, New York, pp. 1270-1281. DOI: 10.1145/2858036.2858259

Ferrario, MAFC, Simm, WA, Gradinar, AI, Forshaw, S, Tavares, M & Smith, IC 2016, Values-first software engineering: research principles in practice. in ICSE '16 Proceedings of the 38th International Conference on Software Engineering Companion. ACM, New York, pp. 553-562, 38th International Conference on Software Engineering Companion, Austin, Texas, United States, 14-22 May. DOI: 10.1145/2889160.2889219

Coulton, P, Burnett, D & Gradinar, AI 2016, Games as speculative design: allowing players to consider alternate presents and plausible futures. in P Lloyd & E Bohemia (eds), Proceedings of Design Research Society Conference 2016. Proceedings of DRS 2016, vol. 4, Design Research Society, pp. 1609-1626, DRS 2016: Future Focused Thinking, Brighton, United Kingdom, 27-30 June. DOI: 10.21606/drs.2016.15

Huck, J, Whyatt, JD, Coulton, P, Davison, BM & Gradinar, AI 2017, 'Combining physiological, environmental and locational sensors for citizen-oriented health applications' Environmental Monitoring and Assessment, vol 189, 114. DOI: 10.1007/s10661-017-5817-6

Gradinar, AI, Davenport, J, Coulton, P & Hill, H 2017, Improving the Visualisation of Renal Blood Test Results to Enhance Patient – Clinician Communication. in Proceedings of EAD 2017. 12th European Academy of Design, Rome, Italy, 12-14 April.

Ferrario, MAFC, Simm, WA, Gradinar, AI, Smith, IC, Forshaw, S, Smith, MT & Whittle, JND 2017, Computing and Mental Health: Intentionality and Reflection at the Click of a Button. in 11th EAI International Conference on Pervasive Computing Technologies for Healthcare. ACM, New York, 11th EAI International Conference on Pervasive Computing Technologies for Healthcare, Barcelona, Spain, 23-26 May.

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Table of Contents

Abstract	ii
Declaration	iii
A Thank You! note.....	viii
Table of Contents	x
What to expect from this thesis	xix
The Scene	1
The Creative Exchange	1
The Creative Exchange PhD Model.....	3
My Creative Exchange Experience	4
The Digital Public Space.....	5
The Internet.....	8
Research Design.....	13
An Epistemological and Ontological Discussion of RtD	15
Other Methodologies.....	20
Grounded Theory	20
Action Research	21
Interaction Design.....	27
Affordances	30
PAC-LAN	37
The Constructed Bits	37
Connection to the Digital Public Space	37
The Team.....	38
The Settings	39
Game Design.....	40
The Physical Game Space.....	42
The Digital Game.....	44
The Mobile Application	45
Map Design	49
The Fog of War	52
The Screen Blanking.....	53
The Blood Drops.....	53
The Game User Interface Design.....	54
Analysis	55

Study 1 - Background.....	56
Study 1 - Findings	56
Study 2 - Background.....	57
The RPG Map	58
The Sketchy Map.....	58
The Anti-Glare Map.....	60
Study 2 - Findings	61
A Discussion of Immersion.....	62
Paths of Desire	68
The Constructed Bits	68
Connection to the Digital Public Space.....	68
The Team.....	69
Introduction	70
Initial Meeting.....	71
The Infrastructure.....	73
Visual Hierarchies.....	74
Map Design.....	77
Mobile Application.....	78
Chas' Designs.....	81
Final Meeting	83
Discussion and Conclusions	83
Perceptive Media.....	87
The Constructed Bits	87
Connection to The Digital Public Space.....	87
Background	88
Introduction	89
The Team.....	91
Initial Meeting.....	92
Sensors.....	93
Camera	94
Microphone.....	95
Location.....	96
Bluetooth.....	97
Distance sensing	98
Perceptive Radio - The Platform.....	99
Mudlark's Perceptive Story.....	100
API	101
Story Implementation on v2	101

Mid-project meeting	103
Admin Interface	104
Case Design.....	107
Final Project Evaluation Meeting.....	107
MozFest 2015 Workshop	109
The Creation Stage	111
The Improving Stage.....	111
The Adaptive Stage	111
The Presentation Stage.....	112
Observations.....	113
Discussion and Conclusions	113
Physical Playlist.....	116
The Constructed Bits	116
Connection to The Digital Public Space.....	116
The Team.....	117
Stop. Play. Record!.....	118
The Initial Idea	118
Design Guidelines.....	120
The Fruit Bowl	121
The Scanner.....	122
The Vinyl Record.....	122
The Vertical Player	123
The Playlist	124
First Prototype.....	125
The Player	125
The Bracelet.....	128
The Mobile Application	129
Final Project Evaluation Meeting.....	130
Second Prototype.....	131
MozFest Demonstration.....	134
Final evaluation meeting.....	135
Master's Workshop.....	135
Final Design	137
Discussion and Conclusions	144
Physical Social Network	147
The Constructed Bits	147
Connection to The Digital Public Space.....	147
Introduction	148

The Team.....	151
The First Meeting.....	152
The Web Interface.....	153
The Prototype.....	154
The Digital Interface	154
The Artefact	156
The Crank	157
The Enclosure.....	161
The Construction of the Artefact.....	163
The Final Prototype	172
Feedback.....	173
Discussion and Conclusions	176
Discussion and Conclusions	178
Reflections on CX and the PhD.....	178
Objects and Spaces within the Digital Public Space.....	181
Digital Public Spaces	184
Interactions.....	187
Real Interactions	187
Virtual Interactions	189
Contributions	190
Manifesto	196
Future Work.....	199
References.....	202
Appendix.....	210

List of Figures and Tables

Figure 1. The mandatory CX team composition.	3
Figure 2. Frayling's design research categories, adaptation from Press (1995, p. 3).	15
Figure 3. The Action Research cycle.	23
Figure 4. Interaction Design as defined by Bill Verplank (ibid, p. 6).	27
Figure 5. Situating DPS objects and spaces within the physical-digital-interaction dimension.	29
Figure 6. Affordance relative to Perceptual Information (Gaver, 1991).	31
Figure 7. Improving Affordance Design adapted from McGrenere and Hon (2000).	32
Figure 8. Idea Sketching, adaptation from McKim (2000).	34
Figure 9. The Design Process, adaptation from Verplank (2003).	34
Figure 10. Product design and research design based on Verplank's design process.	35
Figure 11. Pac-Lan project team.	38
Figure 12. a) PAC-LAN entering the game (left); b) Zombie entering the game with a countdown for 'waiting time' (right).	41
Figure 13. NFC pills (left) and Frisbees pills (right).	43
Figure 14. Player using a cape (left) and all Zombie hats (right).	44
Figure 15. The 'Play' area - original sketches.	45
Figure 16. The 'Scores', 'Leaderboard' and 'Rules' – original sketches.	46
Figure 17. The four different areas from the mobile game as they were implemented.	47
Figure 18. The first two screens from the on-boarding experience.	48
Figure 19. A comparison between the original OpenStreetMap (A), and the Pac-Map (B).	51
Figure 20. The Pac-Map displayed on the mobile screen.	52
Figure 21. The four different levels of the Fog of War covering the screen.	53
Figure 22. PAC-LAN User Interface (capturing UI).	54
Figure 23. Physical 'check-in pill' (left) and 'power pill' (right) shown in the real environment.	55
Figure 24. The RPG Map.	58
Figure 25. The Sketchy Map.	59
Figure 26. The Anti-Glare Map.	60
Figure 27. Paths of Desire project team.	69

Figure 28. A map of the city centre of Lancaster, illustrating major points of interest, often overlooked tourist attractions, and the principal routes taken by visitors on foot. Contains OS data © Crown copyright and database right (2015).	75
Figure 29. A sketched illustration of the first three stages of the recursive process used to construct the quad-tree index. The example here has a simple path network with only 2 segments. Each cell of the quad-tree recursively subdivides into 4 until it either contains only one path segment or reaches a pre-defined minimum size.	76
Figure 30. An illustration of the Quad-Tree index used for this experiment. Cells are coloured according to their area, with lighter coloured cells having undergone more subdivisions.	76
Figure 31. An excerpt from the design sheet for the Paths of Desire map produced by Magnetic North.	77
Figure 32. An image depicting the renderer's inability to display dotted paths and the resulting attempt.	79
Figure 33. The original style (left) and the resulting mobile application design (right).	80
Figure 34. Screenshot of the Lancaster Map, developed in collaboration with Chas Jacobs.	81
Figure 35. A square of paint produced by Chas Jacobs, and the corresponding seamless texture tile used in the map.	82
Figure 36. A comparison between the original POIs drawn by Chas Jacobs and the resulting rendered POIs.	83
Figure 37. Perceptive Media project team.	91
Figure 38. Story logic explained.	102
Figure 39. Wi-Fi selection.	105
Figure 40. Story selection.	106
Figure 41. Story customisation.	106
Figure 42. Sound selection.	107
Figure 43. The Perceptive Radio (v2, right hand side) with the Original Radio (v1) in the background.	108
Figure 44. The initial settings of the workshop.	110
Figure 45. IDEAS Hexagons.	110
Figure 46. The 'Perceptive Dice' (left), with each of its faces explained (right).	112
Figure 47. One of the stories created during the workshop.	113
Figure 48. Physical Playlist project team.	117

Figure 49. The Fruit Bowl Player.....	121
Figure 50. The Scanner Player.	122
Figure 51. The Vinyl Player.	123
Figure 52. The Vertical Player.	124
Figure 53. The Original Sketch.	125
Figure 54. The First Prototype.	126
Figure 55. The first bracelet.	129
Figure 56. The first round of 3D holders.	129
Figure 57. The first mobile application design.....	130
Figure 58. The second prototype.....	132
Figure 59. The first sketch of the GUI interface.....	133
Figure 60. Some of the designed bracelets.....	136
Figure 61. The participants investigating the player.	137
Figure 62. The last mechanism design for the proprietary 3D modelled housing.....	138
Figure 63. The first iteration of the 3D housing model.....	139
Figure 64. Some concept designs for the bracelets.....	140
Figure 65. The final bracelets.....	141
Figure 66. The final player with one of the bracelets on display.....	142
Figure 67. The newly designed writer mobile app.	143
Figure 68. The newly designed reader mobile app.....	144
Figure 69. The first idea of the prototype.	150
Figure 70. Physical Social Network project team.....	151
Figure 71. The Web Interface.....	153
Figure 72. The ‘wall’ of postcards as it was originally envisioned.....	155
Figure 73. The sketch depicting the envisioned interface and interaction.....	155
Figure 74. An image showing a similar air raid siren to the one which was procured.....	158
Figure 75. The first holding mechanism of the crank displaying the air raid siren as well as the rotary encoder directly attached to the crank.....	159
Figure 76. The first round of 3D printing for the new enclosure.....	161
Figure 77. The first fully designed and 3D printed enclosure.	162
Figure 78. The thickness issue encountered (left) and the fix (right).....	162
Figure 79. The final design of the 3D enclosure.....	163
Figure 80. A comparison between the first size (left) and the final one (right).	164
Figure 81. The cardboard prototype with a trapezoidal prism shape directing the viewer’s attention onto the screen.	165

Figure 82. The 3D printed version (left); the sliced laser-cut cardboard goggles (middle); the 3mm plywood version whilst being built (right).	166
Figure 83. The 'finger'.	168
Figure 84. The final designed mechanism for the 'finger'	169
Figure 85. The interior arrangement of the artefact.	170
Figure 86. Different images showing different stages for the creation of the knob.	171
Figure 87. The final artefact.	173
Figure 88. Representation of 'liminal' and 'liminoid' states found in mixed-reality worlds (Coulton, 2017).	185
Figure 89. Atoms and Bits representation (Colton, 2017).	185
Figure 90. A view of all 5 projects with their respective 'real' interactions split following Verplank's designing interactions theme.	188
Figure 91. A view of all 5 projects with their respective 'virtual' interactions split following Verplank's designing interactions theme.	189
Figure 92. My proposed Design Process.	193
Table 1. The evaluation of the proposed cameras.	95

“Now that I begin to see where I’m going with it,
I’ll take a new canvas and start again!”

Pablo Picasso

What to expect from this thesis

Alongside the obvious research interests, my motivation when writing this thesis was to also capture some of the Creative Exchange (CX) experience and relay it back to the reader. My journey as a doctoral candidate within CX found me working on a multitude of projects, sometimes five different ones in the same week; which happened more than once over the span of three years. For example, one day I was running a workshop in London trying to engage the audience in developing ‘perceptive’ stories; on another I was deciphering the mists of a new programming language required for one of the projects I was involved in; some days I was making different sensors communicate over different prototyping boards; other days I was playing with different materials and screwing particular 3D printed or laser-cut designed pieces together to test the veracity of different ideas; at times I worked with children and other days I worked with dementia suffering elderly people; and many days found me deep into reading and writing practices as I was working towards new publications. Many of these activities worked brilliantly whilst others were unsuccessful! If it were entirely up to me, this thesis would have been written as a diary and even then, I fear I would not have been able to properly explain the range of activities and the diversity of my journey as a doctoral candidate with the CX whilst employing suitable academic rigour. Because of the above, a presentation of this thesis as one academia might ‘typically’ expect cannot be fully realised meaning, therefore, whilst it represents my research, some of the messiness of how it was produced is undoubtedly lost to make this material readable and understandable. Therefore, I structured this body of work as follows: the first two chapters set the scene, by explaining CX as a research programme and its particular focus of research, the Digital Public Space, trailed by the methodology I developed in order to contextualise the research and how it was produced. Following this methodological scaffolding is the presentation of five of the research projects I was involved in. Please note, these five projects are the ones most relevant to my consideration of the Digital Public Space and are, cumulatively, just a part of all the projects I undertook. I wrote these chapters as individual pieces of work producing specific research insights, therefore, the reader could jump from one to the other as they see fit. However, their relevance to my overall research on the Digital Public Space is revealed in the subsequent discussion and conclusions.

In essence, there are two levels of research in this thesis: the micro level, representing knowledge derived that relates specifically to the projects and, at the macro level, the knowledge contributing to new understandings of the Digital Public Space.

Whilst I do explain my roles and attributions for each project, I would like to point out from the beginning that all these projects were collaborations between a diverse team of people, therefore, even if some tasks are explained as solely being achieved either by myself or by another member of the team, we often helped each other in achieving them. Furthermore, disregarding some remote events, most of the decisions were taken by the team involved in the project, pending either a formal or informal meeting. The work on which this thesis is built would have never achieved the presented levels had it not been for all the work done by all the members of the project research teams.

The Scene

The work in this thesis is primarily built upon five projects developed as part of The Creative Exchange Research Programme. Through the presentation and analysis of these projects the design challenges encountered are discussed with a final aim of using my critical reflections to producing design guidelines, in the form of a manifesto, which should be taken into consideration when designing interactive objects and spaces within The Digital Public Space.

This manifesto, alongside my reflections on the methodologies used in each of the five projects, as well as the analysis of the design insights each project provides in relation to the particular application context, and more general insights relating to the Digital Public Space are my contributions to knowledge within Design research. Note that particular projects insights are included within each chapter whilst overall reflections contribute to my design manifesto and a consideration of the overall PhD project in my conclusions. In order to achieve this endeavour, I believe you, the reader, requires a thorough description of the scaffolding of this work which should create the necessary mindset to better understand its production. To do so, I first need to set the 'scene' of this research by providing a detailed account of the research programme in which it was undertaken as well as some considerations around The Digital Public Space and The Internet¹ more generally. I then explain my philosophical, epistemological and ontological approach to further reinforce this foundation.

Before the manifesto can be considered, it is important to consider the research programme through which it was undertaken, which follows in the subsequent section, as it provides both the scaffolding for my PhD and the constraints on how it could be undertaken. It effectively shaped and directed my research and practice and thus the overall work presented in this thesis.

The Creative Exchange

The Creative Exchange (CX) Research Project was funded by the Arts and Humanities Research Council (AHRC) (project AH/J005150/1) and it was designed to explore notions around the idea of the Digital Public Space (DPS)

¹ All this can be found in this chapter.

whilst stimulating the creative economy in the UK, targeting, in particular, the north of England. Three different universities took part in this project: Lancaster University, Newcastle University and the Royal College of Art (RCA) in London. The project ran from the start of 2012 and the end of 2015 and was grouped around six different thematic clusters formed through initial iterative consultation with project partner companies and academics. These clusters were: “Public Innovation and Democracy”, “Rethinking Working Life”, “Making the Physical Digital”, “Stories, Archives and Living Heritage”, “Performance, Liveness and Participation” and finally “Building Social Communities - Dynamic Structure for Growth”. During its four-year period, a number of different events gathered academics from different disciplines, creative industry partners, and doctoral candidates from CX to form multidisciplinary teams to jointly explore these different thematic clusters with the aim of coming up with ideas for projects that would explore these themes in the context of the Digital Public Space. Whilst the research area for the projects was relatively open, the composition of the team was fairly strict, but not limited to, the inclusion of at least one academic partner, one doctoral candidate and one external (industry) partner, as shown in Figure 1². Ideally, a project would run three-to-six months and would benefit from a budget of up to £16k. Project funding proposals had to be submitted to the CX board which consisted of members from across the three universities, based on the Creative Exchange’s criteria, following strict rules imposed by the Arts and Humanities Research Council.

Over the course of the four-year period, the CX hub attracted further funding of more than £1.8 million in research grants. From its original budget, almost £350,000 was invested in more than 90 projects generating a collaborative network of 176 academic and industry partners from 107 different organisations. 40 of the attracted 150 academics (principally from the Arts and Humanities area) were actively involved in different research projects, generating over 100 concepts and prototypes of new services with 45 new jobs across both creative and digital SMEs as well as academia. It furthered secured funding of more than £17 million by the CX partners to address similar topics in the creative and digital sectors. Finally, it produced

² Throughout this thesis, I am referring back to this figure to better to illustrate a specific project team’s composition on each individual project by making small adjustments to better reflect this.

21 highly skilled people at the doctoral level capable of working, thinking and researching in academia, industry and the creative economy³.

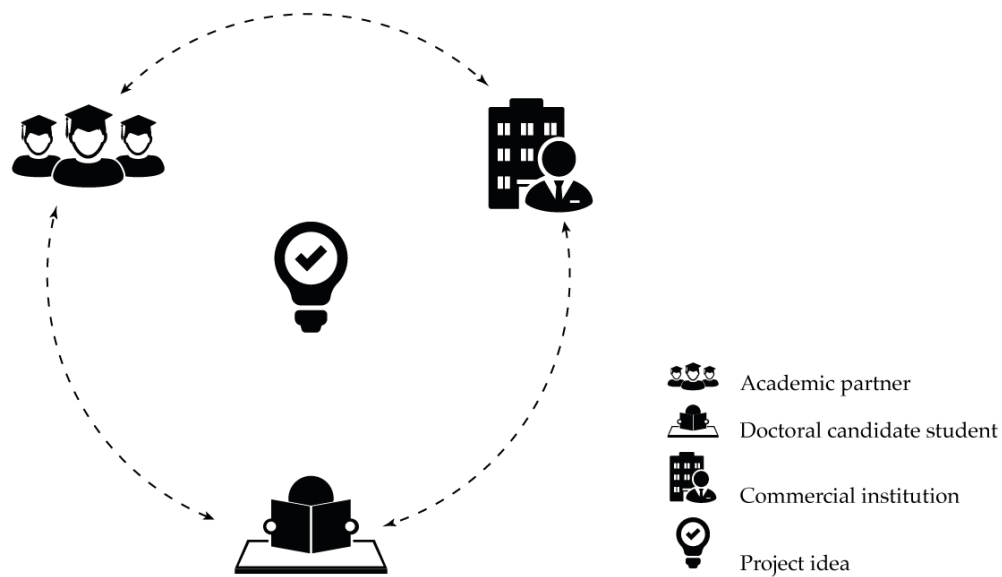


Figure 1. The mandatory CX team composition.

The Creative Exchange PhD Model

At Lancaster University, the Creative Exchange was located in the Lancaster Institute for the Contemporary Arts building (LICA) and was run by Imagination Lancaster⁴, an open and exploratory design-led institution conducting both applied and theoretical research. More often than not, the Imagination team works with different external partners in a collaborative manner to generate new research as well as affect change within the community or working partner.

A 'typical' approach to studying for a doctoral position involves generating a research question that is then to be explored for the duration of the studies by the doctoral candidate. This journey is mostly guided by the student's own research interests augmented with further guidance from their supervisory team. Most of the time, this journey is individual and involves little outside influence. An example of this could be one of a PhD student in Architecture; based on the original idea proposed by the student, some

³ <http://thecreativeexchange.org/#/reports>

⁴ <http://imagination.lancs.ac.uk/>

background research is made into the field followed by an experimentation phase, collection, analysis and interpretation of the results, and ultimately a detailed overview compiled into the final thesis where conclusions are drawn. A similar journey, probably with a different take on the collection of the data, could be envisioned by another PhD student in philosophy or history. Compared to these ‘typical’ PhD student journeys, the doctoral candidates that took part in the Creative Exchange research programme had, most of the times, a totally different experience. As previously stated, from the beginning we were asked to perform research in the context of the Digital Public Space whilst working on projects that needed to be beneficial of all included members. This led up to a PhD model which include theoretical research coupled with a requirement for real-world research and development. To be effective in achieving such tasks, we often had to take roles ranging from managerial, to a facilitator, developer, collaborator, designer, engineer and last but not least, researcher.

My Creative Exchange Experience

My journey with the Creative Exchange started in October 2013, almost two full years after the research programme began. During this initial period within the CX, which I was absent from, different workshops and meetings were held between industry partners, academics and doctoral candidates, where a range of ideas was explored with some materialising into projects. A great many of these projects were already active whilst others were scheduled to start in the forthcoming months. This means that while I did join some of these projects, I was not involved in their formation. In my three-year study period with the Creative Exchange, I was involved in eight different projects under the CX umbrella. It is important to note that not all of these projects are featured in this body of work, as they are not of direct relevance to the presented argument, however, all projects included in this thesis are belonging to the “Making the Digital Physical” cluster.

Within each project, my role shifted from researcher to developer, knowledge exchange facilitator, designer, software engineer and manager. Whilst this mix modus operandi provided high valuable training and transferable skills, it also presented some challenges. Firstly, as a researcher, I

was responsible for the quality and rigour of the research process (Dick, 1999)⁵ pursuing my own research agenda and those of my partners. As a developer and software engineer, I had to provide the technical skills required for the completion of each project. More often than not, these skills had to be acquired, which frequently meant a steep learning curve in order to achieve the desired outcomes. As a designer and facilitator, I had to help the team(s) find and explore different viable solutions while as a manager, I had to keep track of the expenditures, provide updates to each partner and the CX board, keep the project on track, write and submit ethics forms. Finally, as a knowledge exchange coordinator, I had to create an environment that worked positively for all those involved. Whilst the goals of all the stakeholders involved in the project finally converged into a unified area of interest, the process required open mediated discussions to be held at the beginning of each project where each stakeholder explained their role in the project and their outlooks of what was to be expected from the project.

There are many things which could be said about the Creative Exchange, how the project became successful through the individual and collective works of the people involved, how it was run and where it could have been improved, however, this is beyond the scope of this thesis. My aim here was to provide the needed background information to give the reader the required information to form their own understandings of some of the challenges the CX PhD student had to overcome in their pursuit of knowledge gathering and formation. Therefore, in the next part of this chapter, I would like to introduce and discuss the notion of the Digital Public Space, since it was the research area the CX was concerned about and, subsequently, that of my own. The chapter concludes with my overall research questions which I have tried to answer through my work.

The Digital Public Space

In this section, I will consider the Digital Public Space and its interconnectivity and dependency upon the Internet both from a political and technological perspective with the purpose of situating the research presented in the rest of this thesis.

⁵ In the Research Design chapter, I dig deeper into the methodologies involved in the research projects.

According to a news article in *The Guardian* (Kiss, 2010), the original term of the Digital Public Space was coined at the British Broadcasting Corporation⁶ (BBC) by Tony Ageh, after a period of two years of working with the digital archives of the BBC. Ageh believed that many of the challenges of working with digital archives are shared by other institutions. He put forward a proposition for creating a 'Digital Public Space' for publicly owned content where organisations such as the British Film Institute⁷, the British Library⁸ and Europeana⁹ would make their content public and free for non-commercial public use (Kiss, 2010). "In a nutshell, the 'Digital Public Space' is intended as a secure and universally accessible public sphere through which every person, regardless of age or income, ability or disability, can gain access to an ever-growing library of permanently available media and data held on behalf of the public by our enduring institutions" (Ageh, 2015). As such, we could envision the Digital Public Space as a 'server farm(s)' (a physical space) where each company would 'deposit' their archives to be accessed publicly by everyone at any given time whilst "respect[ing] privacy" (ibid). This naturally implies a common and similar method for the storing as well as the access and retrieval of the content thus, the Digital Public Space becomes an arrangement of "shared technologies, standards and processes" rather than a product or service "whose defining characteristics are openness, persistence, engagement, partnership, access and public benefit" (ibid).

When the Creative Exchange research project was conceived, the Digital Public Space was defined as a space "where anyone, anywhere, anytime can access, explore and create with digital content" (CX, 2012). Whilst this is directly intertwined with the notion of working with and around archives since they represent a type of digitally stored content, the above definition encompasses much more. FutureEveryting released a publication in 2013 titled *Digital Public Spaces* (Hemment et al., 2013) where different authors contributed their knowledge on this subject. Hemment and Thompson believe that "the central vision of the DPS is to give everyone everywhere unrestricted access to an open resource of culture and knowledge (ibid, p. 3). Neville Brody defines the Digital Public Space as a unique and attractive space where the

⁶ <https://www.bbc.co.uk/>

⁷ <http://www.bfi.org.uk/>

⁸ <https://www.bl.uk/>

⁹ <http://www.europeana.eu/portal/en>

“opportunity to develop new tools to store, share, exchange and develop human knowledge” presents itself (ibid, p. 10). Jill Cousins sees the Digital Public Space as “a set of protocols, services and resources unified under the public domain to raise awareness and power new forms of engagement” (ibid, p. 12). On one hand, the rhetoric of the Digital Public Space is not that dissimilar to the intentions of the Open Web Platform (OWP) which opposes private, exclusionary and proprietary web solutions (W3C Interest Group, 2017) or, as the CEO of the W3C Jeff Jaffe words it, “a platform for innovation, consolidation and cost efficiencies” (Thompson, 2011). Paula le Dieu believes we should situate the Digital Public Space within the OWP and by doing so “the public does not just consume the artefacts of the Digital Public Space but that the Public can make Digital Public Spaces” (Hemment et al., 2013, p. 17). On the other hand, Parikka and Caplan argue that the Digital Public Space is more than just a space and compared it to an affordance or “a habit of production, sharing, mixing and remixing” (ibid, p. 28).

I would like to stop and reflect on the main ideas being shared so far. If Ageh’s concept of the Digital Public Space was coming out of a desire to democratise the archives held by the BBC, the developed understanding of what the Digital Public Space quickly grew beyond that. On one hand, some of the authors which contributed their ideas and understandings to the FutureEverything document, see the Digital Public Space solely from the perspective of what it could offer by publicising proprietary content, and thus, the sharing of privately owned knowledge. On the other hand, other authors believe the power of the Digital Public Space comes from a two-way communication, where the benefits of the Digital Public Space are exponentially increased by facilitating the public’s own makings to be released back into the Digital Public Space and thus further sharing newly formed knowledge. Based on this, there could be an infinity of routes of exploring the Digital Public Space, from a values perspective of its potential to an ethical approach and the implications of the sharing of private information, be that of a single individual or a company, to the study of the creation of ‘digital spaces’ which are ‘public’ or ‘public spaces’ which are ‘digital’, to a technical aspect of what technologies could be used in the creation of digital public spaces. And this list could go on!

I could go on and investigate all these avenues in an attempt to better express the Digital Public Space from understanding to implementation, delivery and finally its implications. However, this would inevitably render this thesis into a theoretical study of the notions of Digital Public Space and, whilst this is undoubtedly useful, it does not represent my intentions and desires for this body of work. What made an impact on me when I started looking at the Digital Public Space is how it seems to have an innate link to the operation of the Internet (and implicitly, that of the World Wide Web as a consumption medium). It seems that all rhetoric around the Digital Public Space naturally implies the Internet and that they are somewhat part of each other. Ageh believes the differentiation between the Digital Public Space and the Internet is given by the term 'public' stating "the Internet is a digital space and it does deliver plenty of public benefits. But what's different about the 'Digital Public Space' is the underlying intent - the 'application' of the medium, rather than the underlying fabric" (Ageh, 2012, p. 4). Based on this, my understanding reflects on the 'how' rather than the 'what' or the 'why'. How do we create digital public spaces which are within the Digital Public Space? More importantly, how do we create meaningful Internet based experiences which are situated within the Digital Public Space? In order to achieve such an endeavour, I have to take a step back and look at the Internet as a phenomenon as well as situate my work within the 'why' and the 'what'.

The Internet

It seems rather futile to try and define the Internet. Similar to the Digital Public Space, it is a phenomenon which could be approached from a multitude of angles and, more importantly, because it is so widely spread and used, both as an experience as well as a term, no definition would ever suffice. Most of the literature on the origins of the Internet can be traced back to the ARPANET project, an Advanced Research Projects Agency (or DARPA¹⁰ today) initiative of the Department of Defence (DoD¹¹). The core mission of the project was the desire to connect multiple computers and transmit viable information from one node to another (Abbate, 2000). Moving further in time, in September 1981, The Internet Protocol (IPv4) was released whose scope was

¹⁰ <https://www.darpa.mil/about-us/about-darpa>

¹¹ <https://www.defense.gov/>

“to provide the functions necessary to deliver a package of bits (an internet datagram) from a source to a destination over an interconnected system of networks” (Postel, 1981) which we are still using even today. Whilst the emergence of the Internet would not have been possible without overcoming the technical difficulties, the desire behind a connected network of networks comes from a belief in knowledge sharing. It is interesting to note that this ambition for knowledge sharing had been seen before in the works of Vannevar Bush, often also credited alongside with Tim Berners-Lee for the creation of the World Wide Web (Kitzmann, 2001, p. 441). In his essay “As We May Think”, Bush describes a ‘memex’ machine, “a mechanised private file and library” taking the shape of a desk with multiple screens for storing books, records and communications of one individual with the sole purpose of “supplement[ing] his memory”. By accessing the ‘memex’, the information seeker would also create a trail of own thoughts which later on would be recorded back into the ‘memex’ (Bush, 1945, p. 101-108). What Bush is envisioning in his ‘memex’ is what Ted Nelson¹² later on coined as ‘hypertext’ and ‘hypermedia’, nowadays, the foundations of the Web. Whilst Bush’s reasons may have come from a place of “modernisation, efficiency, and progress” (Kitzmann, 2001, p.447) being framed “within the discourse of the solitary and gifted pioneer” (ibid, p. 447), does not defer from the knowledge sharing argument, even if solely addressed to a particular social class, since he stated that “professionally our methods of transmitting and reviewing the results of research are generations old and by now are totally inadequate for their purpose” (Bush, 1945, p. 101-108). Almost twenty years before Bush’s memex, across the Atlantic Ocean, Paul Otlet envisioned a ‘radiated library’ which looks very similar to the Internet of today. The ‘Mondothèque’ was similar to the present-day workstation only based on the technologies available in the 1930’s: the radio, telephone, microfilm, television and record player. “It would be an autonomous machine that allowed the user to create a highly-personalised information environment arrayed around one’s personal interests but directly connected to the larger corpus of recorded knowledge” (Wright, 2016, ch. 10). Whilst I am not trying to credit Otlet’s work for the birth of the Internet, his reasons came from a positivist approach to knowledge gathering, where the creation of new knowledge is derived from

¹² <http://ted.hyperland.com/>

having access to a vast array of information, which is, in parts, the Internet we are experiencing today!

In this respect, this connected network or networks which we loosely call the Internet is inherently linked to the Digital Public Space as a platform and thus why I believe there is a strong connection and an impossible separation between these two phenomena. It is difficult to ignore the political reasons behind the emergence of the Internet since it can be seen as a manifestation of human thoughts coming from a deep desire of accessing knowledge, and in this respect the Digital Public Space and the Internet are the same. On the other hand, if I only consider the Internet from a technical stance, it becomes the 'protocol' to be used for the manifestation of digital public spaces, the 'language' of communication and the means of delivering knowledge to the masses; a military project turned into a scientific and knowledge sharing tool¹³. Therefore, there is an intentionality aspect which clearly separates the Internet from the Digital Public Space.

Lastly, I would like to point out that what the Internet is today, has moved far away from what it was originally envisioned. Nowadays, we are witnessing an information gathering approach driven by concepts such as the Internet of Things (IoT) and the Web of Things (WoT). At its core, the IoT stands for seamlessly connecting devices to the Internet with the purpose of gathering and sharing information "across platforms in order to develop a common picture" (Gubbi et al., 2013, p. 1). According to Kevin Ashton, who is believed to have originally coined the term (Ashton, 2009, p. 97-114), IoT stands for an alternative to human gathering data, since "they [humans] are not very good at capturing data about things in the real world" (ibid). The first IoT object is credited as being the 1990 Interop Internet Toaster build by John Romkey and Simon Hackett (Romkey, 2017, p. 116-119) which had only one control function, that of being turned on over a network. One year later, a robotic arm was added to pick up a slice of bread and put it into the toaster which automated the whole process (Stewart, 2015). Nowadays, the limits to what could be connected to the Internet and remotely controlled are only bounded by our imagination. From simple house appliances like the iKettle,¹⁴

¹³ I am purposefully omitting all the 'junk' out there since one might not consider said 'junk' to be useless.

¹⁴ <http://amzn.to/2vwtRaY>

the fridge,¹⁵ the coffee maker,¹⁶ the thermostat¹⁷ which can be adjusted when not at home or the ever-so-present lightbulb,¹⁸ smart watches¹⁹ and fitness trackers²⁰, to sex toys which can ‘vibe’ at the rhythm of music tracks²¹ and personal assistants similar to Amazon’s Echo²² or Google’s Home,²³ we seem to have them all. Analyst firm Gartner believes that by 2020 there will be more than 20 billion objects connected to the Internet (Meulen, 2017), almost thrice the population of the globe! All these devices will generate data which could easily be recorded; some will be quite crude, limited only to the time and date of when an action took place as well as the type of the action (turn on, turn off) whilst other devices will spawn more comprehensive datasets. This implies that whilst, on one hand, we are clearly witnessing a trend of connecting more and more devices to the Internet, which seems is not about to stop very soon, on the other hand, such actions transform the Internet from a knowledge sharing tool into an information sponge. The current trend focuses on the acquisition of the data to plot graphs and trends, shaped into digital dashboards, for a better personal use of each device. However, it will not be long until different datasets will be brought together with the aim of generating a better human profile or, when one device will decide the ‘behaviour’ of another based on human patterns and available datasets. The rhetoric of IoT and WoT (Web of Things) seem to be positioning themselves on the idea of devices generating data with the purpose of better suiting the human population, large datasets and algorithms understood and designed by humans for humans. Since the IoT is directly and undoubtedly shaping the current understanding of the Internet, and since the Digital Public Space and the Internet are so tightly interconnected, how will the IoT change our current understanding of the Digital Public Space? How do we come to act in this space, be that ethically, politically, socially, technically or technologically? Because of the structure and the particularities of my PhD, I am concerned with how the Internet is shaping our understanding of the Digital Public

¹⁵ <http://bit.ly/2cp2Ys6>

¹⁶ <http://amzn.to/2vG7TD7>

¹⁷ <https://nest.com/uk/thermostat/meet-nest-thermostat/>

¹⁸ <http://www2.meethue.com/en-gb/>

¹⁹ <https://www.apple.com/uk/watch/>

²⁰ <https://www.fitbit.com/uk/home>

²¹ <http://we-vibe.com/sync>

²² <http://amzn.to/2oPvdqu>

²³ https://madeby.google.com/intl/en_uk/home/

Space, which represents the ‘what’ and the ‘why’ of my general area or research.

If our understanding of the Digital Public Space is being challenged and shaped by the constant evolution of the Internet through rhetoric such as IoT and WoT, I believe that the knowledge we generate by consuming different digital public spaces must also come through the construction of new objects and spaces within the Digital Public Space. Whilst this idea is fully explored in the next chapter, in order to bring some justification and validity to my claim, I would like to point out that Jean Piaget²⁴ believed that “knowledge is not information to be delivered at one end, and encoded, memorized, retrieved, and applied at the other end. Instead, knowledge is experience that is acquired through interaction with the world, people and things” (Ackermann, 2001, p. 3). Moreover, this happens ‘in a context where the learner is consciously engaged in constructing a public entity, whether it’s a sand castle on the beach or a theory of the universe” (Papert and Harel, 1991, p.1). This construction of new objects and spaces within the Digital Public Space is the ‘how’ of this thesis. By looking at the processes of creating, interacting and the experiences these new objects and spaces allow, I plan to present how knowledge can be formed. I believe this newly formed knowledge is required for a deeper and more comprehensible understanding of the Digital Public Space and stands as my contribution to our society.

The following chapter presents the design research which stood as the methodological framework, which guided my overall research in the multitude of projects I was involved in.

²⁴ Swiss clinical psychologist known for his pioneering work in child development.

Research Design

This chapter describes the methodology and subsequent methods through which the main body of this research can be perceived. It starts by presenting the theoretical perspectives through which my particular approach to research can be understood. This is achieved by describing my ontological, epistemological and methodological perspectives, which serve to scaffold the subsequent research. It then follows with a thorough practical presentation of the methods utilised in the main body of work.

John Law rightly pointed out that “in practice, research needs to be messy and heterogeneous. It needs to be messy and heterogeneous, because that is the way it, research, actually is. And also, and more importantly, it needs to be messy because that is the way the largest part of the world is. Messy, unknowable in a regular and routinised way. Unknowable, therefore, in ways that are definite or coherent” (Law, 2007, p. 595–606). If everything we see around and do in our lives, research included, is in a perceived disarray, is likely that something “less messy will make a mess at describing it?” (ibid). Furthermore, if our understanding of what the Digital Public Space appears broadly and loosely characterised by the thinkers and researchers of this space, by trying to impose structure and sanitise it, would that make it more comprehensible? I believe it will not! Therefore, in order for you to understand how I approached the research design of my work, given the presented complexities of The Creative Exchange research programme, I need to illustrate how I embraced this mess through considering particular epistemological perspectives and theoretical frameworks which when combined allowed me to come up with the methodology and methods required to successfully act upon my own research agenda as well as those of my partners.

One could never tell a story about the work undertaken in a design led institution without talking about research in the general context of design. In his paper ‘Research in Art and Design’, Frayling (1994) begins his argument by describing the difference between ‘Research’ and ‘research’ by utilising the definitions given by the Oxford English Dictionary (OED) for the two terms. Research, with a little ‘r’, represents the ‘act of searching, closely or carefully, for or after a specific thing or person’ (Frayling, 1994, p. 1). We can attempt to further define research as an inquiry into an object, an oriented search

towards an actor (object or person). This, in the academic realm, is better explained as the acquisition of knowledge and skills new to the investigator (but already known in the field), a sort of self-enlightenment. On the other hand, research with a big 'R', which is often found in conjunction with the word 'development' implies "work[ing] directly towards innovation, introduction and improvement of products and processes" (Frayling, 1994, p. 1). Thus, 'Research' looks closely at the process or method behind a specific way of acting or working in a field with the aims of introducing novelty, the development of knowledge and skills new to the field. Searching for a new thermostat for one's home (research) is quite different to searching for a more practical, economical and user-friendly way of heating one's place (Research) even if the latter might actually end up in taking the shape of a thermostat. To this end, when I talk about design research in this thesis, I will be focusing on the big 'R', since it is this one which is the principal aim of design research in academia.

Looking in specific at the field of research in art and design, Frayling (1994) makes a clear distinction between research into art and design (RiD), research through art and design (RtD) and finally, research for art and design (RfD). Research into art and design, big 'R' considers research into the history, aesthetic, perceptual and theoretical aspects of the arts and design practices; it represents the context of where art and design sit as fields of study. Research through art and design, (big 'R', accounts for material research, development work and action research, thus it better describes the process involved in the creation of the design; it is the union between making and thinking. Lastly, research for art and design, "the thorny one" as Frayling refers to it (1994), or research with a 'little r', is where the knowledge is embedded into the artefact, so that the artefact itself communicates visually and not in writing through the words of the designer; we can refer to this as the final outcome (Frayling, 1994, p. 5). To better express where each approach sits within the design process and especially how they inform each other, I will be using an adaptation of Press' (1995) diagram shown in Figure 2 below.

As such, when we are referring to research as knowledge production, from an academic standpoint, the part which is most relevant to the work presented is represented by RtD.

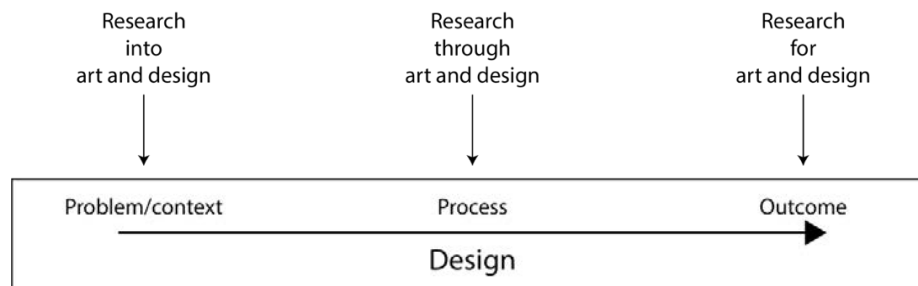


Figure 2. Frayling's design research categories, adaptation from Press (1995, p. 3).

An Epistemological and Ontological Discussion of RtD

One of the essential implications for RtD is that the designer and researcher are one and the same person. This opens up RtD to a vast amount of scrutiny from the research community on the potential bias the designer plays in the role of the researcher. Building on top of Herbert's view of the designer as the one "who devises courses of action aimed at changing existing situations into preferred ones" (Herbert, 1988, p. 67), Mike Press states that "designers look at the material world, compare their observations with their value preferences on how the world should be, and propose material changes" (1995, p. 6). Let us take the design of a website as an example. If ten different designers are tasked with the creation of a website, they will deliver ten different websites. Whilst some of the structural choices will most likely be similar (separation into different pages, the presence of a navigation bar, etc.), the style will be different (typography, colour scheme, the positioning of elements, etc.). In each design process, there is a vast array of decisions on which the designer has to act upon such as the functionality of the design, its aesthetics, the practicalities, the motivation of the work and the socio-political concerns (Gaver and Bowers, 2012). This naturally implies a certain higher level of subjectivity, as opposed to a lower level of objectivity, involved into the process of making since it is intertwined with a system of human values held by the designer. Swann (2002, p. 51), argues that the design process should, in fact, be biased since "design is for human consumption and not bounded by the quantifiable 'certainties' of the physical world" (ibid). So then, what is the position the researcher has to take to generate valid knowledge from the design process if one cannot be objective about one's own thinking process?

One way this can be addressed is by understanding the research paradigm which allows RtD to be considered as a valid research methodology. A research paradigm is “the set of common beliefs and agreements shared between scientists about how problems should be understood and addressed” (Kuhn, 1962, p. 45). According to Guba (1990), research paradigms can be characterised by their ontology, epistemology and methodology. Ontology, or the study of being, “is concerned with ‘what is’ with the nature of existence, with the structure of reality as such” (Crotty, 1998, p. 10), or what reality is. Epistemology looks at the “relationship between the knower and the would-be-knower [researcher] and what can be known” (Guba and Lincoln, 1994, p. 108), or how can we know reality as such whilst methodology is concerned with how do we go about finding out what can be known (ibid). Guba and Lincoln proposed four different research paradigms based on the well-established philosophies at that time: positivism, post-positivism, critical theory et al. and constructivism (Guba and Lincoln, 1994). Each paradigm is described by their ontological, epistemological and methodological perspectives. In a revised edition of the same chapter, and based on the works of Heron and Reason, the authors reposition their original four proposed research paradigms into a five-tier split with the addition of a ‘participatory’ inquiry paradigm (Lincoln and Guba, 2000, p. 165). It is beyond the scope of this chapter to fully present each of these paradigms in detail, as such an endeavour will most likely contribute to confusion around my approach. My aim here is primarily to justify my chosen methodology and methods from an epistemological and theoretical perspective in such ways to be recognised as sound research by any inquirer (Crotty, 1998, p. 13). Ideally, by focusing on a single paradigm and following its ontological, epistemological and methodological perspective, the research will be scaffolded in theory thus minimising the possibility of it being misunderstood. As Guba and Lincoln demonstrated, some paradigms are commensurable since sometimes there is a need to “blend elements of one paradigm into another, so that one is engaging in research that represents the best of both worldviews” (Lincoln and Guba, 2000, p. 174). This is an acceptable practice especially when these paradigms share “axiomatic elements that are similar” (ibid) which inevitably opens up a wider range of philosophies available to the researcher. As such, it also warrants the use of other methodologies and methods, which are not situated

in “contradictory or mutually exclusive” (ibid) ontological and epistemological perspectives. This is an important point to make since it will become clear in the following paragraphs that RtD, especially in the context of CX, can only be understood by acknowledging a crossover between different paradigms. Furthermore, I will point out the need to borrow other practices from well-established methodologies which will contribute to the validity of this research.

Let us go back to the subjective/objective debate on generating knowledge. A position to view the world where “subjective thought and the object of that thought are interlinked is also defended by Constructionism. Constructionism suggests that there is no true or valid interpretation of the world” (Rodriguez Ramirez, 2009, p. 6). This is a theoretical perspective on how I, in the point and case the researcher, come to know the world. “It is a view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and the world, and developed and transmitted within an essentially social context” (Crotty, 1998, p. 42). This implies we have to accept a worldview where objects exist outside of our interactions but are meaningless until we engage with them. As such, meaning (or truth), cannot be either only objective or only subjective, since it is built based on the ‘constructs’ (terminology) we have previously given to the world surrounding us and especially by our interactions with its objects. If we separate the designer from the researcher and implicitly their practices, the design practice could be seen as a subjective approach, since the designer can make decisions based only on personal experiences. Whilst the end product may as well embed knowledge, this would be seen as a constructivist approach (Rodriguez Ramirez, 2009, p. 6) since its focus is on the “meaning-making activity of the individual mind” (Schwandt, 1994, p. 127). This naturally implies that each view is equal and valid thus dissipating the subjective/objective debate. According to Crotty, it is useful to make a clear separation of these two terms by considering constructivism for epistemological views of the individual mind, pointing to our unique experience embedded in each and any of us, with an emphasis on the “instrumental and practical function of theory construction and knowing” (ibid). On the other hand, constructionism should be considered for

epistemological views “where the focus includes ‘the collective generation [and transmission] of meaning’” (Crotty, 1998, p. 58) which inevitably shapes our view of the world. Whilst I am making this stance here, it is of importance to note that these two terms have been used and abused in literature to the point of furthering confusion as opposed to providing clarity. Even Crotty acknowledges that “the terminology is far from consistent” (Crotty, 1998, p. 57). Whilst Crotty and Schwandt refer to constructivism as an epistemological framework, Guba and Lincoln define it as a paradigm, regardless of the fact that they all mean it in similar considerations. Despite advocating for a constructivist approach, Rodriguez Ramirez (2009, p. 1-13) often mixes the terminology in his proposition. To make matters worse, Koskinen et. al (2011, p. 5) build on top of Frayling’s definition of RtD by looking solely at programs which involve the construction of a prototype, mock-up or scenario. In their words, construction research design (CRD) is “design research in which construction - be it product, system, space, or media - takes centre place and becomes the key means in constructing knowledge” (Koskinen et al., 2011, p. 5). According to the authors, the emergence of this new concept comes from the desire to answer the need for stronger theory to guide practice in RtD, raised by Alain Findeli and Wolfgang Jonas (ibid). Whilst the proposed area might be of interest in some circles, the justification is somewhat misguided since constructivist theories already provide the required framework to justify RtD approaches. The constructivist approach to knowledge generation naturally implies the construction of an entity, be that of an artefact or media, thus the added term brings little to the discussion. By situating RtD in the epistemological and ontological frameworks available to the researchers, the focus should fall on the methods used to validate the research not the foundation of the methodological approach.

By putting the individual to the forefront, constructivism has also strong connections to the postmodernism philosophy which rejects ‘grand narratives’ and emphasises ‘local stories’. In order to understand postmodernism, we need to first consider modernism. The industrial age brought into everyday life mass-production by replacing hand tools with power driven machines. In doing so it relinquished the making from the hands of the craftsmen, craftswomen and artisans to the piston-driven, steam-powered engine dependable factories. Soon everything became mass-produced where

generalisation took over individual/local production. Modernism represents a cosmopolitan movement, arising in a period of accelerated globalisation and spread especially across art and culture “reflecting a series of representation, as having arisen in Europe in the middle of the nineteenth century” (Pericles, 2011, p. 1). In social sciences, modernism tends to be associated more with modernity and modernisation. According to Macionis, modernity represents “the patterns of social life linked to industrialisation” and modernisation “the process of social change initiated by industrialisation” (Macionis, 1991, p. 617, 619). In relationship to these two concepts, modernism “evinces great faith in the ability of reason to discover absolute forms of knowledge” (Crotty, 1998, p. 185). This means that the individual voices and local stories give way to larger trends. Postmodernism is a “thoroughgoing rejection of what modernism stands for and an overturning of the foundations on which it rests” (Crotty, 1998, p. 185). If modernism embraces generalisation and absolute truths on how reality can be seen, postmodernism “commits itself to ambiguity, relativity, fragmentation, particularity and discontinuity” (ibid). In this way, local takes precedence over global (and to some extent, a total rejection of global) such that “the artist and the writer, then, [and, in our case, the designer/researcher] are working without rules in order to formulate the rules of what will have been done” (Lyotard, 1984, p. 81). Postmodernism accepts a worldview where everyone’s voice is as equal as anyone else’s, an epistemological plurality which naturally implies an acknowledgement of multiple sources of knowledge creation. Thus, we are no longer recognising reality as it was once defined, but rather we “invent allusions to the conceivable which cannot be presented” (ibid). As such, there is no need for a clear distinction between the researcher and the designer, but rather an explanation for the position the researcher/designer takes which is required to be of benefit to the discussion. Taking such a position would allow any inquirer to create their own interpretations of the presented findings. From a methodological standpoint, this implies taking “situatedness, variations, complicatedness, difference of all kinds, and personality/relationality very seriously in all their complexities, multiplicities, instabilities, and contradictions” (Clarke, 2005, p. XXVIII). Clarke proposes a Situational Analysis with a postmodern turn to Grounded Theory which would address such matters.

Other Methodologies

Grounded Theory

Grounded theory (GM) is a qualitative research approach for “the discovery of theory from data systematically obtained from social research” (Glaser and Strauss, 1967, p. 2). At its core, grounded theory makes use of the grounded theory method (GTM), which encourages the researcher to continually interact with the collected data, whilst in a constant connection with the emerging analysis (Bryant and Charmaz, 2010, p. 1). A typical example of this type of collection would often see the researcher conducting interviews or personal observations. According to Charmaz, grounded theorists code the emerging data from the beginning but also during the collection process. In doing so, they can start formulating concepts and derive ideas to explain the studied phenomenon (Charmaz, 2002). Strauss and Corbin confer that theories are “interpretations made from given perspectives as adopted or researched by researchers - and therefore fallible - is not at all to deny that judgements can be made about the soundness or probable usefulness of it” (Strauss and Corbin, 1994, p. 279). Nevertheless, the proposed approach comes from a positivist standpoint, one where the researcher tries to formalise a scientific discipline (Clarke, 2005, p. 558) and in doing so it creates a reductionist explanation of reality (Law, 2002). Clarke proposes that grounded theory / method can be used with a constructivist epistemology by emphasising the meaning-making and relativist / perspectival understandings (Clarke, 2005, p. 559). “Situational analysis supplements basic grounded theory with situation-centred approaches that can enrich research by addressing and engaging important postmodern theoretical and methodological concerns about differences and complexities of social life” (Clarke, 2005, p. 558). The purpose of these maps is to stimulate thinking and open up the data to fresh / different approaches.

“Flexibility in the methods of research, a focus on defining the researcher and on insights brought up by the stories from the people researched take on greater importance. Such stories are not only from the people researched, but also from the own experience and cultural background of the researcher” (Rodriguez Ramirez, 2009, p. 7). Furthermore, since the designer is the one producing the research artefact, a constructivist postmodern approach with a situational analysis perspective towards grounded theory is a desirable

framework for RtD. This can be achieved if the researcher clearly defines their role, background and motivations. Furthermore, the researcher should provide a thorough description of the design process, and in doing so, the open up the decision-making process to scrutiny.

From an ontological perspective and based on the proposed paradigms by Guba and Lincoln, RtD sits well within Critical Theory et al. and Constructivism since it acknowledges the reality by social, political and cultural values (postmodernism) as well as local and specific constructed realities (constructionism/constructivism). However, RtD can also be used as a methodological framework when considering the Participatory paradigm. One of the mandatory requirements of the Creative Exchange research programme was to collaboratively work on small research projects. If all the participants are actively involved in the projects, they are thus contributing to the production of knowledge and invariably influencing the overall outcome of the research. In acknowledging this point, the participatory paradigm is a good fit since we are looking at a participative reality, a co-created subjective-objective one, based on the shared knowledge and understanding of the work undertaken for the whole duration of the project (Lincoln and Cuba, 2000, p. 168). This opens up the possibility, but not necessity, of other theories and methodologies which could be used in conjunction with RtD to better support and validate it. One such methodology is Action Research.

Action Research

The concept of action research was firstly introduced by social psychologist Kurt Lewin (1946) who developed this methodology and successfully applied it in a series of community experiments in post-world-war America (Kemmis and McTaggart, 1988, p. 6). He believed that: “research that produces nothing but books will not suffice” (Lewin, 1946, p. 35) thus he proposed an iterative approach to solution driven problems where both the researcher and the client would benefit.

According to Dick (2007), in order to find a solution to a dilemma, most of us would follow a simple algorithm: we would examine a given problem/situation, then decide on what steps should be taken, followed by an implementation phase (of the mentioned decisions) and finally a (re)evaluation of the situation to gain understanding of the reached outcome.

Lastly, if the desired outcome was not successfully reached, the process would then continue by examining the current state and iteratively move forward, from the beginning, through each stage until the goal was achieved. By breaking the situation down into multiple steps and iteratively going through each of them until the desired solution is reached, this approach is often used since it allows for a more comprehensive understanding of the problem by taking into account unknown issues. This can be defined as an action-understanding process, where action comes from understating and vice-versa. Action research works in a similar way however, the focus falls heavier on the understanding process by making it more explicit (Dick, 2007).

“Action research is a form of collective self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out” (Kemmis and McTaggart, 1988, p. 5). Bryman and Bell successfully generalise this definition by stating that action research is “an approach in which the action researcher and a client collaborate in the diagnosis of the problem and in the development of a solution based on the diagnosis (Bryman and Bell, 2011, p. 414). In other words, the approach focuses on the collaboration between two entities in trying to solve organisational problems. It “provides a way of working which links theory and practice into the one whole: ideas-in-action” (Kemmis and McTaggart, 1988, p. 6). In general, the action research methodology can be broken down into three different stages: planning, action & observation and reflection (Kemmis and McTaggart, 1988, p. 11).

Lewin’s approach (Lewin, 1946) starts with a planning phase but, in practice, the process springs from a rough idea about a change;²⁵ an improvement which could be made to a given social situation. A group is formed where the individual members identify key concerns about common interests, forming a cluster of ideas until a decision is made to work on a ‘thematic concern’ (Kemmis and McTaggart, 1988, p. 8, Figure 3).

²⁵ This point will be explained in more details in the next section of this chapter.

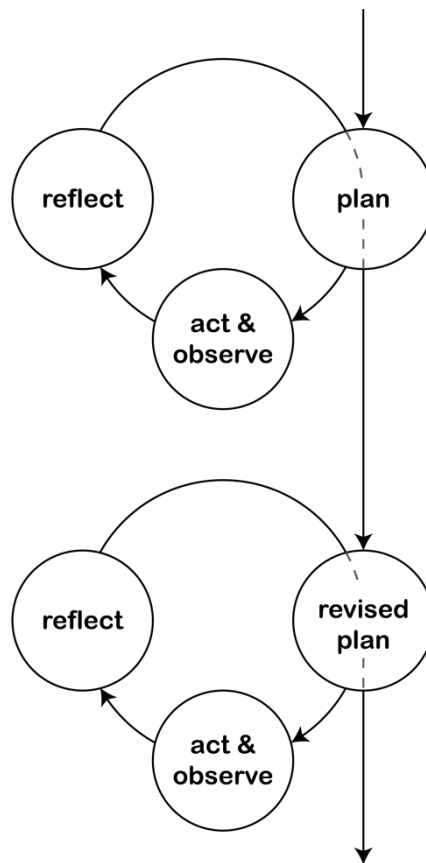


Figure 3. The Action Research cycle.

This prompts the making of a plan of action, where key elements are split into achievable outcomes. The focus of this process is two-fold: direct alteration of the process with an overall aim of its improvement and, on the other hand, a deeper understanding of what other potential achievements might be possible at a later stage. As such, the next step of action and observation is “more effective because of the time spent in the planning phase” (Dick, 2007). Within each executed stages of the implementation new data comes in, thus the possibility for understanding presents itself by analysing each action, the circumstances and overall strategy in practice. This reflection stage also gives room to another cycle of the plan, by proving an in-depth understanding of the current plan and its shortcomings. Based on this process, different key findings can be extracted which are valid for all action research projects:

1. There is a close relationship between gaining knowledge and action. Action is taken to generate knowledge by improving practice. In other words, action research is “research in action rather than research about action” (Coghlan and Brannick, 2010, p. 4). This mode of operandi also fits well within the constructionist epistemological framework.

2. Action research is a participatory process between a research group (or individual) and an external partner (client) where the results are shared amongst all participants. Whilst the client benefits directly from finding a solution to their problem, the research team gains understanding about the process. As such, the output of the action research method is “actionable knowledge” (Coghlan, 2007, p. 293), also defined by Alder and Shani (2001) as “knowledge that is useful to both the academic and practitioner communities” (Alder and Shani, 2001, p. 52).

To conclude this section, action research is a good methodology to be used for RtD when multiple actors, each with their own agendas, are involved. This is a useful way of thinking and acting throughout the different stages of the development which keeps all parties involved in the research project. By situating all actors, a grounded theory approach can be used in defining new concepts to be discussed, facilitating an organic approach to research as well as moving towards the desired goal.

As previously stated, the focus of this thesis falls on the construction of new objects and spaces within the digital public space, and in doing so, portrays alternative ways in which new knowledge can be formed and transmitted. Up to this point, I have presented the epistemological and ontological frameworks I used and in doing so I set a specific mind-frame one has to be willing to acknowledge in order to understand this work. The next section of this chapter talks in more depth about some of the conceptual perspectives involved in the construction of objects and spaces. Ideally, the chapter would conclude with an overview of the methods used to achieve the presented work. However, given the unique shape of this PhD, and the uniqueness of each project, it seems more appropriate to present the methods used for each project, within their own individual chapter.

One of the most important design consideration which has to be acknowledged by any design-researchers of the DPS when considering the construction of objects and spaces is the duality of the environment in which

their final design will be situated. On one hand, any interactions with the Internet, in whatever form or shape that might be, have a digital component which can be associated with a digital environment, a digital world in which the Internet is situated. On the other hand, the final product will ultimately have a physical presence, a tangible object, represented by the embodiment of the actions and decisions taken during the design process. Whilst the digital component is without a doubt important, the object lives in a physical world. Within the DPS, these two worlds have an overlapping area which is where the presented work is situated. I would like to pause here and reflect on this point, since a clear understanding of this space and especially my way of seeing it, is mandatory for this thesis.

Digital archives such as the ones held by Spotify, the BBC or Facebook are just an example of belonging solely to the digital world. Whilst it cannot be denied that such archives are physically stored on hard-drives and thus existing in a physical setting as well, for the clarity of this argument, I would like to point out that viewing an archive in this manner is stripped of meaning and lacking context. In this respect, there is no difference between any archives, or between a photograph and any other document digitally saved, they are all a stream of ones and zeros physically stored in such a manner. Not a view I can fully reconcile. At the exact opposite end, we have the physical objects, which have no digital component. Whilst many of these objects have, most probably, a digital presence having been previously designed with the use of a digital tool, living in an archive of their own, I am only focusing here on their physical enactment, the tactile object. With respect to the DPS, any object, or space for that matter, will simultaneously exist in both worlds.

Whilst these objects and spaces live in this mixed-reality world, I believe it is important to consider how we come to act with and around them. There would be no point in designing anything which sits outside of human benefit; art appeals to feelings, design to use!

At our core, we are physical by nature, our bodies are made up of atoms and whilst we might only have a limited understanding of how the human body actually functions, we can at least experience it through our senses: we can see it, touch it, taste it, smell it and hear it. This is the 'natural' way we experience anything in life, through the use of our five senses. We 'digest' a particular object by looking at its physical properties based on the story it

might tell us through the looking glass of our personal experience. Don Norman better defines these visible physical properties as ‘affordances’ or ‘perceived affordances’; the actionable properties between an object and an actor (Norman, 2013) or what we believe (or perceive) the object can do when we look at or interact with it. There is also a certain level of understanding that comes to the forefront, comprehension which is formed by our own past experiences with the object. In general, an adult will have a deeper, more insightful perception of what an object might be used for since their experience is broader and far richer compared to that of a baby. For a baby, lacking this foundation of knowledge to build upon, understanding of the form and functionality of an object comes through a trial and fail approach. Given a new object, they will grab it, bash it, kick it, stroke it, make it squeak, taste it, chew it, smell it or even throw it to understand what it does, forming that knowledge which will be applied in future engagements with the object or any other ones of similar perceived affordances. One of the most interesting example to be discussed here is that of a one-year old baby showed in a video²⁶ engaging in similar ways with a printed magazine and an iPad. Whilst the context in which the baby is performing all the actions was edited, what we can see is a ‘perceived’ attempt from the baby trying to grab and swipe on the magazine in similar ways in which she did on the iPad. In this context, it can be inferred that previously held knowledge gained by the baby was applied in unfamiliar situations. This behaviour is often seen with adults faced with similar situations; when understanding of an object’s affordances is lacking, we default to the use of our senses and previously held experiences to gain the knowledge we need to engage with them.

Therefore, two points are emerging which need addressing when considering designing within the DPS. On one hand, as a designer, I need to properly understand interaction design as a field of study since the focus of my design is that of objects or spaces situated in a mixed-reality world. On the other hand, I need to carefully consider the ‘natural’ affordances of each world, in such ways that these designs can lift up experiences rather than bring them down.

²⁶ <https://www.youtube.com/watch?v=aXV-yaFmQNk>

Interaction Design

Designing meaningful interactions for new objects, and implicitly interaction design as the umbrella to engulf all interactions, plays a crucial role in the creation of any new object. Bill Verplank defines interaction design as “design for people” (Verplank, 2003, p. 2) in such ways to appeal to “their physical and emotional needs and increasingly for their intellect” (ibid, p. 5). In his view, there are three important questions to be asked by the designer and answered by the final design: How do you do? How do you feel? How do you know?” (ibid, p. 6; illustrated in Figure 4).

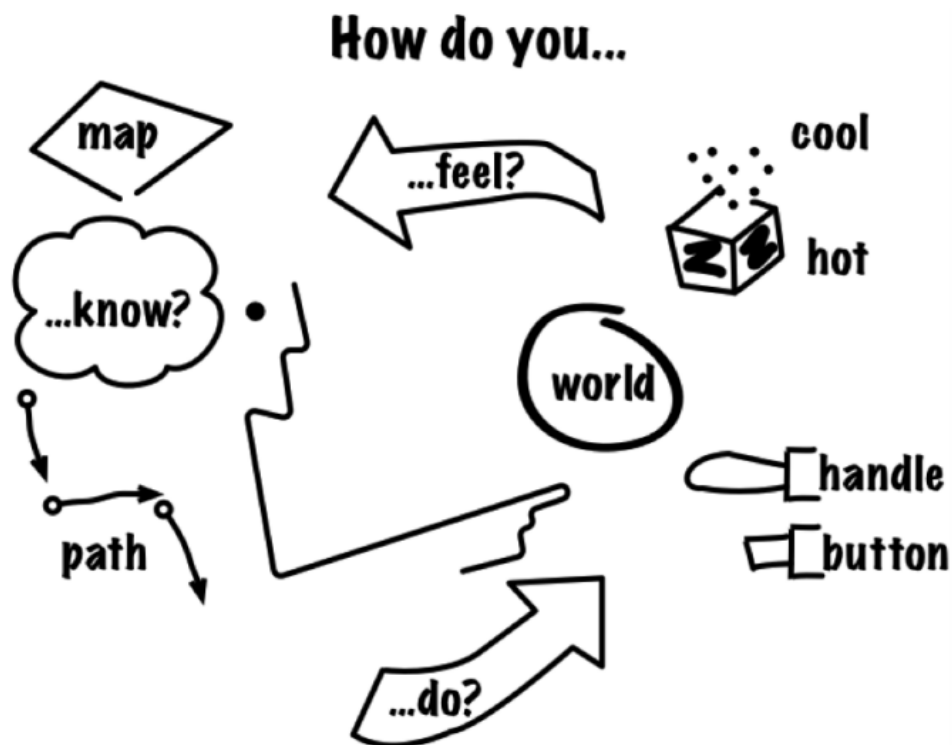


Figure 4. Interaction Design as defined by Bill Verplank (ibid, p. 6).

If we start with ‘doing’ then Verplank distils this to a consideration of whether the interaction is continuous or discrete (represented by the handle and button respectively within the sketch) and while both of these are applicable, and available, in the general design of interactive objects we must extend this also to consider that they are likely to be implemented as a combination of real or virtual interactions. As a designer I must, therefore, carefully consider how such interactions are used and combined them so that it ‘makes sense’ to the user.

In terms of how the user 'feels', while he considers this in relation to the user's physical senses, Verplank presents it in relation to the medium through which the interaction is presented to the user. This draws upon the work of Marshall McLuhan and his definition of a media as "any technology that ... creates extensions of the human body and senses" (McLuhan, M., McLuhan, E., and Zingrone 1995). McLuhan categorised media in terms of 'hot' and 'cool', whereby a hot media, such as print, is one that dominates one particular sense absorbing our attention and leaving little room for participation, while a cool media (sometimes described as fuzzy) that engages across our senses leaves space for participation (McLuhan and Fiore, 1967). When McLuhan wrote this original definition, he considered television as a cool media although nowadays it would more likely be considered towards the hot end of the spectrum. Arguably the Internet does not really fit into McLuhan's definition as it both encourages participation but it also commands our attention and often dominates our senses. As the mixed-reality objects and spaces under consideration would be expected to expand the interaction across many of the user's senses, they are likely to appear at the cool end of the spectrum. In relation to the overall design of these objects and spaces, cool features are likely to attract and engage whereas hot features can be used to provide very specific activities and functionality. Thus, as an interaction designer, I believe I need to consider a combination of these within my designs.

The final question of 'how we know' is illustrated by Verplank as paths and maps where he argues that often the best overall interaction design utilises a combination of both (Verplank, 2009). Note this categorisation is derived from Kevin Lynch's work in his 1960 book, 'The Image of the City', which studied how people developed an understanding of the layout of a city. Paths are, primarily, step-by-step instructions that guide the user through an interaction and it is generally regarded as the easiest form of interaction as the user only needs to know one step at a time (path knowledge). Paths are commonly used in situations that require immediate action by users who are likely to be experiencing the required interaction for the first time (i.e. emergency door release). An example of this can be frequently found at the start of a (digital) game, referred to as the boarding experience, where the player is led to a series of actions in order to grasp the overall mechanics of

the game. Maps essentially represent knowledge obtained through the interface affordances that help users construct coherent mental models from which new tasks and uses can be inferred. The knowledge maps build on affordances through the interactions performed by the users in multiple scenarios using objects and systems that provide similar interactions.

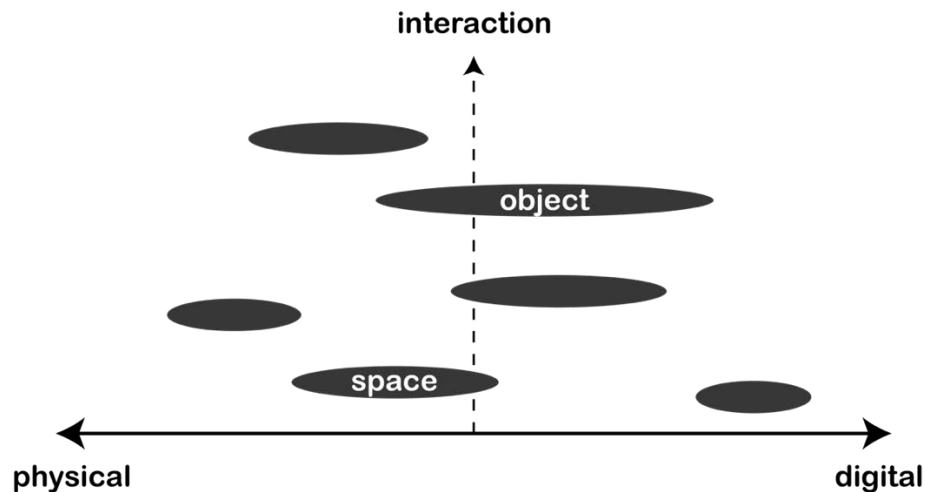


Figure 5. Situating DPS objects and spaces within the physical-digital-interaction dimension.

Based on this, I can go back and revise the previously proposed diagram (Figure 5), by acknowledging the need for another dimension, one which takes into consideration the level of interaction an object or space affords. In doing so, my plan is to move the attention from a general classification of objects/spaces within the DPS to a more meaningful one, with a clear focus on interaction. This diagram will serve as a basis for situation each of the presented projects in a different chapter, where a deeper analysis of them can be found.

The interaction design of objects and spaces within the DPS requires designers to not only fully understand the virtual aspects the affordances they are perhaps used to, but also to extend these to include the affordances we associate with physical objects to ensure their overall design does not cause confusion for the user. It is therefore important to consider the concept of affordance in more detail.

Affordances

The original concept of affordance was conceived by Ecological Psychologist James J. Gibson (1977) to define the actionable properties between the world and a person. He uses the example of a flat surface that affords 'sitting on' whereas a 'pointy' one would not. The important aspect of this is that an affordance of an object exists whether it is acted upon or not. The concept of affordance was most notably developed for design by Donald Norman extended from what he regarded as Gibson's 'real affordances' to include 'perceived' affordances (Norman, 2013). He argued that affordances "play very different roles in physical products than they do in the world of screen-based products" (Norman, 1998) and unlike Gibson, he also believed that affordances could be dependent on the experience, knowledge, or culture of the users (Soegaard, 2003). For example, in Japan, you would expect to read comics left to right and back to front. Further, Norman uses this as a means of distinguishing between the properties of an object that are controllable by a designer and those that are fixed. In the case-and-point of designing real objects, both the actual and perceived affordances are controllable, whereas for screen-based interaction generally, only the perceived affordances are under the control of the designer, "as the computer system comes with built-in physical affordances" (Norman, 1999). For example, all computer screens support the affordance of touch whether they are touch sensitive (i.e. respond to the touch) or not. If we add a graphical target on a touch sensitive screen, we are providing visual feedback that advertises the affordance that touch interaction is supported, and this creates the perceived affordance of the user. This is an important point as it emphasises that while designers might be used to incorporating the established perceived affordances within the built-in affordances of systems and their controllers, computers, or phones, they are unlikely to have contributed to the built-in affordances of the physical systems as these have traditionally been solely belonging to product designers.

Bill Gaver further stressed the importance of affordances for design when stating "affordances exist whether or not they are perceived, but it is because they are inherently about important properties that they 'need' to be perceived" (Gaver, 1991). He also introduced the concept of 'sequential affordances' which describes how in many situations a user's action on a perceptible affordance then leads to new information relating to the next

affordance in the sequence. To help designers consider the ease of use of the object/system they are designing, Gaver developed a diagram (1991), which considers whether perceptual information is available to user (Figure 6).

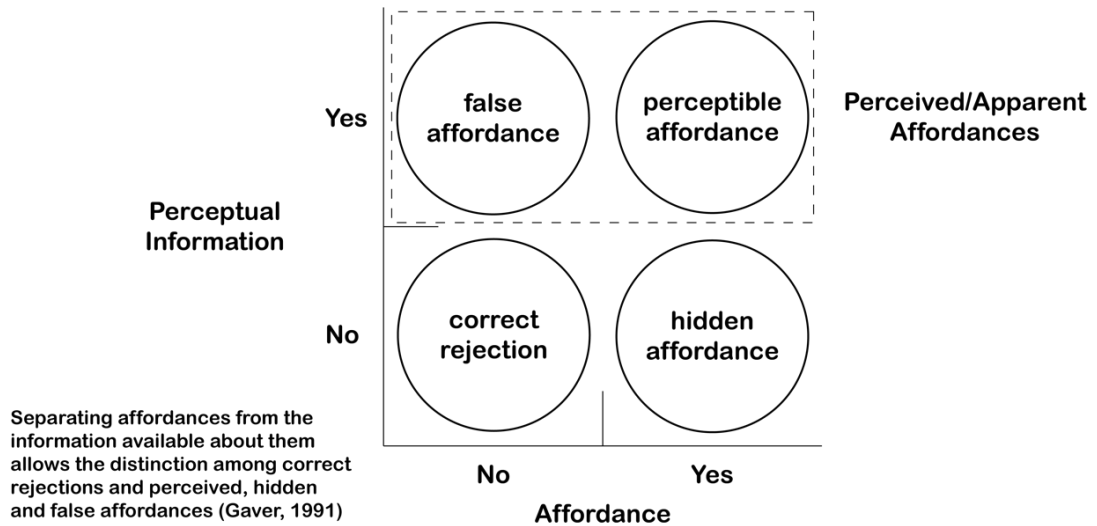


Figure 6. Affordance relative to Perceptual Information (Gaver, 1991).

In this diagram, a false affordance exists when there is no action possible although the perceptual information implies that there is, however, others would argue that in such a case it is not that the affordance is incorrect but rather it is that the perceptual information is incorrect (McGrenere and Hon, 2000). This would occur if a designer created a physical object with a feature that looks like a button that could not actually be physically pressed. A correct rejection occurs when there is no affordance and no perceptual information to specify it whereas a hidden affordance exists when the affordance is present but the specifying perceptual information is not. Dan Saffer (2013) suggests hidden affordances may actually be regarded as ‘discoverable’ in recognition that designers may deliberately allow them to be revealed through accidental use or deliberate exploration.

Whilst recognising Gaver’s contribution, McGrenere and Hon (2000) state, that in order to “use affordances to evaluate and improve design, it is useful to think of the degree of an affordance” and to “regard affordances as binary is to oversimplify them”. To illustrate this, they created a diagram (Figure 7), which presents a two-dimensional space where one dimension

describes the ease of which an affordance can be undertaken and the other dimension describes the clarity of the information that describes the affordance. Each dimension is a continuum and the goal for the designer is to first determine the necessary affordances and then to maximise each of these dimensions (McGrenere and Hon, 2000).

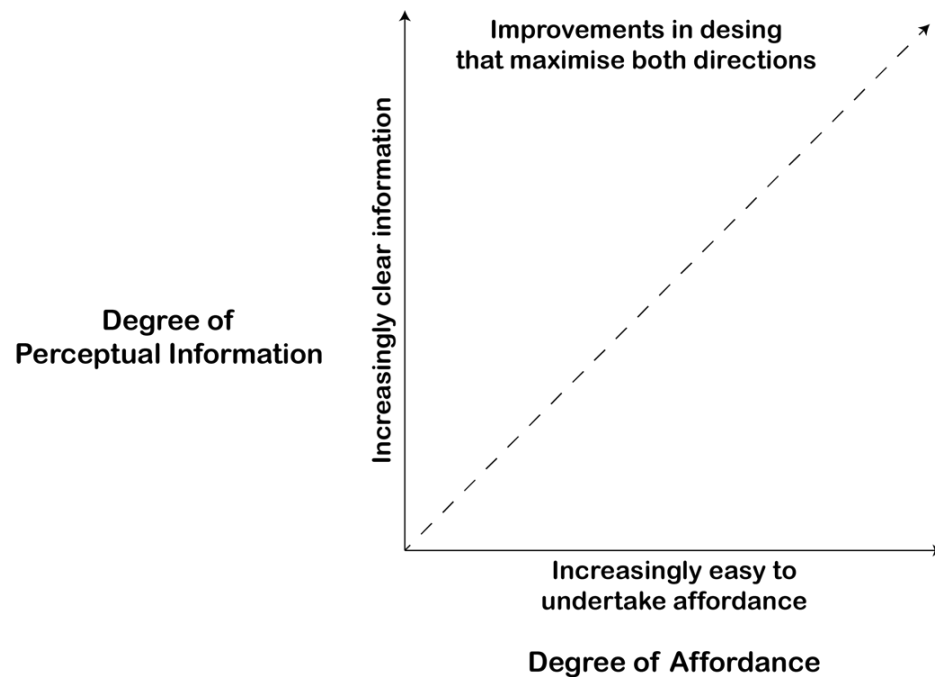


Figure 7. Improving Affordance Design adapted from McGrenere and Hon (2000).

It is my belief that objects and spaces situated within DPS should be considered as dynamically traversing this space and designers should endeavour to unite approaches to affordances from both the physical and digital domains dynamically throughout their designs. This means that designers cannot consider real or perceived affordances separately or that these affordances are fixed and must address both of these throughout the design and testing of their implementations.

Alongside affordances, Norman (2002) also defined 'cultural conventions' which also serve to constrain user interaction and derive from users' conventional interpretations of how they should interact with a particular artefact. Norman further subdivides these cultural conventions into physical, logical, and cultural constraints. Physical constraints are related to

the artefact, logical constraints are when users make judgements to deduce the nature of the interaction, and finally, cultural constraints are conventions shared by a cultural group. The challenge for DPS designers is in understanding which conventions they might inherit when designing an object or space of a particular form.

Before I move towards the presentation, analysis and conclusions of my choice of projects for this thesis, there is one final point which I would like to address in this chapter: the overall method employed which contributed to my understating of and knowledge gathering from each project.

As previously mentioned, each project is unique, both in team composition and its overall requirements. Whilst some of the people involved in the project were the same, such as my supervisor, the idea of the project and its deliverables were always different since they were actual research projects. Some of the ideas which were at the base of the projects came out of different workshops, for example, one which had run before I joined the CX research programme, whilst others were derived from simple discussions on how design could help in different given scenarios. However, in terms of the actual approach of the work, in all scenarios, a hunch-and-hack approach was used.

In his 'Interaction Design Handbook', alongside the interaction aspect which was previously discussed, Bill Verplank also talks about 'sketching' as an "essential designer's tool for capturing preliminary observations and ideas" (2003, p. 2), in which the diversity of the available sketches furthers the designer's creativity. This idea of sketching draws heavily from what Robert H. McKim (1972) defines as 'visual thinking', a concept which in his opinion combines the acts of seeing, imagining and drawing into a single act, that of thinking visually, thinking in images, drawings and sketches. According to McKim, "where seeing and drawing overlap, seeing facilitates drawing while drawing invigorates seeing. Where drawing and imagining overlap, drawing stimulates and expresses imagining, while imagining provides impetus and material for drawing. Where imagining and seeing overlap, imagination directs and filters seeing, while seeing, in turn, provides raw material for imagining" (ibid, p. 6-7). For McKim, the intersection of these three areas represents the idea of visual thinking (Figure 8) which Verplank defines it as 'idea sketching' or 'rapid visualisation' (Verplank, 2003, p. 3).

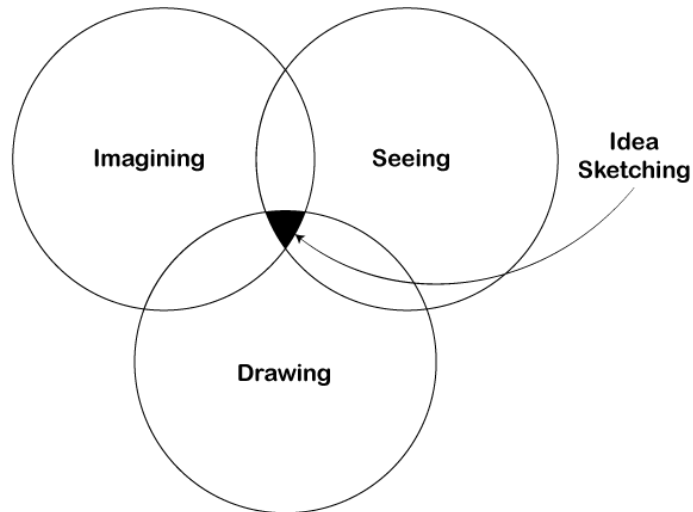


Figure 8. Idea Sketching, adaptation from McKim (2000).

Verplank’s masterfully utilised ‘the sketch’ as a method of explaining the design process of a product whilst also situating it at the core of the creative thinking process. His approach starts with a ‘hunch’, followed by a ‘hack’ and potentially another hunch to generate an idea. The idea generates alternatives, which in turn lead to multiple prototypes to be tested in order to define a principle. The latter provides the basis for discovering the value in the “product which creates a market which creates a paradigm” (ibid, p. 4) reaching a fixed orbit (Figure 9).

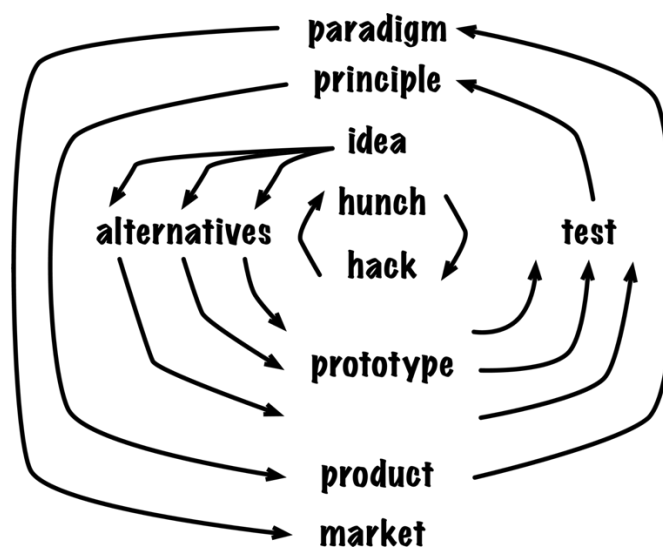


Figure 9. The Design Process, adaptation from Verplank (2003).

I would like to stop here and express two different points where I found his method extremely useful. Firstly, in my own research practice, I often found his method useful in tackling the complexities of my research projects. Whilst some of these projects might have had some original ideas, giving the 'perceived' notion of project 'requirements', in reality, they were mere hunches as we rarely knew if any of these so-called ideas would actually work. When technology is involved, there is little guarantee it would deliver on one's visions. Secondly, whilst his method depicts the design process, I would like to horizontally split his sketch to show the difference between product design and design research, shown in Figure 10.

As a researcher, I was mostly concerned with the top part, which defines the principle and the paradigm, as it better portrays how I was able to draw insights and contribute my findings and ideas to the collective pool of knowledge. On the other hand, as a designer, my work is best portrayed in the bottom part of this figure, which shows how a marketable product could be developed from a simple idea. Nevertheless, Verplank's method stands to point out once more the duality of the researcher in the design field, especially the type of researcher which makes use of RtD as an overall methodology.

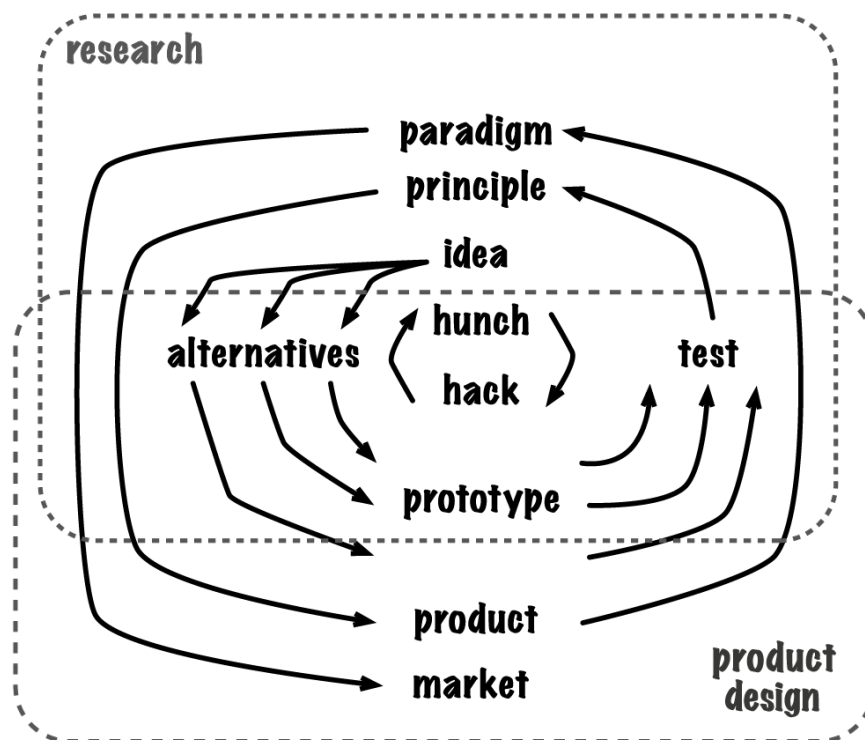


Figure 10. Product design and research design based on Verplank's design process.

What to Expect from the Next Chapters

The rest of this thesis is comprised by seven more chapters; the first five individually present a project I was involved in, followed by a discussion and conclusions chapter and finishing on a chapter presenting potential avenues of investigation for this research in the future.

Each project chapter follows a simple structure of describing the research agenda for the project, a brief overview of what the project constructed and the relationship between these constructions and the Digital Public Space. From there onwards, each project is described individually by setting the scene of the research, the collaborative team which worked on the project and a thorough description of the design challenges and decisions taken to successfully meet the aims of the project. I have written these projects in a manner which allows them to be considered individually, therefore, after reading the research programme description and my philosophical, epistemological and ontological stance, one can freely move to any of the other chapters if one so desires. The reasons for supporting these projects individually in such a manner is deeply anchored by the ways in which the CX worked, that of different teams across projects with varied research agendas. Finally, I would like to point out that each project is built through a constant iterative process based on successful and failed ideas, each informing the other one in a very fluid design manifestation.

PAC-LAN

The interaction design of mixed-reality location-based games typically focuses upon the digital content of the mobile screen, as this is characteristically the primary navigational tool players use to traverse the game space. This emphasis on the digital over the physical means the opportunity for player immersion in mixed-reality games is often limited to the single (digital) dimension. This chapter presents an approach which seeks to redress this imbalance, which is caused, in part, by the requirement for the player's attention to be systematically switched between the two worlds, defined here as the 'Dichotomy of Immersion'. Using different design strategies, the focus falls on minimising the reliance of the player upon the mobile screen by encouraging greater observation of their physical surroundings. PAC-LAN: Zombie Apocalypse is a mixed-reality location-based game (LBG) which illustrates such design strategies for increasing immersion in location-based games which could aid designers in enabling players to more readily engage with the physical context of the game and thus facilitate richer game experiences.

The Constructed Bits

By the end of the project, we developed a location-based game which made use of the Android ecosystem for its delivery. We also created a physical game space by augmenting it with different game elements, further contributing to the overall experience of the players. It is important to note here that whilst the mobile application is a re-enactment of an older game, it emerged through the researching of the initial idea and that its current format is due to the constant iterative approach of developing and testing different avenues which were found useful in relation to the original idea. Whilst the idea did not change, the outcomes might have been different if other decisions were taken.

Connection to the Digital Public Space

One of the notions around the Digital Public Space revolves around the idea of "Public [making] Digital Public Spaces" (Hemment et al., 2013, p. 17) and PAC-LAN addressed such issues. The game area in which the game is

played, is defined both physically, through the addition of game elements in the form of pills but also digitally, through the creation of a custom, game like, digital map. This newly formed game area is accessible only during the act of playing the game, since it would have no purpose outside of the game and the rules imposed by it. Therefore, it is through the act of playing that a new digital public space is enacted and experienced. This builds on top of notions of 'legibility' defined by Lynch which are addressed in a subsequent part of this chapter.

The Team

For this project, the team was composed by Prof. Paul Coulton, researcher and supervisor of the overall project and member of the ImaginationLancaster at Lancaster University, Dr. Jonny Huck, lecturer in Geographical Info Science at The University of Manchester, Dr. Mark Lochrie, creative technologist and researcher in the Creative Industries at Media Studio Innovation at University of Central Lancashire and finally myself as seen in Figure 11.

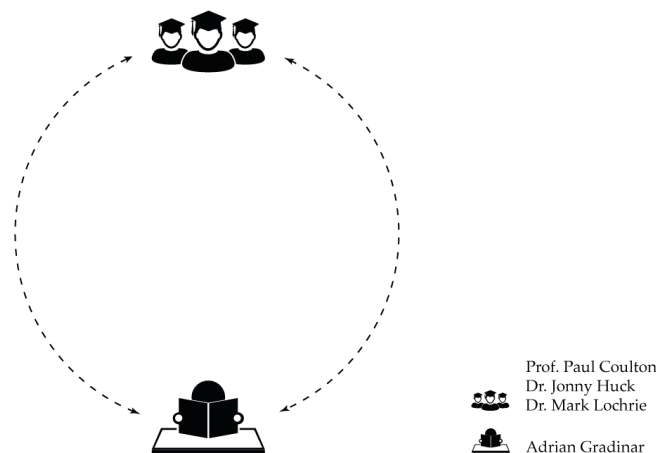


Figure 11. Pac-Lan project team.

Dr. Huck was responsible for setting up the infrastructure for the mapping tool as well as implementing the chosen mapping styles whilst Dr. Lochrie was responsible with the generation of the assets needed for the mobile application. My roles shifted from researcher, focusing on interaction and experience, to project manager, overseeing each member's contribution, writing ethics forms, budgeting, material acquisition, etc. and finally to Android lead developer, fully responsible for the development and

implementation of the mobile application. As a team, we all contributed to the development of the project. It is important to note here that this was not a fully developed CX project per se, as it did not involve an external industrial partner nor did it make use of the budget all other projects had at their disposal. However, based on the above-mentioned reasons, it contributes to the overall argument presented in this thesis. In a similar manner to all the projects presented in this thesis, the direction of the project was not given solely by my own research agenda, but that of the team, where ideas were exchanged, discussed, analysed and tested, with a clear focus towards the benefits of the research project.

The Settings

The idea of this project arose during a supervisory meeting with Prof. Paul Coulton which found us discussing around the different notions of DPS and especially around the multitude of ways in which new digital public spaces could be designed and created. We agreed that since it was also the beginning of my doctoral candidate journey, a focus on the digital side of the DPS would be useful. During this discussion, Prof. Coulton mentioned about an earlier research project, Pac-Lan, which could be used as a starting point for this exploration. The original PAC-LAN game was created to consider the possibilities arising from the combination of mobile devices and Radio-Frequency Identification (RFID) technology to create new entertainment experiences (Rashid et al., 2006a). Pac-Man was chosen as it allowed a comparison with other games of that time which used this theme, namely Pac Manhattan and Human Pac-Man (ibid). At the time of development, hardware limitations meant that RFID rather than GPS technology was used as the method of determining location by requiring players to tag physical objects at known locations. I would like to point out that this particular version of RFID went on to be standardised as Near Field Communication (NFC). However, due to the duality of the interactions required for this game, our focus shifted from the technological developments, which stood at the basis of the original research, to the potential implications of the project, especially towards the understanding and construction of spaces within the DPS. Therefore, it was agreed that it was of worth investigating these ideas by replicating the original game.

Game Design

PAC-LAN: Zombie Apocalypse was built using the Android platform to allow the game to be easily distributed ‘in the wild’ since Android is found on the greatest number of handsets with on-board NFC readers. Because of this, other platforms such as Windows or BlackBerry were disregarded, since, at the time of the development, their handsets were either not featuring NFC technology or, their adoption was still on the low end of the spectrum. In order to best explain the design challenges we encountered during the development of the mobile game, I would like to first explain the basics of the game, so it forms the scaffolding for the next parts.

The game consists of five players, each of which is provided with a character costume (individual character hat), identified by a specific NFC token (attached to the hat) as well as an Android mobile device running the game application. One player takes the role of PAC-LAN, whose purpose is to tag all of the pills in order to earn points; and the remaining four players take the role of the Zombies, whose purpose is to ‘infect’ the PAC-LAN player by tagging their NFC token. As with the arcade version, there are a number of special ‘power pills’ located within the game arena which, when tagged by PAC-LAN, enable the player to ‘infect’ the Zombies by tagging the NFC token on their costume, forcing them to return to the starting location of the game to ‘re-spawn’. All of the main interactions within the game, such as tagging pills or characters, occur physically and do not require any interaction with the interface of the mobile screen. Before a game commences, the game space needs to be set up involving the positioning of the pills both physically in the landscape and digitally on the map. There are 3 types of pills in the game:

1. The base pill – where all players start the game and where players ‘re-spawn’ after being captured (Zombies only) or if their ‘roaming time’ expires (all players).
2. Check-in pills – update the last tagged location of all active players as well as replenishing their ‘roaming time’.
3. Power pills – give PAC-LAN the ability to ‘infect’ Zombies. They also replenish the ‘roaming time’ and extra time for ‘infecting’ zombies.

These pills are only distinguished on the PAC-LAN’s UI as for Zombies they function the same as checkin pills. Once the physical game space has been successfully set up and the players are equipped with their chosen

costume, each player is then required to tag the base pill to start their game. Compared to the PAC-LAN player, who begins play immediately after tagging the base, each Zombie player has a predefined waiting time, displayed as a progress bar before they become active within the game. This gives the PAC-LAN player time to exit the immediate vicinity of the Zombies (Figure 12a and 12b) before they can be ‘infected’. The Zombies are named Blinky, Pinky, Inky and Clyde after the original ghosts from the Pac-Man arcade game, and have to wait for 100s, 80s, 60s and 40s respectively before they can actively view the map and play the game. This is purely a gameplay feature allowing the Zombie players to consider which player is the fastest and slowest, and account for this when selecting which Zombie character they will play.



Figure 12. a) PAC-LAN entering the game (left); b) Zombie entering the game with a countdown for ‘waiting time’ (right).

The game UI displays a map depicting the location of all pills, paths and buildings, and a decreasing progress bar (‘roaming time’) that represents the

maximum time that a player can take between tagging pills before being forced to return to the base. During this 'return period' the player is inactive and so no interactions with the UI or physical anchors are allowed until the base is scanned again. When a player tags a pill, the 'roaming bar' is replenished and the UI refreshed by showing the location of the last pill tagged by each active player, as well as changing the colour of the pill to grey to indicate it is no longer worth any points. Each player's interactions with the pills are visible only on their individual UIs. The player can return and 're-tag' a 'grey' pill to replenish their 'roaming time' and to update the last tagged location of all other active players, though they will not receive any more points for that pill. The game is finished when either PAC-LAN tags all the pills or is 'infected' (tagged) by one of the Zombies and the winner is calculated based on the total points gained during the game. When the game finishes, the mobile application displays a leaderboard showing all five players and their scores.

Based on this, there were two different sides which needed to be developed: on one hand, there was the physical side of the game, requiring the setup of the physical environment to allow for a game to be played whilst, on the other hand, there was also the digital game which needed careful consideration and development to reach a fully working state.

The Physical Game Space

Setting up the game space in the physical environment requires the positioning of the pills in an area which was chosen as the game space. The original game developed in 2006 made use of yellow and red Frisbees and through the use of straps they were attached to different, already existing, outdoor located elements. We used the same pills, however, during one of the testing phases, we decided to change the Frisbees for smaller NFC tags, about 4 cm in diameter (Figure 13, left). At that time, our concerns were solely directed towards the time required to set up the game space since 30 NFC tags fitted quite easily into a side pocket and required only a single person to walk around and position the tags; the same process required two people to set up 30 Frisbees (Figure 13, right).



Figure 13. NFC pills (left) and Frisbees pills (right).

Whilst this was indeed easier and hassle free, it had a massive drawback: despite the team's knowledge of the location of the pills, during testing, we had issues finding the tags. It was then when we realised that whilst the digital game needed to have a careful design to help with the navigation, the physical game elements had to also be appropriate for navigation. Therefore, in subsequent testing, as well as for all the following trials, the Frisbees were attached to physical objects in such ways that there was always at least one direct line of sight between any two pills. Furthermore, they had to be positioned in such ways to be easily visible upon the quick scan of the physical environment. For example, we positioned them on drain pipes and poles rather than under benches or in trees. This was believed to help players navigate heads-up and rely less on the mobile interface.

In the original PAC-LAN game developed in 2006, each player was given a cape based on their chosen game character. This was done to visually identify the physical players during the game. On the back of each cape, the player's NFC tag was attached, which allowed for an easy grab and scan when capturing was happening. Whilst the original game used the personas of ghosts, our version looked at zombies, therefore, with the help of Dr. Claire Coulton²⁷, zombie hats were crocheted. Inside each hat, we positioned the NFC tag associated with that game character. In a similar vein to the capes, the hats were designed to help players achieve a higher immersion level during the game. Unfortunately, due to time constraints, the hats were completed only after the trials so we never managed to use them. Figure 14 shows one of the players wearing a cape (left) and all five of the Zombie hats (right).

²⁷ http://imagination.lancs.ac.uk/people/Claire_Coulton



Figure 14. Player using a cape (left) and all Zombie hats (right).

The Digital Game

The digital part of the game consisted of three different aspects being fully considered and developed:

1. A database - This was used to store all digital game elements, such as a list of the NFC tags of the five game characters, a list of pills with their names and respective GPS positions, the players, as well as a list of active games. During the development of the database, the team acknowledged that there might be situations where the same physical area might be used for more than just a single game therefore, adjustments were made to the database to allow for a game to have multiple instances. Since these instances were actually different games, it was quickly agreed that only a single instance of any game should be active at any given time. This feature would stop players in joining different instances of the same game whilst also allowing for a game to be played as many times as desired. Nevertheless, during testing, this option was often switched off, thus allowing for a multitude of design elements to be tested across different games.
2. A server - A vast majority of online games make use of a backend server to match players across physical locations with the purpose of bringing them into different game instances (depending on location, abilities, options, etc.). Therefore, a client-server architecture was setup for our game. Complementary software was written to allow for the

easy storage and retrieval of database data (players, locations of pills, etc.).

3. A mobile application - The application which allows players to play the game.

The Mobile Application

Initial sketches, seen in Figure 15 and Figure 16, were drawn to simultaneously provide a unified image of the envisioned mobile application as well as helping with the development of the digital side of the game. The interface was thought to have four different main screens, each performing a singular task related to an individual aspect of the game, which are listed below for clarity.

The 'Play' screen, found in Figure 15, was responsible for the overall on-boarding of the player relating to the setup of the game. This was designed to facilitate an easy and enjoyable experience whilst guiding the player through the setup procedure. Upon pressing the Play button, the player was expected to be directed to a 'Lobby' page, which comprised a list of available games. It was envisioned that this list would be sortable by date, locations and alphabetically. Upon the selection of a game, the application would move the player to the next part of the setup which asked the player to scan the NFC tag of their own game character. The purpose for this action is two-fold: on one hand, it allowed the application to link the human player with their chosen digital character whilst minimising the possibility of the same avatar to be used more than once in the same game instance. On the other hand, it was the first physical interaction which sought to point out to the players on how 'capturing' would work (part of the on-boarding experience).

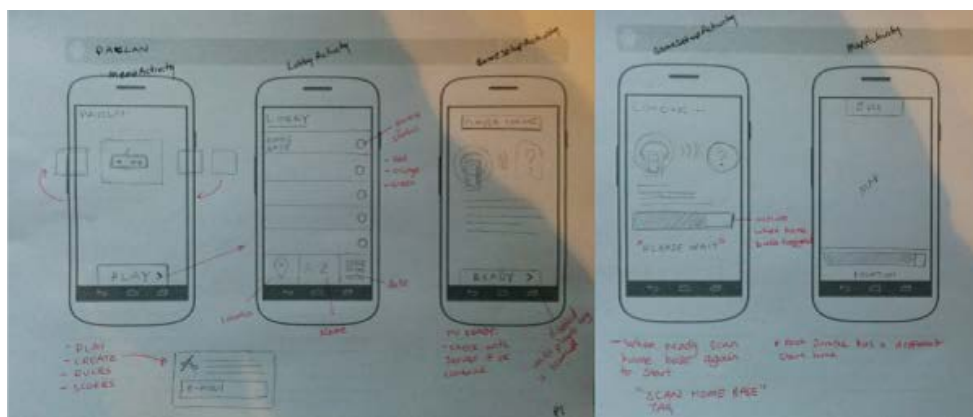


Figure 15. The 'Play' area - original sketches.

Upon successfully scanning their individual NFC tag, the application would change its view by asking the players to scan the base. Whilst for the PAC-LAN player this meant being able to start collecting pills, for the Zombies it implied having to wait their individual times (as described above) only to be asked once more to scan the base. The second scan was added as a security feature, forcing the Zombie players to act accordingly to the rules and allow the PAC-LAN player to move away from the base. This was the final step before the application would display the digital game area; this interface is discussed in more depth in a subsequent part of this chapter.

The last three remaining screens are described below and can be seen in Figure 16.

1. The 'Scores' - envisioned to show the scores for the active game. It was agreed that, by design, this area would not be accessible unless the player was active in a game.
2. The 'Leaderboard' - would have depicted the best scores achieved by all players across all games.
3. The 'Rules' - envisioned to display a simple mobile page with the basic rules and scoring system.

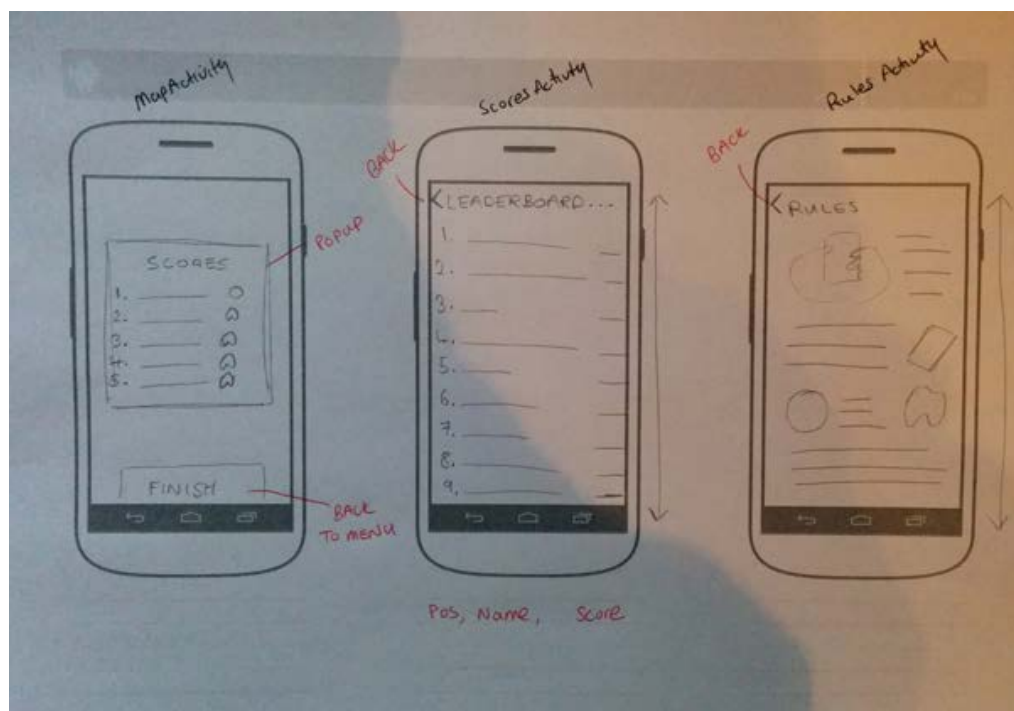


Figure 16. The 'Scores', 'Leaderboard' and 'Rules' – original sketches.

In terms of digital interactions, the application was envisioned to make use of buttons for in-app navigation and the usual pan/zoom for the map. A swipe interaction was envisioned to be used for changing between the four available areas of the application.

During the development of the mobile game, it became clear that, whilst the current design was simple, minimalistic and sufficient, it resembled the modern applications, which was believed to be quite familiar to players (especially for the swipe gesture used to navigate between the previously mentioned four screens). Therefore, in a following meeting, the team agreed to design an interface which would be closer to the look-and-feel of the old arcade machines, especially closer to the ones Pac-Man used to be played on.

In the new and final interface, the central piece of the mobile design is an old arcade like frame depicting all the game avatars (PAC-LAN and all the Zombies). On the top of this frame, the title of the game can be seen, again, in similar vein to how old arcade machines used to display their game titles. Lastly, for the navigation between the four areas, three different arcade-like digital buttons were used: a central round button was used for selecting the desired action whilst triangle like buttons, located on both sides of the round button, were used to switch between the available areas of the game (Figure 17).



Figure 17. The four different areas from the mobile game as they were implemented.

For the three remaining areas, the next modifications were done: the 'Leaderboard' screen was ditched in favour of a 'High Scores' one; the 'Rules' was kept as such and the 'Scores' was replaced by a 'Settings' screen. The later change is due to the previous belief that, if the player is outside of the digital game area, there is little need to access the game scores, since they will be seen as out of the game. It was decided that a scores area would still be required but its location should be within the game. Figure 17 shows all the four areas as discussed above.

The Play area made use of the originally envisioned screens, with some minor tweaks. During one of the meetings, the team agreed to keep the design and functionality of the application to a minimum required level. This implied stripping away all extra functionality which, even if it might have been useful, it was not seen as such until the game was fully functional and ready for deployment. Therefore, upon pressing the Play button, the player was directed to the original 'Lobby' area where a list of active games could be seen. All the sorting functionality was removed. Taping on one of the games would then move the user to a 'Player' screen where, through the use of a simple interface, the user was asked to provide their name. The chosen name would later on be used for the scoring sections of the game. Any visible buttons were removed from this screen however, upon successful scan of the player's own character tag, the application would continue with the on-boarding experience. Figure 18 shows these newly designed screens and interactions. Finally, in order to allow the player to play the game, the same logic around the scanning of 'the base' as described above was implemented.

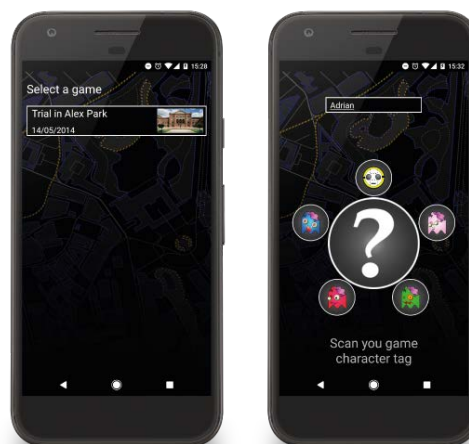


Figure 18. The first two screens from the on-boarding experience.

Map Design

Monmonier suggests that “a single map is but one of an infinitely large number of maps that might be produced for the same situation or same data” (Monmonier, 1996). In order to avoid hindering the user’s understanding by displaying all possible elements, all maps must necessarily be selective regarding the information that is displayed, with decisions as to what to show based upon the purpose of the map and the medium in which it will be presented, for example: paper or screen (Kent, 2008; Monmonier, 1996). For the majority of LBGs, the role of the map is to aid players in their navigation of the game space by following their location on screen, exploring their surroundings, and finding digital game artefacts that are not visible in the real world (e.g. collectable virtual ‘coins’). Whilst useful as a gameplay mechanic, it has been suggested that the map may act to break the player’s attention from their physical surroundings (Coulton et al., 2010), which may have a negative impact upon their immersion into the game. Typically, developers use a commercial mapping provider such as Google to supply their maps in LBGs. This is likely a result of the ease with which such maps can be incorporated into an application, arguably at the expense of a rigorous design process (Field, 2013). Two notable exceptions to this are Ingress²⁸, which had a custom animated map from a ‘3D’ viewpoint and Pokémon Go²⁹, using a similar third person viewpoint of a custom map. The ubiquitous use of generic maps as backdrops for a variety of web and mobile applications has led to a great deal of discussion and criticism in the cartographic literature relating to the idea that their prevalence has produced a global “blandscape”, creating a sense of “unauthoredness” and apparent ‘homogenisation’ of the landscape through the lack of detail and high level of generalisation (Kent, 2008). It is worthy of note that, following this perceived ‘stagnation’ of map production, video games have been described as “the bold future of cartography” (Garfield, 2013). Games such as Grand Theft Auto V, developed by Rockstar Games, and Elder Scrolls V: Skyrim, developed by Bethesda Game Studios, comprise not only detailed 3D ‘open world’ maps to explore within the game, but also accompanying paper maps to aid navigation. Skyrim, for example, comes with a foldout stylised map on textured faux-

²⁸ <https://www.ingress.com/>

²⁹ <http://www.pokemongo.com/en-uk/>

parchment, as well as a 660-page guide, which includes 220 pages of maps, representing the work of many digital cartographers (ibid). It seems only fitting therefore, that LBGs, a game genre that relies heavily upon maps, should engage more fully with cartographic design, rather than relying upon generic commercial products. My hope is that this chapter serves to stimulate conversation relating to this issue within the LBG community. Map design revolves around the need to satisfy a particular communication goal (Field, 2013). In the case of web mapping services such as Google Maps, this purpose is primarily a road atlas, an assertion that may be verified by their appearance, and the route-planning heritage of the web applications from which they are derived (Damaj and Field, 2012; Kent, 2008). It could be seen as inappropriate, therefore, that these maps are often used for a wide range of purposes without due attention being paid to their suitability for a given application (in this case an LBG). In PAC-LAN: Zombie Apocalypse the primary function of the map (referred to as 'Pac-Map' herein) is to indicate the locations of the physical game elements to the players. Additional design goals for the map were:

1. To be in-keeping with the theme of the game through the use of a suitable aesthetic.
2. To perform well within the context of the game (i.e. outdoors).
3. To encourage users to glance at the map and navigate in a 'head-up' manner, using their surroundings, as opposed to navigating in a 'head-down' manner, looking at the map throughout their journey as is typically the case when navigating using a mobile phone.

The Pac-Map was created using data that were derived from OpenStreetMap³⁰, using PostGIS³¹, and are rendered on-demand into 256x256 pixel 'tiles' using Mapnik³². These 'tiles' are requested from the server by the Android application, which mosaics them into a seamless base game map. Rendered tiles are cached on the server for efficiency. Using 'real' mapping data and on-demand rendering allows the game to be played anywhere, whilst maintaining an aesthetic for the game that reflects the style and appearance of the original Pac-Man arcade game. This may be seen as a significant improvement upon both the non-stylised, static image-based map

³⁰ <http://www.openstreetmap.org>

³¹ <https://postgis.net/>

³² <http://mapnik.org/>

used in the original PAC-LAN game (Rashid et al. 2006b), and upon generic mapping products (Google Maps or similar) that are not well suited to supporting gameplay and do not provide a gaming aesthetic. In order to achieve a map that reflects the classic Pac-Man game, all labels and POI's have been omitted, and features have been generalised such that boundaries are only composed of vertices that are oriented North-South or East-West and are rounded to the nearest 10 metres. This simultaneously acts to reflect the characteristics of the Pac-Man 'maze' from the original game and to generalise features on the map, which acts to introduce spatial ambiguity into the dataset. It is intended that this ambiguity will help discourage over-reliance upon the map during gameplay by making it less representative of the true nature of a player's surroundings, and so encourage 'head-up' navigation (Huck et al., 2015). Trees and buildings are drawn in the same blue as the Pac-Man maze, and a complementary red has been used to mark out hazards as shown in Figure 19.

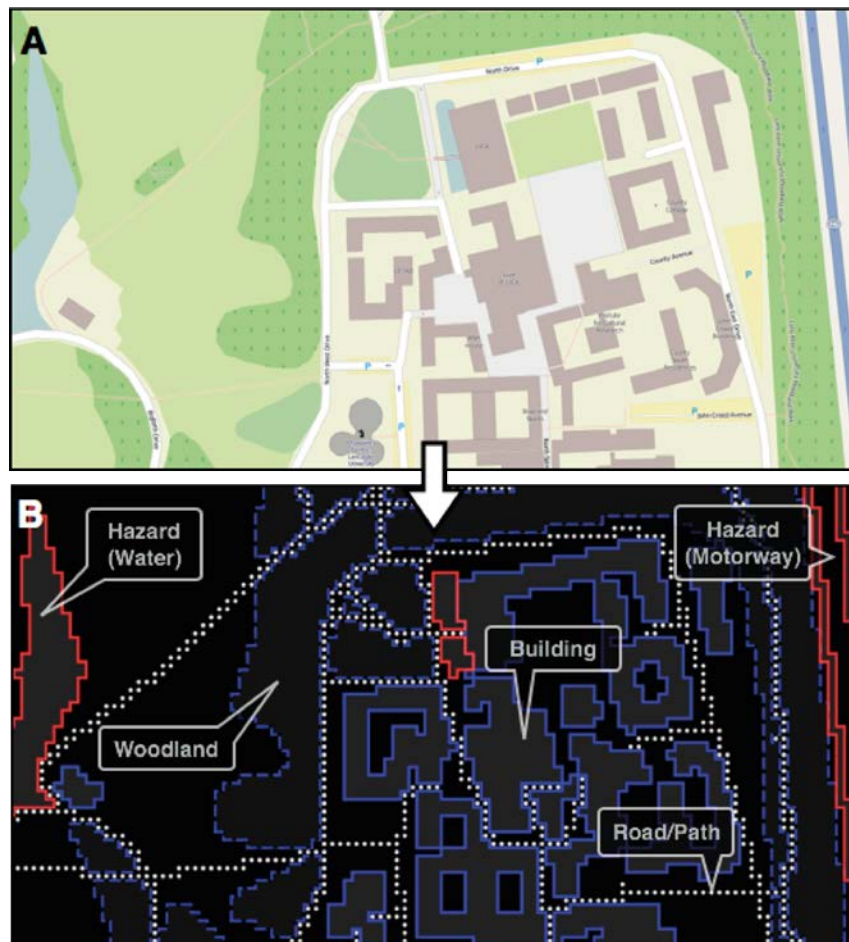


Figure 19. A comparison between the original OpenStreetMap (A), and the Pac-Map (B).

Whilst effective in the evocation of the game itself, the dark palette employed by this map has the potential to be susceptible to screen glare in bright sunlight. In order to combat this, the lines in the map are chunky, with fine white lines drawn into the blue and red in order to increase their contrast with the black background. 'Pathways' (roads, footpaths, cycle tracks etc.) have been marked with chunky white dots (Figure 19B), providing a high contrast with the dark background, whilst reflecting the 'pellets' within the maze in the original game. The Pac-Map is compared with the source-data in Figure 19A, in order to illustrate the effect of this process. Figure 20 shows the Pac-Map as it would be seen on a mobile screen.



Figure 20. The Pac-Map displayed on the mobile screen.

The Fog of War

The 'Fog of War' (FoW) shown in Figure 21 is a game design feature controlled by the 'roaming time'. It consists of incrementally obscuring the map with a white 'fog', thus making it less easy to read. There are four different levels of 'fog', with each level obscuring a greater area of the map as it incrementally 'creeps in' from the edge of the screen towards the centre. To further aid the player's awareness of the passing of the 'roaming time', each level of the FoW is associated with a haptic feedback, with handset vibrations informing the player of their remaining 'roaming time' without the requirement to check the screen.

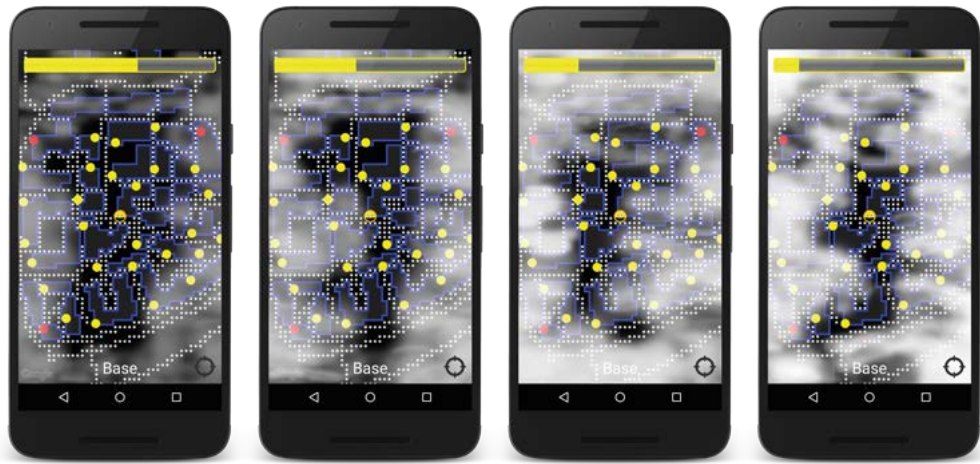


Figure 21. The four different levels of the Fog of War covering the screen.

The Screen Blanking

Similar to the FoW, 'Screen Blanking' is designed to discourage over reliance of the player on the mobile screen. It consists of turning the whole mobile UI into a black screen after 5 seconds from the last action the player performed. There are two types of actions that make the screen fully visible again: either the player tags a pill or player, or explicitly requests access to visualise the game interface by tapping the mobile screen. The latter action displays the UI in its current form, and so does not remove the FoW. It is important to note that the Screen Blanking and the FoW work simultaneously and are not mutually exclusive.

The Blood Drops

The 'Blood Drops' are a design feature used to lessen the level of uncertainty of the location of the Zombie characters whilst PAC-LAN is in 'infect mode', and so it gives a slight advantage to PAC-LAN in their attempt to 'infect' a Zombie. As soon as the PAC-LAN player tags a 'power pill', 'infect mode' is therefore activated. At this point, a 'virtual' trail of blood drops, as shown in Figure 22, is displayed on PAC-LAN's UI, which shows five GPS positions recorded after each Zombie last tagged a pill. Given that the PAC-LAN player does not know how long ago the Zombies last tagged a pill, this information indicates their initial direction of travel from their last tagged pill but does not give away their location with any certainty. In this

way, the 'Blood Drops' may be considered as a 'clue', as opposed to robust locational information, and as such acts to balance the game by giving PAC-LAN a temporary slight advantage, without making it too easy and therefore unfair to the Zombie players.

The Game User Interface Design

The User Interface, shown in Figure 22, displays all the game elements: the players (in this case PAC-LAN and Blinky), the pills, textual location information and remaining 'capturing time' information. As previously mentioned, the roaming UI has a yellow bar and does not display the 'Blood Drops' for the Zombie.

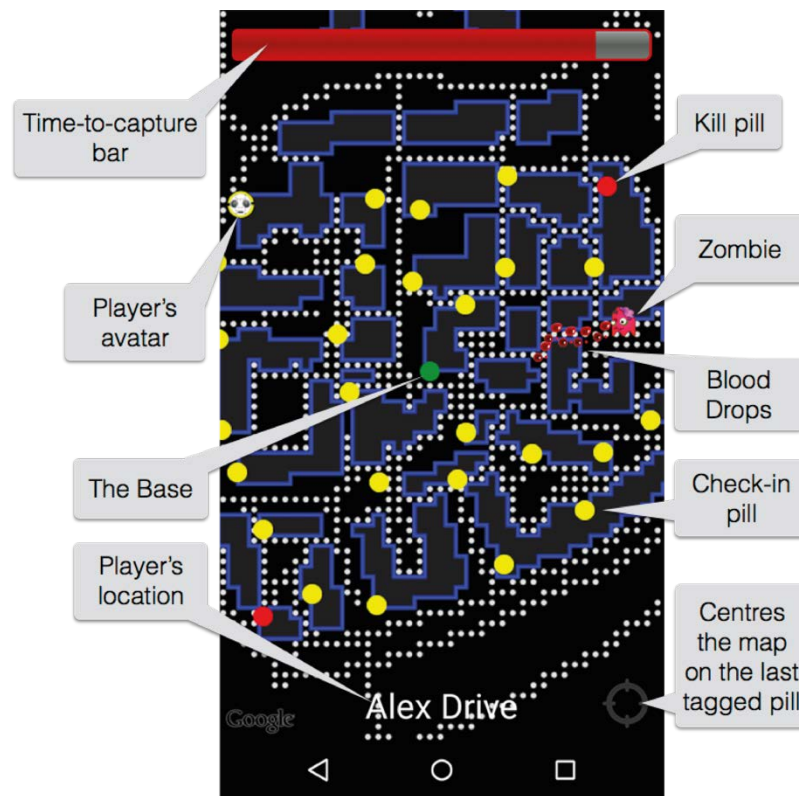


Figure 22. PAC-LAN User Interface (capturing UI).

A very simple, yet intuitive, colour scheme was chosen for the pills, and was shared between the physical game elements and their counterparts on the map (shown in Figure 23). Since yellow Frisbees have been used to identify the 'check-in' pills in the physical game, yellow circles are used on the map. Similarly, red circles identify the 'power pills' to match the red Frisbees. A

yellow bar is used to show the 'roaming time' available for all players which changes colour to red when PAC-LAN enters 'capture mode'. To display the last tagged location of the player, only the user-defined name of the place is used. This choice was made to include this information in order to create a link between the physical element and its digital representation (the same way streets and places have names).



Figure 23. Physical 'check-in pill' (left) and 'power pill' (right) shown in the real environment.

Analysis

Thus far, two preliminary studies have been undertaken: one to evaluate if the game is playable and balanced (Study 1); and one that specifically assesses the design of the 'Pac-Map' in terms of aesthetics, performance in the context of a mixed-reality LBG (outdoors) and the promotion of 'head-up' navigation (Study 2). This approach was used because of the number and variety of design features included in the game would make their individual evaluation impractical within a single exercise. In both studies, the participants were somewhat familiar with the space within which the game area was constructed but had no prior knowledge to the whereabouts of the physical game components. Both studies took place in the same geographical space so that variations in the quality of coverage of the OpenStreetMap database would not influence the evaluation of the map. Informal semi-structured interviews were carried out and recorded at the end of each game

in order to ascertain the perceptions of the players. An in-game ethnography was also performed by our researching team to allow observations of different particularities of individual aspects of the studies.

Study 1 - Background

Study 1 was run on the 14th of May 2014 between 11am and 2pm at Lancaster University with seven participants. Two different games were played with some players acting as the Zombie characters as well as PAC-LAN across different games. The main purpose of this study was to test the game 'in the wild', a qualitative approach used to gain a better understanding of the playability of the game as well as to ensure the game was still balanced in relation to the players' roles.

Study 1 - Findings

During the trial players were encouraged to engage in open conversations with each other to discuss and analyse different tactics and approaches to the game as well as own understanding of the rules. The feedback indicated that the players enjoyed playing the game and that all of them seem to have understood the rules and mechanics when briefly presented prior to gameplay. Overall, the players thought the game was well designed and had enough elements to actively keep one playing: "The features of the game kept you thinking and guessing what to do next". The participants that played both as a Zombie character and the PAC-LAN character believed the game was balanced between the two roles. One of the players mentioned that the 'Screen Blanking' was misleading and was easily confused with the screen lock capability of the device. However, when this feature was explained, the player understood its importance but suggested that instead of a plain black screen a better use of the space would be to display their individual game avatar thus allowing the player to recognise the feature as part of the game.

When designing the map there was an emphasis on removing the clutter from the map to avoid player distractions. According to the discussions at the end of the trial, the map was perceived as a better alternative than a standard Google Map, with players mentioning that it was simple enough to understand and "more than sufficient to quickly know what to do next".

Three players pointed out that the characters and pills could be larger. Although the map was not designed for navigation, some players requested the ability to determine direction, either by using a navigational arrow or rotating the map. Audio feedback was also suggested as an enhancement to the current haptic feedback.

Study 2 - Background

The second study took place on the 5th of February 2015 with 8 different participants in order to investigate the creation of a map to promote 'head-up' navigation in LBGs. This assessment comprised the comparison of the 'Pac-Map' against three other maps that were created using slight variations upon each of the same set of design goals: the 'RPG Map' (Figure 24), the 'Sketchy Map' (Figure 25), and the 'Anti-Glare Map' (Figure 26), all of which were rendered using the same software and the same OpenStreetMap database, presented in the following paragraphs. All 8 players were asked to play a short custom-built LBG that required them to navigate between 20 physical objects (the PAC-LAN game pills) with 5 objects per map type. The initial map was chosen at random and then changed for another randomly selected map after every fifth anchor was correctly tagged. This method was chosen in order to allow the assessment of each map. The LBG tracked the players' progress using GPS and required them to hold down the volume rocker in order to view the map (similar to the 'Screen Blanking' design element in the main game). This slight variation came as a design decision within the team, based on the comments and feedback received from the first study. Furthermore, in order to avoid the confusion reported during the first study, the screen displayed the message "Press and hold the volume rocker to see the map". This mechanic also means that players' interactions with the map are both logged alongside GPS-derived location for later analysis. Following play, all eight players were also given a semi-structured questionnaire and interview about how each map influenced their level of interaction with the screen and their surroundings. To better understand how each map is different and the reasons behind these differences, they are all presented in the following parts of this chapter.

The RPG Map

The RPG Map (Figure 24) is inspired by the ‘classic’ Role Playing Games (RPG’s) of the 1980’s and 1990’s. The data has been abstracted into a grid of 20m cells, each of which can only contain one of five feature classes: ‘building’, ‘road’, ‘water’, ‘trees’ or ‘hazard’. Cells were then dissolved into contiguous areas of each data type and coloured using tiled textures collected from freely available online sources. The use of a coarse 20m grid gives this map a greater level of abstract feature representation than the Pac-Map, therefore making it more difficult to rely upon for navigation, in order to investigate the effect that this has upon the players’ interactions during gameplay. The coarse grid, RPG-style textures and playful features (e.g. the use of a ‘lava’ texture to denote hazards) lend a definite ‘game aesthetic’ to the map, but in less-specific manner to the Pac-Map. In this way, this map allows a comparison of the effect of different levels of spatial ambiguity in the maps.



Figure 24. The RPG Map.

The Sketchy Map

The Sketchy Map (Figure 25) is rendered using a combination of polygon smoothing, line simplification and image compositing techniques in order to give a ‘hand-drawn’ appearance to map features. ‘Sketchiness’ as a device for enhancing the aesthetic or narrative qualities of cartographic outputs has been explored previously by Wood et al. (2012) and has also been employed by Griffen et al. (2014) as a visual variable in maps. In this case, however,

'sketchiness' is used as an alternate approach to abstract feature representation, acting to obscure the precise position and shape of geographic features. The 'hand-drawn' or 'sketchy' effect on the polygons has been achieved by a combination of polygon smoothing, line smoothing, multiple-overlay and image composite operations in order to give the impression that they have been drawn using felt-tip pens, akin to the approach first suggested by Ashton (2012). Conversely, the line features were simplified using the Visvalingam-Whyatt line generalisation algorithm (Visvalingam and Whyatt, 1993), and overlaid using transparency and image composite operations in order to give the appearance of having been drawn using highlighter pens. This approach will allow the comparison of abstract feature representation arising from 'sketchiness' against the grid-based approaches used in the Pac-Map and the RPG-Map as a device for the encouragement of 'head-up' gameplay. The main difference with this approach is that the level of abstraction varies from feature to feature as opposed to being uniform across the dataset as is the case in the grid-based approaches, which may prove more disorientating for users. The 'hand-drawn' aesthetic promotes a 'playful' feel to the map, but without specifically evoking a 'game', permitting further investigation into the effect of the map aesthetic upon game immersion.



Figure 25. The Sketchy Map.

The Anti-Glare Map

The Anti-Glare Map (Figure 26) is intended primarily to perform well outdoors and investigate the alternate hypothesis that a clear and precise map may be more successful than an abstract map in encouraging 'head-up' play as players will be able to digest spatial information more quickly. As such, the Anti-Glare Map does not exhibit any level of abstract feature representation, and so acts as a 'control' in this investigation regarding the effectiveness of this technique. In doing so, this map minimises the interaction time through being clear and easily readable, thus requiring less interaction than other maps due to ease of use, rather than spatial ambiguity. The Anti-Glare Map utilises a triadic colour scheme in order to gain a high degree of contrast between features whilst maintaining colour harmony. Features are divided into five classes: 'building', 'road', 'footpath', 'trees' and 'hazard', and a light-grey background was chosen because lighter background colours are typically less susceptible to screen glare. Hazards are filled with black, accenting them in comparison to the background and other features, whereas all the other features (those using the triadic colour scheme) include an accent using a darker shade of the same colour. This accent is used to outline all of the features except footpaths in order to make them 'pop' out from the light background, and is used as a dashed centreline for the footpaths, in order to create a contrast between the footpaths and the roads.



Figure 26. The Anti-Glare Map.

Study 2 - Findings

The quantitative data collected in the log files confirms that, as expected, players spent the least amount of time looking at the (least abstract) Anti-Glare Map (c. 31% of the time), and the most amount of time spent looking at the (most abstract) RPG Map (c. 47% of the time). Of the remaining two maps, more time was spent looking at the Sketchy Map (c. 44% of the time), with its variations in level of abstraction from feature to feature, in comparison with the uniformly abstract Pac-Map (c. 38% of the time). Whilst these findings are interesting (albeit expected), the amount of time spent looking at the map is unlikely to be inversely correlated to the level of engagement with the landscape. As such, it is the qualitative data relating to the players' perceptions of the impact that the maps had upon their engagement with their surroundings that is therefore of more interest in this chapter.

Through a simple vote within the questionnaire, players identified the Pac-Map and Sketchy Map as being equally the "most suitable map for use in an LBG", whereas the RPG-Map was considered to be the best for generating engagement with the environment. The reasons for the latter, however, were very clear in the associated comments, with the RPG Map being unanimously considered to be "very difficult", and "frustrating" to use, with one player even suggesting that it was "totally unusable". This, along with a complaint that the map suffered from screen glare, is a clear suggestion that the RPG-Map is 'too abstract', and therefore not well suited to an LBG. These comments were interestingly contrasted with those relating to the Anti-Glare Map, which was described as "too easy" by two users and caused one user to feel they "spent too much time looking at the map because it was easy [to navigate with]". These preliminary findings lend support to the hypothesis that a map exhibiting abstract feature representation can lead users to engage more with their surroundings, and that too great a level of abstraction can become counter-productive in this regard. Of the remaining maps, the Pac-Map seemed to be considered as more well balanced: "I could tell what things were represented but still looked up"; and as an attractive or well-suited map design: "Nice feel", "It's like the original Pac-Man". Similarly, the Sketchy Map was considered as "pleasing on the eye" and "more fun", as well as "showed just enough to navigate but required you to look around" and "challenging enough to keep it interesting". These comments suggest that

both were well received by users and fulfilled their desired purpose well, again lending support to the above hypothesis. When the quantitative findings are also considered, however, the Pac-Map appears to have performed best across the three principal design goals: to promote immersion into the game through the use of a suitable aesthetic; to perform well within the context of a mixed-reality LBG (i.e. outdoors); and to encourage players to navigate 'head-up' rather than 'head-down' when playing an LBG.

A Discussion of Immersion

One of the most common components of a mixed-reality location-based game is a digital map that allows the players to visualise the game space and, in many cases, the location of the virtual game elements within the physical space. As such, the map element often encourages players to constantly check their current location on a mobile screen in order to navigate the physical space resulting in their attention being divided between the digital representation of the space and the physical space itself. This repeated switch in attention has the potential to interfere with the immersion of the player in the physical context of the game as the virtual component dominates and so the quality of the locative experience may be reduced. Carrigy et al. (2010) stated that immersion is used to describe a state where the player has lost connection with the world outside of the game and results in "the boundaries of the magic circle", in which the game is played, becoming the current 'real world' of the player. In the case of computer games, one of the metrics often used to identify this phenomenon is presence, better defined as "the subjective experience of being in one environment (there) when physically in another environment (here)" (Witmer and Singer, 1998). In such games, the "players are actively, rather than passively, engaged in the gameplay experience and therefore the quality of the players' interaction with the game system, through the game mechanics, is a key factor influencing immersion" (Carrigy et al., 2010). Immersion can also be described as the degree of involvement of a player with a particular game and can be considered in relation to three distinct levels: 'engagement', 'engrossment' and 'total immersion' (Brown and Cairns, 2004). The engagement level refers to the player overcoming the barriers of basic rules and understanding of the game, whereas the engrossment level refers to game elements influencing the players' emotions

through play. Finally, the player only enters total immersion when they become completely absorbed within the game space and no longer engaged with operational aspects of the game. A good example of this is virtual reality (VR) where, due to some of the player's senses being highly engaged (vision), the player often loses touch with the outside environment. Mixed-reality LBGs are enacted simultaneously in both the digital as well as the physical space, thus presenting a challenge for achieving immersion as the player's attention is inherently divided between both the digital and the physical. Immersion should therefore be considered in both worlds: with 'physical immersion' referring to that when players are immersed in the physical world; and 'digital immersion' referring to that when players are immersed in the virtual world, which in most cases is presented through the screen of the mobile device. Rather than immersion types being viewed as two distinct states, they should be viewed as the ends of an immersion continuum. At any one time, a player in an LBG may be considered to be somewhere along this continuum but being attracted by each pole (the digital and the physical) simultaneously, thus preventing total immersion at either extreme. This fluctuation in the player's attention between the physical and the digital is what I refer to herein as the 'Dichotomy of Immersion' in LBGs.

The majority of previous designs of LBGs only address 'digital immersion' through the use of sound, such as *Riot 1831!* (Reid et al., 2005), *Savannah* (Benford et al., 2004), *Viking Ghost Hunt*, *REXplorer*, *Visby Under*, *Frequency 1550* (Carrigy et al., 2010), undermining the importance of the physical space that LBGs are played in. However, the requirement to navigate through physical space will prevent total digital immersion, and hence it is equally important to address physical immersion. In doing so, players are encouraged to become more aware of their physical surroundings, and less reliant upon the on-screen digital artefacts. Therefore, in this chapter I suggested techniques such as the introduction of additional elements into the physical space in order to facilitate in-game navigation, and an interaction design in which the map acts as a reference to physical elements within the game arena as opposed to a direct navigation device. The introduction of these elements may be considered as facilitating what Lynch (1960) referred to as the "legibility of the space". Lynch argues that when navigating familiar surroundings, people use their own mental mappings of physical spaces to

orient themselves and that each individual has their own distinct image of how a particular place appears. This image is built upon their past experiences and current perception of that space, and it is this newly formed image that is “used to interpret information and guide to action” (ibid). Enabling clear mental mappings of the environment counters the effect of disorientation provided through the unfamiliarity of a new space that can often introduce fear. According to Lynch (ibid), each image is constructed using three major components: ‘identity’ (recognition of physical elements), ‘structure’ (relationship of physical elements to other physical elements) and ‘meaning’ (practical interpretation to each observer). Therefore, in order for a new space to be easily navigable, it has to have clearly defined physical elements that are easily recognised by people. These elements, in connection to other physical elements, can form a story and lay the foundation for the story to be remembered by individuals navigating the space.

If we consider this notion of spatial legibility in terms of video games that operate on a spatial level, such as Pac-Man (1980), the game area is clearly defined as a maze identified by solid lines representing the walls. As such, the player knows exactly what the limitations of the playable area are and there is no movement beyond these hard boundaries. The on-screen representations of the game elements therefore make this space legible in such a way that players can readily deploy different tactics for winning the game. LBGs are inherently open-world games, and even where there are natural boundaries and inaccessible areas (e.g. buildings, lakes, fences etc.) there are generally no physical elements that help identify the bounds and nature of the playable area. This is because LBGs are played in the physical spaces that are already legible and have features that often already facilitate the traversal of such spaces (e.g. defined footpaths). As such, any game elements that are added must not be counter-intuitive to existing perceptions of the traversal of the space. These elements should therefore be unique in their appearance and stand out from all other physical features within the space. However, the positioning of physical elements to act as bridges between the real world and the game world is often deemed impractical or limited in terms of scalability, and as such the vast majority of LBGs are only identified digitally on the mobile phone screen.

Therefore, in order to achieve greater immersion in LBGs, the attention of the player must also be allowed to focus on the physical space as well as the digital space, which will require new design strategies. As there are no such strategies readily available, the presented project focused on this challenge, through the design of a particular game. Gaver states that the exploration and experimentation of a particular design can lead to a better understanding of the underlying design processes involved to provide insights that can be utilised more generally (Gaver, 2012). Therefore PAC-LAN: Zombie Apocalypse explored space legibility as a means to achieve greater physical immersion in LBGs. This game builds upon an earlier location-based game, PAC-LAN (Rashid et al., 2006a) that unconsciously addressed this issue. Zhang and Coulton (2011) demonstrated that the overall players' engagement level with the environment in LBG's could be increased through the use of deliberate design features and game mechanics (ibid). One such mechanic employed by Zhang and Coulton is the introduction of ambiguity into the game, through the use of "obliquity", which emphasises the "player space" over the "game space" in LBGs and thus encouraging interaction with the physical surroundings (ibid). PAC-LAN: Zombie Apocalypse addressed the issue of spatial legibility using ambiguity as a mechanic, with the specific goal of trying to minimise the player's interaction with the mobile screen, which is intended to therefore increase their interaction with their physical surroundings. This approach should therefore re-balance the two ends of the immersion continuum without disregarding the mobile UI as an important feature of an LBG game.

Discussion and Conclusions

This chapter talks about the concept of the 'Dichotomy of Immersion', in which the attention of the player is repeatedly shifted between the digital and the physical elements of a mixed-reality LBG. At any one time, a player's interactions are heavily influenced by one of these two elements, which act to prevent the attainment of immersion within all elements of the game. In many LBGs designed thus far, the effect of the 'Dichotomy of Immersion' is that the digital game elements dominate the attention of players, at the expense of the physical. In order to address this issue, two possible approaches were proposed: the de-emphasis of the digital game elements, by the adoption of

deliberate design features that discourage screen interactions; and the augmentation of the physical space with objects that provide a link to the digital world. PAC-LAN: Zombie Apocalypse is an LBG that explores how different design features can minimise the number of interactions between the player and the mobile device, encouraging engagement with the physical surroundings instead. This chapter has focussed upon the first of the above approaches: the design of the digital game elements, specifically the mobile interface. A number of design features were introduced, and some results were presented in order to demonstrate the effectiveness of those features. Firstly, results were presented from a study that examined the quality of PAC-LAN: Zombie Apocalypse as an engaging mixed-reality LBG. Having played the game, players reported that the rules were clearly defined and easy to follow, and that the game mechanics encouraged play. This preliminary study demonstrated that the game was playable and enjoyable, and so would be a suitable platform for research into the issues presented in this chapter. Secondly, results were presented relating to the specific evaluation of the 'Pac-Map', which was designed to promote game immersion through the use of an appropriate aesthetic, the encouragement of 'head-up' navigation through the introduction of spatial ambiguity into map features, and a good level of performance when viewed on-screen outdoors. The map was user-tested against three other maps that were designed using small variations upon the above design goals and was found to be the users' preferred map both for use in an LBG, and in context of the design goals.

In an ideal scenario, our team would have also tackled the physical side of the 'Dichotomy of Immersion' in more detail, by exploring the augmentation of the physical space with objects that provide a link to the digital world. Sadly, due to the nature of this PhD, and the implicit requirement to move on to other active projects, such avenues could not have been examined. Nevertheless, new ideas could be explored, such as the use of additional physical elements within the game space, and how variations in size, colour, shape or location of the pills might affect game play. Furthermore, as technology evolves in the areas of the Internet of Things and Smart cities, pre-existing street furniture or other physical elements such as benches or streetlights could be incorporated into gameplay and influence the legibility of a space. In this way, any physical space could potentially be transformed

into different games without the requirement to augment the space prior to play.

The contribution of this particular work is therefore a design strategy for the creation of more immersive LBGs. It provides a number of design features that act to minimise the number of interactions between the player and the mobile interface. It is intended that the design strategies demonstrated here could be employed by others in the design of future LBGs, and that an understanding of the 'Dichotomy of Immersion' will lead to the creation of a new generation of LBGs that provide richer locative experiences.

Extrapolating from the world of LBGs, this approach could also be used for any other events where the curators of the spaces need to enlarge their physical environment with digital content, whilst still focusing on the physical side of the mixed-reality worlds which they are building.

Paths of Desire

Despite the rich design history within the field of cartography, the majority of digital maps exhibit a dominant aesthetic that is primarily designed to serve the usability and utility requirements of turn-by-turn urban navigation producing a so-called ‘blandscape’ of map design. In this chapter, and through the exploration of a CX project titled Paths of Desire (PoD), I present not only how to produce more visually appealing digital maps, but also how the cartographic decisions made in the production of maps could potentially influence behaviour, particularly with regard to the encouragement of explorative experiences. Novel cartographic and technological solutions are therefore presented, which address exploration using digital maps in the context of tourism. These examples demonstrate the potential of digital cartography to influence behaviour and the importance of aesthetics in the cartographic process.

The Constructed Bits

By the end of the project, we constructed an infrastructure required to deliver personalised maps and a mobile application which made use of two different aesthetics to demonstrate the concept of the project. It is important to note here that whilst this project built on top of the findings from PAC-LAN, the application and styles emerged through the researching of the initial idea and that their current format is due to the constant iterative approach of developing and testing different avenues which were found useful in relation to the original idea. Whilst the idea did not change, the outcomes might have been different if other decisions were taken.

Connection to the Digital Public Space

One of the notions around the Digital Public Space revolves around the idea of “Public [making] Digital Public Spaces” (Hemment et al., 2013, p. 17). Arguably, the streets, alleys, paths and pathways that are at the foundation of our surroundings are the easiest to be understood as public.³³ Sadly, when it comes to the use of digital tools for navigation, they are primarily designed

³³ I am focusing here directly towards the available infrastructure one can roam freely at any hour of the day or night.

for traffic navigation therefore, the mental maps we all generate upon navigating our surroundings should be seen as being massively influenced by the same digital software used (Google Maps, Apple Maps, Open Street Maps). Therefore, providing the public with personalised digital navigational maps, the foundation of the mental maps is changed thus, new digital public spaces are created. These are defined by the cumulus of interactions generated by the user with both the digital map and their surroundings. To be more specific, it is through the navigation of my own surroundings that I directly contribute to the legibility of a space and the creation of the map which will, subsequently, influence my route decisions in future events. This is how I, a representative of the public, create my own digital public space(s).

The Team

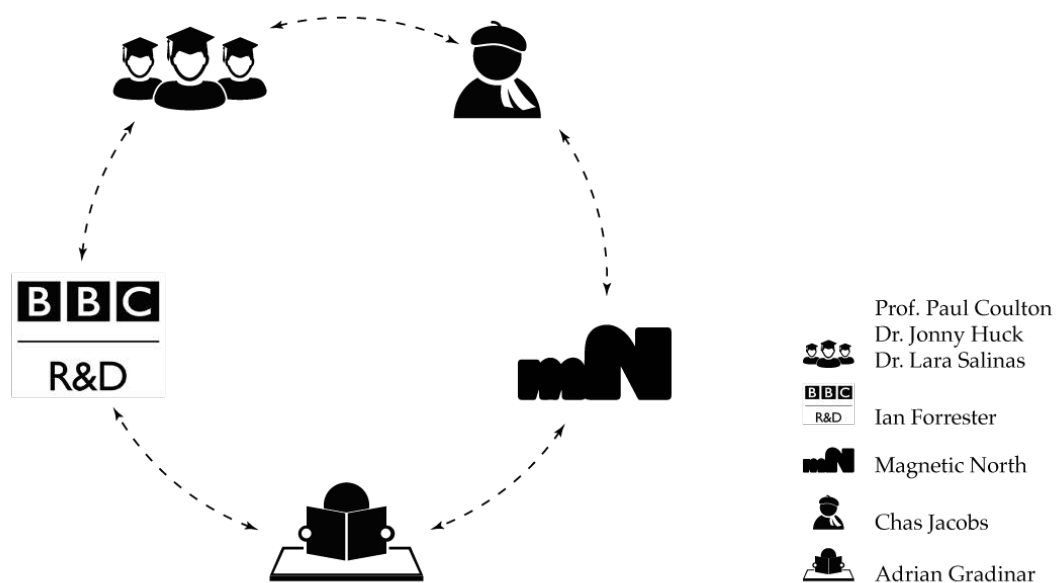


Figure 27. Paths of Desire project team.

Similarly to all other CX projects, the PoD team was a multidisciplinary one, composed of Dr. Lara Salinas, researcher and project manager until she took a new position thus hindering her abilities to fully commit to leading the project, Dr. Jonny Huck, researcher and experienced digital cartographer, responsible for setting up the infrastructure for the mapping tool as well as implementing the chosen mapping styles, Prof. Paul Coulton, researcher and

supervisor of the overall project, Manchester based independent studio Magnetic North, our external non-academic partner, whose contribution was sought due to their mobile and mapping experience, having previously collaboratively worked with the Manchester City Council on a walking tour mobile application³⁴. Alongside the above-mentioned partners, the team was also joined by Chas Jacobs, Lancaster based artist whose expertise was sought since it was believed to be of benefit to creating a personalised mapping style due to his characteristic painting style, and finally myself (Figure 27). My roles shifted from researcher, focusing on interaction and experience, to project manager, overseeing each member's contribution, writing ethics forms, budgeting, material acquisition, etc. and finally to Android lead developer, fully responsible for the design, development and implementation of the mobile application.

Introduction

Following the mobile mapping domination of commercial providers such as Google Maps and MapBox, it has widely been lamented amongst cartographic communities that maps may effectively now be created “without cartography”, as the projection, scale, typography, colour and symbology are generally pre-defined by the map provider (Field, 2013). The ubiquity of these maps has led to a great deal of discussion and criticism in the literature, primarily relating to the idea that the prevalence of such maps has created a global “blandscape” and a sense of “unauthoredness” thorough the lack of detail and apparent “homogenisation” of the landscape (Kent, 2008).

Aside from these aesthetic complaints, however, a deeper issue may also be considered: the effect of these maps upon human behaviour. Map design revolves around the need to satisfy a particular communication goal (Field, 2013), and in the case of Google Maps, for example, this purpose is primarily a road atlas; an assertion that may be verified both by their appearance and the route-planning heritage of the web applications from which they are derived (Kent, 2008; Demaj and Field, 2012). As with other road atlases, these maps characteristically exhibit a strong visual hierarchy in road symbology, making it easy for drivers to select the most efficient route to take. For travellers on foot, however, this visual hierarchy can also influence route decision,

³⁴ <http://thisismn.com/work-by-magnetic-north/walking-tours>

potentially leading to less-efficient route decisions as pedestrians often stick to main roads when navigating through unfamiliar locations with a map. It has been shown many times in the literature that map design can have a significant effect upon route selection (Morrison, 1974; Gill, 1993), and that visual hierarchy of roads and footpaths remains one of the primary influencing factors (Gill, 1993).

This behaviour can commonly be seen amongst visitors to unfamiliar cities, who will often rely upon maps, either paper (e.g. a tourist map) or digital (e.g. a Google Maps mobile application), in order to aid them with navigation. Within this CX project, we tried to exploit visual hierarchy in order to discover the extent to which map design can affect user behaviour. The route we undertook to achieve such an endeavour was through the production of digital maps that exhibit dynamic visual hierarchies based upon visitor movements rather than the physical characteristics of the geographical features themselves and which are automatically adjusted in real-time based upon the movements of visitors throughout the city. As such, this project presents a novel Android application called 'Paths of Desire' which, unlike other applications which use traditional digital maps, has a cartography that can be dynamically adjusted in real-time, modifying the visual hierarchies of paths (including roads, footpaths etc.) and points of interests (POIs) in order to try to encourage visitors to explore the city. It is intended that the varying visual hierarchies will encourage users away from main routes and motivate exploration of areas that would otherwise be ignored.

Initial Meeting

The first meeting took place in the Imagination Space, in the LICA building located at Lancaster University, at the end of May 2015. The purpose of this meeting was to present the original idea to the Magnetic North's team, seek their expertise in the styling and production of maps whilst setting a plan in motion for the development of the project.

As originally presented, the idea revolved around the creation of personalised maps based on human movement throughout the city rather than relying solely on already available datasets found at maps providers such as Google Maps or OpenStreetMap³⁵. During this meeting it was argued

³⁵ <https://www.openstreetmap.org/>

that, in order to create an original base dataset for people's movements, different individuals were to be asked to carry a mobile phone with them at all times whilst they were casually strolling the city, in their usual daily activities. The mobile phone would record their GPS tracks and update a server with this data. For this stage of the project, we agreed that Lancaster would be a suitable location for such an endeavour, since the core of the research and development team was based in Lancaster, whilst different students would be asked to help with the acquisition of the data. This point naturally led to further discussions around what other datasets could be used in the creation of the map. Ideas such as crime, pollution and traffic data were believed to be of benefit to further contribute to the overall idea of influencing people's behaviour. The team believed that creating a road atlas which takes account all these datasets, where paths and roads are made narrower based on increased pollution, crime or traffic data, would be beneficial to the overall exploration of the city. Other ideas such as Twitter data (e.g. tweets from certain locations), spendings, slope terrain and weather could also be part of the generation of the maps. Whilst, for a city the size of Lancaster, weather data seems irrelevant and potentially not really providing any real benefit to city navigation, this is not true for cities the size of London, UK. We also discussed about the potential of making these maps available to the general public which found the team unanimously agreeing on visitor centres being the best starting point. As such, the team started to analyse other potential avenues, such as the points of interest (POIs) which were to be displayed on our maps. If the maps were designed to provide useful information to the public whilst trying to encourage them to explore different avenues, they would also benefit if major and important points of interest were made available. To acquire this data, we considered sources such as Google Places³⁶, since their API has access to more than 100 million places around the globe, and Foursquare³⁷, a technology company which uses location-based services to build meaningful consumer experiences and business solutions, again, with a large dataset which would have benefitted our project. The last points found the team agreeing on the plan for how to best tackle all the complexities of this

³⁶ <https://developers.google.com/places/>

³⁷ <https://foursquare.com/>

project. A rough timeline was drawn on a whiteboard, which stood as a reference for all involved partners.

Since this idea of dynamically rendered personalised maps was never explored in academia, the team agreed that the most challenging part of the project is the creation of a suitable infrastructure for the project. This meant having a fast-computational server which could render our maps in a style of our choosing.

The Infrastructure

At the end of the initial meeting, the team agreed on how the roles for the project were to be split between the partners. Therefore, the Magnetic North's team was responsible for creating a visually appealing style whilst Chas Jacobs was asked to create visually pleasing artwork following his well-known style which could later on be transposed digitally. Dr. Huck became the frontrunner of the development of the maps since his technical expertise was best suited in this area. Finally, I took the lead on the development of the mobile application, which was required to receive, display and facilitate an easy interaction with the maps.

At this stage of the development, the CX team's attention turned to the requirements of the map making, and implicitly towards the required infrastructure. This is where we quickly realise the complexities involved in such a simply perceived task. Originally, we started by acquiring a developing server from the Lancaster University. The research servers, which are available through these options are sadly only virtual machines (VM), and whilst they are more than suitable for the developing and publicising of research outcome (in the form of websites), the speeds at which our VM could render and serve maps were unusable for a mobile application. The first tests showed slow response rates, which were too low for the mobile application to actually display the map. The full algorithm on how the maps were created is described in the next section however, for the reader to understand our issue, one has to imagine that each map is created through the joining of different tiles. These tiles were dynamically created and served by the server. Due to the VM's low calculation speeds and the default network response times Android employs meant the mobile application displayed only some of the tiles whilst other (the majority) were never loaded. One solution to this would

have been to design an algorithm to accommodate for this issue by knowing which tiles were received and make a new connection for the rest of them, which were not served in time. This would have been a recursive algorithm which, even if developed, would have never fully solved our problem since the mobile application would have been unusable in this time. The overall experience of the user would have been hindered to those extents, which might have potentially led to frustration and thus total disregarding for the potential of the application. Therefore, solutions were sought for facilitating faster computational server times and thus, faster serving tile speeds. External providers such as Amazon Elastic Compute Cloud³⁸ were discussed and quickly dismissed due to monthly inquiring fees and the potential of such a solution to not meet the needed requirements. Lastly, the team agreed that the best solution going forward would be the acquisition of our own server. Unfortunately, the delivery, setting up and customisation of the server, whilst sourcing the required funds craved time which sadly, pushed the overall development of the project back by two months; internally we agreed that there was no real benefit of pursuing any other avenues until the infrastructure met the requirements of the project.

Visual Hierarchies

Previous research has demonstrated that map design can have a significant effect on route selection, and that the visual hierarchy of roads and footpaths is one of the primary influencers (Demaj and Field, 2012). As previously mentioned, our main focus in terms of area fell on the city of Lancaster which is dominated by a main pedestrianised street that runs through the town centre and a circular trunk road that encloses the town centre. Both of these features significantly influence the flow of traffic and pedestrians as they move through the city. These are shown in Figure 28, along with the major points of interest and other often overlooked tourist attractions.

³⁸ <https://aws.amazon.com/ec2/>

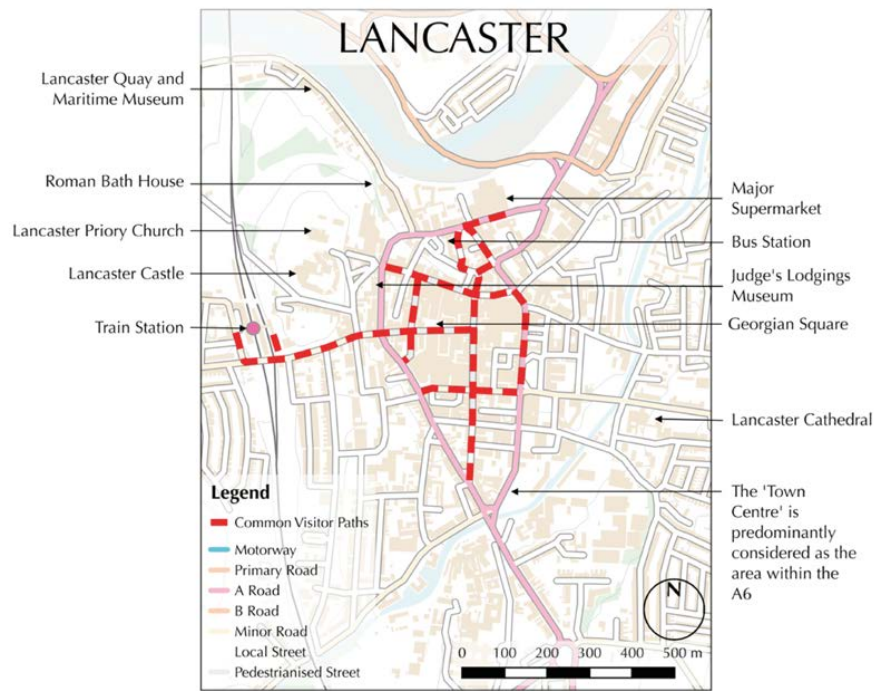


Figure 28. A map of the city centre of Lancaster, illustrating major points of interest, often overlooked tourist attractions, and the principal routes taken by visitors on foot. Contains OS data © Crown copyright and database right (2015).

To give an example of this, Lancaster City Council has been actively engaged in attempts to attract both residents and visitors to these places through outdoor art exhibitions, music festivals, and new street furniture. Whilst these efforts have had some effect, they have not addressed the use of digital maps, which is the dominant way in which new visitors are likely to explore the city.

Quad-Tree Conflation

A key component of this project is the ability to relate the GPS-derived locations to path segments in real-time (conflation), as opposed to building up a 'track' of locations that can later be compared. There are many approaches to conflation including Hausdorff Distance, Voronoi Diagrams and weighted distance surfaces however, for the purposes of this work, a simple quad-tree based approach was chosen for its computational and storage efficiency. The quad-tree was constructed over the area of interest, using a recursive SQL

procedure that creates a large square cell that is recursively subdivided into 4 smaller cells until each cell either only contains a single road segment, or is smaller than a defined stop condition (10m in this case). This process is illustrated in Figure 29, and the resulting quad-tree for the study area (Lancaster city centre) can be seen in Figure 30.

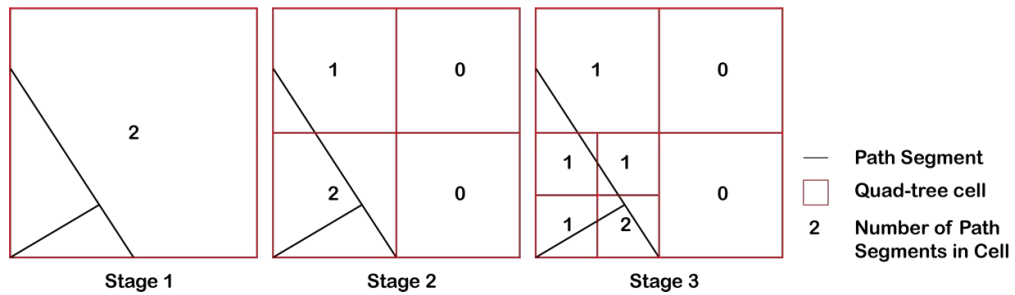


Figure 29. A sketched illustration of the first three stages of the recursive process used to construct the quad-tree index. The example here has a simple path network with only 2 segments. Each cell of the quad-tree recursively subdivides into 4 until it either contains only one path segment or reaches a pre-defined minimum size.

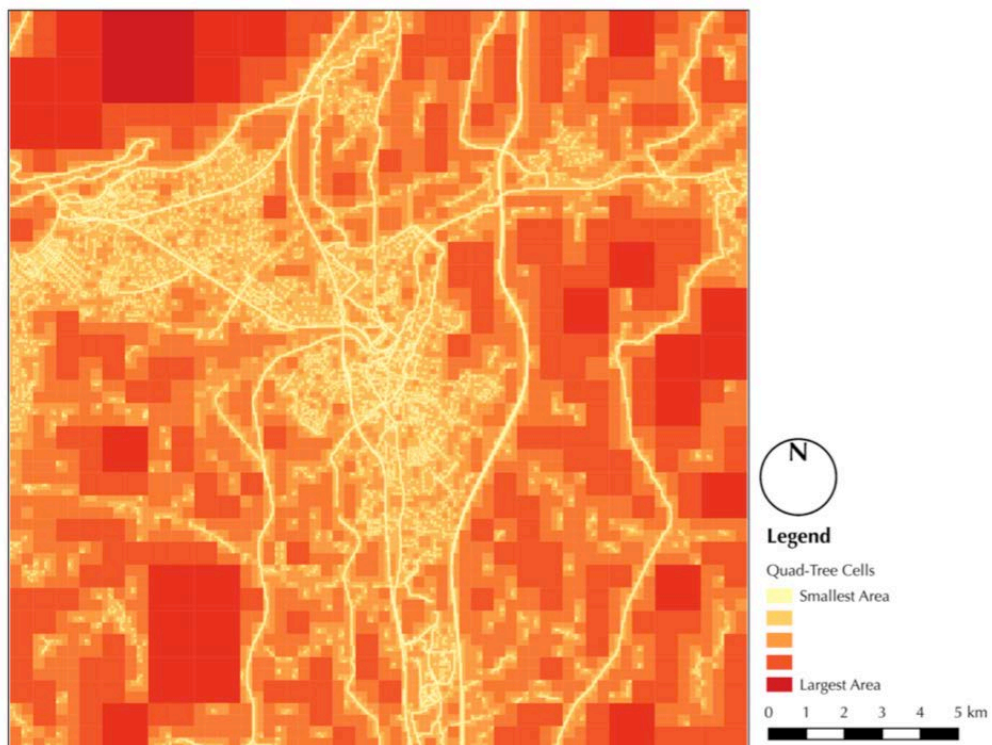


Figure 30. An illustration of the Quad-Tree index used for this experiment. Cells are coloured according to their area, with lighter coloured cells having undergone more subdivisions.

The quad-tree was used to intersect (cookie-cut) the path network, dividing it so that each cell contained its own unique path segment. This means that point data sent to the server from the application can easily be tested for which cell it lies within, and an associated 'counter' attribute for the corresponding path segment is incremented accordingly. Whilst there are known limitations to this method, most notably the potential for misallocation where path segments lie close to cell edges, these are outweighed by the aforementioned benefits for the purposes of this prototype application.

Map Design

The map design is defined by an XML style-sheet that is downloaded to the application from the server at launch, permitting updates to the style-sheet without the need to push an application update to participants' devices. As previously mentioned, the map was designed by the digital design agency Magnetic North, and its original design specification can be seen in Figure 31.



Figure 31. An excerpt from the design sheet for the Paths of Desire map produced by Magnetic North.

The paths and POI's, both exhibit 3-level visual hierarchies based upon how many tourists have visited each attraction. The level attributed to each path segment and POI is determined by an SQL implementation of Jenks' 'natural breaks' algorithm (Jenks, 1963), which classifies each path segment and POI on a scale of 1-3. This is performed as the map tile is requested, resulting in up-to-date data being returned to the application with each feature classified as 1 (least visitors: hierarchical prominence), 2, or 3 (most visitors: hierarchical sub-ordinance). In simpler terms, the width of the path increases based on the available footfall data, calculated in real-time by monitoring the GPS-derived location of other app users in the city.

In order to allow dynamic changes to the cartography, including variations in hierarchies of both paths and POIs, map data from OpenStreetMap are delivered to the application in the form of GeoJSON Vector Tiles. This is achieved using a PostGIS³⁹ database and a Python-based TileStache⁴⁰ server. These data are then rendered into interactive map imagery and displayed to the screen by the Paths of Desire Android application.

Mobile Application

The mobile application developed to support these types of maps was built in Android. The reasons for this were twofold: on one hand, my mobile developing skills were primarily Android focused whilst, on the other hand, Android allows for a quick and easy spread of its applications. At the time of the development, the Android Play Store⁴¹ only required a developer account with no further fees infused subscriptions, making it the ideal deploying store for research based mobile applications.

At this stage, the project presented us with some more decisions to take since we had to determine if we were to build our own Android map renderer, which had to be able to receive and display our custom tiles or, find ready-made alternatives. The former implied spending a massive number of developing hours to implement such a renderer with the potential of gaining no research benefits since we did not know if our overall research question and project were achievable or not. Therefore, we agreed this avenue was not deemed as a viable solution thus we focused our search towards finding

³⁹ <http://postgis.net/>

⁴⁰ <http://tilestache.org/>

⁴¹ <https://play.google.com/store/apps>

open-sourced solutions which were accommodating to our needs. Sadly, our search concluded with only one result: the open-source VTM renderer produced by Mapzen⁴² seemed to be the only viable solution to meet the requirements of the project. At that time, their solution composed a single GitHub repository⁴³ of an Android application which demonstrated a way in which a custom server needed to structure and deploy its tile-based maps to be used in mobile environments. This implied we had to fiddle with their application and recreate it so that it served our custom-made tiles. It also hindered our developing time once more, since we had to understand their base code and modify it to our needs. Lastly, during this extremely ‘hacky’ approach, we observed some of the limitation of their renderer especially around the drawing of dotted lines which was utterly unachievable despite our collective efforts. Our best attempts at rendering dotted lines ended up with a square-base design, which was quickly disregarded as a viable solution (Figure 32).

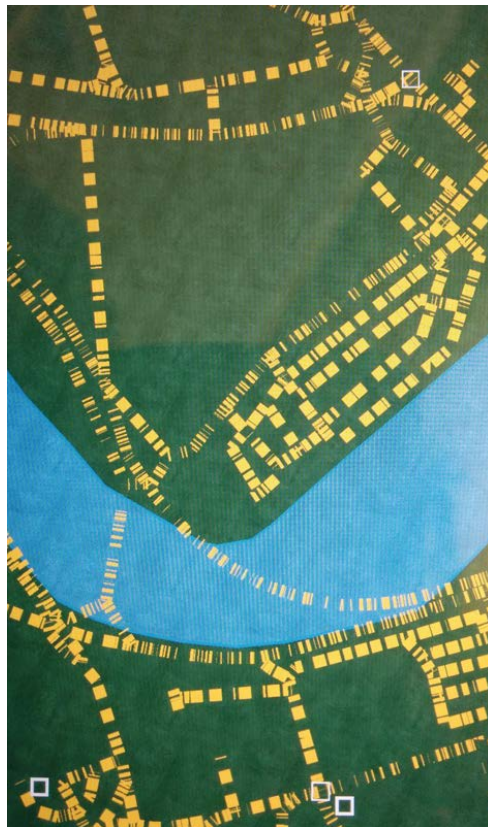


Figure 32. An image depicting the renderer’s inability to display dotted paths and the resulting attempt.

⁴² <https://mapzen.com/>

⁴³ <https://github.com/mapzen/android>

Whilst the Mapzen renderer can actually draw circles, it cannot display dotted paths. Therefore, we had to alter Magnetic North's stylesheet and change the 'most desired' paths from dotted lines to simple and thicker lines. As a result of this, the current version of the application uses three different line weights for the visual hierarchy, as is illustrated in the screenshot to the right of Figure 33.

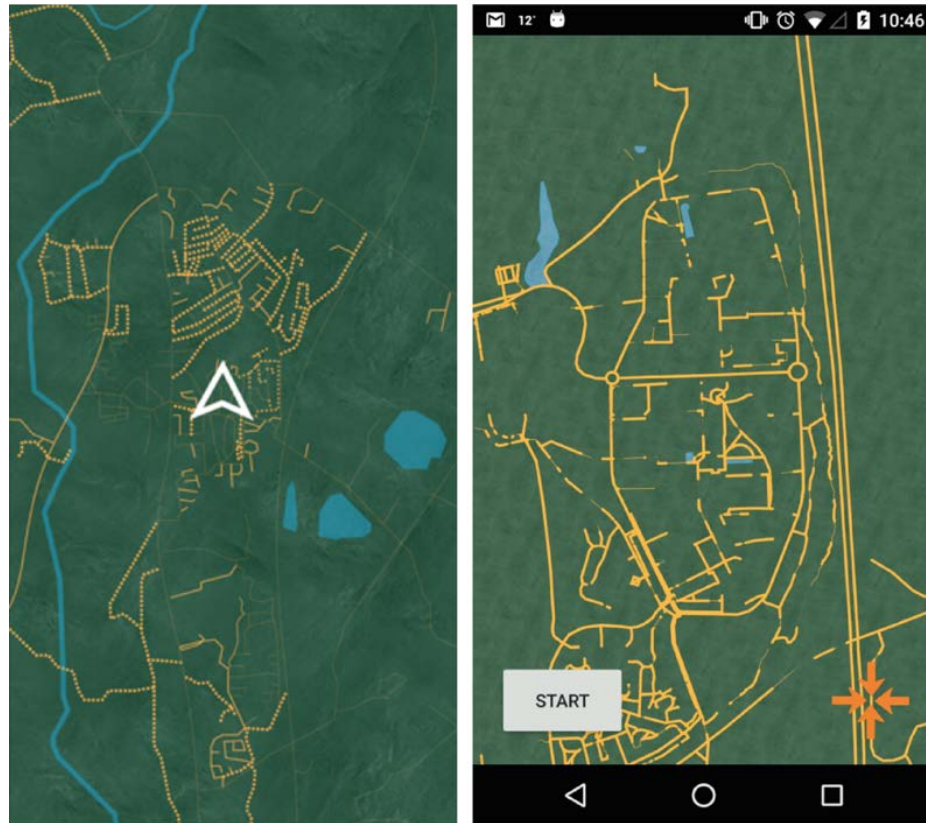


Figure 33. The original style (left) and the resulting mobile application design (right).

Once again, for the purpose of this prototype application, these issues did not pose a significant concern. However, in a discussion with the Manchester based digital studio, their choice for this type of visualisation became clear; their stylistic choice of paths was based on the current one provided my well-known mapping applications. In it well-known that Google Maps employ a dotted line for human-walkable paths and it is an extremely well-used provider. Since the PoD application was designed for human navigation, it made perfect sense to keep the already-known and used Google Map style and just slightly modify the widths of the paths, from the 'most desirable' one (thicker, dotted line) to the 'least desirable' route (thinner,

continuous lines). As such, it was envisioned that people using our application, would not need too much adjusting time to the new design since most-used features were displayed in an already-known style. A comparison between the envisioned (left) and resulting (right) styles can be seen in Figure 33.

Lastly, the application made use of the typical mapping facilities found in application such as Google Maps or OpenStreetMap. The mobile application would allow the user to pinch and zoom, centre on their location and follow the user's movements.

Chas' Designs

As previously mentioned, Lancaster-based artist Chas Jacobs took part in the project through the creation of a new style of maps characteristic to his own practice. The reason for this collaboration is primarily due to his unique and well-known style around Lancaster, making him an ideal collaborator to achieve a pleasing aesthetic that would encourage potential users to interact with the maps whilst promoting playful interactions.

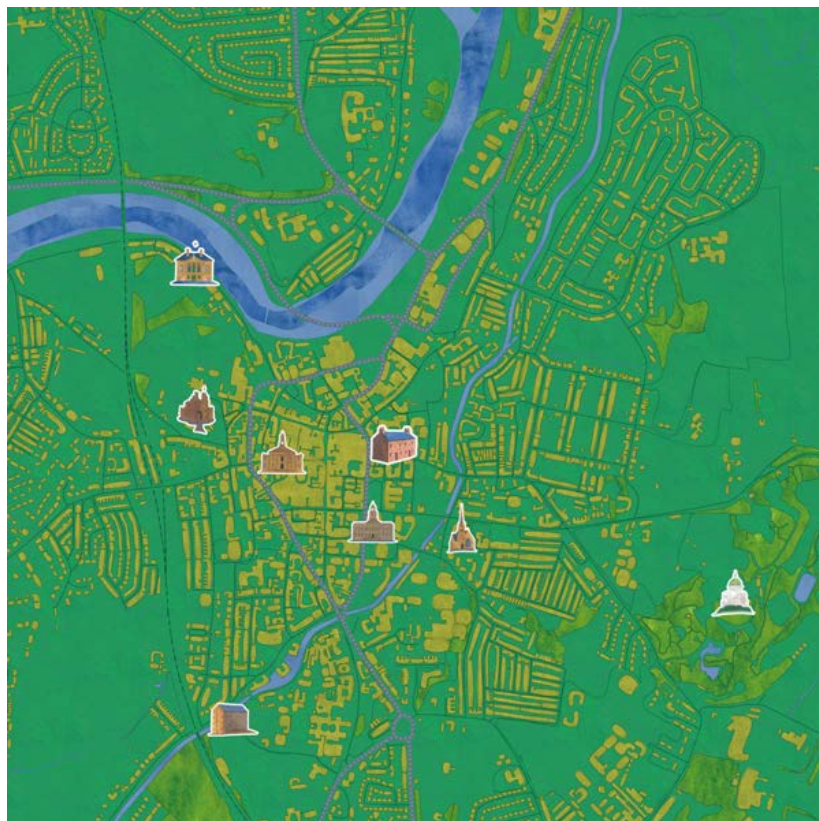


Figure 34. Screenshot of the Lancaster Map, developed in collaboration with Chas Jacobs.

To keep the overall digital map in-line with Chas' own style, the same technique used for the creation of the Sketchy Map in Pac-Lan was used.⁴⁴ The 'Lancaster Map' (Figure 34) is designed to appear hand-drawn, with polygon smoothing techniques used in order to achieve this and give the appearance of pencil guide-lines around map features. The textures for the map were produced by Chas as squares of paint on plain paper, which were then scanned into digital imaging software and processed into seamless tiles that are then applied to the smoothed shapes as textures. An example of a painted square and the corresponding seamless tile that is used for the 'woodland' texture is given in Figure 35.

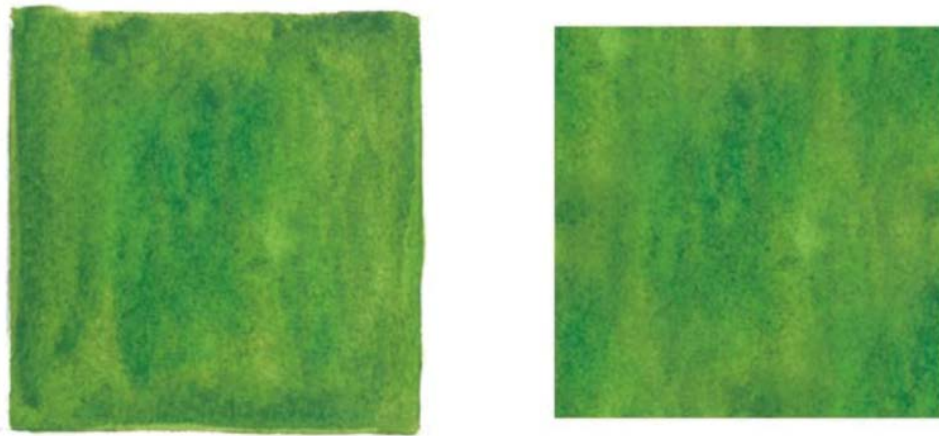


Figure 35. A square of paint produced by Chas Jacobs, and the corresponding seamless texture tile used in the map.

The POIs were drawn in a similar vein, firstly by hand and then transposed into their digital counterparts following a similar method to the one used for the background of the map. Unfortunately, whilst the algorithm worked perfectly, the final POI was not really visible on the map due to its outline being indistinguishable from the patterns on the map. As such, a simple white border was added to the POI to make it stand out when finally rendered onto the map. The final result can be seen in Figure 34, however, a comparison between the original drawing and the final rendered image can be seen in Figure 36.

⁴⁴ See previous chapter for the used technique (p. 58-59).

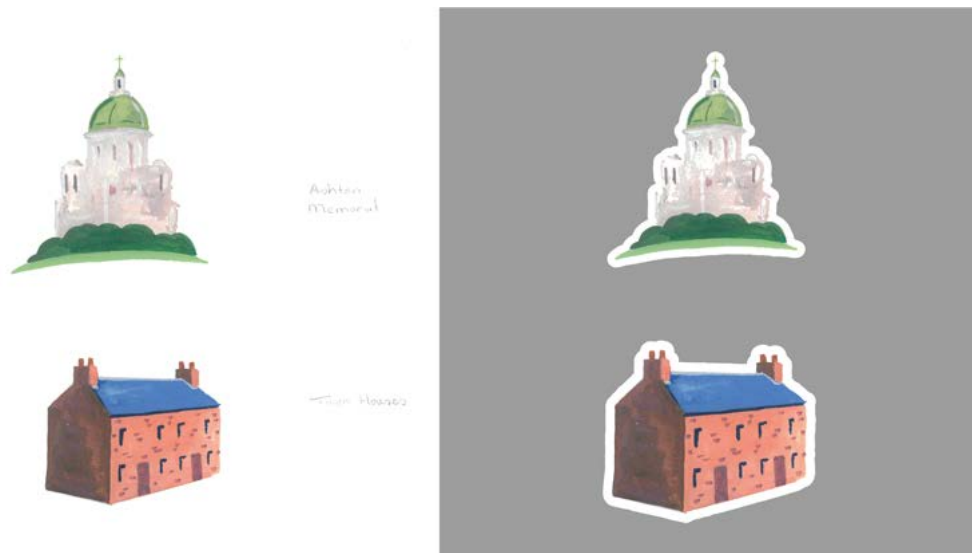


Figure 36. A comparison between the original POIs drawn by Chas Jacobs and the resulting rendered POIs.

Final Meeting

The final meeting for the project took place at Magnetic North's headquarters in Manchester. Overall, the project was deemed as successful, with the team agreeing on the project meeting its original requirements. Issues such as the inability of the chosen renderer to draw dotted paths were disregarded considering the fact that we managed to create a personalised mapping style and display it through the use of a mobile application. This was mostly seen as a small lost battle in a winning war. Chas' stylistic map was highly praised due to its unique personalised aspect. Sadly, due to the time constraints and remaining limited budget which was massively impacted by the acquisition of the server, the team did not have time or resources to pursue the testing of the application. It was agreed that further funding was to be sought which would help in amending this final point.

Discussion and Conclusions

Whilst this project was highly challenging (as will be discussed later) they do not detract from the fact that project achieved its original goals, those of an exploratory journey into the ways in which digital maps are made questioning their overall purpose and finally a need for map makers to

address maps from a ground-up approach rather than retrofitting existing maps to suit the needs of many.

One of the main aspects which this project uncovered is found around the potential for digital cartography as a tool to influence behaviour. If we are to change our digital maps by addressing issues such as pollution and traffic for on-foot navigation, would we want to steer away the population to different paths? And if so, would this be a desirable outcome? A question which springs to mind is how lengthier will the journey be if these factors were to be included into our daily navigation? And by doing this, are we influencing the behaviour of people using this tool? This would require a thorough analysis, possibly stemming from a positivist approach, to give more emphasis to the argument and its outcomes.

On a different note, in respect to the Digital Public Space, the project raises some interesting points. One such point is the debate between public and private? Let us take the inclusion of the data generated by the public for this consideration. Walking the streets with this application on, would inadvertently generate my walking paths, data which, by definition is private and as such, there is an element of privacy concern which needs to be addressed. Yet, its inclusion into the map making renders it public. Opting out from the sharing of such data defers from the map achieving its full potential. It is though the inclusion of a larger number of paths that a certain abstraction is achieved, where individual sets of data cannot be separated. In this respect, the argument of privacy can be balanced as long as these paths do not link back to personal location (home, work, etc). Solely through the privacy looking glass, all of these paths need to acknowledge the security of sharing of this data, therefore, in order to create a 'privacy and security free' map, we might only need to consider where the paths generated by a larger number of people should be taken into the creation of the maps. Furthermore, if we were to include sets of data such as crime, pollution or traffic, we need to be aware of the potential influences this might have on the way in which these maps could be used. Does a lower grade path mean it is less trafficked, more polluted and potentially more dangerous? What are the underlying messages these maps would convey in these cases?

Lastly, the project clearly demonstrates that any number of optional maps may be implemented in the system for a variety of purposes, providing

designs that suit the specific use-case of the application. For example, a map designed to guide tourists around historical attractions in a city might be antique in appearance, or one that is intended to facilitate playful exploration might look like a children's treasure map. In this way, the Paths of Desire application provides a novel approach to using cartography to affect behaviour, as well as a mechanism by which new map designs can be deployed quickly and easily on mobile devices. The ability to dynamically change the design of maps as a reaction to external factors has a number of implications for the future of the role of maps. A simple example of this is that it provides the ability to reconfigure the flow of people through a city in relation to particular requirements or events. Let us imagine a situation, in the smart city where, as the end of a largely populated public event, the maps would undergo slight changes to accommodate for the 'natural' movements of the people when the event comes to its finish. In this way, even deadlocks, which frequently occur at the end of musical concerts, could be avoided. Ideally, such an approach could be implemented during the Haj days where, each year, hundreds of lives are lost in mindless stampedes⁴⁵ due to lack of communication to, from and between organisers.

As stated earlier, this project was highly challenging in that the technical requirements for a 3 months project might be seen as somewhat over ambitious, especially in the light of the infrastructure which was available to begin with; not having a fast-processing VM at our disposal and having to source our own server, pushed the project back by more than two months, consequently scaling back the data gathering process needed. Secondly, whilst the application provided by the Mapzen GitHub repository was sufficient for testing the idea, in the long term, the project would benefit from the development of a new vector map renderer for mobile devices. Whilst these technologies are enjoyed by large commercial concerns such as Google Maps and MapBox, the Mapzen renderer used within this application has many limitations and drawbacks, and there are currently no high-quality, freely available alternatives at this time. It is my hope that further developments in this project, with the required funding, could contribute to remedying this situation. Finally, in this respect, the project also points out some of the issues around the duration of CX projects in general and, in particular, around the

⁴⁵ <http://edition.cnn.com/2015/09/25/middleeast/hajj-pilgrimage-stampede/index.html>

considerations about time management in research. Whilst it is desirable for a research project to have a certain time limit attached, so that academics do not stray away too much from the initial research goals, in practice, due to the unforeseen issues setting up these projects, flexibility needs to be built in.

Perceptive Media

Storytelling techniques within traditional broadcast media have not made major advances in recent years due to the linear and relatively rigid approach to narrative despite advances in the technology that delivers the content. This chapter discusses the concept of ‘perceptive media’ and the CX project which explored it, in which the content creators have at their disposal different tools and sensors to allow for the subtle adaption of the narrative without any direct interactions from the audience members. The concept is demonstrated through the creation of a ‘perceptive radio’ that is able to play specially designed content which is tailored to the physical and social context in which the radio resides.

The Constructed Bits

By the end of the project, we constructed a physical radio which, through the use of a range of sensors and technologies, tweaks and plays a perceptive story. Alongside this, we also developed a mobile application to help with the demonstration of the project. Finally, we designed a workshop which could be used to help content creators with writing perceptive stories. It is important to note here that the radio and its mobile companion emerged through the researching of the initial idea and that their current format is due to the constant iterative approach of developing and testing different avenues which were found useful in relation to the original idea. Whilst the idea did not change, the outcomes might have been different if other decisions were taken.

Connection to The Digital Public Space

The original idea of The Digital Public Space came from Ageh’s desire of democratising privately own knowledge (Kiss, 2010). In my opinion, broadcast media is a perfect fit within The Digital Public Space since it is a typical case of accessing and delivering an archive. Furthermore, since the context of the listener is ‘understood’ through the use of different sensors and technologies, the radio should also be seen as an IoT object, contributing to our understanding of what The Digital Public Space is. Lastly, by bringing the context of the listener into the play, the radio contributes to the notions of space legibility, also presented in the PAC-LAN project. All these avenues

were worth investigating given their direct contribution to a broader understanding of The Digital Public Space.

Background

The driving force behind this project was the Research & Development North Lab at the BBC, in MediaCity, UK. They were our commercial partner in the project and the first ones to explore the notion of perceptive media in their 2013 project titled 'Perceptive Radio'. The project used a large number of sensors to understand the environment of the listener as well as 'sensing' any changes to it. These sensors were able to detect the total number of people in the room; monitor background noises, which facilitated the subtle adaptation of the sound levels being played; count the active Bluetooth antennas, amongst other features. All these sensors were engulfed in a DAB radio like shape box, being run by a small form factor computer. Arduino-like prototyping boards were used to facilitate the access to the sensors in such ways that their data could be read and adapted to the needs of the programme. The main reason for this project came from the desire to adapt radio broadcasting from a one-size-fits-all experience, to a more personalised one.

Our project focused on the re-enactment of the Perceptive Radio, by trying to remove some of the issues encountered by the R&D team during their work on the original radio. The focus here being on a simpler, hassle free and easily demonstrable concept. We were fortunate to have the BBC team working with us on this project in an advisory position as this allowed for previously learned lessons to be shared which ultimately lead to the avoidance of a great deal of issues. The following parts of this chapter detail the steps we took to reach our goals and the current state of the project. In order to achieve this, I will start by introducing the concept of perceptive media whilst also highlighting its potential.

For the purpose of this chapter and to present matters in a clear way, the radio built by the R&D team, will be referred to as v1, or v1 of the radio whereas, the version developed through this project will be referenced as v2, or v2 of the radio.

Introduction

The storyteller greets the group slowly easing them into a relaxed ambiance where everyone is preparing to enjoy a well-told tale. As the story progresses, the storyteller adapts it to the particularities of the location and the group, making use of specific expressions, sayings or habits, referencing landmarks and places in the local vicinity to ensure the story resonates with the audience. The narrator also provides a warm welcome as more listeners join in, as well as becoming more engaged with the audience if their attention is drawn away from the story. It is through the use of these refined techniques, a personalised, unobtrusive storytelling practice is achieved, one where the subtle changes used by the storyteller contribute to the overall immersion level of the audience. In a similar vein, a well-versed stand-up comedian adapts their show to the specifics of the location of the theatre where the performance is taking place, tailoring the jokes around the audience and own perception of how well the audience is engaging with the show. Whilst the show is generally regarded as a performance, with an entertaining lead actor, the audience is experiencing a narrative given by a professional storyteller. Despite the rapid pace of technological development across different mediums, broadcast storytelling content is still inflexible in comparison to these oral traditions. One medium that can adapt is digital games where game developers often create quite complex and twisting stories in which the player's actions, across diverse situations, directly influence the progression of the story as well as the evolution of the character and thus deliver a unique experience to each individual player (Mass Effect franchise⁴⁶, TellTale: The Walking Dead⁴⁷, Alpha Protocol⁴⁸). Whilst this technique has also been adapted to theatre by companies such as Punchdrunk⁴⁹, it has yet to be seen in traditional broadcast media. The main advances we have witnessed recently in broadcast media have only affected the way in which we consume digital content (TV, stream box, mobile, laptop) or how it is being delivered (on-demand media versus traditional media). Whilst online voting can change the outcome of a TV episode or show, no real advances have been made around how program makers are looking at making their content more dynamic and

⁴⁶ <http://masseffect.bioware.com/>

⁴⁷ <https://www.telltalegames.com/>

⁴⁸ <http://uk.ign.com/games/alpha-protocol/>

⁴⁹ <http://punchdrunk.com/>

adaptable. Therefore, in this project, we explored different ways in which content creators can start thinking about how they may produce adaptable stories, by making subtle changes to the storyline based on the context in which the listeners are consuming the media. In doing so, the content creators are generating a new form of media that within this research the team referred to as 'perceptive media'.

Unlike interactive narrative, "in which users create or influence a dramatic storyline through their actions" (Rield and Bulitko, 2012), 'perceptive media' looks at narrative from a different perspective; it adapts a story to the audience by using information about them, gathered through the use of a range of sensors and sensing technologies, whilst shaping the story within the predefined scope set by the storyteller. If the goal of the interactive narrative is "to immerse users in a virtual world such that they believe that they are an integral part of an unfolding story and that their actions can significantly alter the direction or outcome of the story" (Rield and Bulitko, 2012), in the case of the 'perceptive media', the overall story arc does not change, it is simply varying the more ambient parts of the narrative to create an engaging experience for the listeners. Thus, these changes may not be immediately apparent to the user and rather they are subtle and awareness may develop slowly during the course of the broadcast. Therefore, 'perceptive media' attempts to bridge the gap between the 'flexibility' of the storyteller and the 'rigidness' of the broadcasted story delivered. The technologies employed take advantage of the implicit and explicit data the audience is generating and, in doing so, it redefines narrative as a set of logical attributes (variables), which could be moulded into different experiences. It is through the creation of adaptable stories and new experiences that the concept of 'perceptive media' is achieved. Since the story has to adapt to the contextual information gathered by the available sensors, new requirements are being placed on content creators. Whilst they have the unique opportunity to create new experiences, they are also required to generate the essential materials to cover all possible scenarios for a particular story. Each sensory output needs to be thoroughly considered before being used within a broadcast and it is within the responsibility of the content creators to ensure the correct usage of the sensors.

The Team

Alongside the BBC R&D team represented by senior “firestarter” producer Ian Forrester, game design and storytelling digital production agency Mudlark joined our team. The reason for involving Mudlark in the team was three-fold: firstly, they were part of the original team composition which worked on the first perceptive radio with the BBC’s R&D team, which meant they were already intimately familiar with the perceptive media concept; secondly, their expertise on storytelling writing techniques was believed to be of benefit to the current team; and lastly, we already had a connection with them having previously worked on a different CX project. The CX put forward three people, based on their capabilities and research interests being found suitable to the project. The actual development of the project was split between Dr. Daniel Burnett and myself. Dr. Burnett was responsible for building the infrastructure and the required API whilst my roles shifted from researcher, to project manager, overseeing each member’s contribution, writing ethics forms, budgeting, material acquisition, etc. and finally to mobile developer, fully responsible for the design, development and implementation of the mobile application. I would like to point out here the whilst these roles were defined, the working practice followed a collaborative route where Dr. Burnett and I contributed to each other’s tasks. Finally, the project was supervised by Prof. Paul Coulton (Figure 37).

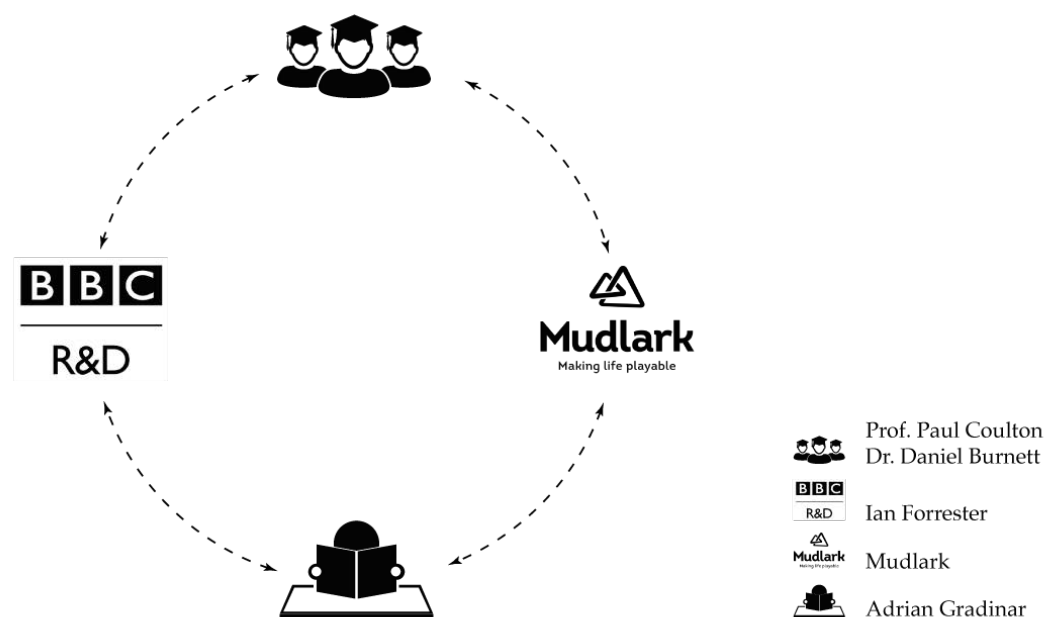


Figure 37. Perceptive Media project team.

Initial Meeting

An exploratory process was used in which different technologies were used independently and concurrently to gather contextual information about the current context of the audience in order to influence specially created media. In a similar fashion to all the other projects detailed in this thesis, the perceptive radio platform was built through an iterative process.

The first step involved a Skype meeting with all the partners where different ideas were explored. One of the most important point raised during this meeting, which shaped the overall direction of the process, found the team discussing the best ways to develop the new platform to a level which could easily be demonstrated. This meant that the radio had to be easy to carry around and the setup process as seamless as possible. This was due to the issues previously encountered by Ian when trying to demonstrate v1 of the radio. It was at this meeting where the team came to an agreement on using web-based technologies to achieve this goal, focusing on JavaScript (JS) as the main platform for the creation of 'perceptive stories' for the v2. This was due in part to how v1 worked but also because the team agreed on this technology being the easiest to learn for any content provider willing to create new content for the perceptive media platform. During this meeting, v1 was analysed, by unpacking each sensor and discussing on its relevance as well as its potential to provide meaningful context, which could be used in new stories. By the end of the meeting, a full list of sensors was agreed upon, which are presented in more detail in the following parts.

Mudlark took the lead on creating a short adaptable story, which was to be presented, tested and analysed in a future meeting. This was to be developed for the browser as a prototype and later on incorporated into v2. Since not all discussed sensors would have been available on this platform (web browser), it was agreed on an interface, which would only simulate sensor data. This would keep the development of the platform and the story separately and thus moving the project forward whilst maximising the available human resources.

It was quickly agreed that a small form-factor PC would be the desired platform for v2 of the radio. In terms of the operating system to be used, the three most obvious options were discussed with a Linux based distribution being the only viable solution; OSX was quickly dismissed as it required

proprietary hardware whilst Windows would have required licensing. One of the desires of the BBC R&D team was that the software should be made publicly available for anyone wishing to download and incorporate it into their own version of a radio, which was also one of the prerogatives of this CX team with respect to any of our prototypes.

During this meeting, the design of the new radio and its final shape were also discussed. Ideas such as tilting the radio to play / pause / stop or waving one's hand to achieve the same results were also debated. It was agreed that such avenues were to be explored at a later point in the project due to the focus falling extensively on the v2 incorporating the agreed list of sensors and being easily to demonstrate. The Trello⁵⁰ platform was suggested as means to keep all partners actively involved in the process and its progression, based on its fairly ease of use and features such as task-to-person association. Trello had been previously used in another CX project and it was found to be a good project management tool.

Sensors

The discussion around the proposed sensors continued on the Trello platform, where positives and negatives on each sensor were addressed.

One of the first mentioned sensors was a camera. The camera would be located on the front of the radio and facing the audience; in doing so, it could easily count the number of listeners in view. Depending on the type of camera used, it could also approximate the distance to the listeners, and thus facilitate the same functionality of increasing / decreasing the volume, in similar ways to v1. Multiple voices within the team pointed out that low light environments would severely interfere with the desired outcome.

Another sensor discussed was the microphone. This was also a sensor, which was part of v1 and thus deemed to scrutiny. The microphone was envisioned to be detecting the sound levels in the room and contribute, either alongside or separately to the camera, in managing the sound levels of the played stories. It was quickly pointed out that the microphone might suffer from interference produced by the radio itself thus, the team decided to focus on the other sensors and reconsider it at a later stage in the development.

⁵⁰ <https://trello.com/>

Since Bluetooth was another sensor heavily used in v1, it was also debated here. In v1, this sensor was used to determine the number of people in a room. The team agreed to investigate further.

V1 used an active Internet connection and reverse geo-location software to determine the location of the listener, thus providing some contextual information. This was also debated within the team where alternative suggestions were made. One such alternative would explore the possibility of a GPS sensor to be incorporated into v2.

Researching these sensors was split between Dr. Daniel Burnett and myself. Internally, we agreed on Dan testing the camera and the microphone whilst I was in charge of the Bluetooth. Due to the proposed GPS sensors, presented below, this task was split between us both.

Camera

Different camera types were considered and debated: traditional web-camera; infra-red camera and traditional camera; traditional camera with infra-red filter removed; traditional camera with infra-red filter removed and infra-red LED backlighting; and finally, the Intel RealSense camera with depth and infra-red options. A range of different environments in which the radio would be situated was discussed and each camera was tested in said environments, which has been listed Table 1. CPU usages were also monitored when each camera was connected and running to see its feasibility in conjunction with other running sensors.

The tests were performed in an office environment, where the visibility of the camera was determined by its ability to determine the faces in its view, since this was ultimately the purpose for its usages. For consistency testing, we aimed for a similar lit environment with the camera being placed in the same location. Originally, it was decided based on the tests, that the traditional camera was the best option however, within 6 months since the start of the project, the Intel RealSense camera became available. At that point, and based on a new iteration of testing, it was observed that the latter one uses less CPU power and has a depth sensor, compared to the previous option, making it the final choice for v2. According to Dr. Daniel Burnett, the traditional camera without a filter is usable but does not provide a wide enough angle for an indoor environment. With it being new, Intel RealSense

camera had no official software released for the Linux platform at the time of the development. As such, in-house software was developed which, whilst providing some sense of depth, caused dropping of frames. This meant it was unreliable and could potentially disrupt the stability of the overall software running on v2 thus, it was decided to be disabled until better software was available. Unfortunately, until the end of the project, this never happened and so it remained disabled.

Camera Type	Visibility (good-light)	Visibility (low-light)	Resolution	Depth	Processor Usage
Traditional Webcam	excellent	poor	720p	no	100%
Infra-red camera and traditional camera	excellent	excellent	720p	no	200%
Traditional camera w/o Infrared Filter	excellent	poor	720p	no	100%
Traditional camera w/o Infrared Filter with LED backlighting	excellent	good	720p	no	100%
Intel RealSense Camera	excellent	excellent	1080p	yes/no	100%

Table 1. The evaluation of the proposed cameras.

Microphone

In a traditional storytelling environment, the sound levels within the environment, could be a useful indicator for the level of engagement of the listeners. By comparison, it is easy to imagine a classroom, where the teacher

easily knows how to tailor the given class based on the noises their pupils make. As such, when thinking about the microphones available, several options were considered: single microphone, dual directional microphones, webcam microphone, single microphone passed through a noise filter and finally, dual directional microphones passed through a noise filter. Sadly, the costs involved into the acquisition of dual directional microphones was above the limits of the project, invalidating these two options.

In an ideal scenario, the microphone would acquire the background noises from the environment as well as the sound emitted by the radio and pass this new audio stream through the noise filter which, after processing, would eliminate most of the output generated by the sound card. The background noises stream left could then be passed to a Fast Fourier Transform (FFT) algorithm of which output could be used by any story creator to adjust the sound levels emitted by the sound card. Unfortunately, within the span of the project and due to procurement issues within our university, the selected filters never reached our team, leaving us with only two viable options for testing. The webcam microphone picked up lower levels being emitted by the sound card compared to the single microphone, which meant it was the team's final decision for this category of sensors. When audio filters become available to test and implement, they are theoretically deemed as better alternatives to webcam microphones.

Location

As previously mentioned, the context awareness of the radio was one of the most important aspect of the project. By locating the radio within the physical landscape, the content creators could make use of the location, in similar fashion to that of the storyteller which can easily tailor their stories based on this location, thus making it more personalised. In order to regionally locate the radio, different location sensors were considered: a GPS receiver plugged directly into the computer; a GPS receiver connected to an Arduino like prototyping board; an external IP address of the player; and finally, a mobile phone with GPS and A-GPS network location technologies.

The first two listed options had similar issues when being physically incorporated into the v2, and the reported location had accuracy errors due to the performed indoor testing. The accuracy was greatly improved when the

sensors were located outside however, this would directly interfere with the first prerogative of the project in it being easy to demonstrate. As such, these options were deemed not viable for the final v2.

Whilst being the only free of charge option, acquiring the external IP of the radio had also its downsides. Different scenarios were tested to understand when the IP might be falsely reported. One test involved the radio being connected to a VPN and, as expected, the location of the radio was that of the home server of the VPN; this was again not a viable option. Further tests revealed more issues; the team decided to see if in the case of a mobile hotspot this would achieve better results. Unfortunately, it was not the case and whilst the mobile hotspot provided the correct country, in some cases, the location of the mobile endpoint was reported hundreds of miles away. Lastly, the team investigated the wired and wireless network connection options which reported the location within an average of a mile. Whilst this accuracy was to the desired level, it implied knowing it prior to its acquisition to verify its veracity.

Finally, we explored the possibility of acquiring the location via a mobile phone. An Android mobile phone was used, due to its in-built sensor and low-cost compared to other mobile phones. This would not require a Wi-Fi connection but would greatly increase its accuracy in some in-door environments. Testing revealed the accuracy to be within meters, even without a Wi-Fi connection, and less than 2 meters when the phone had a network connection. Despite this being the most expensive option, the team agreed on it being the most suitable one, as it required little managing and was, according to our testing, the most consistent one.

Bluetooth

The reasons behind the investigation of these sensors were two-fold: primarily, every listener would be handed a Bluetooth sticker which would act as a counter in determining the total number of people in the room and, secondly, the same sticker could be used to approximate the distance of the listener to the radio. This was seen as a better alternative to the camera, since it does not require direct line of sight. The proposed beacons to be tested were manufactured by Estimote⁵¹. Companies such as Texas Instruments have their

⁵¹ <https://estimote.com/>

own beacons however, due to the overall look and feel of the final design of the Estimote beacons, this option was desired.

Testing was performed both in an indoor and outdoor environment and it focused on the time required to acquire the signal of the beacon as well as its reported distance. Alongside multi-path, Bluetooth works on a similar frequency to that of a wireless network, thus interference was a factor not to be easily dismissed. For a single beacon, the time required for the mobile phone to pick it up was seen as minimal, with an average of less than 15 seconds of detection. As we increased the number of beacons, the time and accuracy started to shift. A total of 5 beacons located in close proximity of each other, reported only 3 to 4 beacons being detected. The consistency was also misleading since the beacons seen were not always the same ones. The same misleading results were observed when distance was tested. A single beacon would require somewhere between 10 to 20 seconds to stabilise itself and report its accuracy with a margin of almost 50 centimetres, in a room size of 6x5 metres. By focusing only on the close proximity of the beacons to the radio, this loose accuracy could have been avoided. Unfortunately, in the same scenario of 5 beacons in the same room, the overall results were unusable, with a distance accuracy of even more than 2 metres per beacon. Even if we had focused on a narrow area of half a metre to the radio, the sensing of the beacons and their location within that region would have been highly inaccurate. To be sure that these errors were not derived from the used software, we tested both the original software suggested by Estimote⁵² as well as the AltBeacon⁵³ library. Sadly, our tests found similar results. As such, the team decided the beacons were not a better alternative to the camera, despite their perceived potential.

Distance sensing

Due to the limitations of the beacons and the traditional camera, the team decided to quickly investigate the possibility of detecting the distance by using a distance sensor connected to an Arduino board.; the testing revealed the limitations of the sensor. With respect to the distance, the sensor would perform well, unfortunately, it did not make the difference between the nature

⁵² <http://developer.estimote.com/android/tutorial/part-1-setting-up/>

⁵³ <https://altbeacon.github.io/android-beacon-library/documentation.html>

of the objects thus, a wooden pillar and a person were seen exactly the same. This could have been compensated by an algorithm in which the room would have been read and ‘subtracted’ leaving just the moving objects. However, in a later discussion, this method was deemed inappropriate as it would require too much time to be spent on a single feature of the radio. Furthermore, other perils were identified, such as people introducing new objects into the view (an umbrella, a hat, a coffee cup). The Intel RealSense camera was still seen as the only viable solution for the requirements of the project.⁵⁴

Perceptive Radio - The Platform

As previously stated, it was agreed from the first meeting that the radio was to be running a Linux distribution on which the platform was to be built. This would then have to make use of other software to achieve the project’s overall goals. In order to allow for JS scripts to be developed and run, different other platforms were proposed and discussed. In the following parts, I present just a few of these and the consideration for their inclusion in this discussion.

Python is an open-source server-side language which tends to be used often when open-source and speed are found within the list of requirements. It also offers a comprehensive list of packages which allows for easy implementation and development. One such package is NumPy, extensively used for fast processing numerical data. This was in line with the desired outcomes for v2, since the multitude of sensors could have had the need for such behaviour.

PHP: Hypertext Preprocessor, better known as ‘PHP’ or ‘php’, is probably one of the most utilised open-source server-side languages to date. This is due to its easiness of use and fairly low-level learning curve whilst also offering great processing speed. Unfortunately, connecting the sensors to different php scripts could sometimes be a hassle since it does not typically run with an open connection, thus the response transfer speeds would have been low; not the desired outcome for v2.

⁵⁴ At this point in the sensor testing phase, the Intel RealSense camera was still not available for purchasing.

NodeJS is a JavaScript runtime environment, for the execution of JS code at the server side. In a similar vein to Python, it also provides a package based extending library to suit the needs of many developers and different requirements. This means the potential of the required functionality to be already available, thus minimising the development times. NodeJS packages also offered the potential for avoiding developing additional C/Python scripts to read the generated sensor data. One of these libraries is Socket.IO, used to send data back and forth between multiple clients. In our case, such a model would facilitate the radio to act both as a server, updating an external client with data, as well as a client, performing different actions upon being instructed. This behaviour would have made the demonstration easier as it could be controlled from such an external client. Additionally, anyone wishing to take v2 further and rewrite any of its internal logic could easily do so since NodeJS is an open-sourced platform.

There are many other server-side languages which could have been presented here however, the above were only included since they were believed to be the only ones to meet our list of requirements. NodeJS was finally chosen since it meant that the total number of required languages to be used would be kept to a minimum since the development of the stories would also require JS skills.

Mudlark's Perceptive Story

As previously mentioned, Mudlark developed a 'perceptive story' for the radio with a clear focus on demonstrating the concept of perceptive media and the capabilities of the radio. As such, all the functionalities of the radio were simulated in the browser and did not require any active sensor development from their team. The chosen story was an adaption of one of the most well-known Aesop's fables: The Two Travellers and the Farmer.⁵⁵ It made use of browser specific elements such as drop-down lists to facilitate the customisation of the 'sensors'. For this version, Mudlark focused on contextual information such as location, weather, 'felt' outside temperature, time of day and total number of listeners. To bring the experience of the audience closer to that of a storyteller rather than a radio play, Mudlark's version allowed for the addition or removal of listeners from the room in such

⁵⁵ <http://spellbinders.org/story/the-two-travelers-and-the-farmer/>

ways that the story would react to such behaviour. A simple play button was used to start the story. A more in-depth explanation of how the story is played is explain in a subsequent section.

API

The API (Application Programming Interface) was agreed and designed by the CX side of the team. To keep it simple and consistent, we decided to follow a strict format, which could be easily understood by anyone interacting with the API. As such, the following structure was proposed for each sensor: get 'Sensor Type' 'Sensor Function' (e.g. getCameraPeopleCount, which returns the total number of people in the camera view).

With the inclusion of each sensor into the API, thorough testing was performed to verify its functionality and output and modify or adapt its output to the needed requirements. The development of the API was based on the agreed sensors whilst taking into consideration the available story created by Mudlark. In order to start a story on the radio, a simple function named 'beginAPI();' is called which starts the sensors in the radio. During the development process, we observed that this function is too inclusive since it starts all the sensors thus, in a later cycle of the development, we added a list of sensors as parameters to the function, in order to specify exactly which sensors this story makes use of. This API is greatly increased in simplicity and functionality compared to the original API developed by the BBC R&D team which required a thorough understanding of the whole base code in order to modify the story; a design feature which, according to Ian, has proven detrimental when explained to content creators. Our API features one-line functions which bring back only the data required by the producer, allowing for a simpler, faster and much easier creation mechanism.

Story Implementation on v2

After the CX team acquired Mudlark's story as well as the additional files and whilst the development of the API was still on-going, we started working on the algorithm for allowing the radio to play the story. The first contextual information gathered by the radio is its own location, by using the GPS position provided by the mobile phone. Based on this location, data such as the current weather and 'felt' temperature are obtained from online

weather services. The time of day is also acquired from the internal clock alongside with the number of people currently within the sight of the camera. Based on this data, the story is dynamically generated. The ‘campfire story’ starts by greeting the listeners acknowledging their numbers, the time of day and ‘felt’ temperature. During the play, the radio monitors the activity of the listeners and the ‘virtual storyteller’ greets the listeners as they walk in or out of the room. Similar to the original Aesop’s fable, the ‘virtual storyteller’ asks each traveller about where they came from. Since the radio already has the contextual information about the location of the broadcast, the replies given by the travellers in the story reflect the current location. This is a subtle adaptation of the story, one that might not be perceived by all members of the audience, however, if registered by some of the listeners, it could enhance the overall experience. The whole process of the story logic can be seen in Figure 38.

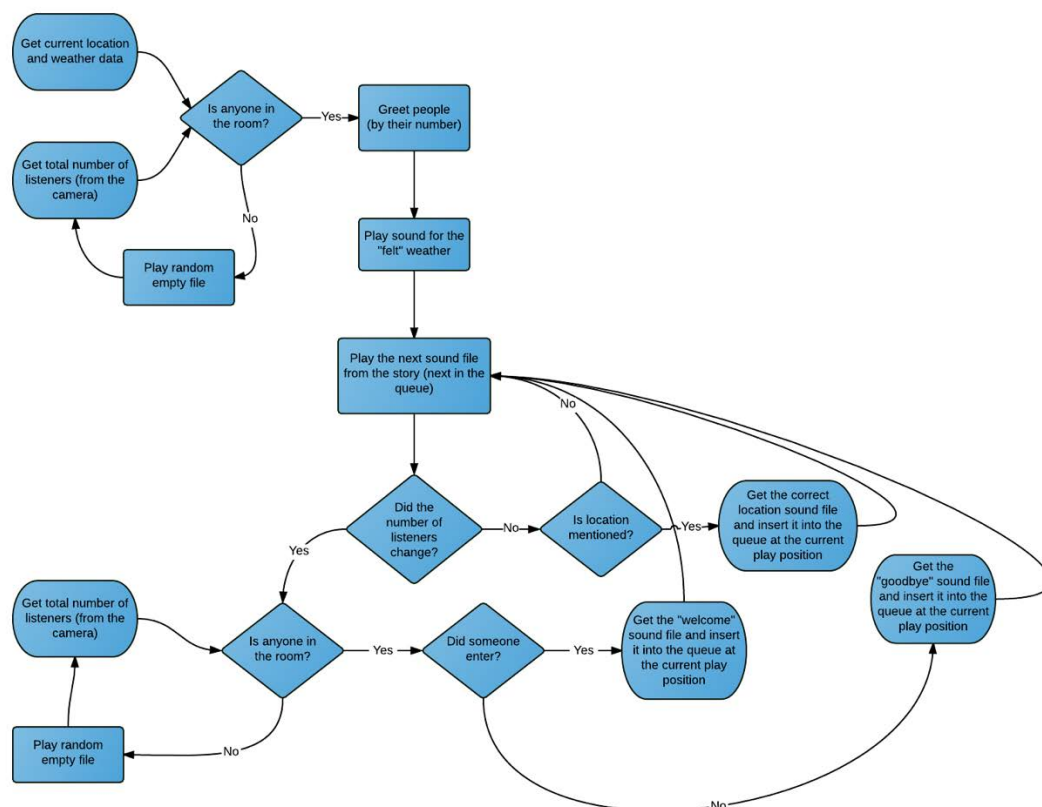


Figure 38. Story logic explained.

Mid-project meeting

With the API written and the story running on v2, the team met on the BBC premises at MediaCityUK, to demonstrate the current progress and discuss future steps. From the initial feedback, the overall progress was seen more than satisfactory, especially around the API and its design and presentation. One of the points raised during this meeting was around the presentation of the radio. V1 always required a keyboard and mouse to be able to start the radio and select a suitable demo which was seen as hindering the demonstration process. It was decided that it was of worth to investigate alternative solutions. This point also led to an agreement from the team that selecting and joining a network should be done without the use of a monitor thus making the demonstration process even easier.

During this meeting, it was also pointed out that whilst doing these demonstrations, people are sometimes left confused by how the 'perceptive' elements of the story work. According to Ian, this was overcome by playing the same story twice, with slight manual modifications to the code before the second run; a potential pitfall which requires a great deal of time that most of the people engaging in these demos do not seem to have. As such, the idea of an administrator interface was born. The interface would facilitate the manual selection of a network, without an additional keyboard, mouse and screen, whilst also allowing for overriding the contextual elements gathered by the radio. This would not be part of the story creation process however, it will help with the demonstration.

The last discussed point addressed the current case for the radio. It was believed that while the case was protective enough and did encompass all the required elements, it did not evoke the same feelings associated with v1. As such, it was suggested that a new encasement should be considered.

Most of the discussed and agreed points to be investigated pointed out the need for a closer collaboration with Ian, since he was the project's beneficiary upon completion. As such, the CX team agreed to provide updates and receive feedback over Skype until the last points were fully developed and finalised.

Admin Interface

The second iteration of the prototype involved working on the API to facilitate the addition of an admin interface to allow for Wi-Fi network connectivity selection as well as customisation of a story. All this required extending the API with new functionality to meet these newly set requirements. Since the API was designed following a simple yet intuitive structure, the process of extending it was relatively straightforward. Through a series of discussions, we quickly agreed on the interface to be designed as a web-app, allowing for different mobile devices to act as 'remote controls' for the radio. We dismissed the native application format (e.g. Android, iOS, etc.) since this implied developing the app individually for each platform.

A workflow was created by the CX team for how the admin interface should function which is listed below:

1. Physically connect all sensors to the radio (e.g. the camera).
2. Plug in and start the radio.
3. Connect the admin device to the radio (e.g. a mobile phone or tablet).
4. Load the admin interface (web-app) onto the admin device.
5. Select one of the Wi-Fi networks and connect to it by entering the correct password in the field provided within the app.
6. Select a story and play it. A dropdown box was used to list all available stories.
7. Control the playback and variables of the story from the admin device.

To allow for such commands to be sent to the radio, an additional network card was required. This card was set as an ad-hoc network which would broadcast its own network. The admin device would then connect to the radio via this network in order to send and receive commands. Because of this, the admin device would be able to pick an SSID 'seen' by the second network card and facilitate the connection of the radio to the network.

During the development stage, the team's focus fell only on the functionality and making sure the admin interface meets the discussed requirements. When this was considered to be satisfactory, we worked on the visual side of the web-app, which was designed to comply with current HTML5 standards. The web-app follows a three steps setup in order to send

the 'play' command to the radio, described below and shown in more detail in Figure 39 to 42.

1. Stage one - The admin is presented with a simple menu selection where they can select from the list of available Wi-Fi networks discoverable by the radio. A simple text box is available for entering the password for the network. This is not mandatory in case the network has free access (Figure 39).

2. After the radio is successfully connected to a Wi-Fi network, the admin is presented with a simple dropdown menu where all the available stories are listed, shown in Figure 40. Upon selecting the story, the admin can then proceed to the third stage.

3. The last screen allows the demonstrator to manually modify some of the contextual parameters by overriding the sensors' data. This can be achieved by ticking the Override tick box, which enables the manual selection of a desired output (Figure 41). Three buttons are listed at the end of the page to play, pause and reset the story. Whilst the play and pause buttons are evident, the reset button can be used to return the customised story to the original data acquired from the sensors (Figure 41). Additionally, the admin has the option to choose between the two audio outputs available (stereo and HDMI), shown in Figure 42. This functionality was added after a few demonstrations took place and it became evident that not all locations would necessarily have HDMI audio inputs.

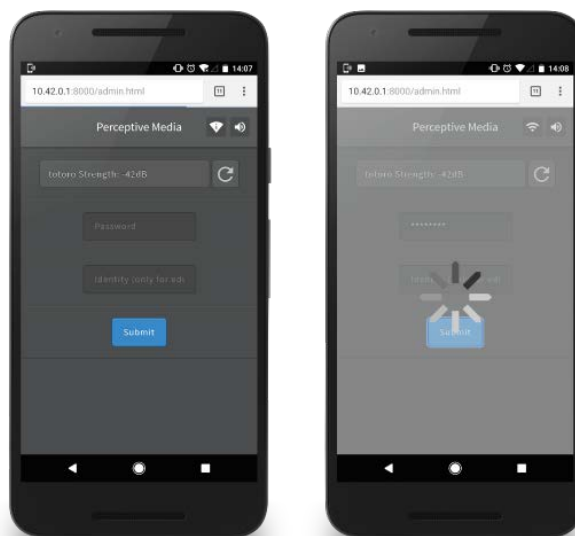


Figure 39. Wi-Fi selection.

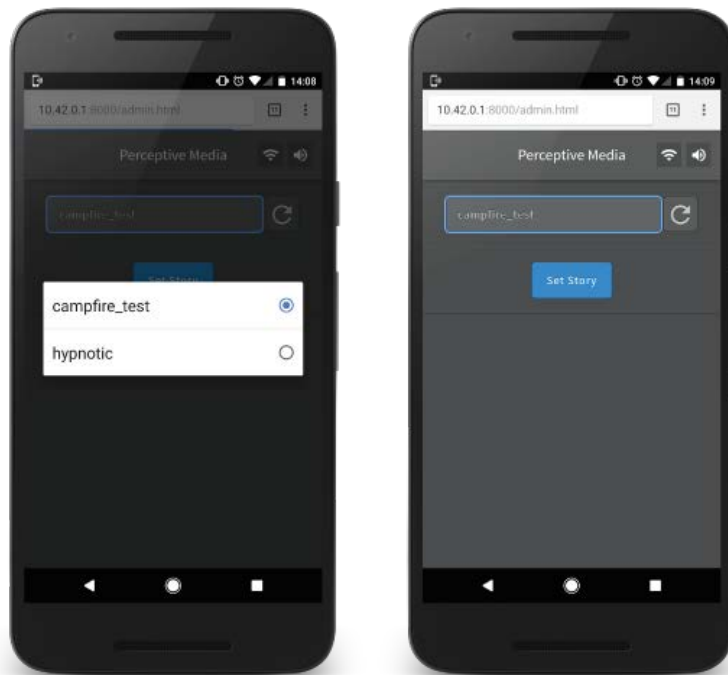


Figure 40. Story selection.

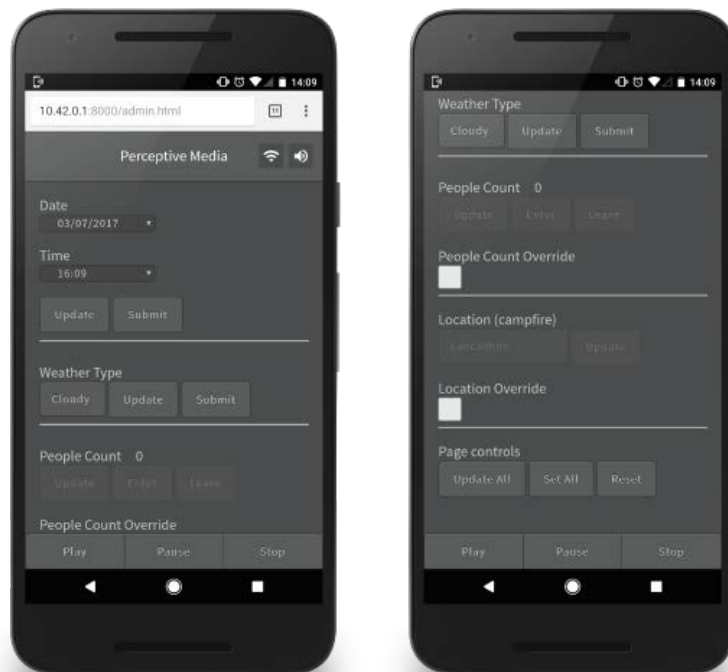


Figure 41. Story customisation.

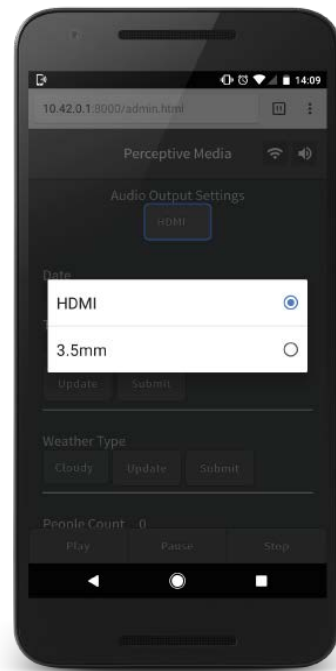


Figure 42. Sound selection.

Case Design

Sadly, the time spent on developing the API and adapting it to the requirements of the admin interface coupled with the thorough testing of all the sensors and the story setup from the newly added admin device, was not sufficient enough to allow for a new encapsulation for the radio to be designed. Whilst the new case was envisioned to contribute to the overall discussion the project would have generated in a demonstrating environment, the current one had to suffice.

Final Project Evaluation Meeting

After all the changes were done, the team met once more to evaluate on the final state of the project. The meeting was held on the BBC MediaCityUK's premises with all partners in attendance. Internally, the team agreed that the project reached its goals in delivering a workable platform to demonstrate the concept of perceptive media.



Figure 43. The Perceptive Radio (v2, right hand side) with the Original Radio (v1) in the background.

Two points were considered to have exceeded the preliminary expectations of the project: firstly, the ease of use of the API was believed to allow for hassle free implementations of perceptive stories with little effort from content creators and secondly, the admin interface was praised for its simplicity and a good design solution for controlling the radio without the need of external hardware. Since the case redesign never happened, the team agreed on further funding to be sought from different external partners to finalise this aspect as well. With a workable platform for development of perceptive stories, the team discussed which further steps to be taken to gain insights from the content creators into how stories could be generated. Having previously successfully demonstrated a different CX project at Mozilla Festival in 2014, Ian suggested that MozFest 2015 would be an ideal opportunity for such a challenge to be tackled. This would also allow for demonstrating the radio and its capabilities and further engage in acquiring feedback. The final version of v2 can be seen in Figure 43.

MozFest 2015 Workshop

Whilst perceptive media enlarges the possibilities of the well-established radio broadcast when it comes to the creation process, it also demands a transference of the methods and methodologies employed by writers to happen; the 'traditional' ways of writing need to be adapted to the particularities of this media. To help with the acclimatisation of content producers, different aid tools have to be considered. However, the creativity process is unique to the artist⁵⁶ which requires the need for designing tools tailored to their personal preferences. Instead of providing a tool to each artist and independently evaluating them, our team started with the design of tools to facilitate discussions around the creation of narratives for this medium. As such, this part of the project considered a prototyping tool, manifested in the form of a workshop, during which the artist can acquire understanding of the particularities of the perceptive media. On the other hand, for us, as researchers, this workshop should have facilitated a better understanding of their creative process.

The workshop was implemented and successfully delivered in two different instances with two different communities. The first workshop ran with 25 master students on the Design Management course at Lancaster University. The trial allowed our team to gather valuable information and insights about its structure, which were subsequently used to tweak the final structure of the workshop with the overall aim of creating a greater impact on the target audience. In the following parts of this chapter I refer only to the second workshop as it represents the current form of the activity. The second workshop had a total of 24 participants and was run during the Mozilla Festival in London in 2015⁵⁷. The festival attracts a diverse range of participants, with different backgrounds and qualifications where journalists and fiction writers were identified amongst the attendees of the workshop.

It was held in an open space (Figure 44) and the participants were invited to take a seat at one of the existing tables. Each table was provided with different prototyping materials such as post-it notes, pencils, markers, sharpies and IDEAS Hexagons⁵⁸ (Figure 45). To keep the attendees involved

⁵⁶ By artist I am referring to any content creator.

⁵⁷ <https://2015.mozillafestival.org>

⁵⁸ Created as an alternative to a post-it note, the hexagon has a shape that allows easy connecting of ideas (as thought processes) as well as branching out ideas (similar to interactive stories). <http://goo.gl/ApIDXA>

and maximise collaboration, no more than 7 people were sat at a table, and groups of two or three were formed. The workshop was designed to run for an hour and was split into four different stages (The Creation Stage; The Improving Stage; The Adapting Stage; The Presentation Stage). Finally, in my role as the workshop facilitator, I kept track of the time spent as well as the evolution of each group throughout all stages.



Figure 44. The initial settings of the workshop.



Figure 45. IDEAS Hexagons.

The Creation Stage

Stage one focused on the creation of a story and familiarising the participants with the provided materials. To provide diversity as well as inspiration for the initial part of the story creation stage, each group was provided with three different Rory's Story Cubes⁵⁹. All groups were asked to roll the dice and create a short story based on the upward facing side of each die using any of the materials provided; the created story had to be written in sections on the provided hexagons. To encourage creativity, no limit was set for the number of hexagons to be used per story however, participants were asked to use at least one hexagon for each Rory's Story Cube. This allowed for the easy implementation of additional information in the upcoming stages. When each group seemed to have successfully created a story, I eased them into the second stage.

The Improving Stage

All groups from the same table were asked to merge their stories into a unified single narrative facilitating a greater participation in the finalisation of the story as well as a wide diversity of ideas across the stories. This stage allowed the participants to present their original ideas to the other groups (from the same table) and cumulatively agree on which parts to go into the final story. During this stage, the advantages of the hexagons were first seen as they provided for an easy way to break-up a story in different segments and merge them into the final narrative.

The Adaptive Stage

At the beginning of this third stage each table was provided with three 'perceptive dice' (Figure 46, left). The perceptive die consists of a regular wooden six faced die where each face is etched with a symbol depicting one of the sensors from the perceptive radio (Figure 46, right). It allows for a simple yet visual way of listing all the available sensors of the current perceptive radio and works well in conjunction with the Rory's Story Cubes used for the generation of the story.

⁵⁹ <https://www.storycubes.com/>



Figure 46. The 'Perceptive Dice' (left), with each of its faces explained (right).

Similar to the Creation Stage, each group was asked to shuffle and throw the dice however, these dice were used not in the creation of the story but in its adaptation. Based on the upward facing faces of the dice, the participants were asked to identify the 'adaptive' elements of the overall story arc that the perceptive radio could easily change whilst playing. In its entirety, this activity simulated the sensors interaction provided by the current capabilities of the radio.

The Presentation Stage

The final stage of the workshop asked the participants to describe their stories in front of the other groups whilst clearly detailing how the adaptable parts were integrated. At the end of each presentation, the presenting group was asked different questions detailing their vision on how the perceptive radio would play the created narrative.

Observations

Overall, the participants seemed to have enjoyed the workshop with each group creating a relatively detailed narrative around the provided cubes (Figure 47).



Figure 47. One of the stories created during the workshop.

More importantly, each cluster successfully identified adaptable elements of their narratives and different scenarios were presented during the last stage. All sensors seemed to have been easily pointed out by the participants as adaptable parts in their stories however, location, weather and time of day were amongst the easiest concepts to create variations for. Furthermore, during the workshop, the participants were actively engaged in discussions around their stories with just a few clarifying questions around the requirements of each stage or how a specific task could be achieved.

Discussion and Conclusions

The chapter introduces the concept of ‘perceptive media’, a new type of broadcast media, which makes use of contextual information provided through a range of different physical and digital sensors, to create a more

engaging experience for the listeners by simply varying some of the ambient parts of the narrative. To demonstrate this concept a 'perceptive radio' was developed. Through the use of a revised fable, the radio delivers an adapted narrative based on the location of the play, number of people in the room, time of day and weather data collected through the available sensors.

There are two main avenues which this project explored: firstly, the creation of a platform which demonstrates the concept of perceptive media and secondly, an investigation into how a perceptive story could actually be created. The platform in itself, aimed for a simplistic realisation, one which exposes the available sensors and, through the use of a fully developed API, facilitates the creation of perceptive stories. Without the API, this work would have had little impact as whilst the project is demonstrable, it would have not had any room for exploration.

Solely looking at the content creation, writing a story for radio is arguably very similar to writing one for a book in that situations have to be described as there is no visual information available to the listener. Furthermore, because of the rigidity of the medium, the writer does not have to consider any of the contextual information about the listener; thus, whether the broadcast is listened to at noon or at midnight, during the holidays on a beach or just after finishing the working day while preparing dinner, does not impact the writer in any way. On the other hand, perceptive media provides the writer with a range of information about the context in which the listener is consuming the media, which allows the content to be dynamically adapted. The sensors and sensing technologies available in the perceptive radio permit the writer to create a deeper connection with the listeners through the written narratives. Tapping into the context the listeners are experiencing can be achieved through this connection within the immediate surrounding of the listener, potentially leading to the creation of more meaningful narratives and experiences.

Whilst the written narrative constantly draws inspiration, benefits, and evolves from the technological advances, the way content creators think about the development of the new content is rarely considered by the designers of these technical innovations. Due to the unique nature of the perceptive media, shifting the current perception of writing 'classical' narratives towards writing 'perceptive' ones require content providers to adapt their existing practices.

This chapter presented a workshop format as the starting point for promoting an understanding of the development of 'perceptive narratives' and to create a discourse around supporting the existing creative practices of content producers. The perceptive dice, a simple and minimalistic yet powerful tool, allowed the participants to think creatively about the adaptive parts of the narrative and how stories could be made more engaging based on the current technological advances.

To further encourage creative writers to question and discuss perceptive media, it would be desired for the BBC R&D team to borrow ideas and solutions from the presented workshop and run their own creative engagement activities with content creators from the BBC at MediaCityUK. It is my belief that this would allow for an even deeper understanding of what tools need to be designed to help with the transition to the new type of media. Based on the outcomes from these workshops, a simple drag-and-drop interface, similar to the popular coding program Scratch, where the writer would be allowed to create a narrative by writing parts of the story and integrating the required sensors by dragging and dropping them into the narrative, could be designed. Such tools should facilitate an easier and more pleasant experience when creating 'perceptive narratives'.

Lastly, I believe that HCI researchers, and for that matter designers as well, should not only consider the use of new technologies but how they will allow content providers to adapt their practices to new technologies. If the general trend from larger companies is to push their technical advancements onto the masses, sometimes with little regards to the implications of their actions, I believe us, as academics, should think twice about how certain technologies might affect us. In this particular case focusing directly on the content providers and how their general practice will be affected if they were to only create stories for such a type of media.

Physical Playlist

The Physical Playlist project re-imagines the mix-tape for digital content as physical customisable jewellery that can once again embody values not generally attributed to digital content. Whilst memory and meaning can be indirectly embedded into any object either through personalisation or simple mental association of the object to a place, this project is different from the memory boxes explored by Frohlich & Murphy (Frohlich and Murphy, 2000) or Stevens (Stevens et al., 2003), as it portrays the time and effort the creator took to personalise the gift with the overall purpose of making it more evocative than a purely digital playlist. Therefore, in this chapter I expand on the design considerations, paths and decisions which were taken to explore such an endeavour.

The Constructed Bits

By the end of the project, we constructed two different parts: a piece of jewellery, a physical sharable bracelet embedded with digital content and, a player, a reader capable of understanding the information stored on the bracelet. It is important to note here that these objects emerged through the researching of the initial idea and that their current format is due to the constant iterative approach of developing and testing different avenues which were found useful in relation to the original idea. Whilst the idea did not change, the outcomes might have been different if other decisions were taken.

Connection to The Digital Public Space

Whilst the project direct area of research was coming out of the desire to re-enact the mix-tape, the project also looked as a very good contender for an IoT object (or platform); albeit, not the most typical one! The tendency for an object to be classed as an IoT one seems to be revolving around two main possibilities: either the object is connected and controllable over the Internet, such as the case of the kettle, the fridge, the lights, the thermostat etc., or, it is a sensor or a multitude of sensors, used to derive ‘understanding’ of human practices. Nevertheless, if the sharing of information stands at the forefront of the IoT definition (Gubbi et al., 2013, p. 1), the bracelet should be considered

as an IoT device. In this respect, it was worth investigating as it would have contributed to a broader understanding of The Digital Public Space.

The Team

Compared to other CX projects, the composition of this team was simpler and was comprised by doctoral candidate Joel Porter in his capacity as project manager; lead developer Dr. Daniel Burnett, responsible for building the required infrastructure as well as the design and development of the platform, myself and Prof. Paul Coulton, researcher and project supervisor. Our external partner for this project was the Research & Development North Lab at the BBC, in MediaCityUK, represented by senior “firestarter” producer Ian Forrester. My roles shifted from researcher, focusing on interaction and experience, to Android developer, fully responsible for the design, development and implementation of the mobile applications, to artefact designer where, together with Dr. Burnett, designed and developed the artefact (Figure 48).

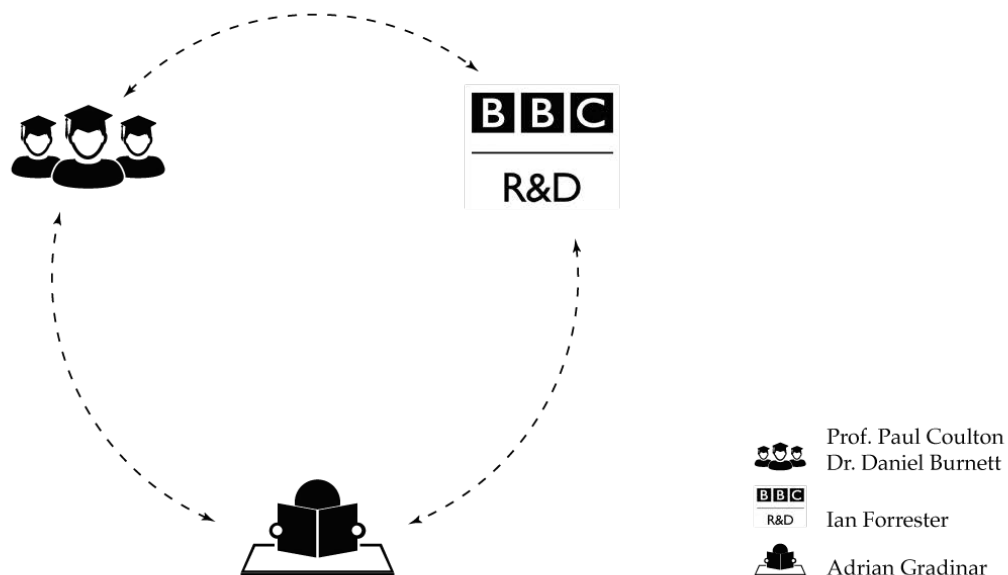


Figure 48. Physical Playlist project team.

Stop. Play. Record!

In 1963, a revolution in the music industry happened when Philips introduced their first audio compact cassette at Berlin Radio Show⁶⁰. This small plastic enclosure housed a 30 or 45-minute magnetic tape which allowed the recording of analogue speech but was mostly used by the music industry as a financial gain method through the recording and selling of artists' albums. With the tape players taking over vinyl record players and becoming more affordable and popular in people's homes, a social phenomenon started as well: the mix-tape. Probably one of the first most inexpensive ways of recording music of those times, the mix-tape allowed for the creation of personalised playlists in the comfort of one's house. Due to their relative small size, tapes were easily carried around inside one's pocket and they slowly became social objects which people would give as gifts or carry with them to social events. It took time and effort to create 'the perfect summer collection' or 'this year's Christmas tape' often longer than it took to listen to it, nevertheless, there was an emotional and physical impact which digital shared content often lacks. This connection comes from the fact that objects or artefacts often symbolise something more than their intrinsic value which is often preserved over the years. Our personal associations with objects often gain subjective meaning based on the memories we hold of them, although such memories are generally hidden and intangible (Csikszentmihalyi and Halton, 1981). With the advent of the digital era, where anything and everything is accessed through an online connection, this meaning is slowly fading away; the time it takes to curate a playlist is massively diminished, averaging nine playlists created each second for online streaming services such as Spotify. Sadly, the mark it leaves behind onto one's experience becomes suddenly difficult to acknowledge.

The Initial Idea

The project initial idea arose from one of the first workshops held by the CX in its first year. As previously mentioned, I only joined the CX in its second year thus, the explanations found only in this section are based on the collective knowledge acquired from the above-mentioned team. The

⁶⁰ http://vintagecassettes.com/_history/history.htm

workshop brought together people from the industry, academia and the creative sector under the umbrella of “Making the Digital Physical” where they would explore ideas and concepts around the physicality of the digital medium and how digital elements and experiences could be better shaped to form more meaningful physical objects or experiences. Among other findings, the workshop revealed the underlying lack of personal engagement, meaning and personalisation around the practices of sharing digital media, therefore, the idea of physically sharing digital content came to life; a physical object to store a selection of digital media tracks that could easily be shared with others. The team loved this idea so a decision was made to have an initial meeting where the potential of achieving this physical playlist was prototyped through an ideation phase.

The first discussed topic revolved around the appropriate means to embed digital content into a physical object. The obvious solution to this challenge was the use of Near Field Communications (NFC) tags since they are relatively cheap and available in different formats and sizes. Being also easy to program over a mobile phone incorporating an NFC reader (such as an Android phone), this was seen as the best and quickest option. The meeting revealed other topics, some of which are listed below, which were the basis of the design guidelines used to later on develop the artefact:

1. The need for the object to have a physical presence.
2. The object should easily show, in a physical manner, how much it covered and is still left to be played from the playlist.
3. Whatever shape of format the playlist would take, it should be easily customisable. This came from a desire of keeping close to the nature of a digital playlist.
4. The playlist should only be played in the order it was envisioned by the creator; decision which was seeking the design of the playlist to be closer to that of a physical mix-tape;
5. The total number of interactions should be kept to a minimum, ideally just turning on/off the player.

Similarly, to all other CX projects, it was deemed that the code for the project should be made publicly available so that any other parties wanting to extend it could effortlessly do so. Due to the bureaucratic ways in which The BBC work, it took considerable time for the paperwork required by the CX to be signed off. By the time this happened, I joined the team as well. The next sections are explained from this position.

Design Guidelines

Throughout the ideation phase, different objectives were identified; firstly, and most importantly, the conversations held always seemed to identify the need for two independent devices, a reading mechanism and a container for digital tracks which would sit freely from the reader. This seems to have been the natural response to the overall arching purpose of the project in trying to replicate the physical gesture of sharing a mix-tape thus, an emphasis fell on the playlist to take a form which could be carried around so that it could ultimately be gifted as desired. It was quickly decided to focus on two different objects:

1. A physical player, which would embed the reading functionality of the playlist, in similar ways to an old cassette deck player. This was envisioned to be standing on a desk or table, where the listener could stop by, attach the playlist and enjoy the creation. Four of these options are visually⁶¹ shown and explained in this section.
2. A physical playlist - an object which can be attached to the player. It was highlighted that it would be more convenient if the playlist would take the form of a wearable object, so that it would be easier to carry around.

⁶¹ I have drawn these figures to better visualise the discussed options as they happened since they were never part of the team's discussions.

The Fruit Bowl

The Fruit Bowl idea explored the potential of a physical player taking the shape of a fruit bowl which would recognise any objects 'dropped in', in any form, size or arrangement no matter of their placement (Figure 49).

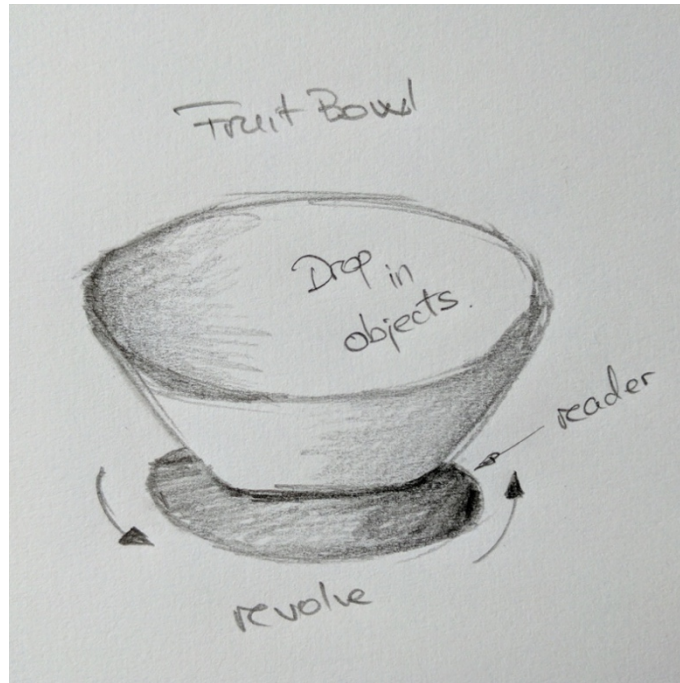


Figure 49. The Fruit Bowl Player.

The player would revolve around itself such that it would identify the position of the track within the playlist. This idea seemed to have the biggest echo within the team, having been seen as one of the most elegant solution. Potential scenarios of people visiting friends and 'dropping' their playlists into their friend's player (similar to the drop of the keys when getting back home or the dropping of loose change into a jar) was seen as both a different and novel interaction however, from a technical stance, it brought some challenges. On one hand, it was difficult to guarantee the desired way of playing an object which sits loosely into a bowl even if the mechanism of reading was to be designed to revolve around the circular shape of the bowl. A potential solution to this challenge would have been to have the reader sit above the bowl, such that the reading of the playlist happens during the drop. Unfortunately, whilst the latter solution would have resulted in a fluid read of the playlist, it was believed that due to the short reading distance of the NFC

reader, the potential for unintentional skip of a track might be unavoidable. The same holds true for the loose object in the bowl, as different NFC tags could have ended up in being one on top of each other and thus not read by the player.

The Scanner

An old computer scanner mechanism was envisioned which would horizontally scan an object that held digital tracks (Figure 50). The position of the scanner within the given area would react to the current position within the playlist. The scanner was perceived as a fast and easy way of testing the physical playlist since the mechanism of moving was already incorporated, however, it was felt that it would diminish the potential for customisation and further personalisation of the player.

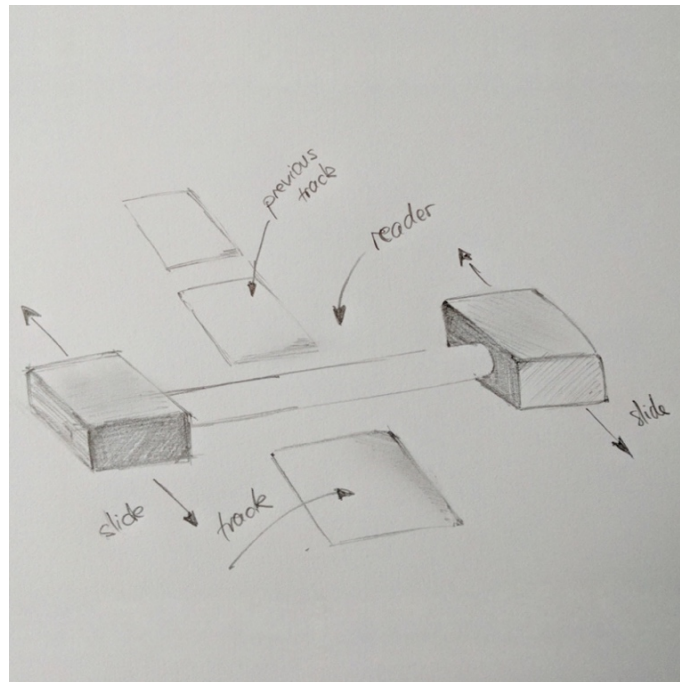


Figure 50. The Scanner Player.

The Vinyl Record

This idea explored the potential of an object to be situated on a vinyl record where the arm of the record player would move across the record and translate the read information into playable tracks (Figure 51). The vinyl record player confronted the team with a different design challenge: a gloomy

concern was raised about the implementation of the reading mechanism onto the arm especially how it could cope with identifying each part of the playlist due to its relative small size. It was envisioned that an additional structure would have been required to properly sustain the arm and the NFC reader whilst moving across the playlist which would have defeated the purpose of using the record player in the first place. Alternatively, the record player could have housed the reading mechanism with the playlist being located onto the arm. This was also believed to be technically challenging as it implied designing a system where the movement of the arm had to be synchronous to the movement of the record player.

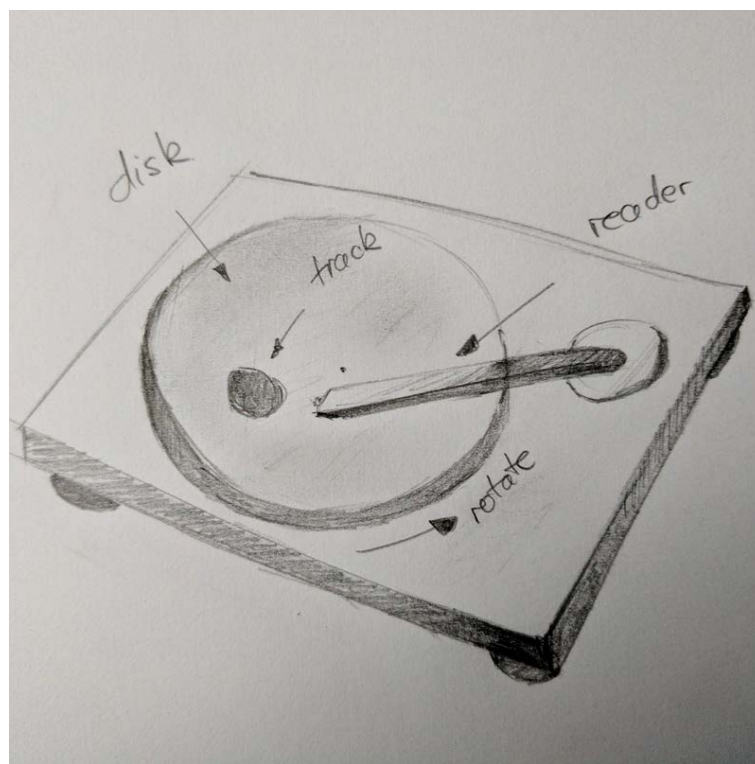


Figure 51. The Vinyl Player.

The Vertical Player

This idea explored the vertical movement of a platform, a reader, which would decipher the information located on a different object, the playlist (Figure 52). As the player moves up and down it translates the acquired information into a playable element and finally a position within the playlist. Alternatively, the player could also sit horizontally, with the playlist object

being situated above or underneath the reader. The vertical movement of the reader was seen as the favourite avenue to take due to the simplicity of the design which would easily sit within the given time frame. This solution would allow the playlist to be enjoyed in an in-order manner which would further emphasise the similarities between the physical playlist and the cassette player. The design was believed to allow for an agile method of development and testing of the prototype whilst not compromising shape, function or design of the final artefact. Therefore, it was the one the team decided to pursue.

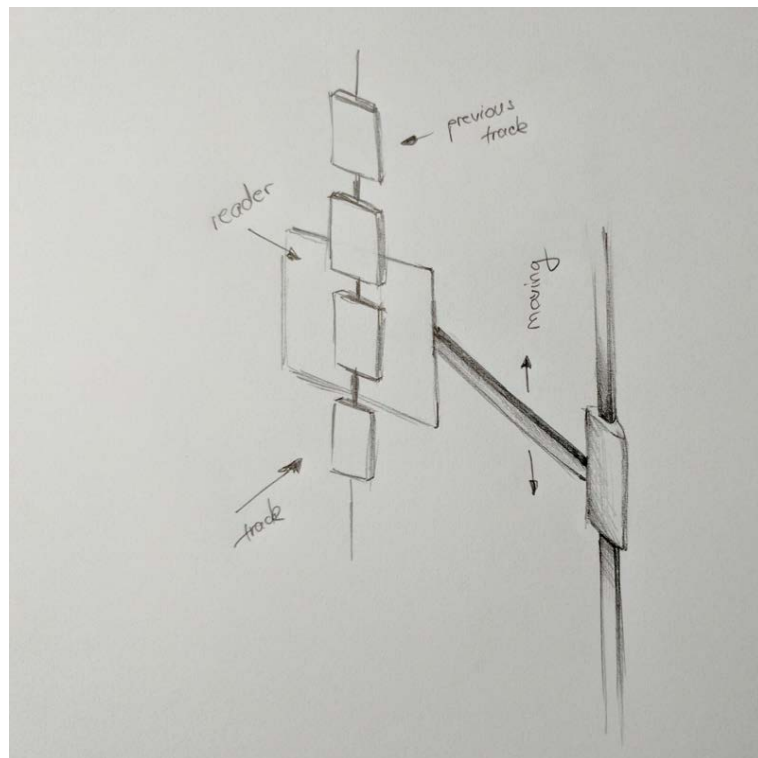


Figure 52. The Vertical Player.

The Playlist

Upon deciding for a wearable object to represent the playlist, we started to investigate different options related to what and how common everyday objects are worn by people. Clothing articles were dismissed since they occupy a relative large area and would have presented more challenges to be overcome compared to the overall time available on the project. As such, for practical considerations, we were only left with articles which could be worn

on wrists, fingers or around one's neck. Rings were easily dismissed since their relative small size was seen as working against the extensibility requirement of the playlist. Necklaces were also discussed and removed from thought since they were seen as quite bulky, thus occupying a large area and potentially presenting multiple issues relating to the player movements whilst playing the tracks. Augmenting an already existing watch strap was seen as an interesting idea unfortunately, it was also dismissed since not all people wear watches. Furthermore, even if some did, they might not want to change the design of the strap, or the strap itself would not be suitable for augmentation. Thus, considering the time constraints on the project, the only viable solution was that of a bracelet. Upon further consideration, it was agreed that ultimately, the bracelet should resemble as close as possible to a piece of jewellery, so it could be also worn as a symbol of pride as well as a conversation starter.

First Prototype

The Player

A rough sketch was drawn to better portray the working mechanism, having a metal rod sat at the centre of the design with an attached platform, as seen in Figure 53.



Figure 53. The Original Sketch.

The platform would house the NFC reader and allow for the scan of NFC tags. Different cogs powered by a small motor would permit the rotation of the rod thus facilitating the platform to be raised and lowered as desired. A nut was used on the platform, in conjunction with two clear Perspex tubes, which would prevent a lateral rotation of the platform whilst facilitating a smooth up-and-down movement. To stop the whole mechanism from lateral shaking, a top static platform was also added. The cog designed to rotate the rod was attached to the metal rod through the use of a locking nut which enabled the rotation of the rod when the motor was turning. At this point in the design, we were not interested in how the NFC reader were to be attached to the moving platform since we believed there is a plethora of solutions at our disposal. As such, during the first in-house trials, it was secured with insulating tape.

The bottom part of the artefact where the circuitry was expected to be housed, followed a laser-cut tabbed design box (Figure 54), which we sourced from an online repository and adapted to the desired size. All these parts were secured together through the use of 30 mm bolts and respective nuts.

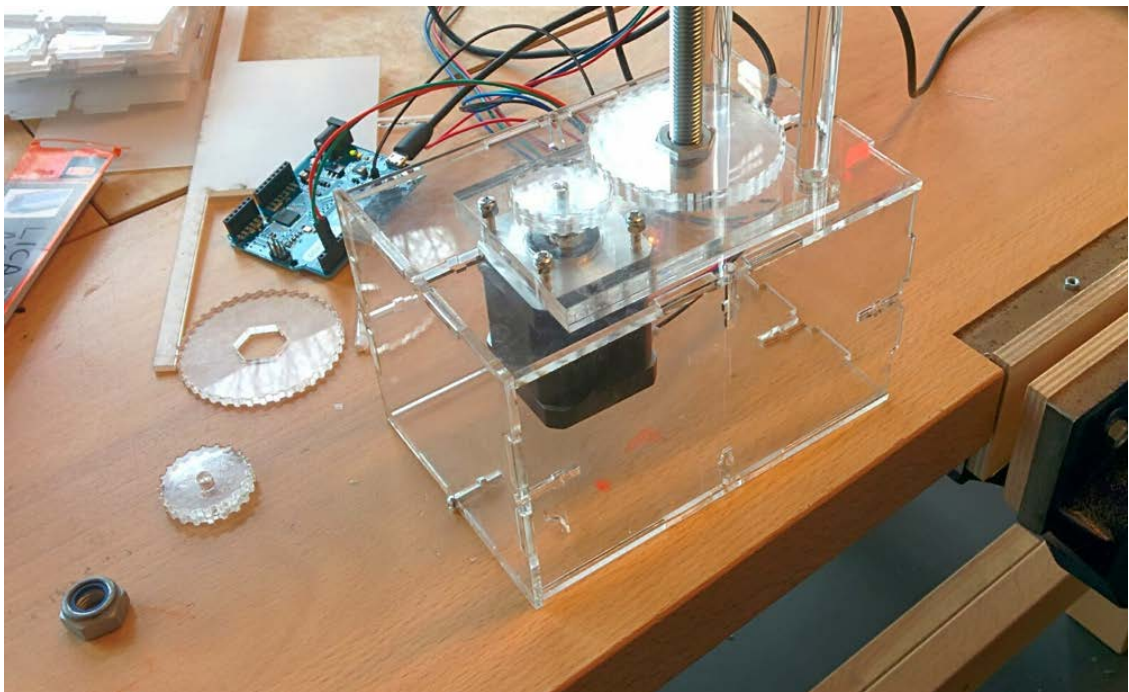


Figure 54. The First Prototype.

The chosen motor was a stepper one, which was connected to an Arduino board. Control software was written which allowed for different rotating speeds to be tested. When the platform was moving, we observed we had not considered how to stop the mechanism when it reached either the top or the bottom of the rod. The simplest solution was that of using limit switches. Upon the platform hitting the switch, the Arduino board would inverse the rotation of the motor; a simple and elegant solution. Since this was the first stage of prototyping, we used two bulky switches we had at hand. These were later on replaced with finer one which were seen as more pleasing to the eye.

Having completed the rotating mechanism, we focused on the reading capabilities of the player. Discussions were held around using a custom build antenna but were quickly disregarded due to potential size constraints and unforeseen design challenges. As such, we used an NFC breakout board, which is of a relative small factor size, self-containing all required parts and facilitating the read of a multitude of tags. This was a good solution since it allowed for a wider range of tags to be used thus not limiting the design of the bracelet.

The next step of this process involved the connection of the NFC reader to a RaspberryPi. The RaspberryPi was seen as the best solution due to its small size and Internet connection. Since the Arduino has the capacity to output information via its Serial port at a certain baud rate, we decided to create our own protocol for sending the data read by the NFC board to the RaspberryPi system. This would also overcome any potential issues which might have appeared due to the serial communication being prone to errors. The simplest solution we found was to enclose the required information by Chevrons "<" and ">" thus disregarding any other received information.

Lastly, we were left with deciding on which type of media the player should play. It was agreed that in order to cover both video and audio formats, whilst not ignoring our partner and their proprietary media outputs, the list of providers would feature: YouTube and BBC iPlayer videos as well as Spotify audio tracks. Dr Daniel Burnett had already developed a Spotify Player for the RaspberryPi for a previous project he worked on, so we decided to re-use his base code. Additional software was sourced from GitHub

libraries such as Youtube-dl⁶² and get-iPlayer⁶³. We adapted our communication protocol to take into consideration which library the RaspberryPi software should fire when a tag is read, by adding an identifier within the chevrons. As such, the final communication protocol had the following design:

<x, unique_identifier> where

1. x - chosen letter for the provider. i - for iPlayer videos; s - for Spotify audio tracks; y - for YouTube videos;
2. unique_identifier - the URI (Uniform Resource Identifier) associated with the audio or video track.

Example - <y, NMNgbISmF4I> which points to an Aerosmith YouTube video⁶⁴.

At this stage, the first prototype was built, thus we focused towards the design of a bracelet prototype as well as a mobile application to allow for the writing of tags following newly designed communication protocol. Whilst there were still some amendments to be made to the player, we agreed on having another meeting with the whole team once the other parts are also in place, so we can collaboratively decide on the next steps.

The Bracelet

Final considerations were taken around the shape and size of the NFC tags to be incorporated into the bracelet. At the moment of the research, 14 mm laundry tags were agreed on, as they were small enough to be easily engulfed into any shape and size band. They also allowed for the wearer to be less concerned about the wear and tear of the tags, since the tags were designed to be washed. To test this idea, simple fabric bracelets (Figure 55) were chosen and 3D in-house designed holders (Figure 56) were created to hold the tags and be attached to the bracelets.

⁶² <https://rg3.github.io/youtube-dl/>

⁶³ https://github.com/get-iplayer/get_iplayer

⁶⁴ <https://www.youtube.com/watch?v=NMNgbISmF4I>



Figure 55. The first bracelet.

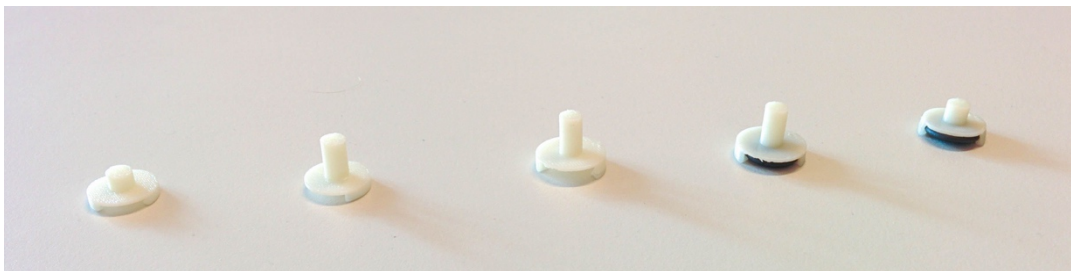


Figure 56. The first round of 3D holders.

The Mobile Application

For the first round of prototyping, a simple mobile application was written to test the writing process of the tags (Figure 57). A simple input box allowed the user to enter a search parameter. To draw similarities between this project and the original mix-tape, we agreed to add a cassette image and locate the search box on top of the cassette's label, in a similar fashion to how one would write the contents of the tape onto the physical cassette. The three media providers were selectable by tapping the associated button located at the bottom of the mobile application and identified by their own logos. Upon this process being completed, the mobile application would then navigate the

user to the next screen, which displayed a list of possibilities based on the searched criteria. The last step involved the user selecting the desired list element by tapping it. A pop-up would then invite the user to place the tag underneath the mobile, to securely store the URI for the selected track onto the tag, following the requirements of our previously designed protocol.

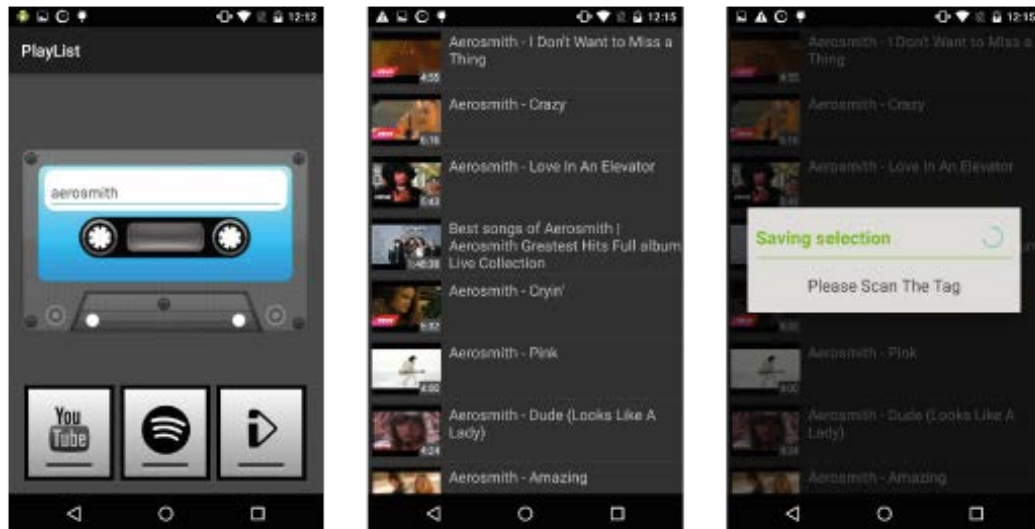


Figure 57. The first mobile application design.

Final Project Evaluation Meeting

Having completed the very first stage of prototyping, the team met to discuss on the evolution of the project and the future steps to be taken. Overall, the project was seen as moving ahead on the desired path, with an overall positive look from the BBC's team however, there was still much to amend to bring all pieces together to suit an in-the-wild testing phase.

Whilst the first enclosure for the player was satisfactory to hold the reading mechanism, the team pointed out that because there was only one screw located on the bottom of the box, it had a back-to-front rocking movement, which should be amended. Further, the team believed it would be better to house all electronic parts into the same container; the bottom part of the reader was suggested as being probably the best place for this. It was also pointed out, that the cabling for the push-buttons should be tighten up, to stop potential handling or moving misuses. Next, we realised we needed a support to hold the bracelet. Whilst testing from one's wrist made sense, in

case of a finished playlist, it was considered that a vertical stand would work best. This would allow for an even constant reading of the NFC reader thus minimising distance related reading issues. It was also agreed that the stand should be freely moved and not fixed to the reading mechanism, to facilitate a smooth experience placing and removing of the bracelet. The last point made in respect to the player, found the team acknowledging the need for a suitable enclosure to be designed, one which would be more appropriate to stand as an exhibit, not just a simple prototype. As such, we agreed to invite a 3D designer to join the group whilst we were focusing on fine-tuning the current design.

In respect to the written software, the team agreed the player would need an interface to inform the user of what action it was performing, so that the user was informed when tracks were being buffered or played. Regarding the extensibility of the current software, it was pointed out that being able to send written commands to the player via the serial port, would be a useful tool, even if only for testing purposes. Commands such as 'read', 'play', 'pause', and 'reverse' were sought as desirable and should be investigated for their feasibility. Next, the team expressed a desire to have an automatic process for starting up, to minimise the total number of interactions when the player was to be set up in a new environment. Finally, the mobile application was seen as satisfactory for the time being and we agreed not to modify it.

Second Prototype

The second round of prototyping was based on the comments and notes made during the last meeting. To address the balancing issues discovered on the first prototype, the second version used a distribution of three screws on each side. They acted like small feet on which the whole device was resting. Having done this, we focused on the redesign of the case so we could fit all prototyping boards inside. It was agreed that for simplicity as well as keeping the new housing to a relative small size, the RaspberryPi would be sat outside. The new player's housing was built of 5 mm yellow Perspex, with the NFC platform being replaced by a similar one with a cog like design. For the gears and the platforms, we used 3 mm black Perspex sheets (Figure 58).

The cables were shrink wrapped and passed through the Perspex tubes with one tube housing the wires for the top push button whilst the other one,

for the NFC reader. For the latter, we cut the wires to a length which would not interfere with the movement of the platform.

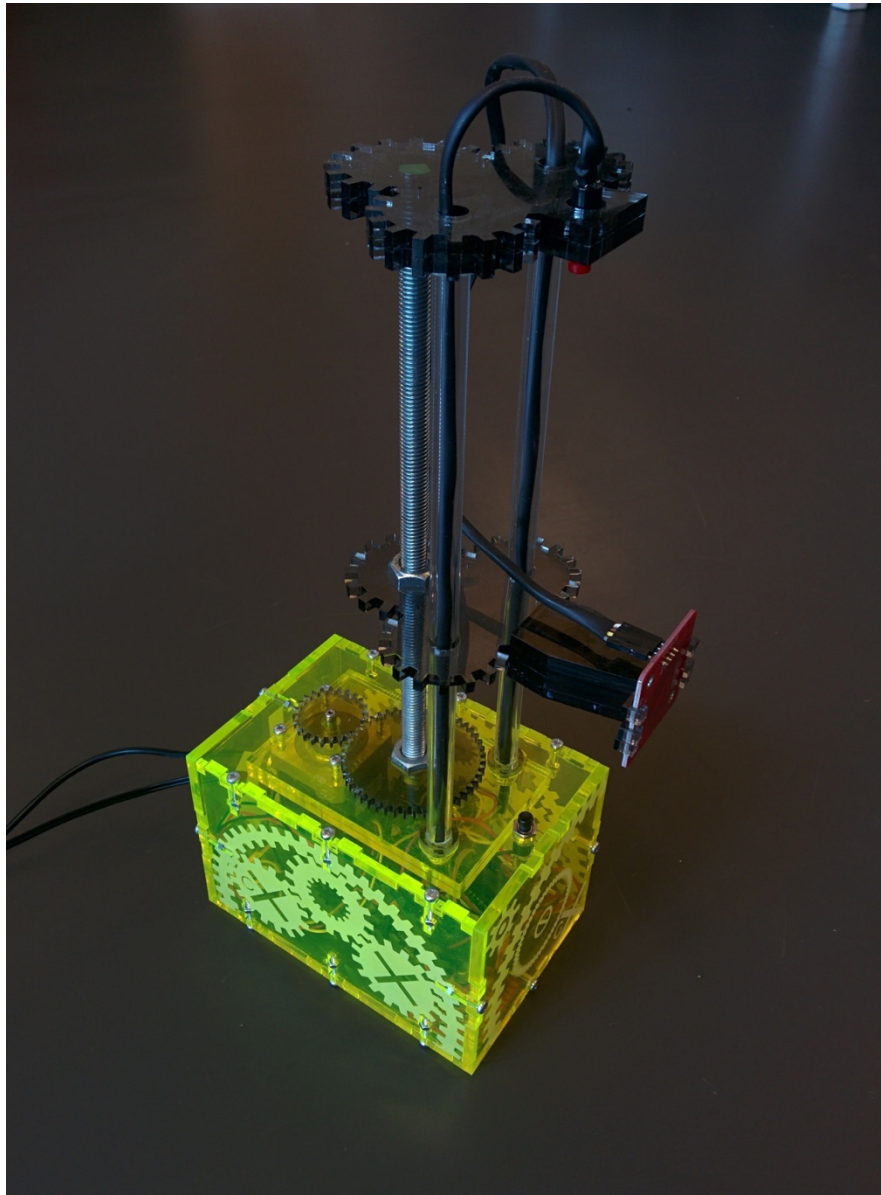


Figure 58. The second prototype.

In order to allow for the software to respond to different commands, the Arduino base code had to be changed. This meant creating a protocol to allow for messages to be passed from the RaspberryPi, to the Arduino code which would then interpret and finally act upon the received commands. After some testing, we agreed on the following functionality:

1. Start - Wherever the player might be positioned on the rod, this command sent it back to the top and slowly move down until a track is found.
2. Stop - Stop the movement of the motor and wait until another command is received.
3. Fast Forward - Upon receiving this command, the motor was set to accelerate its rotation speed and stop at the very bottom of the rod (upon hitting the push button).
4. Rewind - The opposite of the previous function, this would send the platform to the very top. In order to be closer to the functionality of a cassette player, we calculated the rewind time, from the bottom to the top of the rod, to match that of a 90-min cassette player rewind time. Joel Porter was the only one who still had a cassette player, so our calculations were based on his audio deck.
5. Scan - Scan a tag in the current position.
6. Speed - This function would set the rotational speed of the motor to the number received as a parameter.
7. Delay - This command would delay the movement of the platform by a previously set number of seconds.

Following an in-house meeting, the CX team decided to create a visual interface which would facilitate the user knowing the actions of the player. A quick mock-up was drawn to show an initial idea which was then used as a base for drawing up the GUI interface (Figure 59). In a similar fashion to the mobile app, the interface showed an audio cassette, where its label was depicting the action of the player.

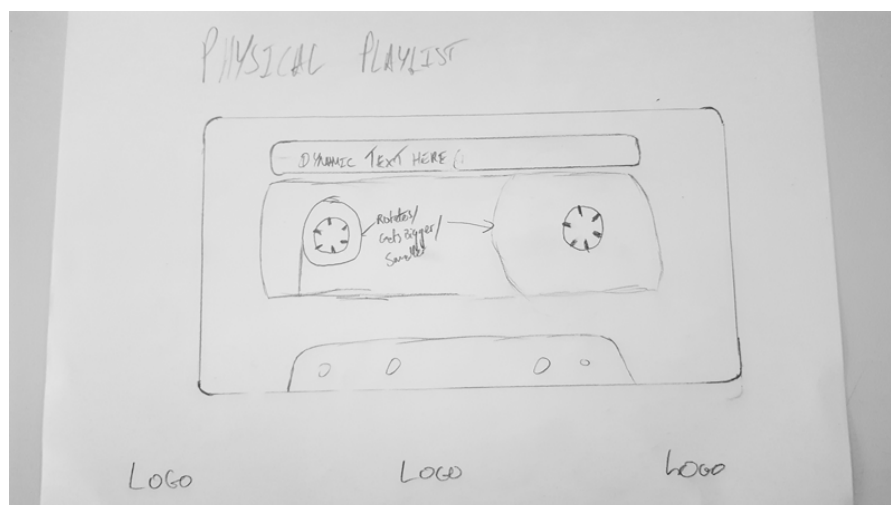


Figure 59. The first sketch of the GUI interface.

Furthermore, to add more authenticity to the virtual cassette, we agreed on investigating the possibility of moving the reels of the cassette, from left to right and backwards, mimicking the movements of the NFC platform. Two different methods were considered and tested. The first one involved the creation of a high-resolution GIF (animated image format). Unfortunately, despite the different resolutions tested, the output on the screen was always jagged, which we believed it was the result of a low-resolution graphics card on the RaspberryPi. The second approach involved having a looping movie playing in the background. This method also failed because it raised the CPU levels too high thus slowing down the overall application to a halt. Therefore, it was agreed the best and only sustainable approach to be one where a static image was used.

MozFest Demonstration

We took the current state of the project to the Mozilla Festival 2014 which was held in London. The purpose of the demonstration was to engage the audience and gain any feedback they would like to share. To do so, we designed the workshop around two exercises: one would seek to engage the participants in their sharing habits whilst the other one would allow them to create their own bracelets. For the second exercise, we gave them our laser cut bracelets and tags, which we had at hand. A total of 24 participants engaged with both exercises allowing us to draw insights into the creation process, and implicitly its limitations, as well as to gain more insights into what information participants are willing to share. An interesting finding revealed that the physical nature of the bracelet invited people to share more personal information compared to an online social platform (such as Facebook, Twitter). Furthermore, even if the young audience might not have been familiar with the concept of mix-tapes, they thoroughly enjoyed the slowness of the prototype, especially its constraints on not allowing a track to be skipped; they romanticised about the idea of making their friends listening to the whole compilation in the way it was designed. The older participants, were found to be exactly at the opposite end, being keen on rushing through and skipping to the end of the playlist. The slowness of the technology acted more as a provocation and the discussion held seemed to be revolving around how media is consumed today.

Final evaluation meeting

The final project evaluation meeting took place on the BBC's premises with all project's members in attendance. We are also fortunate to have Jasmine Cox,⁶⁵ designer and producer in the Future Experience team at R&D, who's user-experience expertise and feedback contributed to the overall value of the project.

The overall prototype and project were seen as a success with all key points being met. The physical player was still in a prototype version with the external designer working on a different enclosure for the mechanism. As such, Prof. Paul Coulton suggested applying for a different grant, where an external company could be paid to produce the artefact in the new form. Whilst the new enclosure was envisioned to be costly, it was also believed that such an avenue was worth exploring since the displaying of the prototype in an exhibition space should have a greater impact on the audience. The bracelets were seen as meeting the needed requirements for wearability and customisation however, they were still in a prototyping phase and more was possible. Similar to the player, a different grant could facilitate the employment of an external company to work on more pleasing ideas. In terms of the functionality, the player was playing the tracks in the envisioned order of the creator since the overall design of the player assures it. Furthermore, it also minimised the interactions of the user, with the addition of the push switches which were seen as 'a nice touch'.

Master's Workshop

To gain even more knowledge into the project's ability to demonstrate the ideas which led to its creation, we handed the player and the mobile app to a master's student, who ran a 3-hour long workshop with her classmates. The project was given as a whole package, which led her to believe it was ready for production in the current state, shape and format. For clarification, from the CX board's perspective, the project was reaching its end however, it was still in a prototyping phase.

The results of the workshop were shared with the team and they showed promise in that the participants were able to design and create their bespoke

⁶⁵ <http://www.bbc.co.uk/rd/people/jasmine-cox>

bracelets and playlists (Figure 60). According to the student's findings, the participants took care and attention into the customisation of the playlists and the decoration of individual tag holders. Furthermore, they seemed to have already decided on the receiver of their designs.



Figure 60. Some of the designed bracelets.

The project was not introduced by explaining its uses instead, the students were asked to give a short description of what the player was. From all the participants, only one correctly identified the prototype as a player with others given responses such as 'electric generator' or 'printer' (Figure 61). Considering the project could be seen as unique on the market, it is understandable that prior knowledge could not be applied thus, its perceived affordances to be misleading to new users. Furthermore, given how the project was introduced to the participants and having no interface per se, it becomes clear how it can be perceived as a different object, with people trying out ideas of its uses. However, once the project was properly explained, the participants were able to playback their playlists and create new ones when asked.



Figure 61. The participants investigating the player.

Personally, and based on the findings from the MozFest trial, I do not find surprising that a prototype which shows the inner mechanism in visible sight, does not portray its needed affordances. As a comparison, we can imagine a piano with no cover for the keys in a shape not resembling that of a piano, showing all its internal wirings; whilst still functional, it is hard to imagine many would understand its purpose. The lesson to be learn from this is simple: either the project is presented as a prototype and its functionality properly explained or, the mechanism is hidden revealing only the final product; in this case, an appropriate enclosure with the bracelet hanging down in place.

Final Design

As previously pointed out, both the bracelets and the design of the player were sourced out to external partners with Joel Porter taking the lead on finding an appropriate partner to design the jewellery bracelets, whilst Prof. Paul Coulton suggested another PhD student with product design background for the creation of a 3D player model enclosure. Despite the final designs coming from these additional partners, the process was still a

collaboration with comments and feedback being made from our team, as different ideas were presented.

The final design of the player housed the last iteration of the internal mechanism (Figure 62). This version followed closely the second version but removed all the Perspex layers in favour of 3D in-house designed and printed models. New cogs, NFC support platform, box and top platform were designed using Autodesk Fusion 360⁶⁶ which meant that the area occupied by the new mechanism became smaller and easier to house.

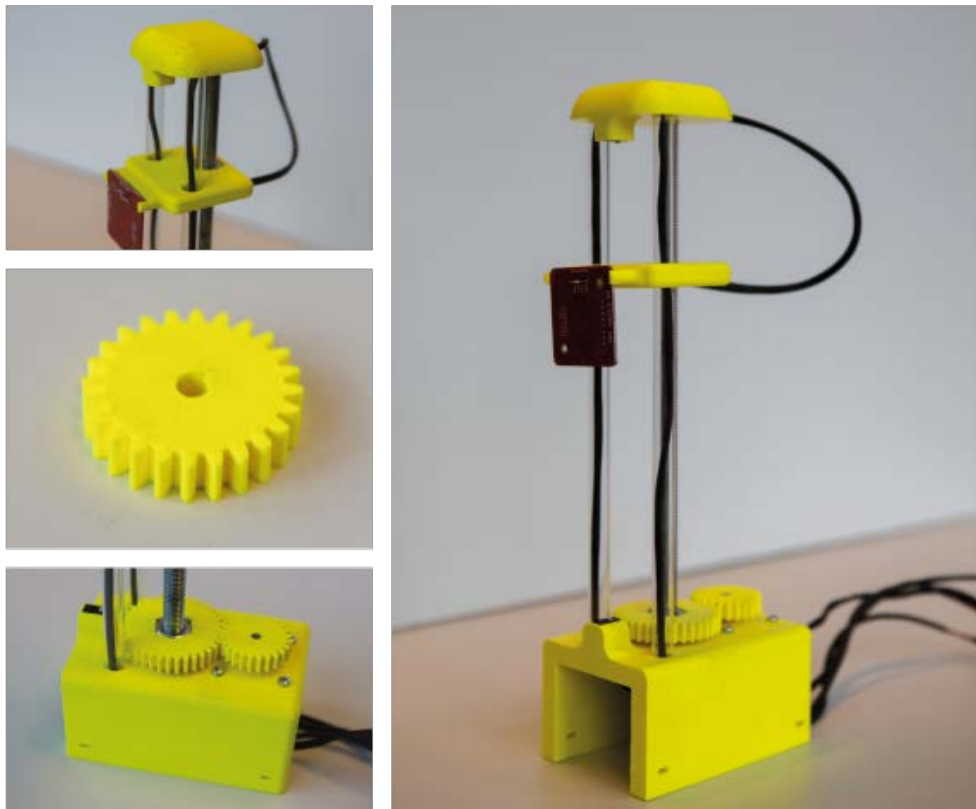


Figure 62. The last mechanism design for the proprietary 3D modelled housing.

For the housing, we worked iteratively with the presented model, 3D printing smaller versions of the prototype and test for robustness, functionality, stability and overall design. It is through this process we realised some of the fallbacks for the virtual design. The first presented version, whilst portraying the desired look of a new type of player, had one massive downside: stability. Because of its ovoidal shape (Figure 63) and

⁶⁶ <https://www.autodesk.com/products/fusion-360/overview>

small base relative to its overall height, upon pushing it a bit harder, would always find the player swing back and then forth until landing on its front side.

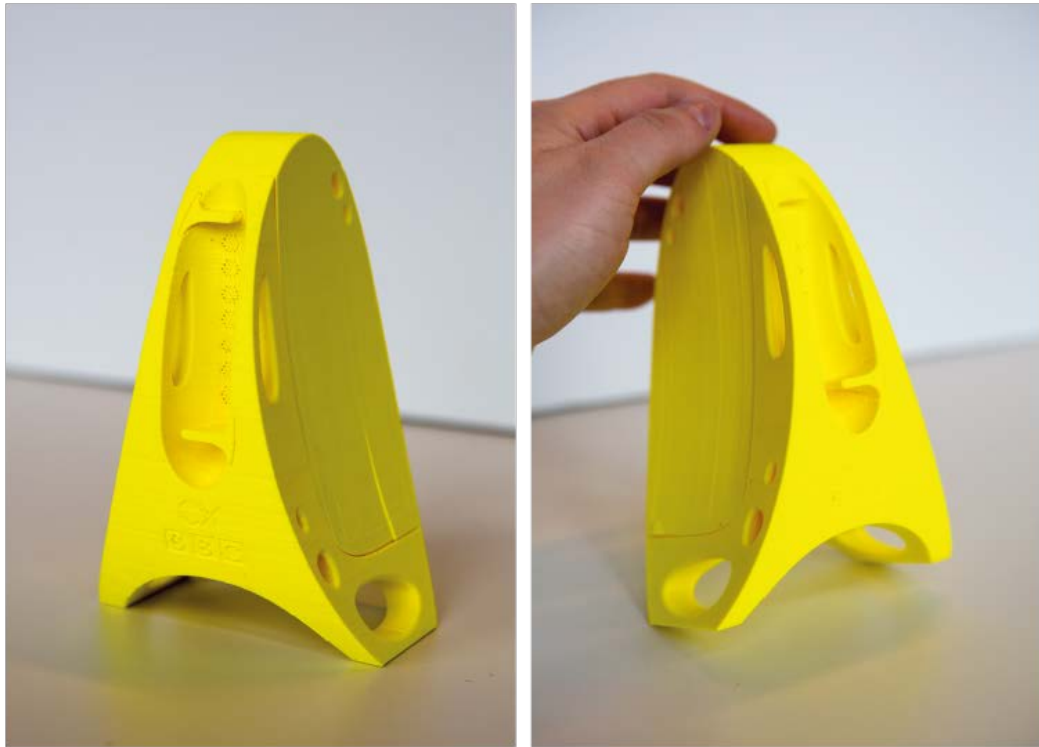


Figure 63. The first iteration of the 3D housing model.

This issue was easily corrected by modifying the base of the player by adding a new lip to the back feet of the enclosure so that it would allow for more stability. Another modification which was done from one version to another involved the removal of the support for the bracelets. In the first version, two different moving parts attached to the top and bottom of the player, were designed to hold the bracelet by sliding it in (in a similar vein to how the original holder worked for the prototype). However, since the designs for the bracelets were also modified, we realised this idea will not suffice so we removed these sliding supports in favour for a magnet, which allowed the bracelets to be easily attached to the player. This would also decrease the time spent on attaching the bracelet thus making the overall experience more enjoyable. When all aspects were finally crystallised, we sent the model to an external company for 3D printing. This was due to our 3D printers not meeting the height requirements for the player. Different companies were contacted with only one meeting the imposed scale,

timeframe and material requirements: Laser Prototypes Europe Ltd⁶⁷ were our pick. During different discussions with their engineers and technicians, key issues were identified on the proposed prototype which had some parts thinner than 1.0 mm. Whilst technically this model would have been possible to print at their laboratories, their team suggested that by increasing the widths on these parts, a better, stronger and less expensive model could be printed. It was an easy decision to follow their advice. I would like to point out here that whilst this was the final design of the player (Figure 66), it is by no means whatsoever, a final design or the route to be taken if the project was ever to be manufactured for mass-production. The overall cost for printing the player reached almost £2000, an amount which does not take into consideration any investment on the mechanism, both time and materials wise.

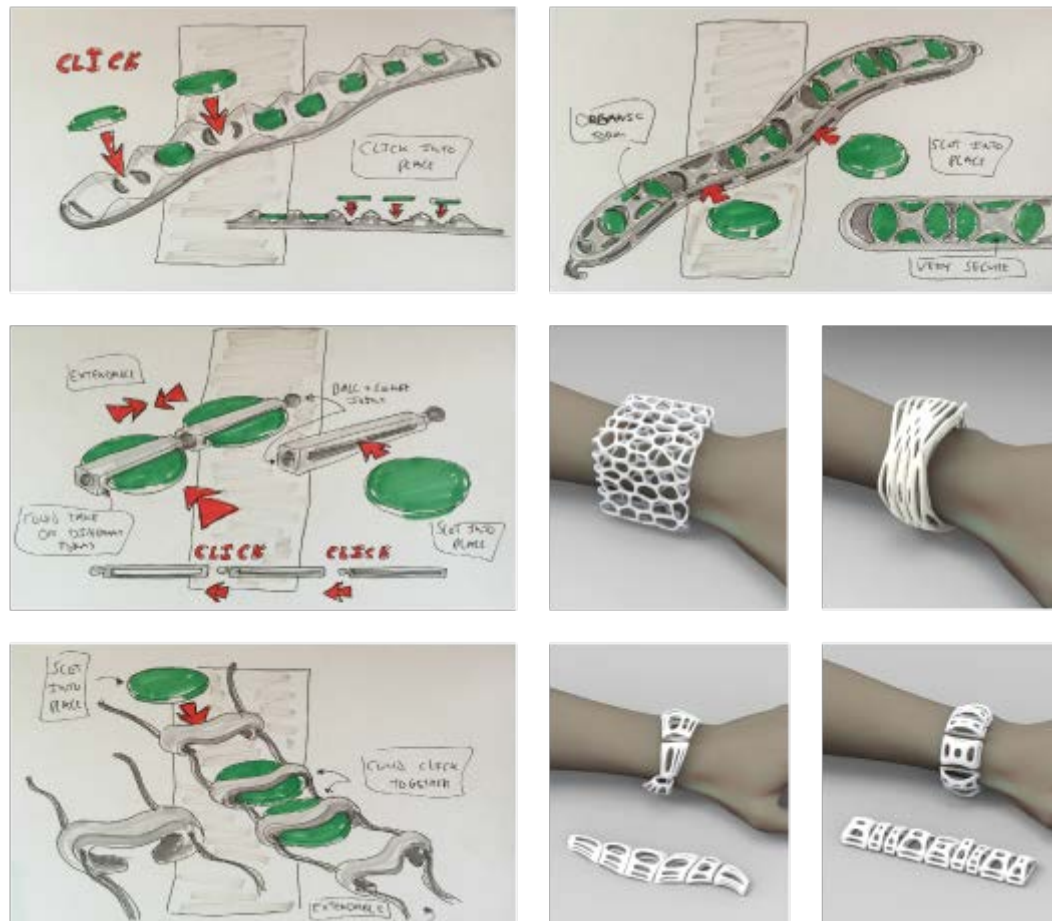


Figure 64. Some concept designs for the bracelets.

⁶⁷ <http://www.laserproto.com/>

The fabric bracelet was suitable for testing the overall interaction and handling of the interaction of the tags with the player, however, for the final design of the bracelet, we looked at ideas more suitable to sit within the jewellery spectrum, something that would have a feeling of completeness that people would wear proudly. Through the works done by the external company, different options were discussed around the mechanism for adding or removing a part (or parts) from the bracelet without compromising its final look and feel (Figure 64). Different concepts were explored on how these bracelets could come to life. Some of these concepts only explored the ease with which a tag could be swapped in case of damage whilst looking at different shapes and forms for the bands. Another solution looked at a ball and socket joint, that could rotate around and easily be coupled or decoupled as needed to create a simple mechanism for an extendable bracelet. All of these were disregarded since it was felt they did not fully portray the idea of a 'piece of jewellery' or were seen to have robustness issues when handling as they were easily breakable. Through multiple iterations, new designs were created which conveyed the desired message for a bracelet to be worn as a fashion statement whilst allowing for a quick swap of the tag if so desired. From the multitude of concepts and designs, two different ones were selected as they were considered to be suitable for both a male as well as a female wearer, shown in Figure 65.



Figure 65. The final bracelets.

The final design of the player and bracelets were showcased at the last Creative Exchange Exhibition which took place at FACT Liverpool (Figure 66).



Figure 66. The final player with one of the bracelets on display.

Despite all the modifications made up until that point, there were still some issues arising as the player was set up and tested. One such issue involved the rotating mechanism getting jammed from time to time, which oddly never happened before. We never managed to correctly identify where this issue was coming from, however, it is important to take consideration of this matter and account for it in any future designs. Another unique situation

was observed when the player was fully build. Despite the normal ranges of around 6 cm distance read for the NFC reader, and the bracelets being within less than 5 cm when attached to the player, the reader could not read the tags. It is our belief that this was due to the thickness of the new enclosure. A solution to this might be that of having larger holes designed into the player so that the reader can 'see' the tags. Alternatively, a new design could have the position of the bracelets even closer to the reader. Whilst these were only observed during the final iteration, they are all part of the prototyping experience and without such a process, they would have never been found until after production.

Having the player and bracelets on display at this exhibition presented our team with an opportunity for allowing the exploration of a digital player; a mobile app which would translate the tags into associated media and display it on a mobile screen. We had previously developed a mobile application for writing tags, however, it was agreed, it would be better suited to have two mobile applications, one for writing tags (Figure 67) and one for reading them (Figure 68), so that people could easily understand the process. Furthermore, it was also agreed that whilst the original designs were suitable for their intended purposes, in this case, it would be best to redesign the app to better fit the environment. One last modification was made by removing Spotify as a media provider due to licence restrictions.

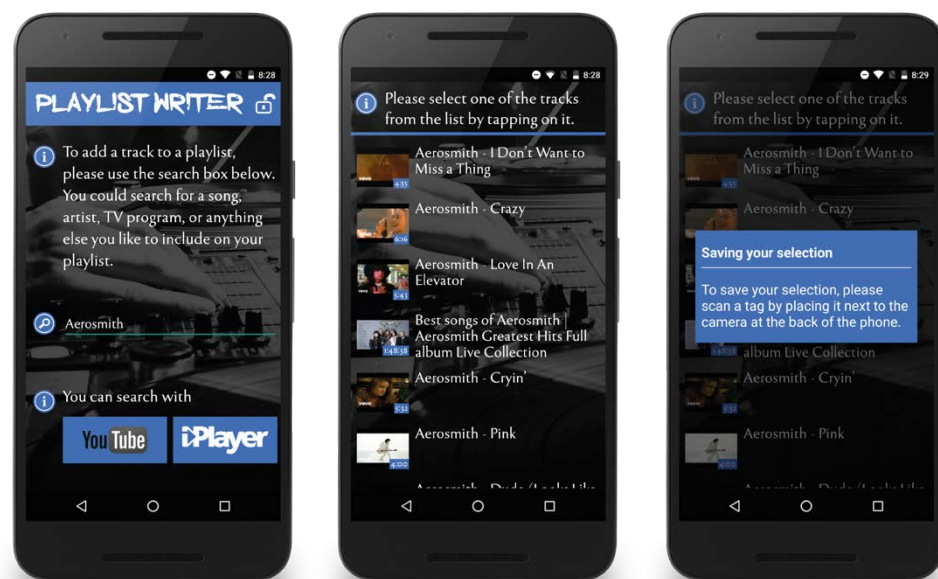


Figure 67. The newly designed writer mobile app.



Figure 68. The newly designed reader mobile app.

Discussion and Conclusions

Whilst our overall goal was to understand if more meaning can be embedded into the sharing of digital artefacts, the undertaken process resembles more the one used for crafts and craftsmanship, where the material, form and final shape of the artefact take priority over careful planning and deep analysis with immediate results to be seen. As Bill Verplank wisely said, ‘the only learning is by doing’ (Verplank, 2003).

Leaving aside the analogue content of the cassette, the original mix-tape offered a good level of physical personalisation, through the writings often found on both the cassette and the sleeve of the case, as well as the shape, colour and size of the plastic enclosure. In comparison, this project raises the bar for personalisation even higher, since both the player and the playlist could virtually take any forms as long as the technical challenges are met. Furthermore, since the playlist is actually composed of digital elements, it could potentially house a large number of items without any constraints on the type of information stored. It could be made so that the playlist is only played based on a specific weather type (sunny, rainy, overcast, etc.), at specific hours of the day or even solely at special occasions (birthday,

anniversary, wedding, etc.) thus allowing the creator to produce a highly-personalised experience. Moreover, the media stored on the playlist could be expanded to other sources not just the ones used in this project. A potential scenario could see the creation of a playlist with all Star Wars Films (streamed from a Netflix account) in the order envisioned by the creator of the playlist and not the one chosen by the viewer. In an alternative scenario, one could easily create a cooking recipe, where each step is accompanied by a short video, where the time between each video would match that of the time required to complete the step.

It is important to consider both the interaction of the user with the product as well as the overall aspect, shape and design of the product in itself. The final product had to be modern so that its shape fits within the current world we live in. As such, even if some of the explored ideas could fit within the 'retro' movement, a 'better' design to emphasise the closeness to the cassette player, nowadays, they would have been out of scope in one's home. The interaction of the playlist with the player had to be as easy as possible and whilst dropping a playlist into a bowl would have been simpler, and probably hassle free (compared to attaching the playlist to a support), it would have been more difficult to create the in-order play similar to how a cassette player would play a mix-tape.

Since 3D printing is becoming increasingly more available in people's homes as well as commercially over the Internet, own customisable bracelets and players could be easily created. Whilst we opted out for a physical player, as we were exploring ideas behind shaping the digital into physical forms, from a practical stance, a mobile application would suffice to perform the reading of the tags as long as the mobile phone has an NFC reader incorporated. By simply exchanging the physical player with a mobile 'reader' application, the financial constraints around mass producing players could be avoided. If the order of playing a given playlist is still a requirement, the writer app could easily be developed such that it would allow the user to design the order of play as well. Thus, the focus of the beneficiary, will always fall onto the creation of the playlist. I would like to point out here, that whilst technically all this is possible and could easily be achieved in a short timeframe, it will happen at the expenses of the physical interaction. If

memory, matter and experience are required, the digital avenue should be avoided.

From the CX perspective, the project was deemed as successful, since it bridged the gap between academia and industry, through the collaboration with the BBC R&D team which further contributed to the knowledge exchange in this space. Whilst the personalisation of physical object with digital content is probably in an extremely nascent time, the project demonstrates the potential as well as the benefits for embracing such endeavours.

Physical Social Network

The consumption of digital visual information is intrinsically related to that of a screen since there is no better way of displaying such content. Interestingly enough, our screen-based interactions seem to be irrespective of content and resumed to a handful of actions, for example, the scroll of a mouse is used to interact with an online gallery, read a blogpost, fast forward or rewind a video, navigate a website, etc. The touch screen has seen this increased through the addition of the swipe, nevertheless, the same gesture is used, yet again, across different media types and interactions. It can be argued that, currently, the predominant practice seems to be revolving around adapting the presentation of the content to the range of interactions available rather than designing interactions around the particularities of the content. The Physical Social Network project explores such concerns and proposes the use of a physical object, taking the shape of a handle, to interact with a digital collection of images.

The Constructed Bits

By the end of the project, we constructed a physical artefact displaying a collection of Edwardian postcards which can be interacted with through the use of a physical handle. The project was fully designed and developed in-house, at Imagination Lancaster. It is important to note here that this artefact emerged through the researching of the initial idea and that its current format is due to the constant iterative approach of developing and testing different ideas which were found useful in relation to the original one. Whilst the idea did not change, the final shape and interaction might have been different if other decisions were taken.

Connection to The Digital Public Space

The original idea of The Digital Public Space came from Ageh's desire of democratising privately own knowledge (Kiss, 2010). The digitised Edwardian postcard collection used in this project is a good example of such privately own knowledge taking the shape of an archive. Through the use of such an archive, the original aims of the project are matched by the notions describing The Digital Public Space, especially around content consumption.

Furthermore, the embodiment of the artefact represents a different way of accessing such privately own knowledge and therefore is directly and undoubtedly connected to The Digital Public Space.

Introduction

At the end of the Victorian era, a new craze began to take shape, people turned towards the use of postcards for quicker and easier communication rather than relying on the formality of letters. Due to the mass-production techniques around the 'newly' discovered field of photography, postcards introduced an attractive, fast and quite cheap way of communication where, an image was used for both visual impact as well as a written means of expressing oneself. The postcards allowed people to take "the opportunity to communicate in a short, convenient form that could not be governed by the relatively formal tenets of letter writing etiquette, as bolstered as that was in formal education and prescriptive manuals" (Gillen and Hall, 2010, p. 5). According to Gillen and Hall (*ibid*, p. 2), in major cities there were even up to 10 deliveries per day, and in this respect their usages resemble the ones of social media websites and applications practices which, to some extent, allow for the same unstructured and laid-back communication style to take place. They became so popular that, during the Edwardian era, which lasted for a period just short of 10 years, almost 6 billion postcards were sent, averaging around 200 postcards per person (*ibid*, p. 2).

Despite their increased use during those times, 100 years later, they are just memories and, in the best-case scenario they might be found in a digital collection. One such collection is held at Lancaster University by Dr. Julia Gillen⁶⁸, senior lecturer in Digital Literacies at Lancaster University. For more than ten years, Dr. Gillen has been interested in Edwardian postcards, her work focusing on the writing practices of the Edwardians, as well as the travel patterns, concerns and social networks of that age. Throughout her work, she gathered and digitised more than 3,000 Edwardian postcards and she believed the Creative Exchange research programme would be a good fit for extending her work with a potential of reaching even more collectors and the general public which might have aligned interests. A first preliminary and informal meeting was held, where I met with Dr. Gillen and Dr. Naomi Jacobs, at that

⁶⁸ <http://www.lancaster.ac.uk/linguistics/about-us/people/julia-gillen>

time working as a research associate⁶⁹ on CX, being in charge of research ideas, new collaborations, partners and outcomes, to assess the feasibility of bringing both Dr. Gillen and my own research agendas together. Based on the presentation held by Dr. Gillen and following the approval of Dr. Jacobs, an agreement was set in motion, which sought the exploration of how physicality could be used to extend the original work done so far. Having found Dr. Gillen's expertise better suited for the curation of the postcards, I turned towards Prof. Coulton (my supervisor) to help generate some ideas towards how we could turn these ideas into a CX research project.

Two main ideas arose from our conversation: firstly, an interactive application which would display a map of the UK depicting location-based postcards and secondly, a physical machine which could allow for a different type of interaction with a digital collection. Both of these ideas and their implications are presented below and stand to prove how keeping an open mind during the research and development process is key to achieving successful results.

The first idea envisioned an application which would allow a user to interact with a map and visualise how postcards travelled between different locations. The application would also facilitate an easier way of admiring the postcards as well as providing an easy way to read the written messages. Since the purpose of the project was primarily oriented towards reaching as larger the audience as possible, so that more people could be made aware of the work Dr. Gillen was performing, the application was envisioned to be working on a touch table surface, being shown in an open space, where visitors could easily and freely interact with the collection. Whilst Dr. Gillen warmly received this idea, agreeing her involvement in the project would now focus towards the finding of a suitable commercial partner, quick research into the feasibility of this idea pointed out some major concerns. After careful consideration of the multitude of marketed solutions, Ideum⁷⁰ touch tables were seen as meeting both the quality expectations as well as the requirements of the project. Sadly, upon contacting the company and receiving a list of the prices for their available solutions, it became clear that whilst the budget for the project was significant (~£16k), it still fell short in meeting the proposed

⁶⁹ <https://www.abdn.ac.uk/staffnet/profiles/naomi.jacobs>

⁷⁰ <http://ideum.com/products/touch-tables>

prices. An alternative to this was the acquisition of a touchscreen and the build of a custom implementation however, upon further consideration, this option and the overall ideas were finally dropped. Whilst the latter solution would have been possible, it was felt within the team that the time requirements for the exploration of such an avenue is not of worth. Furthermore, during different supervisory meetings, it started to become clearer that finding 'the research angle' on this project would be difficult, since this solution best portrayed itself as a Design Studio outcome, not the one of a research team. Therefore, our interests were quickly turned towards the second idea.

The physical machine idea, whilst still focusing on the presentation of the digital collection of postcards to the general public, it also explored a different type of interaction. The prototype was envisioned to have a similar shape to the end-of-the-pier machines, with a crank on its side which, when acted upon, would allow for a Facebook like webpage to be interacted with (Figure 69). The choice for the overall shape of the prototype has roots into creating mental connections with the early 1900s, due to the popularity of these type of machines juxtaposed with the collection of postcards having originated from the Edwardian era. This idea was also presented to Dr. Gillen and, since it was met with success, the team agreed to pursue it.

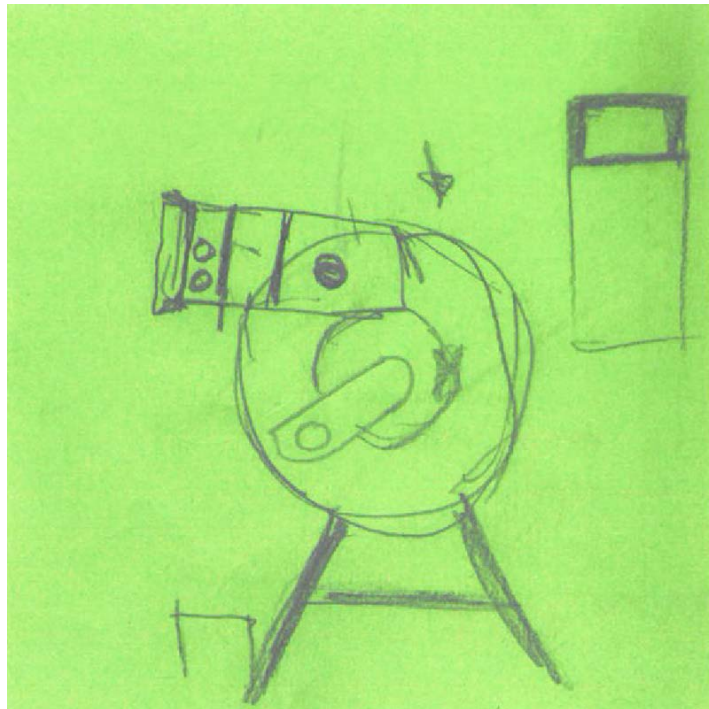


Figure 69. The first idea of the prototype.

Lastly, in order to fulfil the requirements of the CX project, we had to bring in an external, non-academic partner into the fold. We believed it would be of benefit if this partner would be one more aligned in practice and interests to the research Dr. Gillen undertakes, which could provide their expertise into the acquisition of Edwardian postcards as well as facilitating a wider spread of the project. As such, after some considerations, Dr. Amanda Pullan, research associate working with Dr. Gillen on a different research project, set in motion a collaboration with The Royal Pavilion & Museums, Brighton & Hove, represented by digital manager Kevin Bacon, which seemed keen on the core idea of the project. As digital curator, the museum was envisioned to meet the CX requirements of being a project partner whilst their core activity and location was seen to be perfectly aligned with the prerequisites of our project.

The Team

To briefly summarise the above, this team was comprised by Dr. Gillen, researcher and owner of the digital collection of postcards; Dr. Amanda Pullan, researcher; Kevin Bacon, external partner; Prof. Coulton, researcher and supervisor of the project and myself. My roles shifted from researcher, focusing on interaction and experience, to project manager, overseeing each member's contribution, budgeting, material acquisition, etc. and finally to designer and developer of the artefact, both of its digital and physical sides (Figure 70).

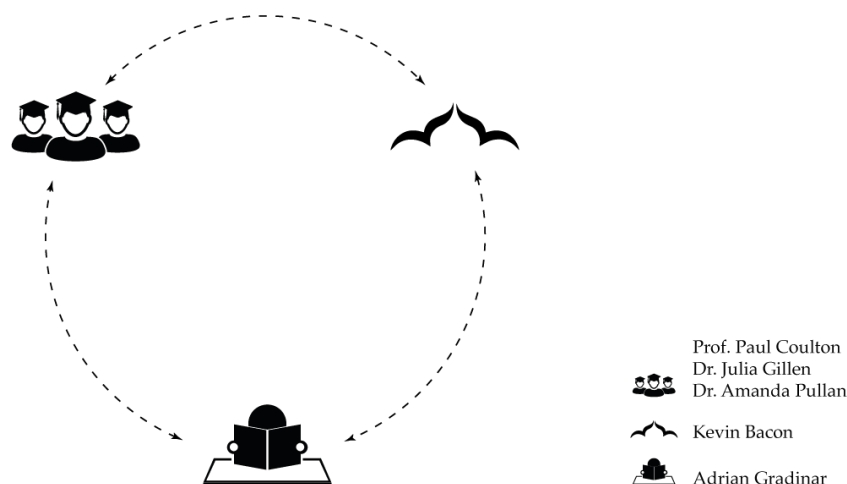


Figure 70. Physical Social Network project team.

The First Meeting

The purpose of the meeting was to facilitate conversations between the partners, so a team could actually be formed. Whilst discussions were held over emails, for me, there is little debate on having all members in one place at the same time, which allows for ideas to be easily exchanged. Despite all the conferencing software available nowadays, which still feel a bit clunky at times, nothing beats a face-to-face meeting!

The first point on the agenda found the CX team presenting the idea to the rest of its members. It was highly praised and some potential pitfalls were discussed. One such issue was observed when Dr. Gillen presented a Microsoft Excel spreadsheet where she had transcribed part of her collection, with tabs of no more than 200 postcard data. It immediately became clear that, whilst the information was accessible, it was not in a form which would be benefiting to the project. Furthermore, it also became obvious that this practice could easily be improved by creating a web interface which would allow for an easier transcribing of postcards' data.

Since the available digital collection was perceived as large with a potential stress on the final interaction people would experience, the team discussed the possibility of having different groupings, based on both illustrational information as well as written text, which would then break this collection into multiple smaller and more manageable collections. Therefore, since Dr. Gillen already had some physical postcards with her, we started to create these groups. In addition to the web interface transcribing the postcard data, it was envisioned that this interface would also allow for the 'tagging' of each postcard and therefore assigning it to a group. This final addition would allow the physical prototype to better manage the collection, which could have been achieved through the addition of a physical switch, facilitating the change between different groupings.

The last point found the team discussing different dates and locations for where the prototype would be shown but was agreed that, such a decision is best to be made at a later stage, when the prototype might be closer to a state of finalisation, one in which it could allow people to interact with it.

The Web Interface

Based on the ideas and issues which arose during the first meeting, we started working on the interface. A new database was set up where all the data from the Microsoft Excel spreadsheet was added. The web interface was developed following HTML5 standards using AngularJS, a JavaScript open-source front-end development framework, due to its dependency injection, routing and data binding, making it an ideal tool for displaying and modifying postcard data in 'real-time'. Different meetings were held with Dr. Gillen to provide feedback into the development of the platform since her team was the final recipient of this application.

The final implementation displays a webpage split in three different columns with only one header and can be seen in Figure 71. The header is used to quickly search the collection, either via an index number or just in an incremental/decremental manner via arrows, whilst the three columns are used to display the postcard's scans (left), data (middle) and finally, a list of all the available themes can be seen on the rightmost column. The ticks represent the selected themes for this particular postcard. If the user so decides, they could add new themes; this functionality is located at the top of the column.

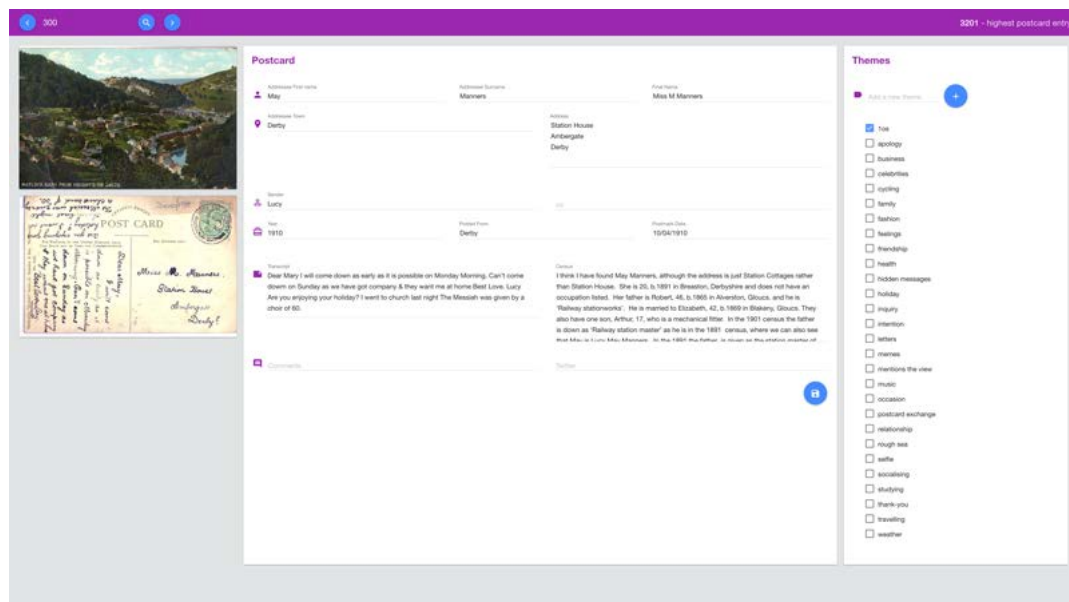


Figure 71. The Web Interface.

The Prototype

Once the web interface was built and the process of ‘tagging’ postcards could commence, the focus shifted towards the actual building process of the prototype. The prototype had two major parts which needed to be addressed for it to be seen as a final product. On one hand, there was the actual physical manifestation, the object which would house some of these postcards and would allow the envisioned interaction to take place. On the other hand, there was the digital side of the prototype, an interface which needed to show the postcards in a manner which would be suitable for the conceptualised interaction. Whilst this prototype is a single entity, its duality of existing in this mixed-reality space, is better explained by presenting these two sides individually.

The Digital Interface

As previously mentioned, there is a strong connection between how the postcards were used and the social networks of today. Therefore, when the original idea was discussed between myself and Prof. Coulton, the digital interface of the product was envisioned to behave in a similar manner to that of the mostly used social networks of our times; a scrollable interface that would display the front of the postcards and their associated text (found on the back of the postcard) in a news-feed like display. The interface would replicate the movements of the crank, by scrolling up, when the handle was rotated towards the user and, scrolling down, when it was moved away from the user. Figure 72 shows the first sketch of this envisioned interface.

For the first attempt, a set of 6 index cards, hard coded into a webpage and displayed in a similar vein to that of a deck of playing cards, was used. This interface was developed on a local development server, running on a MacBook Pro laptop, built following HTML5 standards and made use of CSS3 transform⁷¹ properties of the modern browsers. The transform property allows the spatial coordinates of the CSS visual formatting model to be modified thus facilitating the index card (the HTML element) to be rotated in place.

⁷¹ <https://developer.mozilla.org/en/docs/Web/CSS/transform>

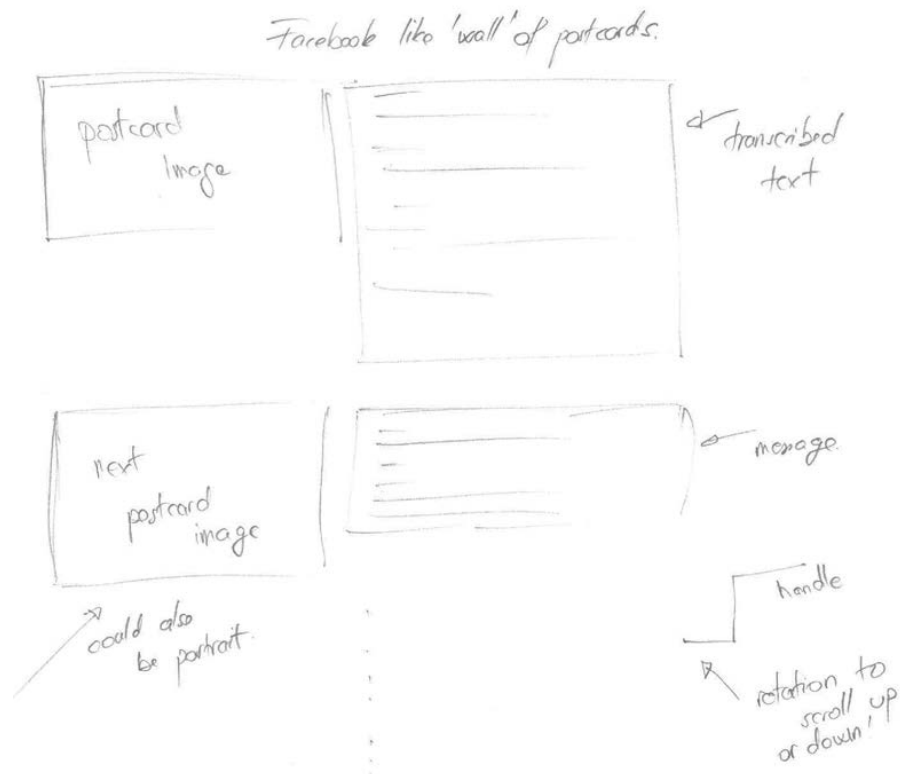


Figure 72. The 'wall' of postcards as it was originally envisioned.

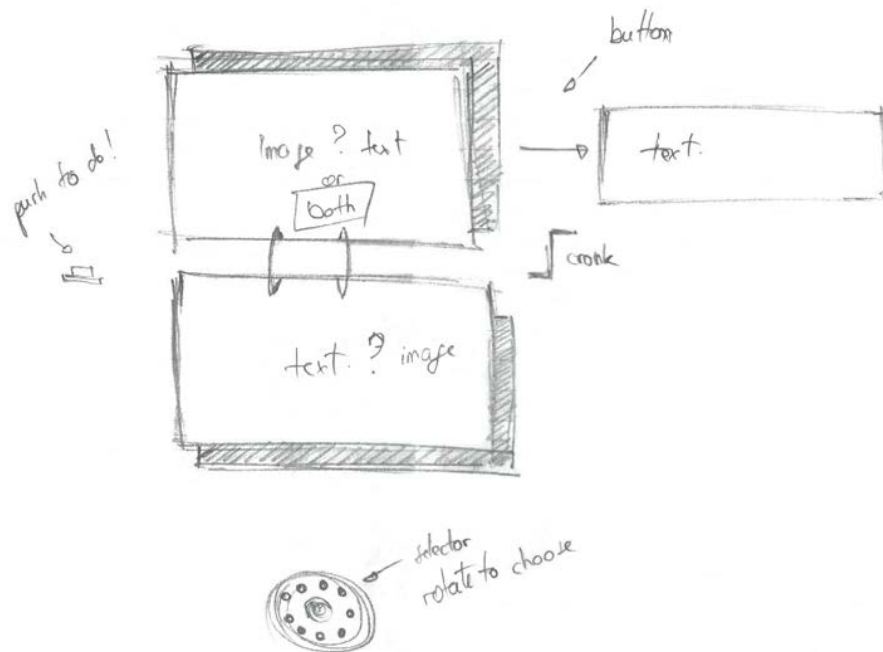


Figure 73. The sketch depicting the envisioned interface and interaction.

By repositioning the rotating angle of the HTML element, a rolodex like movement was obtained. Since the mechanism of the crank was not yet connected to the digital interface nor converted into digital output, the scroll of the mouse was used to simulate the rotational mechanism of the crank. In the next supervisory meeting, it was quickly agreed that this type of interface affords a better connection with the physical crank and therefore, was seen as the suitable developing path for the digital interface (Figure 73).

The following steps involved the testing of this interface onto the envisioned infrastructure: a RaspberryPi board, running a Chromium web-browser, where the interaction would be facilitated by an attached mouse. Sadly, when this configuration was built, we encountered our first major problem. Due to the low display capabilities of the built-in graphics card available on the RaspberryPi, upon rotating the index cards, a jagged, sometimes very rough rotational movement was observed. In some situations, depending on the applied scrolling speeds, some cards would not even be registered as moved, even if they were later on displayed in a different location! Whilst the addition of an external graphics card to a RaspberryPi is possible, this solution was seen as potentially inserting even more challenges to the overall design of the physical prototype. Therefore, it was quickly agreed that, since the scrolling mechanism worked well on a MacBook Pro, a Mac Mini could be used instead since their graphics cards are similar. Whilst the difference between the two systems was little, different trials onto the Mac Mini were still required and therefore performed, to reassure the feasibility of the method. Successful testing meant the focus of the development could be switched towards the physical counterpart of the project.

The Artefact⁷²

Based on the initial sketch, there were two important aspects which needed to be considered for the successful delivery of the final product. On one hand, there was the rotational mechanism, focusing on the crank and its implementation as seen in Figure 69, which had to act as the interface for the digital collection whilst also being integrated into the physical mechanism. On the other hand, there was the outer shell design of the artefact, with

⁷² To not confuse the reader since different prototypes were developed for different reasons, I am referring to the physical prototype as 'the artefact' or 'artefact' whilst all the other prototypes are referred to as 'prototypes'.

considerations towards the materials to be used, its final shape and finish. To be sure the project's requirements could be met, the starting point had to be that of the rotational mechanism therefore, the first point on the agenda looked at the translation of the rotational movement of the crank (a physical device) into a digital output such that, whatever receiver (e.g. maybe a prototyping board) was attached to the mechanism, could 'understand' and 'act' upon such movements.

The Crank

As previously stated, there was a strong desire for the physical object to have a physical aspect which had connections to the Edwardian era therefore, a quick investigation was performed to uncover different solutions for the acquisition of a crank like mechanism. One such idea looked into the procurement of a mangle, an old washing aid consisting of two rollers and a handle, which was used to remove excess water from wet laundry. In general, these types of machines were cast iron with their overall weight exceeding 100 kg. Whilst transforming such a machine to suit our needs would have been possible, the overall envisioned weight of the artefact, raised transportation and handling concerns within the team. Therefore, we quickly decided to focus on finding smaller devices, where only the crank could be used, thoroughly disregarding the rest of the device. This led to the discovery of World War II hand-held air raid sirens, devices which were small enough to be carried around, having a small factor handle which could be used in our artefact. An image of the similar air raid siren we procured can be seen in Figure 74.

Having sorted this aspect out, the next steps involved the creation of a simple support to hold the crank so that different ideas could be tested. To achieve this, we decided to keep the overall rotational mechanism of the siren and disregard its support. One idea explored the possibility of using a dual-axis gears motor (similar to the ones used in Arduino-based robots) which would be attached to the end of the crank's shaft through the use of two different cogs; one would be fixed on the crank whilst the other one would be fixed on the shaft of the motor. At the opposite end of the motor and attached onto the second shaft, a rotary encoder was used to translate the rotations of the cogs into digital outputs. It was envisioned that this output was to be sent

via the Arduino Serial port to a webpage which in turn would translate the received input into JavaScript code and finally translated into scrolling movements.



Figure 74. An image showing a similar air raid siren to the one which was procured.

Whilst this arrangement could have very well work in some instances, we encountered some issues which were seen as disconcerting with potentially ending the project in failure. One such issue revolved around the capabilities of the rotary encoder which was delivered with the dual-axis gears motor. The encoder outputted a series of numbers based on its rotational speed; positive numbers were produced for one direction whilst negative numbers were seen for the opposite direction. Sadly, the sensor had a cap of around 12,000 rotations which could be directly translated into either positive or negative numbers depending on the direction of the rotation. During testing it was observed that, at high speeds, the output on the Serial port would display some inverse numbers; negative for forward rotations and positive for backward rotations. The team believed this was due to the gears motor having a 1:10 (or 1:100 depending on the motors used during testing) conversion rate, massively amplifying the rotations of the crank and its internal cogs. The potential problem here being that if positive numbers were to be translated into forward movements and negative into backwards

movements, how could we handle the negative outputs at high forward speeds? One solution would have been to design additional cogs to decrease the overall speed of the handle however, this would have inevitably rendered the overall design of the artefact much more complicated. Therefore, we decided to investigate the possibility of directly attaching a rotary encoder to the shaft of the crank and, through the removal of the gears motor, entirely dissolving this issue. This implementation can be seen in Figure 75.

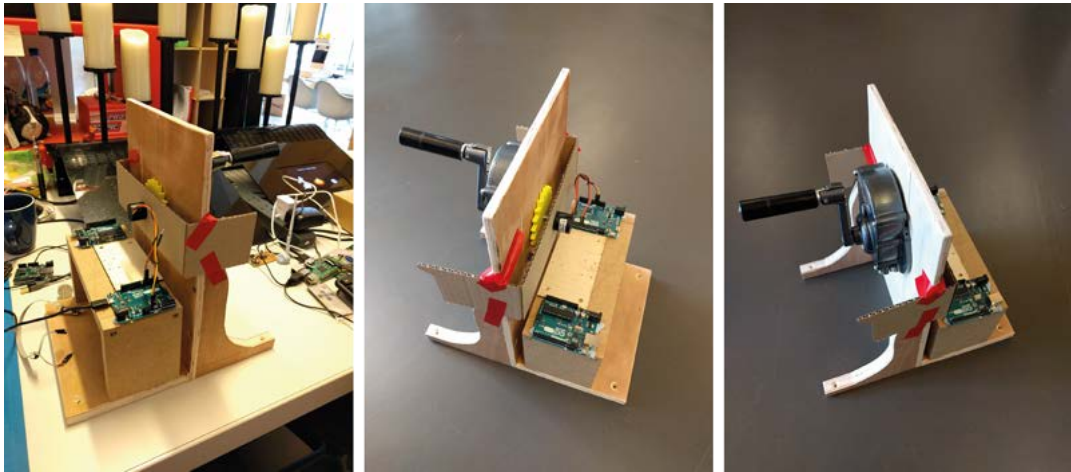


Figure 75. The first holding mechanism of the crank displaying the air raid siren as well as the rotary encoder directly attached to the crank.

Sadly, things were still not that easy. Upon testing, this method proved to suffer from the same issue presented above, which led the team realising that whilst the gears motor had a conversion rate, the crank and its internal cogs had to have one as well. Upon opening up the siren and discovering a series of four different cogs, our concern quickly materialised. Whilst the previous suggested solution would have worked, keeping in mind we would have encountered the design concerns as before, the team decided the best avenue to be pursued would be that of building our own encapsulating mechanism for only some of the cogs. Whilst the possibility of entirely removing the cogs was also discussed, it was quickly decided that this option would have removed some of the actual feel of the original device, thus moving away from the requirements of the project. Therefore, using Autodesk Fusion 360⁷³, a

⁷³ <https://www.autodesk.com/products/fusion-360/overview>

new enclosure was designed and 3D printed⁷⁴, which housed only two of the original four cogs. Since the chosen cogs were similar in diameter, any potential internal conversions of the rotary mechanism were removed, and the final output of the sensor became cleaner, producing only some inverse numbers. This was believed to be the result of the chosen rotary encoder and was quickly agreed to be handled via the software. Since the rotary encoder was not supplied with a library of its own, we were forced to play with different Arduino boards and libraries, which led to the discovery of the easiest way to incorporate the output of the sensors into the webpage. As previously mentioned, this was envisioned to be handled via JS control software however, the Leonardo board of the Arduino family can be interfaced as a keyboard / mouse output, with the 'move()' function provided by the Mouse library acting as a scrolling function.

During further testing it was observed that, whilst a one-to-one physical-to-digital movement was desirable, it was found not suitable since, at very low speeds, this direct translation resulted in no scrolling being performed whilst, at very high speeds, it ended up in to quickly rotating all available cards. Therefore, an algorithm was implemented which works smoothly at very low speeds as well as, through the use of a simple progressive mathematical formula, exponentially decreasing higher rotational speeds whilst still allowing for a subtle increase of speed. Internally, the team decided that the current implementation was meeting the requirements of the project and, until different external feedback was provided, this would be the final implementation of the algorithm. Finally, a rotary switch was added and complementary software was written which allowed for a simple way of changing between different groupings of postcards.

⁷⁴ The design of the enclosure is presented in the following part of this chapter.

The Enclosure

As previously mentioned, a new enclosure had to be designed since it best suited the needs of the project. The first iteration of the prototyping focused only on creating a suitable enclosure for the two chosen cogs. Its sole purpose was to test the accuracy of the obtained measurements and it can be seen in Figure 76.



Figure 76. The first round of 3D printing for the new enclosure
and the attached crank.

Despite the use of a digital caliper for accurate measuring, some small adjustments had to be made to the outer shell of the encapsulation, since the cogs did not perfectly match. This might as well have been the result of the printing resolution of our 3D printer. Whilst the next iteration sought to fix these issues, it also focused on the addition of a second shell, which could then allow for the cogs to be secured inside this enclosure. Since this shell was the one which would be used to attach the whole enclosure to another surface, holes were also added beneath the cogs, where 20 mm M3 screws would easily fit. To fasten the two shells together, 20 mm M3 type screws and corresponding nuts were used which meant modifying the shells to accommodate for their addition. This implementation with the chosen rotary sensor and Leonardo board can be seen in Figure 77.

During thorough testing of the crank and its enclosure, the small dome located on the outer shell of the encapsulation near the tightening mechanism of the crank snapped off (Figure 78, left). Whilst this was partially due to the

corresponding cog exerting an opposing force and pushing the shell away from its counterpart, it appeared that the dome thickness was less than 2 mm, thus not providing enough resistance. By applying a concave shape to the meeting location of the dome with the shell, the thickness of the material increased to more than 4 mm fixing this issue (Figure 78, right).

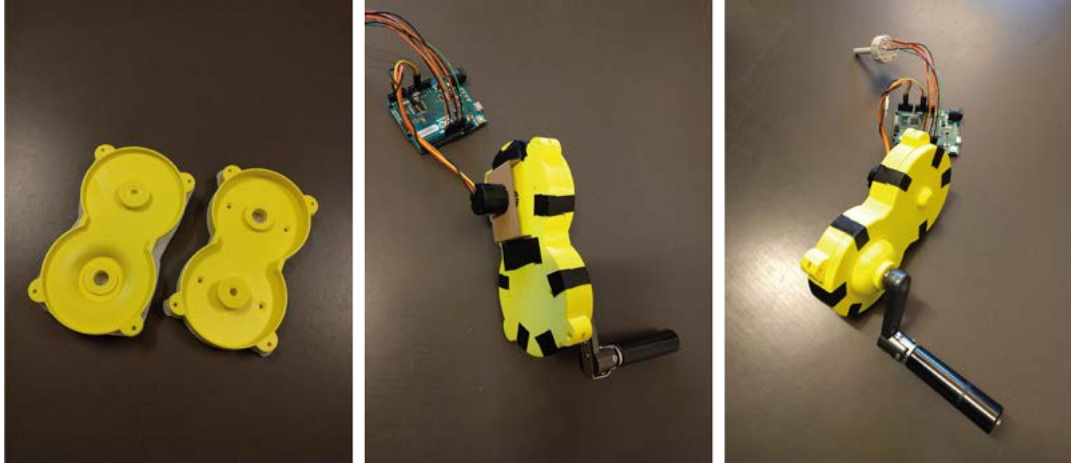


Figure 77. The first fully designed and 3D printed enclosure.



Figure 78. The thickness issue encountered (left) and the fix (right).

Finally, to match the original colour scheme of the air raid siren, the enclosure was 3D printed using a darker grey material and can be seen in Figure 79.



Figure 79. The final design of the 3D enclosure.

The Construction of the Artefact

Since both the physical interaction as well as its digital counterpart were fully designed, the focus now moved onto the creation of the physical artefact. The original design (Figure 69) featured a cylindrical shape for the physical prototype, supported on a trapezoidal, leg shaped, structure and using a rotating cuboidal container, designed to guide the viewer's attention directly to the screen. Solely analysing the importance of these parts, it was clear that the overall shape of the artefact took precedence over the other two parts. Since it was agreed that the prototype was to be built into our workshop, there were two choices of materials: Perspex or plywood. As a material, plastic only became popular and widely used in the 1960s therefore, in order for the design to keep in line with the Edwardian era, the team believed plywood would be a much more suitable material for the final prototype. A simple design of the overall shape was drawn and laser-cut to test the

dimensions of the artefact. To keep the material costs as low as possible, whilst allowing for a physical construct to take shape, only cardboard prototypes were built until the tested feature was found to meet the set requirements. When the first iteration was fully built, the team quickly reached the conclusion that, whilst the shape was in line with the overall vision, the prototype was too large. Therefore, a scale reduction in height from 55 cm to 35 cm was made and a second cardboard prototype was laser-cut and built. The difference between the two prototypes can be seen in Figure 80.

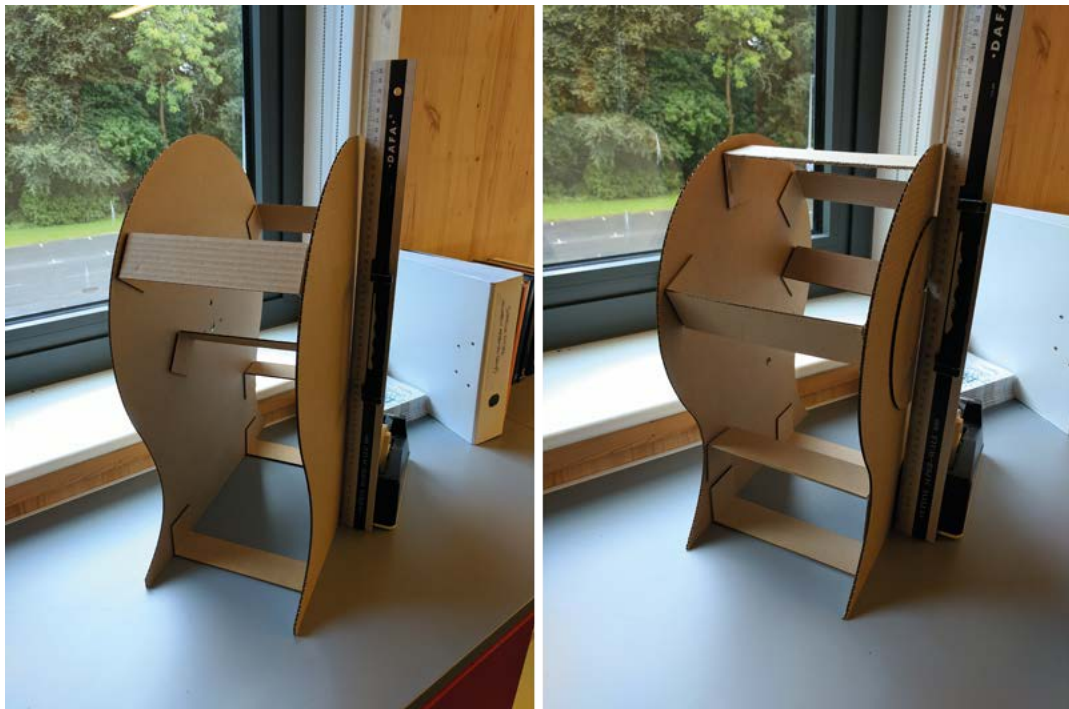


Figure 80. A comparison between the first size (left) and the final one (right).

Having found the second version more suitable in size, a decision had to be made about how to best direct the viewer's attention onto the screen. Whilst the cuboidal rotational shape would have worked, it presented some design challenges: firstly, it implied creating a self-sustaining and rotating mechanism, with the screen attached at one end whilst the same end had to be used as the pivotal point of the design; secondly, since it was supposed to be rotated, the exterior of the artefact had to allow for a relative large area of movement of this cuboidal shape; thirdly, the rotational mechanism had to also incorporate a mechanism for fixing the shape in place, so that it could

allow for an easy viewing of the digital collection; lastly, whilst this design would have addressed different viewers' heights, the actual rotational angle of the cuboidal shape would have been rather small, thus not really making a massive difference. Therefore, the team agreed to consider simpler design solutions with a fixed design. The simplest solution concerned itself with only directing the viewer's attention to the screen. A trapezoidal prism structure was quickly designed to address this design consideration which can be seen in Figure 81.



Figure 81. The cardboard prototype with a trapezoidal prism shape directing the viewer's attention onto the screen.

Whilst the shape seemed to address the concerns about the viewer only experiencing the digital collection, its outside shape, was found to be uninviting and quite repulsive due to its overall cubic design. Therefore, this part had to be replaced by a shape which should have further improved the

viewer's experience. Some goggles like structure was found to be best suiting for such a challenge which was 3D designed using the previously mentioned software. In order to allow for a multitude of people to enjoy the final artefact, the design of the goggles took inspiration from a GearVR headset. When the final design was 3D printed, the look and feel of the material was found, yet again, not to be in line with the wood finish seen on the artefact. Using a simple technique called slicing, which cuts a 3D model into slices of desired thickness, a cardboard version was laser-cut to test for its accuracy. Having found this model to be better suited for the final artefact, the model was extended through the addition of six different supports, designed to securely hold the goggles structure in place. The evolution of the goggles can be seen in Figure 82.



Figure 82. The 3D printed version (left); the sliced laser-cut cardboard goggles (middle); the 3mm plywood version whilst being built (right).

The goggles were attached to the top of the frame and the screen was positioned at an acceptable distance based on its resolution and size. A frame for the screen was built, consisting of three different 3 mm plywood layers: a bottom one, on which the screen was laid on; a frame surrounding the screen, which was design to keep the screen from any vertical or horizontal movements and finally, a top layer consisting of a smaller frame which concealed the screen's original black frame. M3 screws and corresponding nuts were used to secure the layers in place. To attach the screen's frame to the artefact, angled bracelets and screws were used.

As previously discussed, a Mac Mini was used for the software. Given the overall design of the artefact, there was only one logical solution to position the machine inside the artefact: on its bottom. Two additional design problems required addressing: on one hand, the machine needed to be tightly

secured to the artefact so that, when the artefact was being transported, the machine would not move whilst, on the other hand, when the artefact was finished, an option to turn the Mac Mini on and off was still required.

To address the first concern, a simple frame was designed to surround the Mac Mini and prevent any lateral movements of the machine by gluing the frame to the inside bottom of the artefact. An additional frame, holding 2 pairs of M3 nuts located on opposite sides to each other and between the Mac Mini and the lateral sides of the frame, were glued on top of the first frame. On top of the nuts, two individually built decks of slats were also attached. These were cut to width so that they fitted the exact distance between the Mac Mini and the sides of the artefact, further preventing any lateral movements. A top platform, cut to size, and corresponding M3 30 mm long bolts were used to firmly secure the Mac Mini in place (Figure 85).

Since the machine was secured into the artefact, the focus moved towards finding a suitable solution to power on/off the Mac Mini. Different solutions were analysed and discussed. One idea considered the attachment of an on/off button (similar to a typical light switch) on one of the sides of the artefact and directly wiring it into the Mac Mini. This could have been achieved by removing the machine's cover and redesign its power button. Upon further consideration, the team felt that whilst this would have voided the warranty of the machine, it might have caused other potentially unforeseen issues therefore, other ideas were considered. One of the aspects where Apple products have always shined, is in the quality of the overall design, in this case in point, the power button on the Mac Mini is small and perfectly designed to be used by a finger (usually the thumb or index). Since we wanted to keep our artefact as physical as possible, the team decided to investigate ideas of creating a 'finger', a mechanism that would allow users to press on a physical button located on the side of the artefact in order to push the actual power button of the machine. For the outside of this new mechanism, we took the power button from an older machine, consisting of a rectangle piece of aluminium of ~20x6 cm dimensions with a plastic button. This particular power button worked on a simple arm like mechanism which, upon being pushed in, required a force being applied from the opposite direction in order to be pushed back into its resting state. Probably, in the original mechanism, this involved an actual push button located behind the

plastic cover. Therefore, the 'finger' had to be created of a mechanism acting in a similar manner to a push button, allowing for an opposite force to be exerted.

The first version of the 'finger' involved a short Perspex tube inserted into a thumb like shape made of foam (Figure 83).



Figure 83. The 'finger'.

During testing, we observed the foam had a tendency of sliding along the Mac Mini's power button, mainly due to the Mac's power button being located on the rounded side of its enclosure. As such, our 'finger' mostly got stuck, never returning to its original designed position. To sort this issue, a simple 'wedge' like design was added to deter the foam from sliding alongside the Mac's power button (Figure 83, far right). This implementation had some successes however, there were some instances where the 'finger' would still not return to its resting position, mostly being 'caught' between the wedge and the enclosure of the Mac. The team believed this was due to the resistance material qualities of the foam not being the same to a human finger; a more rigid material was required instead of the foam. A quick investigation into different materials led to the discovery of an eraser being found as the most suitable material to simulate the presence of a finger. Therefore, a new mechanism was designed which consisted of creating a revolving arm like structure with a piece of eraser to make contact with the Mac's power button which was pushed in by a Perspex tube cut to size. By playing with the length of the Perspex tube and the thickness of the eraser, a desired opposing force was achieved, where both the Mac's power button and the plastic one located on the side of the artefact were pushed back into their original resting locations. The final mechanism can be seen in Figure 84.



Figure 84. The final designed mechanism for the 'finger'.

Based on the internal technical pieces, the current design needed two different power sockets: one to power the Mac Mini and one to power the screen. Therefore, on one of the sides of the artefact, a socket was added, which was wired internally to a 2-way extension lead, firmly attached with screws to the platform sitting on top of the Mac Mini. Lastly, to position the Leonardo and the screen's controlling boards, the back of the newly built frame for the screen was used to design plywood holders with nuts where these boards were attached to. Finally, cable ties were used to tightly secure in all the internal wires and keep the interior of the artefact in relative order (Figure 85).

The next part of the design involved the creation of the previously mentioned prism which sole purpose was to direct the attention of the user to the screen. Different measurements were taken to best achieve the desired results until the prism was constructed. Firstly, the lateral sides, parallel to the sides of the artefact, were added, then followed the other two sides. They were secured in through the use of M3 screws and corresponding nuts.

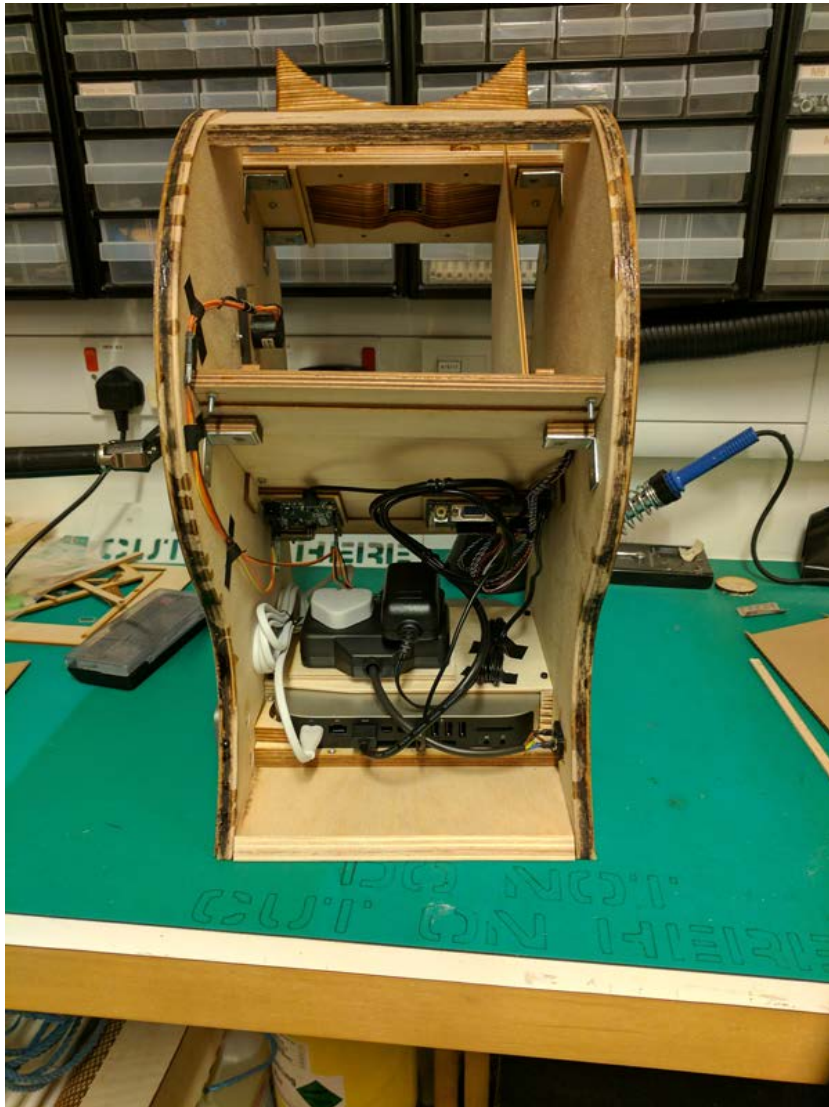


Figure 85. The interior arrangement of the artefact.

The last part of the design, the rotary button which facilitates the switch between different groupings within the digital collection was constructed using the same 3D slicing technique described above. Firstly, a digital button was designed using Autodesk Fusion 360, which was later on laser-cut using 1.5 mm plywood. A thinner material was used to achieve the desired curvature. This part of the button was secured in directly to the artefact through the use of M3 screws and respective nuts. On top of the last slice, 6 different icons were etched which correspond to the digital groups. Lastly, a knob which rotates the physical switch was added to complete the design. Some images demonstrating the creation process of the button can be seen in Figure 86.

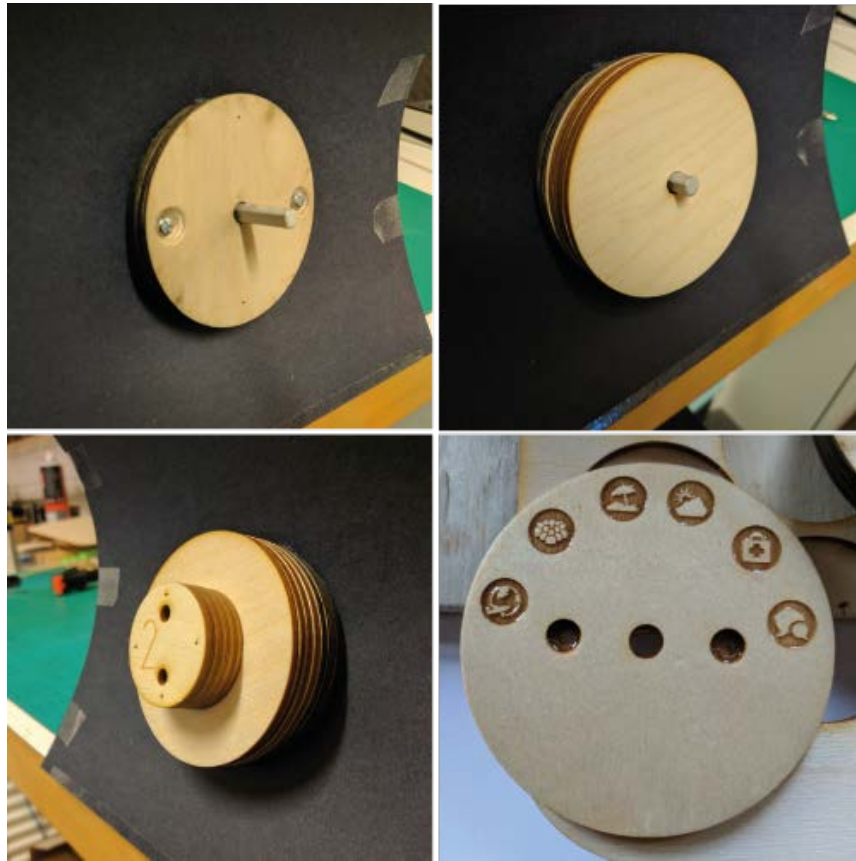


Figure 86. Different images showing different stages for the creation of the knob.

Finally, 1.5 mm thick plywood was used for the cover of the artefact. Whilst it would have been easier to design a single cover, the team felt it would have better suited to have this cover split in two parts: one part, running from the front of the artefact and finishing half-way through its back, and the second part, starting where the first one finished and running all the way to the back of the artefact. The reason for this design is based on raised concerns around potential failures taking place whilst handling, or any other unforeseen errors, which would require accessing the internal parts of the artefact; the second part of the cover accounts for such potential issues. However, to be sure that any software issues might be easily solved without the removal of the cover, a Bluetooth receiver was added to the Mac Mini, which allowed for the connection of a keyboard and mouse, if so required. Lastly, both covers were secured to the artefact through the use of Black Japanned wooden screws which were chosen to contrast the overall light aspect of the artefact.

The Final Prototype

Even from the beginning of the development stages of this project, the team always believed the artefact should require the most minimalistic setup possible. Therefore, a decision was taken to duplicate the previously built infrastructure, used for the testing of the software, onto the Mac Mini and, through the use of a local development server, have the webpage served onto the screen of the artefact without the requirement of an active Internet connection. This approach removed the need to have the artefact connected to a wireless hotspot every time it was demonstrated. Therefore, a MAMP⁷⁵ server was setup on the Mac Mini, where the final touches were added to have a complete look-and-feel. This involved the styling of the webpage to be more in-line with a rolodex, by adding different stylistic elements onto the page. A final touch was added through the creation of a central gradient, from white to a dark grey, to simulate the impression of a circular monitor. Lastly, corresponding icons were added which matched the physical etched ones located on the front button of the artefact whilst visually identifying each group of postcards.

Two more points needed addressing: one, how to start the web server and display the webpage with just the push of the start button; and second, how to turn off the artefact without the loss of any data. To solve the first point, additional software was sought to provide exactly this feature which, incrementally started all the required programs. Firstly, it turned on the web server, followed by a one-minute delay and lastly, the browser with the required web page. The delay was required since the web server required a certain amount of time to be fully operational. For the second scenario, an additional OSX script was written which, upon the constant press of the power button for a total duration of 5 seconds, initiated the shutdown procedure. In the original design of the Mac Mini, by pressing the power button for 5 seconds, the machine turned the power off, without any regards to the operating system. This feature was purposefully designed to account for situations when the operating system was not responding. By overwriting this functionality, our script turned the machine off in a safely manner.

To give a finish look to the artefact, four different layers of varnish were applied to the sides and covers, which gave the final design an overall

⁷⁵ <https://www.mamp.info/en/>

pleasing aesthetic. For the goggles, a wax base solution was used. This choice was made on the premises of potential users touching the physical design with their faces therefore, a more human-friendly solution was chosen. The final built artefact can be seen in Figure 87.

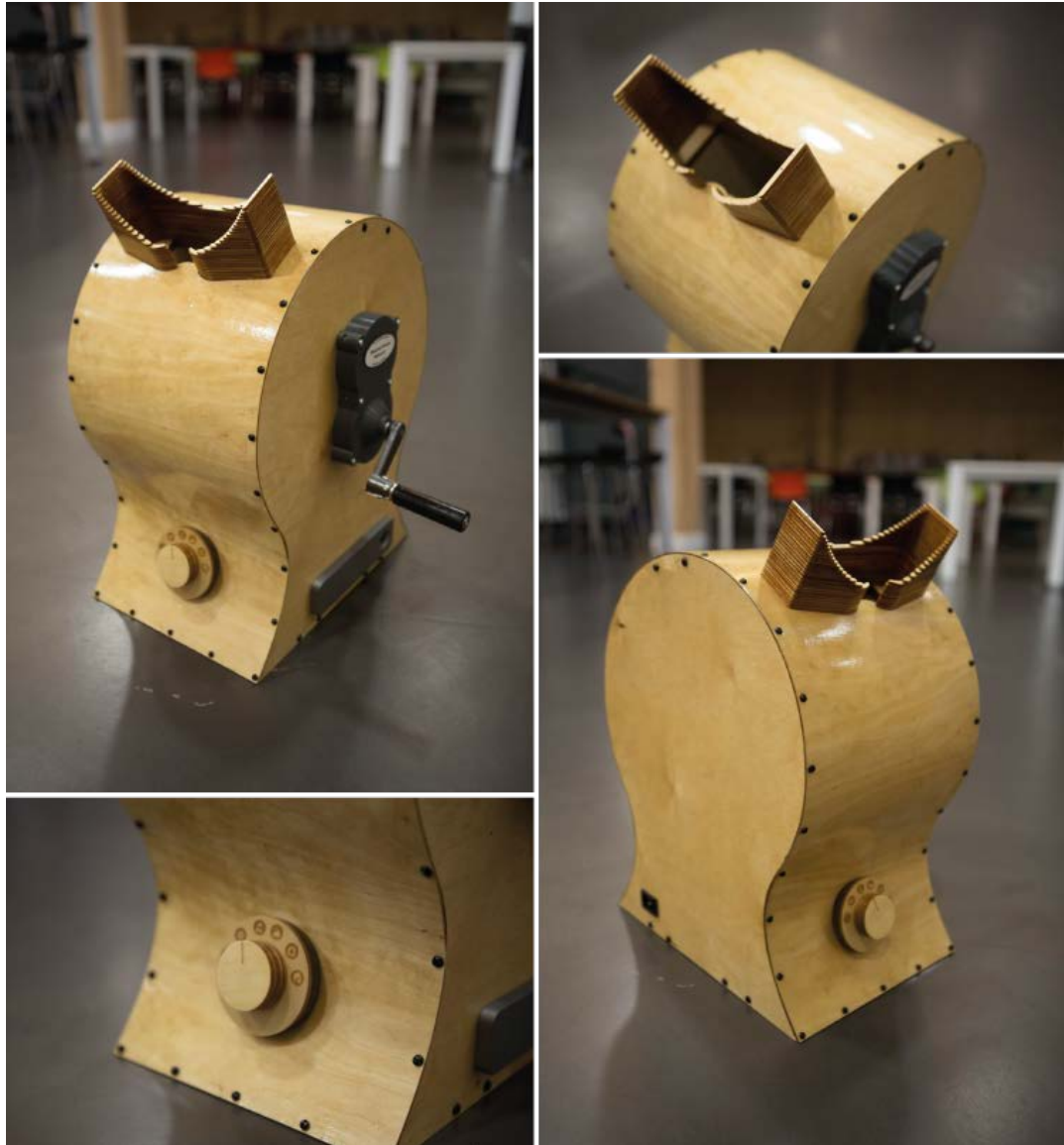


Figure 87. The final artefact.

Feedback

To gain insights into how this artefact was perceived by the general public, two different approaches were used. Firstly, the artefact had been in constant display in the office, allowing anyone stopping by to leave their impressions, and secondly, two different events were used to allow for the

gathering of more feedback. The first event saw the team displaying the artefact at one of the open days held at Lancaster University in 2017. Over the span of 6 hours, more than 80 different people stopped by and interacted with the artefact with more than 25 people leaving written comments. The feedback was acquired through informal conversations which involved the demonstrator explaining the artefact and finally the participants writing down their impressions on nearby post-it notes. The second event was held in a more formal environment where the team was invited to talk about their research interests. It felt appropriate to demonstrate this prototype and, in this process, gather more feedback. A total of 15 participants interacted with the artefact with only 5 of them leaving written comments. It is important to note that, since one of the requirements of this project was to 'spread the word' on Dr. Gillen work with the Edwardian postcards, these types of demonstrating environments were found suitable. Furthermore, by facilitating informal settings, the participants were not deterred from the overall research interests, but rather they were found commenting on their impressions on how the finished artefact and the interaction were found, or any other comments which they deemed appropriate to provide. It is because of these reasons why the artefact was also on display in the office allowing for other people to comment freely on it. If such an interaction could be used in other public settings, for the case in point of this argument I could say replacing a typical screen-based interaction found in museum exhibits, it is of little importance who provides the feedback; the more and diverse the population reached, the better! Therefore, the next part of this chapter collates all the given comments with a further analysis and discussion concluding this chapter.

In its entirety, all the written feedback, as well as the verbal comments obtained through informal conversations, towards the artefact were positive, with not a single participant having found the overall experience negative. Participants believed it was an "Interesting way to present the postcards. Great idea"; "A wonderful blend of the digital and the retro"; "A beautiful piece of machinery. Tactile + pleasure to look at the pictures at this pace" whilst "Forcing people to use the handle to change the pictures gives an interesting feeling of slowness which is something that a real postcard does", pointing to the overall speed of the interaction to be in line with the design of the artefact as well as the displayed content.

With respect to the finished aspect of the artefact, participants believed it is “Beautifully made”, with the choice of the material being seen as “Nice in wood” and “Smell[s](ing) good”. However, due to the overall shape of the artefact resembling a mutoscope⁷⁶ (also better known as “What the Butler Saw Machine”), some participants did not know if it was “safe for children”, despite the participants being informed it was displaying a selection of Edwardian postcards. One particular participant said “it’s all wrong! It’s electric!” referring to the previously mentioned mutoscope which solely had physical interactions. However, other participants believed it is a “Great combination of old and new technology”; “(a) Lovely way to view postcards from a digital collection, referring to the old viewing machines”; and “It’s comfort in the familiarity”. One participant mentioned it recreates the “old peepshow” whilst “capturing the essence of Edwardian life visually”. The participants which made a connection between the way the postcards were displayed and the social networks of today, truthfully considered the project being “The Edwardian Internet” or “The Facebook of the era - look at me - where I am!”

Whilst some of the comments were positive towards the design of artefact, the content was less appealing, with one participant mentioning: “This is a beautiful object. It looks gorgeous and draws people in to examine it. The content on the screen is less interesting though”, whilst another participant pointing out they “Can’t read the postcards”, referring to the written messages located onto the postcards. Because of this, “Interest is quickly worn off because of the inability to connect to the content”.

Regarding the practical aspect of the artefact, one participant was concerned by the goggles, mentioning “I was a bit concerned that I would have to take off my glasses to get up close enough to see the images but I didn’t - no need to worry, it is spectacle friendly” whilst another participant told their friend “careful with those glasses, you might drop them in there”. However, due to the size and shape of the goggles which took inspiration from the GearVR headset, no such issues were encountered.

Not many improving suggestions were made however, a few comments were given, such as the “Handle/knob could be used for changing the rotation of the images”; “Sound would be good”; “I like the idea to preserve

⁷⁶ <http://www.earlycinema.com/technology/mutoscope.html>

the postcards, but somehow it misses the portability and sensorial aspects of an actual postcard. Something physical like a viewmaster could work better”; a desire to understand the icons: “Wish there was a legend (key) for the signs on the front knob”; and finally, “Would like a like, love, don’t like physical button”

Lastly, analysing only the perceived feelings which the artefact brought out, participants said “...it’s more organic than passively touching a screen”, being seen as “Super immersive” and wanting “something like this attached to my phone!”

Discussion and Conclusions

Overall, from the CX perspective, the project was seen as a success, creating a new collaboration between the Imagination team, Dr. Gillen and The Royal Pavilion & Museums, Brighton & Hove. Whilst the final artefact is not in a state in which it could be mass-produced, it does stand as a finished product and therefore it could easily be used in a museum environment to showcase Edwardian postcards, or any other content which such an interaction is suitable for. Unfortunately, due to the project reaching its final stage only after the CX finished, demonstrating the artefact at Brighton, took place after this thesis was submitted. Whilst it would have been beneficial to gather the input from all partners at the same time, some comments were passed along via emails. Kevin Bacon, representative of The Royal Pavilion & Museums, Brighton & Hove, highly praised the novel interaction, pointing out that, during their collection of feedback relating to the exhibits found at the museum, the ‘typical’ touchscreen interaction is something which people can enjoy in the comfort of their own homes therefore, investigations into novel interactions might be useful. Furthermore, based on the feedback we acquired at our end and passed along to him, pleasing comments were received towards evidence which “points out to an overall desire towards novel interactions”.

In this project, compared to some of the other projects found in this body of work, I found myself in a position of having more freedom in my decisions, mostly because the expertise of the other partners was not in line with the physical construction of the artefact. Having mentioned this, the team was always consulted regarding general matters of the project however, when it

came down to the design and implementation of the artefact, the discussions held were solely internally, between myself and my supervisors. This made it easier to keep the focus onto my own research ideas and preferences.

Based on the received comments, the artefact is clearly a success being found both aesthetically pleasingly as well as a perfect blend of interaction and content. However, there were some interesting points which could be addressed. Personally, my focus on this project was directed towards the presented interaction and therefore, the experience one has when interacting with the artefact. However, this approach, misses on the connection some would have liked to gain through their interaction with the actual content, directly towards the messages found on the postcards. One solution to such a challenge could be the transcription of the messages into a digital format, one which could be found better suited for reading. It is important to note that, whilst such possibilities exist, they would remove the 'feel' of the postcard therefore, a physical switch, which could dynamically change the scanned postcard into a transcribed one, might be better suited. This solution would find a compromise between maintaining the original aspect of the postcard whilst also providing an easier reading experience. Furthermore, since some of the postcards were originally displayed in a portrait mode, due to the stylistic choice of design and it being more representative of a rolodex, another knob could be added to facilitate a rotational movement of the postcard. On the other hand, if such endeavours are found suitable for investigation, I would like to point out that, the current design is as simple as possible, with only two touch points of interacting: a handle and a knob. The addition of other switches and knobs has to be carefully considered to provide additional functionality whilst not interfering with the overall experience. The further addition of sound upon handle/knob interaction is a valid possibility, which might prove to also improve the overall experience however, this has to be carefully considered since repetitive sounds tend to become annoying with the passing of time.

Discussion and Conclusions

This chapter is intended to provide a meta-analysis of all the included projects and draw conclusions on the points raised in regards to the design research highlighted in the first two chapters. Therefore, I start by providing an analysis of the CX doctoral candidate in comparison to the ‘typical’ one, followed by a discussion of the presentation and particular decision for inclusion. I then explain my characterization of the interactions used within each project which, in their cumulative presence, form the basis of my argument towards what I understand as Digital Public Space and how it can be used. The chapter concludes with an overview of my contributions, summarised in the form of a design manifesto and finishes on potential avenues which could be further explored.

Reflections on CX and the PhD

As per my previous statement, the PhD journey I had, was, most of the times, quite different to the more ‘typical’ PhD journey one might be accustomed to. The fact we had to work on different projects, where sometimes they were not even our own creation, massively impacted this work. Overall, The Creative Exchange was an eye-opening journey, in which I have gained new knowledge and acquired an even more impressive set of skills. This is due primarily to the nature of the PhD and the requirements of the CX to be actively involved in different projects. Furthermore, by having access to both academic as well as commercial professionals, the overall levels of my knowledge reached even higher stages. However, whilst the understanding of a more ‘typical’ PhD student runs deep and narrower as their knowledge pool is being enlarged into one particular field, I would like to argue that my knowledge of the design practice spreads across a multitude of fields. The trade-off here being the depth of the fields, which are therefore directly impacted and overall affecting the knowledge of a singular area of study. In this respect, I believed I have gained a better understanding of Design as a discipline, rather than focusing all my efforts on a particular field of Design.

In this respect, I see the CX programme as being unmistakably and undeniably a success since, in my opinion, a great designer and implicitly the knowledge acquired through the study, has to be spread across a multitude of

fields, not just solely focusing on a singular aspect of a chosen subject. Let us take the Physical Playlist project as an example to further highlight this point. As previously mentioned, the project was trying to reimagine the mix-tape in a digitally dominating and driven world. My interests principally tended towards the creation of the artefact whilst focusing on the overall experience one would have whilst interacting with the product. However, at its core, the project stands as a good example of service design, with its focus towards providing a different way of interacting with digital repositories, from implications towards privacy and content management to user experience. Therefore, whilst I focused my search towards the creation of the interaction, I do believe I have also gained good insights into what Service Design as a field of study is trying to achieve. And therefore, despite all the hurdles the CX research programme imposed on its doctoral candidates, I believe it was a success. At least for me!

I would also like to address some of the challenges of working across multidisciplinary teams. I find it more appropriate to discuss this here and address these challenges at a global scale rather than analysing them individually in each project since some of them have spanned across different projects. As I was mentioning in my Scene chapter, the CX imposed on their doctoral candidates to work in a diverse team formed by both academic partners as well as commercial/industry ones. The challenge here lies exactly in this aspect: how does one handle the overall aims of the project whilst accounting for the different roles and agendas of the project's partners?

Firstly, there is the difference of agendas where each partner pursues their own goals. On one hand, academics tend to focus more on the research aspects and in their overall search for knowledge and will to express outputs with 'meaningful'⁷⁷ impact whilst, on the other hand, industry partners were focused more on the delivery aspects of the project, more often than not found through the embodiment of the prototype. One could easily envision a financial gain as one of the goals of our industry partners and, whilst this might have been the case for some of the CX projects, I did not find this to be true in the projects I was involved in. Since our commercial partners were paid for, their interests seemed to have shifted from the long-term prospect of financial gains to those of providers of knowledge, expertise or support. In the

⁷⁷ Own or institutional goals which might differ from what the reader considers to be meaningful.

Perceptive Media project for example, Mudlark's roles were to create and deliver a 'perceptive story', a service which they were compensated for. The same holds true for the Paths of Desire project, where the artist was commissioned to create elements of maps matching his artistic and well-known style. This meant that we benefitted from their knowledge and expertise whilst also being able to pursue our research free from any monetary gain constraints. This however is not the case where The BBC's R&D team were involved since they were not compensated for their participation and, therefore, had to find compensation in other aspects of the project. For example, in projects such as The Physical Playlist and Perceptive Media, Ian Forrester roles were both that of a researcher, focusing on addressing research agendas in-line with the BBC's vision as well as that of a consultant, providing needed expertise in the field of media. Naturally, this implies the need of compromises to be made however, I would like to turn this on a different side and point out that whilst some decisions could be seen as 'political' in order to allow our partners to pursue their agendas, in fact, they were all done for the greater good of the project since the knowledge exchange which took place during the projects were, in the end, beneficial to both the partners and the overall projects.

On the other hand, as a doctoral candidate I was naturally drawn to my own research area further guided by the senior academic staff involved in the projects which, as one might suspect, pursue their individual research agendas. This, in itself, is a challenging environment to work in as, even here, there is a multitude of aspects addressed and understood differently by each researcher. At the beginning of my journey, I found myself to be in-line with the beliefs of my supervisors which I believe stems from my limited understanding of the field of study however, as I grew and acquired more knowledge into the field, I found my own voice which I started to pursue more and more. The Physical Playlist project is a good example of learning experience and developing where, my own input was limited, it felt more driven by the senior academics involved in the project. This may very well stem from my joining of the team at a later date by which time the general ideas and overview of the project were already formed. Nevertheless, to me, this is a great experience since it allowed me to better understand the project and the multitudes of fields of study as well as how to address the team in

ways which we can all benefit from. The Physical Social Network stands as an example of where my own design sensibilities came to the fore as I both led and directed the design aspects of this project.

Based on this experience, I believe the power of collaborating in multidisciplinary teams lies in the knowledge shared amongst the team members whilst pursuing the overall agenda of the project. By openly accepting the motivations of others we can all accomplish so much more!

Objects and Spaces within the Digital Public Space

A quick skim over the presented projects might leave the reader with a pondering question: why this structure since it does not seem to be chronological, which would be the 'typical' way in which a thesis is structured. Furthermore, why this structure is explained only now and not before delving into each project? Alongside the goals which I have clearly stated at the beginning of this body of work, I have also declared that the CX research programme was rather unique, asking all the doctoral candidates to work on different projects with a diverse team composition. Sometimes these projects run simultaneously and therefore, a chronological approach to their presentation would have been both impossible and ineffective. On the other hand, because I took part in a lot of projects, much more than included in this thesis, a full understanding of each and any of the projects was not always possible until the project was finished. Some knowledge was gathered and retained during my involvement and work on each project, however, I have achieved a greater clarity since their presentation and inclusion into this thesis. In this respect, to provide a greater emphasis on the intricate ways in which CX worked, whilst also presenting my understating of this work, I have deliberately decided not to talk about this structure until it emerged. Furthermore, since a thorough analysis of each project was not fully completed, trying to provide an explanation for any chosen structure would not have been possible nor accurate.

One of the mandatory requirements of any thesis, and implicitly of the doctoral candidate, is to demonstrate their contribution to knowledge. I have stated in my Research Design chapter that such a contribution could be achieved through an approach where knowledge is constructed with a clear focus towards the "meaning-making activity of the individual mind"

(Schwandt, 1994, p. 127). In the case of this thesis, the making activity of the mind emerging through the presentation of these projects is primarily represented by the construction of artefacts. In this thesis, I have often defined these artefacts as mixed-reality ones though their physical and digital presence. However, if I were to analyse these artefacts in terms of their final construct, that defined by what they achieve when they are enacted, they are best split into 'non-material artefacts', best explained by their contribution to the creation of spaces and 'material artefacts', which are easier defined as objects, having physical and tangible attributes. Let me take all these projects, one by one, to better explain this classification.

Pac-Lan explored space creation through the design of a game. Despite the addition of the physical game elements, the area where the game is played does not change its purpose until the game is effectively being played. It is through the addition of the game and the act of playing it, that a new space is created. By changing the visual hierarchies of a digital map, the Paths of Desire project tackles the creation of new mental maps, and implicitly, that of new conceptual spaces. Arguably since exploration sits at the basis of any mental map, by radically changing the presentation of the navigational map, alternate mental maps can be formed. Lastly, Perceptive Media does not directly create a new space in the same way in which Pac-Lan does, but rather it contributes to the spatial anchoring of the listener into their physical environment. By taking advantage of the listener's context, the perceived surrounding space of the location where the play is being listened to, is being altered; whilst this is a subtle change, it is nevertheless a change in perception. I would like to give a short example of the potential of this last project which might better portray the reasoning behind its inclusion into this characterisation. A while back I discovered a new running application which I have been using ever since. *Zombies, Run!*⁷⁸ is a mobile application which allows joggers to take the persona of 'Runner 5' and, whilst enjoying a mission based split narrative, they can perform different tasks for a settlement of survivors. More often than not, the story uses physical elements to guide the runners (e.g. taking a turn at the church or circling around the back of the old gas station, etc.) however, all these elements are not anchored in the context of the physical environment of the runner. Whilst the application itself creates

⁷⁸ <https://zombiesrungame.com/>

new spaces and experiences for the runners (in a similar manner to how Pac-Lan does), the inclusion of contextual elements into the story might provide even more immersion into the game. Anchoring the runners into their physical environment by simply referencing different POIs taken from their physical environment and incorporating them into the story, might contribute to achieving a higher experience. This type of story alteration is at the basis of the Perceptive Media project. It is in this way that the project contributes to the creation of a new space. To fully clarify this point, what I have loosely introduced as the creation of a space, Lynch referred to as the 'legibility' of a given space, directly pointing to the mental maps formed based on our understanding of a given physical space.

At the opposite end, objects are best explained through their materiality, their physical form which can be interacted with; tangible, palpable objects. The Physical Playlist project focuses on rendering a digital repository physically shareable through the creation of a concrete, material and substantial bracelet. In a similar vein, the same materiality can be seen in the Physical Social network project, embedded into the final built artefact. They are also explained by the so-called actor-network theory which states that "objects are an effect of stable arrays or network of relationships" (Law, 2002, p. 91). Whilst this network could be seen as being solely defined by the relationships it has with the outside influences (people, places, etc.), it is also expressed by the materials which define the object. Let me take the artefact described in the Physical Social Network as an example. It is built in plywood, plastic and metal and held together by screws whilst its shape and interaction are given by my understanding of what its function affords which are both internal as well as external relationships. If I were to replicate this mixed-reality artefact and change the handle of the crank with a wheel, I will end up with a different object. Solely the act of duplication will render two different objects since they will have an external relation! As Bruce Sterling wisely puts it, "no object stands alone; it is not a static thing, but a shaping-thing" (Sterling, 2005, p. 49).

I do not want to delve deeper into the philosophical debate about the existence of objects however, I wanted to point out the difference between these projects in connection to the structure of this thesis, which is mostly based on their materiality as well as function. Hence why I saw fit to present

them in this order. I have chosen to use the term ‘non-material’ rather than ‘immaterial’ to not confuse the reader since immaterial might be easily mistaken for a lack of importance rather than a lack of physicality. This materiality can also be understood by looking at the tangible aspect of the project and by this, I am only focusing on the clarity each project provides towards them being definite enough to be easily seen, felt, or noticed. In this way, the projects which tackle the creation of objects are tangible and material whilst the ones dealing with the construction of spaces, become intangible and non-material.

The concepts of material and non-material are also relevant to the inclusion of all these projects into the Digital Public Space, since the material artefacts directly tackle notions such as sharing, exchange and democratisation of archives mentioned by researchers of the Digital Public Space. On the other hand, non-material artefacts directly address the creation of spaces, engagement and raising awareness. Nevertheless, they are all enactments of “new tools to store, share, exchange and develop human knowledge” (Hemment et al., 2013, p. 10) and this body of work, through their in-depth presentation, stands as proof.

Digital Public Spaces

Drawing from Milgram et al. (1995) and Turner (1974), Coulton (2017) provides a good framework for understanding the current mixed-reality space in which these ‘objects and spaces’ live in by defining the ‘real’, the physical world we reside in, stripped from anything non-physical, and the ‘virtual’, the totality of non-physicality created through the use of software (code, media object, algorithm, etc.) According to the same source, the current scene is best defined by two states, that of ‘liminal’, a threshold “used to indicate that a being is between two states, neither here nor there” (Coulton, 2017, p. 2) and ‘liminoid’, which is represented by “activities outside normal life such as theatre” (ibid). These two states can be seen in Figure 88. Nevertheless, due to rhetoric such as IoT and WoT, where the consumption of the Internet moves away from the domination of screens, Coulton (ibid) argues the need for a different framework based on Atoms (the real) and Bits (the ‘new’ virtual) which can be seen in Figure 89.

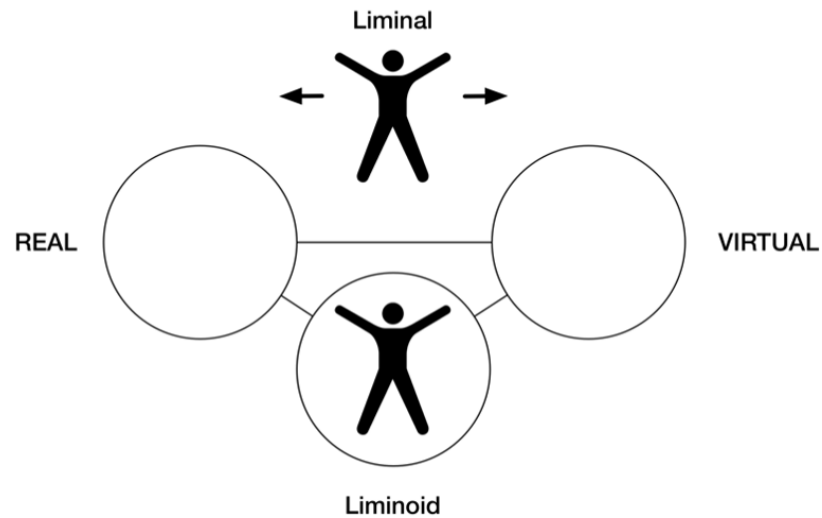


Figure 88. Representation of 'liminal' and 'liminoid' states found in mixed-reality worlds (Coulton, 2017).

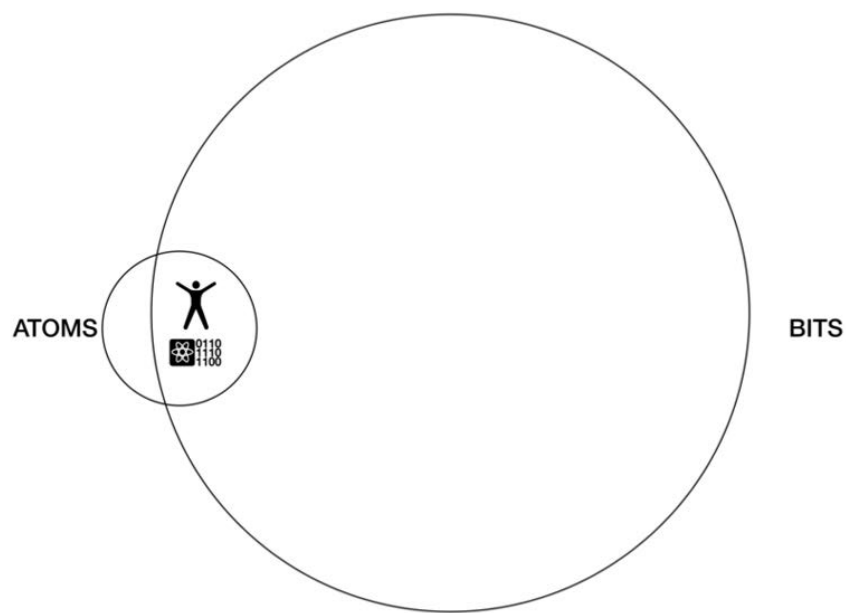


Figure 89. Atoms and Bits representation (Colton, 2017).

Let me pause here and analyse this in more depth. First and foremost, what Milgram referred to as 'Real', Coulton called it 'Atoms' and I, within this thesis, named it 'physical' in a similar vein to how 'Virtual', 'Bits' and 'digital' are used. These are just terms and arguably represent the same concepts or, as Humpty Dumpty said, "when *I* use a word it means what I choose it to mean - neither more nor less" (Carroll et al., 1961).

Secondly, whilst 'liminal' states might have been used not so long ago, nowadays, it is becoming increasingly difficult to define the boundary between 'physical' and 'digital' states. A simple example might be more useful: currently, I am writing this explanation onto a file stored in a Dropbox folder, using the keyboard of my machine, whilst being sat on a sofa and listening to a Spotify playlist. A digital wall clock is counting down the time until my next break. Sometimes, it seems to be matching the rhythm of the playlist. I believe, similar to Coulton (2017) that, IoT/WoT have destroyed this liminal state and trying to understand where one moves from the 'real' environment into the 'virtual', or vice-versa, is neither practical nor accurate. On the other hand, since the Internet "will be no longer a space we visit but a place we live in" (Colton, 2015), liminoid states are also inaccurate, since this mixed-reality space we live in is, in fact, our current reality. Personally, I would characterize this new space as a 'heterotopia', which is best explained not by the existence of two individual worlds, but rather of their fusion, anchored to my own perceived reality.

According to Foucault, a heterotopia is a part metaphorical, part fictional phenomenon "capable of juxtaposing in a single real place several spaces, several sites that are in themselves incompatible" (Foucault, 1986, p. 25). To emphasise, the 'real' place Foucault refers to is not the same as to the one discussed by Milgram (1995) or Coulton (2017) above, but rather the one defined by the apposition of the digital and the physical into a new place with the role of creating "a space of illusion that exposes every real space" (ibid, p. 27). Given the current trend, it is my belief that this new place will become our everyday reality, a place defined by tangibility, physicality, the unseen and the abstract. A small step forward and I can use the same analogy to describe Digital Public Space creations since heterotopias have an important accumulative character; they gather everything "establishing a sort of general archive" whilst "constituting a place of all times that is itself outside of time and inaccessible" (ibid, p. 26). Pac-Lan constitutes a good example here, since the game space it creates is only accessible at game play, existing outside of time until its function is summoned. Furthermore, heterotopias also "presuppose a system of opening and closing that both isolates them and makes them penetrable" such that, through their inclusion, they exclude (ibid, p 27). The artefact built in the Physical Social Network stands as proof of

being opened, since anyone can interact with it, however, during this interaction and implicit inclusion into this environment is when the exclusion from the previous environment takes places.

To conclude on this point, I understand digital public spaces as heterotopias(n) since they share some of the same principles: they produce new spaces and places, they are both including and excluding, sitting outside of time whilst juxtaposing spaces and places of different natures, but real!

Interactions

In my Research Design chapter, I stated that designers of digital public spaces need to acknowledge the presence of both physical and digital interactions, in order to not cause confusion to the user. As previously pointed out, these projects belong to a mixed-reality space and therefore could also be defined by a mixture of both digital and physical interactions. Thus, in the following part of this chapter, I present a discussion of the projects included in this thesis, based on the separation presented above, whilst also answering all of the three questions asked by Verplank and discussed in the Research Design chapter⁷⁹. Figure 90 depicts the ‘real’ interactions while Figure 91 shows the ‘virtual’ ones.

Real Interactions

In terms of physical interactions, Pac-Lan asks the player to scan NFC tags, either the ones located on the physical pills or the ones found with the players. These interactions are discrete, since they represent a one-time only action, closer to being seen as hot media rather than cool since they tend to dominate the visual spectrum only and lastly, they should be seen as paths, since they require “knowing only one step at a time” (Verplank, 2009, p. 8). However, the player is also required to find their ways to the next pill, base or player, depending on their individual state, which I see as being a continuous and cool interaction belonging to a map. Whilst the navigation might be seen as a path, moving from one pill to the other, the sudden disturbance lent by an opposing player appearing in their visual zone, implies the need for a good mental map to be used.

⁷⁹ How do you do? How do you feel? How do you know?

The Paths of Desire project is much simpler, requiring the player to only navigate their physical surrounding, therefore, reaching a POI can be seen as belonging to paths, for point-to-point navigation, until a good mental map is achieved, and hence the classification will shift. In a similar vein to Pac-Lan, these types of interactions are cool and continuous.

Perceptive Media is a particular case since the listener can only enter/exit the field of view of the camera. Everything else happens in the background and cannot really be classed as an interaction. This is due to the way the project is set to slightly alter a story based on the context of the listener. Therefore, I can only classify this as a discrete interaction, and cannot be seen as answering any of the other two remaining questions.

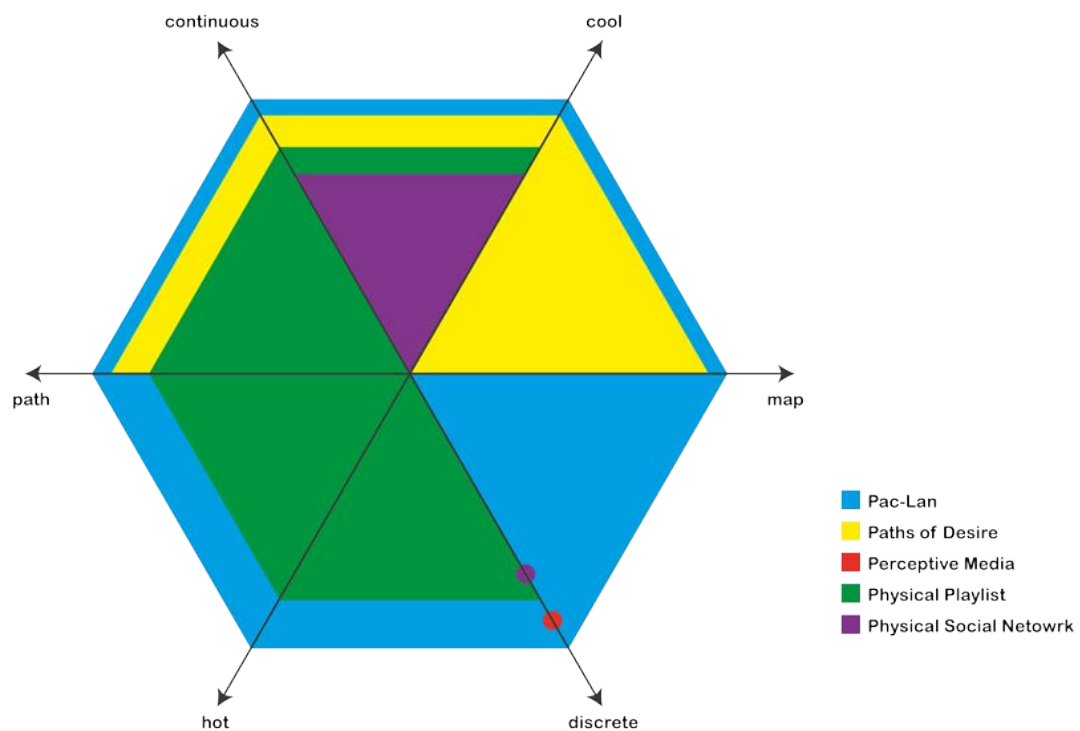


Figure 90. A view of all 5 projects with their respective 'real' interactions split following Verplank's designing interactions theme.

Physical Playlist has some similarities to Pac-Lan, especially around the scanning of NFC tags. As before, these are discrete, hot and paths like interactions. This is true for both the creation and playing of the playlist. On the other hand, if we look at the player mechanism, this is clearly a continuous interaction, which can also be seen as cool since, alongside the visual spectrum, it also engages our hearing sense, due to the rotational

mechanism of the player. Lastly, the top and bottom buttons are discrete and hot. Again, since this is outside of the control of the user, I cannot really allocate it to being either a map or a path.

Physical Social Network has two interactions, one handle and one knob: the former is clearly continuous whilst the latter is discrete. Because of the tight connection of these interactions with the digital interface as well as the physical artefact, they are both representative of cool media, in a similar vein to how Physical Playlist is. Lastly, whilst it could be debated that they might be seen as paths rather than maps, I believe they should be seen as neither since they do not provide instructions nor help with achieving a better mental map.

Virtual Interactions

Pac-Lan's digital interactions are found only on and within the mobile application, either initiated by the player or by the app itself (GPS, the screen blanking, etc.). Some of these, such as the player's interactions with the mobile app are discrete and hot, requiring only the pressing of buttons. Since they provide instructions on how the player should proceed, they are better seen as paths.

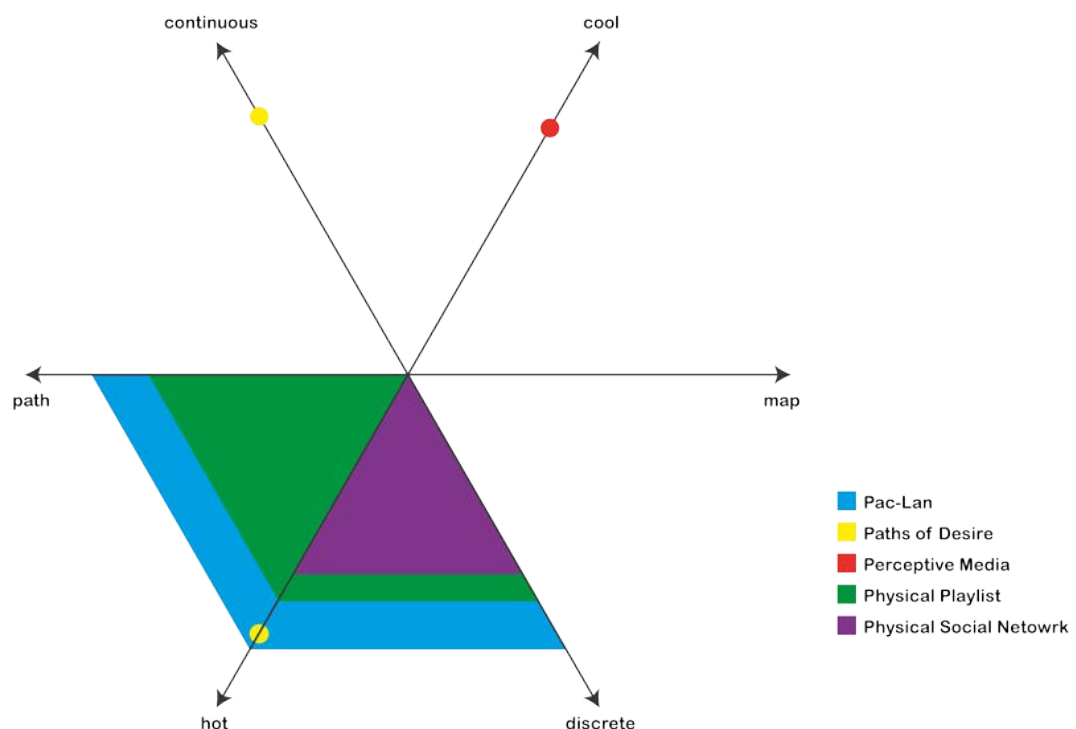


Figure 91. A view of all 5 projects with their respective 'virtual' interactions split following Verplank's designing interactions theme.

Paths of Desire allows the user to interact with the map by rotating it and zooming in/out of the map. These are continuous and hot interactions since they tend to dominate only the visual spectrum and are constantly responding to the user's physical location.

Perceptive Media removes all digital interactions from the user, however, the story in itself should be seen as a cool type of media, since it allows different interpretations.

Physical Playlist and Physical Social Network share the same similarities since the interactions with their respective interfaces are discrete and hot. The difference comes from the consumption since for the writing of the playlist is clearly a path, providing instructions at every step whilst, for the Physical Social Network, neither a map nor a path could be argued.

Contributions

One of the immediate advantages of my chosen methodology is that it caters for a large degree of uncertainty. During the development of the projects, both the team and I, have often found ourselves in a need to find the best ways to meet the requirements of the projects. In some cases, we had quite a good understanding of what we needed to achieve, however, in some other projects, we just had an idea of providing a different solution to a perceived problem. Quite often, as it can be seen in all the projects, there were technical difficulties which needed to be overcome. If we had set ourselves on a fixed path, prior to the start of the project, I fear some of these projects would have never seen the light of day. As I have shown, more often than not, we had to modify our approach. One such example is the Physical Social Network and the final built artefact. There was a rough idea, a hunch as Verplank calls it, however, we had little understating of what the rotary encoder can do! Furthermore, we had little knowledge if the chosen, Facebook feed-like, interface was appropriate or not. It was during the development of the project, especially during the play-testing of the physical interaction, that we decided to try a different digital interface. The same holds true for the Perceptive Radio where, as it was previously presented, the technical difficulties with the Beacons, microphones and cameras, forced us to re-think our original approach. Due to the encountered issues, we had to research alternatives. This approach would not have been possible if a stricter

methodology would have been used. Therefore, this type of approach demonstrates the uses of both little 'r', when we need to research alternatives, as well as the big 'R', which is found in the description of the projects and the overall thesis.

Action Research allows for a cyclic approach, which facilitates a very fluid approach to any project. Furthermore, it also takes into consideration the presence and incorporation of multiple actors. On the other hand, the "conclusions drawn (in AR) are data-based, preferably drawing the data from multiple sources" (Dick, 2000) which, based on my practice, is not the case for the work presented here. The knowledge presented is gathered through the process of designing, not by analysing the outcomes and comparing them to other, maybe similar, or dissimilar, findings. This is more closely to RtD since the focus falls not on the design of an artefact but rather on the knowledge gathered through the design process. Based on the work presented in this thesis, the artefact only stands as a proof of concept and the embodiment of the knowledge acquired through the process of designing it. GT, on the other hand, allows for theory to emerge, by defining new concepts as they are emerging. A good example of this is the need for personalised maps. The knowledge and understanding acquired in Pac-Lan led to the setup of the Paths of Desire projects and a further exploration of how personalised maps could be used. Lastly, the postmodernism turn on RtD allowed me to situate myself both as a researcher as well as a designer whilst also acknowledging that, at the end of the day, all voices matter and are equally relevant. The feedback I gathered and acknowledged led to a better understanding of the build artefacts, sometimes contributing to the overall improvement of the project. I believe I cannot be objective in my own subjectivity! Whilst the partners in projects were assigned different tasks to perform, their constant feedback and involvement also contributed to the creation of a more robust artefact. Therefore, in my opinion, and regarding the design process, it is important to acknowledge as many voices as possible. There is no negative feedback, only feedback.⁸⁰

⁸⁰ There is also irrelevant feedback, which is addressed in a subsequent part of this thesis.

One last important point is to be made here relating to the actual research development process of each of the presented projects. I have stated in my Research Design chapter that Verplank's design process was used as the foundation for understanding the design process. Other models, such as the Double Diamond⁸¹, proposed by the Design Council, or the one proposed by Moggridge, focusing on constraints, synthesis, framing, ideation, envisioning, uncertainty, selection, visualisation, prototyping and evaluation (Moggridge, p. 729-735, 2006), could as well be used. They are highly abstracted models focusing on different ways of visualising and understating the same complex process. I prefer Verplank's solely because it fits better with my understanding of how design is achieved, and it feels closer to the arts and crafts practices, especially since constructivism sits at the core of the presented work. Nevertheless, whilst they are all valid models, the design process is a fluid one, and each project and product has its own process, driven by the particularities of the design brief and influenced by the technological and material challenges they offer. Therefore, I would like to propose my own design process which addresses the process from the initial idea (the hunch) until a prototype is built.

My intentions are to contribute further to understanding of design processes, not at the same abstracted levels as the ones mentioned previously, but one derived through my own practice during my doctoral journey by building on top of Verplank's (Figure 92). As each project has contributed to my research practice journey it is best presented and analysed in this chapter in order to fully appreciate how my design manifesto was derived.

⁸¹ <http://www.designcouncil.org.uk/news-opinion/design-process-what-double-diamond>

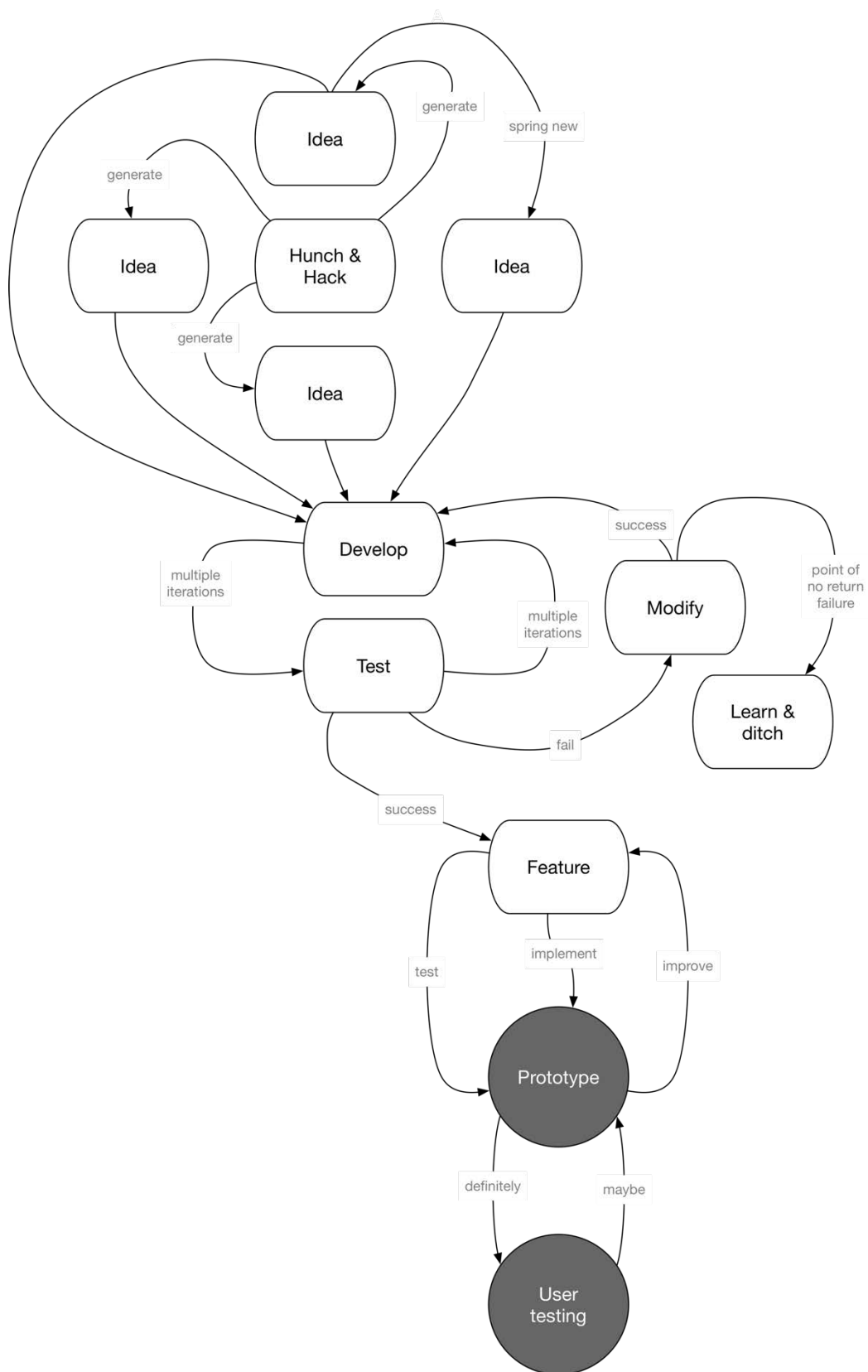


Figure 92. My proposed Design Process.

It can easily be seen that this model is a mixture of RtD and AR, allowing for an organic development of the prototype, where ideas are explored, individually developed, tested and, if successful, included in the prototype. There is an important cyclical process⁸² of developing and testing involved in all ideas. In my practice, I have rarely encountered situations when an idea turns into a feature in one iteration. Whilst it has happened, the tendency is to iteratively develop, test and further increase the performance of one idea, until it either matches the envisioned functionality or, the designer is 'happy' with the achieved state. Also, there are situations when some ideas fail however, they can be slightly modified and put back into the same cyclical process. 'The finger' in the Physical Social Network is a good example where the initial approach was good but the first few iterations were unsuccessful; by entirely changing the approach, the same idea was used and it finally turned into the desired feature. Nevertheless, the above diagram, whilst still highly abstracted, points out that some ideas reach a point where they need to be disregarded (point of no return failure). In the Perceptive Media project, some sensors could not be used due to their particularities not matching the requirements of the project (the microphone, the Beacons, etc.). Whilst that particular idea was disregarded from that design process, there were lessons to be learned which could be used in other design processes involving the use of similar technologies. Failures are a natural part of the design process and need to be acknowledged; they are not a negative aspect of the design process but rather a critical one to achieving successful outcomes. Whilst from a commercial perspective, these 'Failures' represents time, resources and money which, ideally, would have been better spent elsewhere, from a critical perspective, they provided valuable insight into both the current design and potential future designs. Furthermore, only by going through a number of iterations one can achieve the desired outcome and this can only happen by acknowledging the diversity of routes and mistakes made. I learned so much from all the side tracks I explored, even if, in the end, they were never used in the final prototypes. This knowledge has benefitted me even since in other projects, some of them not even discussed in this thesis; nothing is lost, even if it did not make it into the final prototype.

⁸² This process resembles and is influenced by AR methodology.

In order to make this process more legible, I am focusing here mainly on how initial ideas turn into features, sometimes with the possibility of not being incorporated into the final design.

Whilst individual features are being slowly incorporated into the prototype, bringing the design to life, their constant addition also influences and modifies the product since there might be connections between different features. Thus, they need to adapt and grow in a similar vein to how the prototype grows since the prototype is representative of the cumulus of all these features. Again, this is an organic approach and needs to be reflected in the design process. The last part of the design process is naturally related to the user testing which, in some cases, will be fed back into the prototype. I would like to stress here the importance of the user testing, be that of qualitative or quantitative approach, since it is the best way in which designs can be understood. If our designs are directed towards the public's consumption, surely, we need to acknowledge their feedback. Nevertheless, there are moments when the received feedback is sadly outside of the scope of the project, or, outside of the prototype; whilst the received feedback might be of use in future or similar endeavours, we simply need to acknowledge it but not rush to make use of it.

This Design Process should be seen not as a replacement for any of the previously mentioned design processes but rather as an in-depth one focusing on the construction of the artefact.

This Design Process and the Research Design chapter, in particular, the methodological framework, is knowledge in itself and, therefore, both stand as my academic contributions. Alongside this, I am also proposing a set of guidelines, ideas and points which have been extracted during my doctoral journey; whilst some might have been said before, they are included as they were confirmed in this research. In some circles, the following list would be seen as a manifesto, hence why I chose this title, however, my only aim here is to provide some insights which have been distilled over the course of my studies.

Manifesto

- ◆ **Understand the duality of the mixed-reality artefacts**, be that material or non-material. Since these are defined by their physical and digital qualities, designers need to consider the interactions and affordances for each of the worlds as well as their cumulative effects.
- ◆ **Affordances (both real and virtual) are key for designing objects; legibility is key for designing spaces.**
- ◆ **Mixed-reality artefacts need taking care of both their physical, perishable qualities as well as their digital bits.** A mixed-reality artefact might make use of an active Internet connection to gather data from outside sources. In general, this would be achieved by querying their APIs. Due to the rapid technological advancements, many providers update their APIs constantly, by changing naming conventions, locations, functions, data served back, etc. Therefore, previously used API calls will need to be updated to keep the artefact up-to-date.
- ◆ **Consider the ethical concerns around the designed mixed-reality artefact!** Due to the digital side of the artefact, there might be privacy concerns which need to be addressed and considered (location recording, etc.); the user needs to be made aware of what information is being gathered.
- ◆ **Mixed-reality artefacts require a fluid /organic design approach.** Designing physical products is a complex process, similarly, designing digital products is also challenging. Mixed-reality artefacts, be that objects or spaces, require the acknowledgment, consideration and finally, the use of the complexities given by each of the two worlds. Trying to structure each side individually might seem like a good approach yet, it is often the case that decisions taken concerning the digital side of the artefact will inform the ones relating to the physical side and vice-versa. Therefore, the design of mixed-reality artefacts needs to address both sides simultaneously.

- ◆ **Embrace the above-mentioned mess!** There is no point in fighting it but rather understand the complexity of the process and work with it, not against it. Think big and work in small, controllable steps, across the entirety of the design.
- ◆ **Do not slap a screen interface on it!** Just because we consume most of our digital content through screens, this does not naturally imply that every digital interaction should have an interface at its core! Designers should use the medium which is best suitable for the task, not the default one.
- ◆ **Design for the five senses.** This idea builds on top of the previous point, that of understanding that our designs could also tackle other senses, not just sight. The more senses we engage through our designs, the 'hotter' the design! HDesign!
- ◆ **Build simple prototypes first!** Some ideas could be quite large and difficult to implement, breaking a design into smaller chunks and individually prototyping and testing these parts would give a better understanding of the overall design.
- ◆ **Sketch and draw!** Use visual aids! Scribble if you need to! Explain yourself visually, especially since we consume so much information through sight. People understand better the ideas they can see. One can be easily misled by thinking this can be achieved only when it involves a physical construct, however, mental processes can also be visually explained. This is not about frequency of use, but rather about finding the best tools to convey ideas!
- ◆ **Play! Try! Test! Fail! Repeat!** Maybe some designs are totally unachievable due to their technical requirements, however, sometimes, you will not know until you try. Failing is as valid as following a known recipe!
- ◆ **Understand your audience.** Who is your design address to? What is this new design providing? Does the observed situation require a new design or just an amending of an already viable solution?

- ◆ **Work collaboratively.** I think I have tried to point this out quite often in this thesis and whilst I am not trying to imply that great designs cannot be achieved individually, I am definitely advocating for collaborations; a multitude of options and opinions would always give a rounder view of any design challenge.
- ◆ **Design is for change, not for the sake of designing!** If our designs do not affect positive change, then maybe we should not design. Just because we can do it, does it mean we ought to do it? Designers should accept when designing is not always the answer. Computer programmers often refer to this as “if it works, don’t break it!”.

The presented manifesto is not an exhaustive list of practices, but rather a useful perspective which I arrived at through the knowledge acquired in all my projects, even those not included in this thesis. For some of the points raised within this manifesto, their connections to one of the projects might be clear, whilst, for other points, these connections might be an amalgamation from a number of projects. All of these projects have contributed in one way or another to my writing of this manifesto and an attempt to connect individual points to each project, is a futile exercise since, I strongly believe, each of these points is valid in each of the discussed projects. A good example of this would be learning to read since this cannot be tied to a single experience but rather is a series of events which contributed to an overall acquisition of knowledge. Furthermore, some of the points raised in this manifesto could be seen as theory and, as theory goes, it is anything if not fallible, therefore, I am encouraging you to debate and critique it and hopefully expand upon it as the points I raise are becoming increasingly prevalent as the complexities of designing in spaces that are both simultaneously digital and physical.

Future Work

Due to the particular ways in which CX ran and especially around its imposed practice of moving from one project to the next, all the projects I was involved in, were never fully explored.

Pac-Lan looked at the creation of new game spaces around location-based games. It only tackled the digital side of the project, with little exploration being done around the physical environment in which the game is played. I am thinking here about what already available objects, which are currently just props in the current game area, could be used as elements of the game. Would it be possible to maybe repurpose already available street furniture and influence the legibility of this new space? Would sound be a positive addition to immersion, or would it be seen as negative? Personally, I would also like to explore the implications of creating these types of spaces. If I think back to my childhood when I used to go outside and play, my parents knew exactly where to find me since there was a single play area around our flat. Given the fact that these mixed-reality games could be setup anywhere, how would they be seen by partners and the community?

Paths of Desire is the best example of things not going according to plan, due to time and budget constraints, we never managed to properly engage the audience. Therefore, the first step would be to make the project public and understand the public's perceptions of these types of maps. A large-scale user testing would have allowed for the validation of the methods used within the application, such as how effective the quad-tree index approach to conflation is, whether Jenks' algorithm is the most suitable classification approach, and whether or not the map design is well suited to the exploratory navigation of unfamiliar urban spaces on foot. At the time of this writing, there is another funding proposal on the works, which is exploring exactly this missing point. Furthermore, as I previously mentioned, it would be interesting to see if multiple layers of data would influence behaviour or not. And if so, what data layers would be useful? Taking a future step, where could we adopt such maps? Online property websites still use Google Maps as their default mapping applications. Could PoD like maps benefit customers? On the other hand, if maps such as these are used, would they directly affect the local community since people might not want to move in a specific area due to high-risk crime? Or would it have an opposing outcome of attracting specific

segments of the population? We only focused on city exploration but could these types of maps be used for outdoor hiking and exploration? What kind of hazards should be part of these maps and would they work in the same way as the ones used in cities?

Perceptive Media removed all interactions from the user and provided a contextual-based adaptive narrative. The CX project only explored the audio side of broadcast, however, at the time of writing this thesis, the BBC had already started working on video broadcast and the possibilities this medium affords. Focusing solely on the audio broadcast, could the same technologies be used with the live broadcast? Considering autonomous voice enabled AI, such as Amazon Echo and Google Home are becoming increasingly popular, and their synthesised voices becoming more 'human' like, would these types of devices be better suited for the delivery of such content? Furthermore, since the project explored personalisation without the direct involvement of the listener, could social media be included? And if so, what would be the ethical considerations? How about privacy and confidentiality? If IoT is to be regulated, could Perceptive Stories be told anymore, or will the listener be required to provide acknowledgements of their environment being 'scanned' and used into stories? We only had little time to run a few workshops and provide the audience with the basis for creating such stories, however, if this type of broadcast is to be used, a shift in working methodology will be essential, since writing a story for this media cannot be done in the same ways in which 'normal' narratives are written. Could we design interfaces which would help with this? How would they look like and, more importantly, would they be practical enough to be used?

Physical Playlist explored the physicality and shareability of media; whilst it is without a doubt that other wearables could be further explored, are there any other objects which could be used? Only considering the practical aspects, the reader we created for the project would, most probably, never be mass-produced. However, due to the increasing availability of NFC readers in Android phones and with Apple finally providing developer access to their NFC sensors, there will be a valid option to create playlists which could be read by mobile phones. This, however, creates a few challenges such as educating the public on how to use these objects or creating applications which would allow in-order playing. How would these applications be

designed and what type of interactions would they require? Since the player acts as a reader, would it be part of a physical design allowing playing only when the phone is fixed, or will the user be required to scan all tags before enjoying the gifted selection? Given the fast-technological developments, it will be a matter of time until one NFC tag, even the size of the ones we used, could store a full song or a full playlist. Would storing the songs directly onto the tags be a better use, or the privacy implications would deter from such ideas?

Physical Social Network displayed a collection of postcards which was accessible through a continuous type of interaction by rotating its crank. Based on the comments from our museum partner, this type of interaction could be a suitable alternative to typical swipe-based types which are mostly found in museums at the moment. Therefore, what collections would be suitable for such interactions? Also, would the current physical shape of the object be appropriate for other types of content? Could a video be enjoyed in a similar manner? Or would it require maybe a front-facing wheel instead of a side-located crack as means of interaction? Would the digital interaction be discrete or continuous? If I were to imagine the same deck of postcards used in this project and physically in my hands, I would say that my interaction would be seen as discrete, since I would physically take each of them and analyse. This is not the case for the current project. But if I wanted to display the same collection as a timeline, would the designed interface employ a discrete interaction, stopping when a new object would be in view, or continuous, in a similar vein to how the current project works? Could the design of the artefact allow for switching between both types of interactions?

No matter which area of investigation one chooses to pursue, I can only encourage towards a collaborative approach to research, simply because one cannot make the best decisions when one is engulfed into the work; team discussions and decisions tend to be better suited towards goal achievement. It is also more enjoyable and quite fun... most of the times at least!

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Appendix

The code for each project can found at the following addresses:

1. PAC-LAN
<http://cxprojects.lancs.ac.uk:8585/Adrian/pac-lan>
2. Paths of Desire
<http://cxprojects.lancs.ac.uk:8585/Adrian/paths-of-desire>
3. Perceptive Media
<http://cxprojects.lancs.ac.uk:8585/redspike/perceptive-media-bbc>
4. Physical Playlist
<http://cxprojects.lancs.ac.uk:8585/redspike/physical-playlist>
5. Physical Social Network
<http://cxprojects.lancs.ac.uk:8585/Adrian/physical-social-network>