Temporal Representations in Human Computer Interaction

Designing for the lived experience of time

By

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A dissertation submitted to the University of the West of England in accordance with the requirements of the degree of DOCTOR OF PHILOSOPHY in the Faculty of Environment and Technology.

APRIL 2017

Word count: Twenty two thousand seven hundred and forty four

Abstract

Temporal representations in Human Computer Interaction: is a portfolio of peer reviewed papers and media artworks representing several years of investigation, experimental making, and study into the perceptions and representation of time in digital media and Human Computer Interaction (HCI). The lived experience of time is fundamental to our understanding of the world and the work investigates the complex and contradictory nature of time and the powerful effect temporal representations have on health, well-being and perception.

The investigation, methodology and outputs are based in the traditions of interdisciplinary electronic arts, technology research and digital culture. Practice-led, research through design techniques, are used as a means to explore alternative framings of temporal processes. I discuss the importance of temporal experience as a concern for contextual design and consider the models and lived experiences of time and how system-centric representations alter our perceptions of time.

The papers and works (discussed in chapters 4, 5 and 6 and included in full in appendix a) cover three broad areas:
Analysis and discussion of practice and language in HCI related to time;
Experimental designs for temporal objects and media artworks;
Finally through critical artefacts, media art and publications I discuss a new perspective on temporality in design and representation and present a framework for re-assessing how we include time in interaction design.

The framework is designed to be used as a tool to support understanding of the temporality of users, or situations of use, and to assist in translating and re-framing insights into practical outputs for improved design of interactive systems. It contrasts *system-centric* with *user-centric* temporal representation, and contributes a new design methodology that is aimed at improving contextual design processes. By increasing awareness of temporal context, and the multi-dimensional nature of user's temporality, designers can better understand user context when creating truly user centred interactive experiences.

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Lost Time Never	Buzzo	Conference paper	2013	Proceedings of the 2013 Inputs-Outputs Conference: An Interdisciplinary Conference on Engagement in HCI and Performance
The Shape of Time: Reconsidering Time in the Context of Pervasive Media	Buzzo	Conference paper	2013	Proceedings of the 1st Fascinate Conference Thoughtful Technology and Beautiful Interfaces
Time Travel: Time Dilation	Buzzo, Jonas	Conference paper	2014	Proceedings of British Computer Society, Electronic Visualisation in the Arts
Designing for the Impossible: Creating a Mobile Application to Track Time Dilation	Buzzo, Jonas	Conference paper	2015	Proceedings of British Computer Society, Electronic Visualisation in the Arts
Time Travel software for AndroidOS	Buzzo, Jonas	Open source Software	2015	`http://timetravel-app.com` and `https://github.com/danbz/timetravel`
Not all Days are Equal: Investigating the Meaning in the Digital Calendar	Buzzo, Merendino	Conference paper	2015	Proceedings of the SIGCHI conference on Human factors in computing systems
Time Travel: Time Dilation and a Year of Airflight - Recent Photographic Work	Buzzo	Artists Book	2015	Forlaegger Fabrik20
'What do we Know of Time When all we can Know for real is Now'	Buzzo	Generative Video Installation	2016	'Digital Futures' British Computer Society and Victoria and Albert Museum
Perfect Days. A Benevolent Calendar to Take Back Your Time	Hassenzahl, Buzzo, Neuhaus	Conference paper	2016	Celebration and Contemplation, 10th International Conference on Design and Emotion
JourneyMap: Visualising the Time-bound Student Journey	Buzzo, Phelps	Conference paper	2016	Proceedings of British Computer Society, Electronic Visualisation in the Arts
'Making a Time Machine'	Buzzo	Generative video Installation	2017	'Digital Futures' British Computer Society and Victoria and Albert Museum
Arguing for Temporality in HCI: A Guide for User Centred Temporal Design'	Buzzo	Journal Paper	2017 (in press)	Interacting with Computers, Oxford University Press

Table 1: Peer reviewed papers and works included in this portfolio for consideration. For full papers please see appendix a

Dedication and acknowledgements

Thanks go to many people who have been supportive, and contributed to this body of work, at different points over the past several years. I would specifically like to acknowledge and thank:

The generous support of the Department of Computer Science and Creative Technology in the Faculty of Environment and Technology at University of the West of England.
The patience, guidance and timely, reasoned advice of my supervisors, Richard McClatchey and Robert Stephens.
My co-creators and collaborators, Marc Hassenzahl, David Jonas, Nicolo Merendino, Robin Neuhaus and Phil Phelps. With gratitude for the advice and dry humour of Frank Nack.
Semay Wu for patience while proofreading. Any remaining mistakes are mine alone.
My external examiners Joel Ryan and Mark Blythe who so graciously gave up their time.
The editors, curators, chairs, reviewers and readers of my published work. Thank you for your support, positive feedback and advice. Yes, *including you*, reviewer number 3.

Kristina Andersen, inspiration and co-conspirator. Reflective, calm, encouraging and insightful. Always.

AUTHOR'S DECLARATION

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

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CHAPTER 1

INTRODUCTION, MOTIVATION AND METHODOLOGY

1.1 Introduction

TIME has traditionally been measured in relation to physical phenomena witnessed in our environment, or our internal perception of it. On one hand we look to the transit of heavenly bodies across prehistoric skies, the distance to walk from here to there or the arrival of birds on the wing from other continents. Observable, predictable, cyclic, physical phenomena have shaped our understanding of, and brought about, the standardisation of time. The drive to measure in increasingly precise increments has led us to the fundamental building blocks of our physical world. Observing emissions of particles from the predictable decay of isotopes in devices such as caesium beam clocks takes our traditional, anecdotal measurement of the physical nature of time, to its ultimate root in the very fabric of matter. On the other we see an increasingly sophisticated set of models analysing what it is to experience time, and how we may describe what we feel and perceive.

New definitions and descriptions of time are evolving from the numerical digital reality we exist in, that bear little relation to the physical and mental ones we have come from. The fabric of which is built of significantly different fundamental elements. Old presumptions that time is immutable, of its relation to space, that it moves in one direction, no longer maintain significance.

The works presented here are the peer-reviewed, published outputs from an auto-ethnographic, practice-led study using interaction design and lens based digital media as the principal investigatory tools. Taking lessons and techniques from the growing body of practice in the *research through design* approach (Frankel and Racine, 2010, Gaver et al., 1999, Gaver, 2012), the investigation, methodology and outputs are based in the traditions of interdisciplinary electronic arts, technology research and digital culture.

Peer-reviewed publications and outputs in the body of work build on a foundation of work that describes the area of temporal studies in human computer interaction and digital media. Specific ideas have been investigated in depth through design works (Dourish et al., 2004, Simonsen and Robertson, 2012, Wallace et al., 2013), peer-reviewed publications, and the *critical making* (Ratto, 2011) and publication, or public exhibition, of a series of digital, time based, lens media pieces. Each of these works or publications explore a given aspect and angle of the tension that exists between the *externally mediated* and *internally lived* perceptions of time.

The individual creative pieces complete a larger statement as a coherent, interrelated body of work. This work seeks to analyse the representations of macro and micro time-scales in digital media, with specific interventions into areas of the debate from a personal and phenomenological perspective. Written papers and media artefacts, as two complementary strands of material, represent a sustained critical contribution to the ongoing academic, design and artistic debate on the elusive nature of the experience of time. While definitive answers, in an epistemological sense, are beyond the scope of this work, and possibly beyond the scope of any research discipline, I provide context and grounded contribution to this complex debate. As Stappers and Giarcardi (2013) point out in their work on *Designing for temporal context*; (Stappers and Giaccardi, 2013)

> 'The most important thing designers should know is that there is no such single thing as time'

1.2 Motivation

Time, its presence and absence, and the effects and evidence of its influence has been central to my work - academic, industrial and artistic - for nearly three decades. Observing my industrial and artistic output, the repeating theme of how time is both represented and perceived, has occurred over and over. This is apparent within interaction design, published commercial products, photographic work, video installation and interactive media art. More recently within formal academic research the question of the influence and awareness of time and temporality in interaction design and human computer interaction has come to the fore, both within my research focus and published outputs.

The body of work presented here represents only a small portion of work undertaken over the past several years as part of more formal investigations into time and temporality: undertaking studies in the intersecting contexts of media, technology, HCI, research and media art practice. As can be expected, the work has continuously crossed disciplinary boundaries often finding that the boundaries are largely imagined in day to day practice, sometimes only becoming apparent when choosing fora within which to disseminate outputs and findings.

When approaching peer-reviewed publication this disciplinary rigidity can be seen as challenging. Even areas that are statedly cross-disciplinary can occasionally present rigidity with a conformity of canon, language and approved process. As a largely solo researcher-practitioner, in

Figure 1.1: Panoramic, time-shifted, multi-element video, San Francisco, 2001. Assembled from individual video clips shot over a ten minute period, the final piece runs to 60 seconds.
https://www.youtube.com/watch?v=A0ihIDMpkYU

an often practice-led context of *making*, the process of assembling this body of work has been a rewarding, and at times eye opening opportunity that has enabled me access to a deeper way of working and thinking.

Figure 1.2: Multi-frame, panoramic, extended-exposure composite image. Walking the Dragon's Back trail, Hong Kong, 1998

The process of relating a wider narrative around my work has enabled me to see it within a formative rather than summative context. There are now clearer, more direct links between the topics and themes presented here. These form a consistent, coherent body of work, underpinned by a deeper understanding and wider knowledge of both practice and theory.

My early lens-based observations began with experimental analogue video in the mid 1980's, explicitly investigating the challenging, philosophical nature of creating contemporaneous narrative, from non-temporally contiguous pieces. The challenges of recording in one temporal order and reassembling to represent the other, is apparent to creating new artificial temporal realities:

Figure 1.3: Multi-frame, panoramic, long exposure image, Devon, 2005

or as Paik, and others would call it, *input time and output time* (Paik, 1976). Later on, alongside new perspectives in media and philosophy, access to digital imaging equipment and computer hardware - for flexible, fast, processing of images - brought me new ways of perceiving, capturing and representing time.

Through the period spanning 1987-2000 my work developed from a passionate involvement in early video art, creating non-narrative video pieces using VHS and later U-matic tape and edit facilities. The video camera, initially the classic Sony Porta-pak, was a means to capture materials to feed the edit suite process: one that was occasionally assisted by the Fairlight CVI, a hybrid Analog Digital video processor designed by Australian engineers Peter Vogel and Kim Ryrie. [1] Released in 1984 it was the video cousin to the iconic Fairlight CMI computer music workstation. [2]

The edit suite soon became, for me, solely about manipulating the abstract conceptual space inside a VHS tape cassette. The cassette, and the arrangement of magnetic particles on the tape itself, has always contained the potential of an image, (a conceptual, transitory space that comes to life when activated as the glowing phosphor dots on a visual display monitor). Wipe a magnet over the tape and realign the ferrous dots, it destroys your original image, but the electronic space is still there, full of possibility, waiting to be manipulated and activated at the moment of pressing 'play'. In this respect, the jog and shuttle, time-code punch in and punch out, became a pair of tongs with which to reach inside this transient electronic space: a space that seemed one of limitless *potential*. First and foremost, it was one of temporal potential, of multiple temporalities, from recording to re-ordering, to repetition to replay. The arrival of the early days of scratch video and artists such as the Duvet Brothers, Rik Lander and Peter Boyd Maclean, [3] called into question the linear nature of TV, of visual materials, and the primacy of mass media.

[1] `http://www.audiovisualizers.com/toolshak/vidsynth/fair_cvi/fair_cvi.htm`
[2] `http://petervogelinstruments.com.au`
[3] `http://www.duvetbrothers.com`

> 'Scratch video establishes a radical new approach to television itself. It abandons the idea that TV images are mere representations of what's real. It starts to disassemble the images themselves by indulging in orgies of editing. In a sense scratch is the epitome of what professional broadcasters would call irresponsible television.' [4]

This disruption in visual media was occurring just as the audio sampler was enabling the same to happen within popular and experimental music (Cunningham, 1998). Timothy Taylor, author of 'Strange Sounds: Music, Technology and Culture' (Taylor, 2001) acknowledges the sampler as being:

> '...the most fundamental change in the history of Western music since the invention of music notation in the 9th Century'

Bridging the gap from Paik and the passage into modern media of Dada via Fluxus [5], my early work grew against this upheaval in art, media and access to means of production. In retrospect it all hinged on the need for investigation, to comprehend the ontological space around me, through tools that allowed the moulding and reworking of time.

Figure 1.4: Multi-frame, panoramic, extended exposure composite image, Hong Kong, 2000

Later work, from the period 1998-2001 in Hong Kong explicitly plays with the collision between space and time, with pieces such as *Hong Kong bus track*. (see figure 1.4) originating from a hand held DVCAM video recording, and being assembled as one image from a tracking shot of horizon, buildings and landscape. Each frame of video was taken as a spatially congruent but temporally unique period, and each of these short periods could be seen as discrete slices in the assembled larger whole.

Work from 1998-2001, contrasts with subsequent bodies of work such as the series of long exposure, traveling, composite images, created in 2001-2004 (see figure 1.3 and figure 1.5). These are multi-frame panoramic photographs held static as two dimensional images, with elapsed time stretching away in three dimensions. This sense of time in the images moves (not only) into each frame as the vehicles, from which they were shot, record the passage forward, spatially,

[4] Benjamin Woolley, The Listener, 14th Sept 1986

[5] `http://fluxus.org`

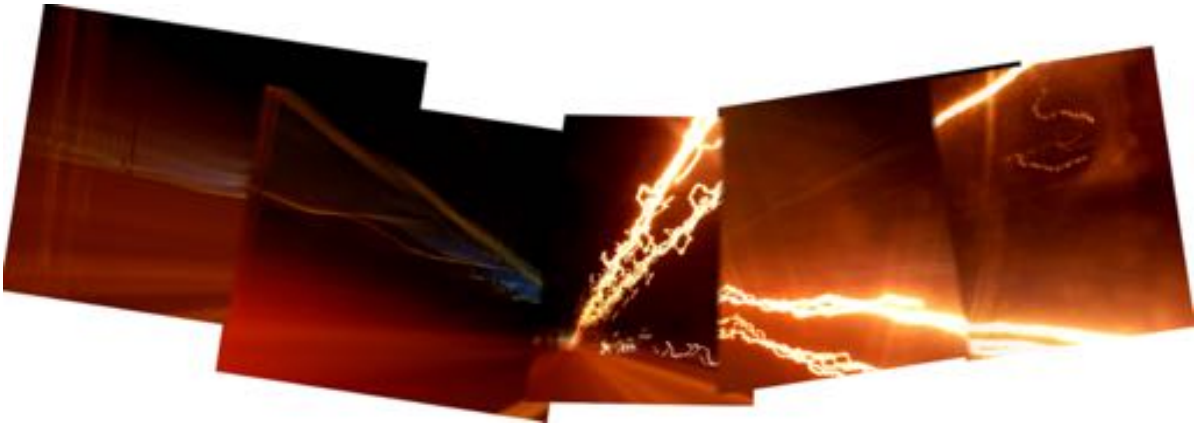

Figure 1.5: Multi-frame, panoramic, long exposure composite image, M4 motorway, Bristol, 2005

and temporally through the blurred, over-run lines; they move also as measures of different discrete moments. This process of travelling long exposure is repeated again and again, and finally assembled as a spatially coherent but temporally exotic panorama.

Figure 1.6: Still from panoramic, time-shifted video, Glastonbury festival, 2009. https://www.youtube.com/watch?v=231ZP5UaHB8

Later works, such as the series of travelling, tracking shots from Los Angeles (see figure 1.7), both mirror and complement the works from Hong Kong (see figures 1.4 and 1.2). Conceptually they expand further as the spatial dimension is compressed and overlaid in new extremes, and where kilometres of horizon are compressed into meters, and the integral durations are overlaid and made static.

From 2000 onward, static photographic work was complemented by an increased number of video pieces, such as *San Francisco Street Corner, 2001* [6] (see figure 1.1), which took extended video sequences and composited them to create spatially contiguous video panoramas, that were explicitly temporally non-contiguous. When viewing, the buildings and environment of the street corner make sense, but the moving people, cars, cyclists and traffic appear and disappear from temporal slice to slice. The elements in the video appear to move across the scene, appearing to

[6] https://www.youtube.com/watch?v=A0ihIDMpkYU

weave in and out of existence, at least in the idea of the *'now'* existence of time. This dynamic contrast between observation and temporal representation could be seen as the keystone to much of my later work. In the work's explicit, confrontational depiction of temporal discontinuity, the observer has to contend with the complexity of what we see as time, and what we see as now.

Figure 1.7: Panoramic, time shifted video, assembled still, Los Angeles freeway, 2001

1.3 Methodology

Aligning with the interdisciplinary nature of the investigatory area and process: The methodology has been suitably diverse, from mark making with ink on paper, to the non verbal investigations that cameras and lens based media allow. Much of the work presented here in the portfolio of papers and writing, originates in the tools I use to comprehend the world around me.

As Blevis notes in 'Digital Imagery as Meaning and Form in HCI and Design' (Blevis, 2011) visual thinking, and digital imagery directly, is particularly salient for HCI and interaction design. The descriptions of ontological design and transdisciplinarity in this and other works is particularly relevant. As Blevis and Stolterman note in 'Transcending disciplinary boundaries in interaction design':

> 'Transdisciplinarity is an approach that focuses neither on particular collection of methods nor on particular bodies of knowledge, *but rather focuses on a broader goal.*' (Blevis and Stolterman, 2009) (emphasis added)

The wide variety of projects undertaken in this body of work utilised a range of methodologies, such as qualitative, quantitative or comparative approaches. Some projects used visual thinking and tools such as camera or video to support non-verbal investigation, with a grounded or mixed methods approach. Other projects have combined quantitative data from sources such as web servers, calendar logfiles or other technical means, to record and subsequently analyse participant or subject actions and interactions.

Qualitative techniques included participant observation, semi-structured interviews and autoethnographic methods. Data from observations was commonly recorded through video, audio or photographic means for later analysis. Video and audio material were coded using a variety of techniques, often employing techniques of emergent coding. This allowed the collected materials to indicate suitable forms of measurement rather than dictating preconceived categorisation. This was found to be the most appropriate process for organizing and sorting the data. Using

emergent coding served to help label, compile and organize the gathered information. Coding in this way facilitated more relevant summary and synthesis of the observations or recordings. This was usually supported by contemporaneous notes or self-reported materials from participants in the style of design probe artefacts. eg, diaries, sketches, recordings etc.

Some projects have combined quantitative methods allied with qualitative ones, for example, analysing system usage and accesses by subjects, during observation sessions or in some instances longer adoptive studies. Data was derived from interactions with systems and the generation of system and server logs, combined with usage analysis of the selected information. The qualitative data often became extremely useful in gauging the accuracy of self-reporting by participants. This gave a new level of insights, particularly in work such as 'Perfect Day' project (see section 6.3) (Hassenzahl et al., 2016). In this instance, trends seen in server and quantitative usage data appeared to conflict with what participants self-reported of their usage; however, by using deeper analysis of the qualitative data, and also by taking onboard ideas of 'reactance' (Brehm, 1966) [7], we were able to propose alternative explanations. These appear to reconcile the apparent differences between the quantitative and qualitative data observed.

1.3.1 Reading strategies

Background literature searches and reading, have been wide-ranging and intently cross disciplinary. Contextual and primary research has covered mathematics, physics, art, philosophy, linguistics, cultural theory, design, and interaction design. To cover this seemingly diverse material, the reading and background research approach has taken what Iris Van der Tuin, taking from Bergson, calls 'diffractive reading' (van der Tuin, 2013). Popularised by other notable writers and theorists, such as Karen Barad and Donna Haraway, diffractive or diffraction reading addresses the problems and highlights, of reading and working in a cross disciplinary sense. It emphasises the great benefits to be gained after revealing insights not readily available to a single discipline or research context. In fact, the broad reading strategies cross disciplinary work requires, can actually work effectively in finding new areas of knowledge or confluence.

The metaphor of dropping stones across a pond, and seeing where the expanding ripples combine to create peaks of interest, is commonly cited as a strong visualisation for the diffractive reading argument. Both Barad and Haraway describe how diffraction is a method for reading and writing, and is a way of coping with some of the epistemological challenges of representation.

As Iris van der Tuin notes (van der Tuin, 2013):

> 'Diffraction is meant to disrupt linear and fixed causalities, and to work toward *more promising interference patterns*' (emphasis added)

[7] 'Psychological Reactance is a reaction to people, rules, or regulations that threaten or eliminate specific behavioural freedoms. The effect occurs when a person feels coerced or that someone or thing is taking away his or her choices or limiting the range of options.'

From the wide range of background materials gathered, influences identified include fundamentals of process and practice. Proven and evidential research techniques are illuminated, such as the experimental design probes of Dunne and Raby (Dunne and Raby, 2007), and the critical design approaches of Bardzell and Bardzell (Bardzell and Bardzell, 2013) rooted in Research through Design. This is complemented by working in media with an understanding of the lessons in media art from Paik and Fluxus, (Friedman, 2011) the deep maps and founding psychogeographic work of William Least Heat Moon (Gregory-guider, 2004), Guy deBord (Debord, 1956), and Situationist International (Jakovljevic, 2003). The lessons to be learned come as much from the deliberate use (and abuse) of technology as from the political questioning of the nature of technology, especially in relation to the individual and society as a whole. Technology often being seen as artefacts from a controlling society, mediating the experience of the individual (Dunne and Raby, 2007). Critical and provocative designs are but one response to that hegemonic proposal. Historical influences are considered against a backdrop of contemporary Human Computer Interaction (HCI), User Experience (UX), and Interaction Design (ID) practice. In the visualisation of any time series data it may be useful to maintain an awareness of the contradictory or even the possibly imaginary nature of time. The discourse here is explicitly at the intersection of art, design, science and technology: that which observes and measures, records and creates; exploring both from the rationalist, external view and also the internal, lived one.

Amongst the numerous disciplines and areas that address the complex aspects of time that I have found central to my research and underpinning much of this project have been;

- The work of Speed (Speed, 2013) and more recently of Pschetz (Pschetz, 2014, 2015) and Huang and Stolterman (Huang and Stolterman, 2011) all investigate aspects of temporal influence in HCI. Notable here is the proposed framework from Karapanos et al (Karapanos et al., 2009) which represents how experience changes over time. The 2012 SIGCHI workshop 'Changing Perspectives of Time in HCI' organised by Lindley et al (Lindley et al., 2013), of which I was honoured to be invited to present my work (Buzzo, 2013a), brought together researchers from around the world to discuss what time may be in the context of HCI (Lindley, 2015).

- Chen, Boroditsky, Tenbrink, Furhman et al. (Boroditsky and Gaby, 2010, Chen, 2013, Fuhrman and Boroditsky, 2010, Hendricks and Boroditsky, 2015, Moore, 2006, Tenbrink, 2011, Tenhouten, 2004) and the complex world of how culture and language shape the metaphors and subsequently the cognition and expression of the lived experience of time. Of particular interest were elements of Lera Boroditsky's 2011 book, 'How languages construct time' (Boroditsky, 2011a) where she examines the role that spatial metaphors and spatial representations play in constructing representations of time across languages. Although there is much debate regarding *linguistic relativity* and *linguistic determinism*, the underlying sentiments of the Sapir Whorf hypothesis (Lucy, 2015), both in its *strong*

and in its *weak* interpretations are still very much current. The principle appears to be supported by experimental evidence (Cibelli et al., 2016) showing that language, at the very least, influences thought; and that linguistic categories limit and determine cognitive categories, thought and decisions. In my analysis of how temporal representation and perception are intimately linked, this appears to align with Kevin Birth's (Birth, 2012, 2013) ideas of cognitive artefacts, such as clocks and calendars, and how they may 'think' on our behalf.

- Marx, Booth et al. (Booth, 1991, Tombazos, 2013) and the discussion of the socio-economic and cultural factors involved in the exchange of a person's *time* for monetary or social gain or value.

  As Booth writes in Chapter II of 'Gone Fishing: Making sense of Marx's concept of communism' (Booth, 1989):

  > 'Time is the "space" (Raum) of human development, the forum of one's "active existence."" A person's wealth, Marx adds, does not consist in the objects he or she accumulates, but rather in the time freely available to him or her. That is, wealth is not the sum of embodied past activity, of "dead labor" as Marx calls it, *but time yet to be shaped*' (emphasis added)

  Tombazos investigates this area further in 'Time in Marx: The Categories of Time in Marx's Capital' (Tombazos, 2013) where he expands not on the political or economic social but on the socio-temporal. Where he writes of both of time *represented* in capital but also of the time *perceived* within it.

- Husserl and the complex discussion of phenomenology and how one can articulate and quantify the lived experience of *being* (Husserl, 1991). This extends directly into discussions of time and the bodily experience of it. Husserl proposes that *being* must not be taken physically, but as directly experienced from within, making "the body as directly experienced by the embodied experiencer concerned": a theme for the investigation of temporal phenomenology.

- Kevin Birth (Birth, 2012, 2013, 2004) and his insightful writing on the phenomenon of *cognitive artefacts*, describing how *necromantic*[8] objects (designed in the past) have become things which we rely on to effectively *think* for us. His particular focus on clocks, calendars and timepieces of all descriptions is clear, thought provoking and provides a welcome perspective against which to work. Though as he cautions, time is not easy to think about, let alone talk about:

[8] In this instance Birth considers inherited artefacts such as clocks and calendar processes designed by persons or ages long past as necromantic, simplistically put, it is the dead thinking for us.

> 'Time is a fundamental dimension of human experience, but its study presents special challenges, including the methodological problems of how to get people to talk about time and how to recognize discourse and actions that reveal cultural conceptions of time.' (Birth, 2004)

- Wolfgang Aigner - and his work on the technical visualisation of time series data (Aigner et al., 2007, 2011): particularly that which involves multi-dimensional aspects such as time, task and resource allocation. Of use are his thoughtful descriptions and experiments with three dimensional graphing of temporal data. This combines with work from writers such as Tufte (Tufte, 2001) and Boyd-Davis (Boyd Davis, 2012), who are investigating the foundations of recording time visually. While they do not specifically discuss the nature of time they take one epistemological approach to *time as a problem of time-series data* and their work is invaluable in illuminating practical strategies for temporal visualisation.

- Dagfin Aas et al. working within the area of time use of individuals and populations: specifically in surveying and understanding the *actual* use to which people put their time, and in what greater capacity it can be seen. Aas's *Time Use Survey* activity classification built a conceptual framework, which is still used by many countries in their statistical survey and census work. Practical examples of how this work can give insight en massse include Hancock's work in New Zealand, discussing how time use studies 'categorises different activities into groups thus providing a picture of how people lead their lives,' (Hancock, 2011). This work provides insights not commonly available when observing individuals at 'ground level'.

- Physicist Craig Callender, (amongst numerous other writers on contemporary physics): his lucid descriptions of the physical science background to temporal theory and comparisons of conflicting theories of time has been particularly enlightening (Callender, 2000, 2008, 2010). As Carl Sagan says *"[Time] is profoundly resistant to simple definition."*

  Discussing the nature of time, Sagan, in an interview during the making of NOVA's TV program 'Time Travel', goes on to note (Sagan, 1999):

  > 'Ever since St. Augustine, people have wrestled with this, and there are all sorts of things it isn't. It isn't a flow of something, because what does it flow past? We use time to measure flow. How could we use time to measure time?'

- The physicist, feminist writer and philosopher Karen Barad and theoretical physicist Lee Smolin: Their complementary but diverse approach to new theories of time is intriguing, challenging and brings into question much that current physics holds fundamental. Particularly of interest is Smolin's search through past and current theories of time in search of the fundamental essence of what time may be, from a physical sciences perspective (Smolin, 2013). This is counterpointed by the assertion (Barad, 2016) that in the end time may be

an ontological issue rather than an epistemological one. Simply put, the challenge may be more a question of asking what time is than of measuring its effect.

The literature and discussion is long, broad, and wide ranging, and I have moved through the vast array of material to *diffractively* find the roots that underpin my current area of study. This is by no means exhaustive and in some cases only pertains to this specific study and area of interest. This sadly curtails many fascinating strands of additional research. This has sometimes been necessary to prevent becoming swamped by deep and complex arguments, theories and bodies of work from some of the world's finest thinkers and practitioners.

CHAPTER 2

THE RESEARCH CONTEXT

This portfolio of work contributes to the shared body of knowledge of the representations and perceptions of time within arts, design and HCI. Advancing the discussion of temporality and interaction with electronic systems, and specifically in how we comprehend and embody the complexities of time in designs for digital media and HCI.

2.1 The contribution

As published, peer-reviewed works (included in appendix a), the contents of this portfolio have been accepted as individual contributions by the HCI community. Brought together here as a body of work, they contribute a critical context within an artistic and in a formal research capacity. The primary arena for the peer-reviewed outputs from this work are published within the HCI research community, as exemplified by the Association for Computing Machinery Special Interest Group on Computer-Human Interaction (ACM SIGCHI)[1] and the British Computer Society Electronic Visualisation and the Arts[2].

Designs and artistic outputs have been peer-reviewed and selected for exhibition internationally in and by the interdisciplinary community in arts, science and technology. Fora for the work includes the Victoria and Albert Museum, London, the International Society for the Electronic Arts (ISEA)[3], The Computer Arts Congress[4] and artistic tracks associated with conferences such as ACM Multimedia[5].

[1] http://www.sigchi.org
[2] http://www.eva-london.org
[3] http://www.isea-web.org
[4] http://www.computer-art-congress.org
[5] http://www.acmmm.org/2016/?page_id=919

Each of the published papers, and works included in this portfolio, are brought together to pursue individual questions or investigations in one of the three identified, main phases:

- Foundation and Mapping (chapter 4)
- Design led investigations (chapter 5)
- Deeper study and conclusions (chapter 6)

Following these phases, I present Chapter 7, containing a brief discussion, conclusions and thoughts for future work. In the conclusion, I re-iterate the main points of the final journal paper in the series of publications, *'Arguing for temporality in HCI: A guide for user centred temporal design'* (Buzzo, 2017)[6]. This paper is a summation of several years of research work and is informed by the significant elements of the overall contribution. In it I discuss new perspectives on the nature of user centred design and the importance of temporality in designing for users. The significant contribution of this final paper, is the presentation of an experimental framework for investigating *user centred temporal design* to the interaction design community for consideration and usage. The intention of the paper is build on the ideas of contextual design into the explicitly temporal: to extend understanding and meaning. As Dourish writes (Dourish, 2001):

> 'Meaning arises in the course of action ... the meaning of a technology is not inherent in the technology, but arises from how that technology is used. Meaning is something that comes about through an encounter with the technology.'

I would argue that, what Dourish refers to, as the *how* of use, is not the only element of great significance to the meaning of our interactions with technology, but also the *when* of use. In our context, as I will go on to show, we mean *when* in all its manifold forms. Dourish, discussing why this understanding of the *context of use* is so important, goes on to note:

> 'The significance of this for design is that, in designing interactive systems, we typically take the meaning of the elements of the system - its components, processes and representations - to be given or static within the frame of the application. What an action in the interface 'means' is something that we typically imagine to be determined by the designer.'

Here *static* is used in contrast to *dynamic*, in the sense of action. However, all dynamic systems change, i.e., they are timely and time-full. As I discuss in the next chapter, as long ago as Aristotle, it was understood that time and change are intimately linked. In this body of work I approach this explicit point, that of the static nature of systems framing and design, and investigate what it means to embrace timeliness within design for interactive systems.

The concluding paper is written explictly to allow scrutiny of ideas, methods and proposals and to encourage other designers and researchers to use, critique and improve upon the framework

[6] Interacting with Computers, Oxford University Press. In press.

presented. The temporal design framework builds upon existing work in the field (Dourish, Wright and McCarthy et al.) and extends the vocabulary of contextual design tools and processes available to designers and researchers alike, who seek to improve the design of interactive experiences with electronic systems.

2.2 The research context

The generation of portfolios of work, commonly illustrating the process, theoretical underpinnings and outcomes of research probes, is a common format within exploratory HCI design research (Gaver et al., 1999). This 'annotated portfolio' (Gaver and Bowers, 2012) approach is considered as particularly useful in our context: both as a suitable format to contain a variety of materials in a balanced and coherent way; but especially through clearly communicating research, of work undertaken, and of the context in which the interdisciplinary body of work should be received and read. When presenting work for peer scrutiny the challenges and rewards of interdisciplinary and transdisciplinary research approaches, are a complex conundrum. Whilst approaches within transdisciplinary research, are widely discussed and the benefits of such an approach are lauded: presenting interdisciplinary or transdisciplinary work and results in an inter- or trans- disciplinary context is often received in a less positive light. As Nicolescu argues in 'The Need for Transdisciplinarity in Higher Education in a Globalized World' (Nicolescu and Ertas, 2013) (Chapter 2):

> 'The new production of knowledge implies a necessary multidimensional opening of the process of learning'

In the undertaking of a body of work for doctoral consideration, especially one such as this - a practice orientated work, and being presented as a Doctor of Philosophy, by publication (DPhil), there are certain risks and unknowns when presenting transdisciplinary work. Within this bounding portfolio I will show an introduction to the peer-reviewed work (relevant publications are included in the appendix), and illustrate context for my work and discuss methodology, findings and conclusions. The central approach to this body of work is rooted in the process of research through design, using design as a generative process to investigate the lived experience of time. I explicitly rely on the exploratory and generative nature of design to investigate the complex interdisciplinary world of temporality, often using an ethnographic approach (McCarthy and Wright, 2004) to gathering and evaluating research data. This ethnographic approach is to be seen as firmly embedded in the recent *'turn to practice'* - witnessed across Human Computer Interaction (HCI) and design research (McCarthy and Wright, 2004). Lens based media art practices are also used in an auto ethnographic fashion to facilitate non verbal, phenomenologically orientated investigation.

The use of design and art processes within serious HCI research is well documented and the advantages of the *making* approach in what has been termed *research through design* are

manifold (Gaver and Bowers, 2012, Sas et al., 2014, Zimmerman et al., 2010). At its heart, is the argument between: the rationalist, what Morozov calls 'solutionism' or 'solutionist', approach of a belief in optimal, linear answers being definable to every problem; and the alternative generative approach of design processes (Morozov, 2013). Blythe articulates this clearly, and deftly puts the commonalities and conflicts between commercial and deliberately provocative designs in the discussion of *BinCam*, an internet camera-connected solution to reducing waste, seemingly by social media shaming (Comber and Taylor, 2013) [7]:

> 'If BinCam were a prototype of a commercial product such criticism might be justified. But research prototypes are intended to generate knowledge not products. As a research prototype BinCam was all the more interesting because it generated such a furious backlash in the media.' (Blythe, 2014)

Underpinning part of this argument against optimal, single solutions, are the insights first documented by Rittel and Weber at the beginning of the 1970's (Rittel and Webber, 1973), when dealing with what they termed the *wicked problem*. This is the awareness of seemingly intractable problems containing many variable factors, especially relating to human behaviour, with no single optimal solution, has been widely recognised. Many HCI and creative technologies researchers have embraced the generative nature of design as an effective counter to this challenge (Buchanan, 1992, Gleasure and Road, 2013).

These investigations have been used in manifold ways as start-points into formal investigation, as beginnings of iterative design work and for the generation of hermetic artefacts developed as part of a wider artistic and philosophical discourse on time. The expanding world of research through design, and the myriad sub-divisons and interpretations of this approach is fertile ground in the arena of visualisation and human-centred design. Intimately tied up with the core idea of applying generative processes to research, are historical roots of critical thinking, participation in the design process and interdisciplinary and trans-epistemological working.

By *trans-epistemological approach* I mean the process, that many artists use quite naturally, of taking the epistemologies of different disciplines, the core foundations of what these disciplines hold to be true of how the world is, and using what is useful from each one. Utilising the differing approaches and beliefs of how the world is made up as I see fit for different tasks, projects and problems. Allowing the deployment of these varying epistemologies and their encumbent *justified true beliefs* to give a different perspective or view point onto any particular problem or idea, the better to reveal more of the nature of the ideas, areas or problems at hand.

Whilst the idea of using central values, tools and approaches from one discipline to re-appraise another is not particularly new or novel, it is notably less common than one might expect. This approach of trans-epistemological working features strongly in much new thinking globally (Max-Neef, 2005). As Carlos Brandō writes (Brandão, 2007):

[7] `https://www.theguardian.com/environment/blog/2011/jun/08/camera-bin-waste-facebook-recycling`

> 'Transdisciplinarity is not in one of those poles but the space between them, in the oscillation from one to another, and in its interchange and contagion. Contagions result in profound modifications to the structure of knowledge, and to methods and principles of disciplines, which are not often found in multi- and inter- disciplinary approaches. Transdisciplinarity transfigures disciplines internally to bring them closer'

2.3 The practice led doctoral process as Dphil

Founded in media art and interaction design, the Doctoral process undertaken in this body of work is based around a critically situated, practice led approach. It combines 'critical design', in the context of the work of Dunne and Raby et al. (Bronner and Kellner, 1989, Dunne and Raby, 2007, Dunne and Martin, 2006) with 'making as research' (Wallace et al., 2013), and alternative, peer-reviewed, creative outputs that complement more formal publishing activity. Often referred to as 'Research through Design' (RtD) and tracing its roots to Corbusier and architecture, and industrial design in 1920's and earlier, the approach is discussed in detail by Frankel and Racine in their 2003 paper, 'The Complex Field of Research: for Design, through Design, and about Design' (Frankel and Racine, 2010). The RtD approach has gained widespread acceptance within the fields of human computer interaction (HCI) and interaction design over the last four decades (Bardzell, 2011, Gaver and Bowers, 2012, Zimmerman et al., 2007). The interdisciplinary worlds of creative technologies, digital and media art, and user centred design processes have all informed each other to create the cross disciplinary world of art, design and technology practice we see today.

It is important to clarify at this stage the context in which I use the expression *'critical design'*. Whilst there has been much written and spoken about what critical design is and may constitute in the arenas of design theory and design criticism I take my understanding from Dunne and Raby's original FAQ list where point 1 states:

> 1. What is Critical Design?
> Critical Design uses speculative design proposals to challenge narrow assumptions, preconceptions and givens about the role products play in everyday life. It is more of an attitude than anything else, a position rather than a method. There are many people doing this who have never heard of the term critical design and who have their own way of describing what they do. Naming it Critical Design is simply a useful way of making this activity more visible and subject to discussion and debate.
>
> Its opposite is affirmative design: design that reinforces the status quo. (Dunne and Raby, 2007)

This last point being the most crucial in my interpretation, I believe it can be assumed *all design is automatically affirmative*, by nature of it being a process serving, and a product of, the socio-political industrial complex, ie the status quo. If a design is intended or designed to question, subvert or challenge this status quo, the established way of doing or thinking things, then it may be *the alternative*, critical design.

The practice led approach is contrasted against a 'practice based' approach to Doctoral study, wherein a practitioner of a particular craft or activity, may root their study and research into furthering that particular craft, through the production of a new range of exemplary artefacts. There is a wide range of, often somewhat polarised, discussion on what the basis of a practice based or practice led approach is, regards research efficacy, at a Doctoral level. As Andrew McGettigan discusses in the article 'Art practice and the Doctoral Degree' (McGettigan, 2011), although the UK leads the world in practice led and practice based doctoral study (with fifteen years or more of successful candidates), there are a number of unresolved arguments on process, content and assessment. Significant progress has been made since the turn of the century, driven particularly from schools such as Goldsmiths and the Royal College of Art in London, where design, technology and culture, and critical theory intermix in an industrially focussed discourse. When considering practice based rather than practice led, the argument behind the '50:50' model holds true. This is a model where two components (theory and practice) are separately assessed and where theory is the route through which the practice is presented. However, for a practice led or RtD approach, this is not necessarily the case.

McGettigan goes on to note:

> '...one of the 'characteristic outcomes of the research degree', as suggested by the Quality Assurance Agency for UK higher education is that those who hold them are able to demonstrate 'the general ability to conceptualise, design and implement a project for the generation of new knowledge, applications or understanding at the forefront of the discipline, and to adjust the project design in the light of unforeseen problems.' (McGettigan, 2011)

Contrasting this discussion of the practice led doctoral study, I have undertaken the process as a DPhil of works and publications, centred on a theme, explored through writing and making. I have published a body of peer-reviewed works contained within this narrative portfolio rather than the production of a single thesis.

From: Art practice and the Doctoral Degree (McGettigan, 2011)

> 'The research degree which includes practical, creative work of any kind alongside a written component, is assessed in terms of a 'contribution to knowledge'. This combined submission is understood to advance a case or set of claims, a 'thesis', which is significant, original and robustly supported. While this general rubric may seem

> vague, it reflects the flexibility of the model: the individual's research project sets the test it is to undergo and effectively determines the specific criteria which are brought into play at final assessment. Accordingly the 'art practice' submitted can be of any kind, media or form (whether artefact or documentation of processes or events) depending on what is held to be at stake. It may, for example, function as evidence for the overall claim, a method underpinning that evidence, or in itself as work somehow instantiate the claim. Christopher Frayling's distinction between research *through* art or research *as* art reflects this varying role, but also indicates that the artefacts produced are judged in relation to the thesis advanced, and may therefore assume a subsidiary or instrumental role, or at least primarily reflect a focus on the something other than the aesthetic or art experience. (Frayling, 1993) Thus it is the originality of the claims that is at stake rather than the originality of the work submitted - derivative work may support an original thesis.' (emphasis added)

The idea that material outputs and artefacts can be considered, and are valuable, as significant elements of research is the subject of serious and widespread debate. For further discussion of the usage, benefits, efficacy and process of portfolios and artefacts as outputs of Research through Design, see (Andersen and Wilde, 2012). The 2016 SIGCHI workshop 'Attending to Objects as Outcomes of Design Research organised by Jenkins, Gaver, Andersen et al. was explicitly convened to discuss experience and share examples of good practice whilst using this as a methodology (Jenkins et al., 2016). The artefacts from the project 'Tracking The Imperceptible: Designs to Visualise Time Dilation' (Buzzo and Jonas, 2016) were presented as part of this SIGCHI symposium in San Jose in spring 2016.

CHAPTER 3

WHAT IS IT WE TALK OF WHEN WE TALK OF TIME?

'What then is time? If no one asks me, I know: If I wish to explain it to one that asketh, I know not'

St Augustine's Confessions, Book IX

In any discussion that begins with 'What is time?', it must be remembered that the question itself pre-supposes that time exists in some 'real' sense. Much like the idea of 'common sense', the idea that we *understand* time in any meaningful way is elusive when put under scrutiny. Moving from one discipline to another exposes differing epistemological thinking on what time is. I argue that, historically, there have been three significant phases in the understanding and common comprehension of time:

1. The time of Aristotle.
   Time exists because things change, where there is much change there is much time. Aristotle claims that time and change are intimately related, and that time is something dependent on change. (Coope, 2005)
2. The time of Newton.
   Time is considered constant, consistent, immutable and universal, like graph paper underpinning the cosmos (Newton, 1687). However, time in the Newtonian model is also seemingly absent, the orrery of the planets and universe, as explicitly seen in Newton's theory of gravitation, can be wound backward and forward like a clockwork toy, seemingly at will, with time removed as a fundamental influence, placed outside the universe. Lee Smolin (Smolin, 2013) argues strongly against this model of observing minute portions of the world and then extrapolating to the whole, refereeing to it as a 'model of the universe in a shoebox'.

3. The time of Einstein.
   Time is relative, malleable and everywhere. It is universal but seemingly not uniform from any human perspective. It is a world where time becomes a dimension alongside space, where it warps, folds and stretches depending upon how we each move through the world.

It can be argued that these three significant phases have shaped successive popular thought. Ideas, expressions and phrases from high scientific and philosophical thought, filter into popular culture and consciousness. With the adoption of ideas and language having long shaped the ideas and artefacts of each age in history, I would venture that we may be witnessing the beginning of a fourth phase:

4. The time of *quantuum.*
   A time when the strangeness and uncertainty of the world becomes part of main stream consciousness, with fresh perspectives and appraisals of what time may be and how we may talk of it. As Karen Barad puts it; *'The past is yet to come'* (Barad, 2016) [1], she argues that time may be an ontological issue, butting between physics and metaphysics. Experimental evaluation provides insights formed from such ideas as entanglement - what Einstein apparently referred to as 'spooky action at a distance' (Bell p143) (Bell, 1989); and experimental observation such as the temporal slit experiment, first theorised by Moshinsky in 1952 (Moshinsky, 1952), show that time may be stranger than anyone expected. The time slit experiment investigates *the time-energy uncertainty principle* (Szriftgiser et al., 1996) and is almost a parallel to the classic particle/wave double slit experiment [2]. It appears to show in practical experimentation *time diffraction*, evidence that events can occur that only resolve *when* they occurred in time, when observed after the event has occurred. Perhaps described as the Schrödinger's cat paradox with a clock instead of a cat. [3]

3.1 Perception and representation and cognitive artefacts

There have been a number of studies of the effect of the passage of time within HCI (Karapanos et al., 2008, 2009, 2010) and its influence on factors such as memory or adoption of products (Stappers and Giaccardi, 2013). These studies commonly focus on the influence of single elements

[1] Troubling Time/s, Undoing the Future; Lecture June 2, 2016 at The School of Culture and Society, Aarhus University, Denmark. https://www.youtube.com/watch?v=dBnOJioYNHU

[2] http://micro.magnet.fsu.edu/primer/java/interference/doubleslit/

[3] 'Schrödinger's cat is a thought experiment, sometimes described as a paradox, devised by Austrian physicist Erwin Schrödinger in 1935. It illustrates what he saw as the problem of the Copenhagen interpretation of quantum mechanics applied to everyday objects. The scenario presents a cat that may be simultaneously both alive and dead, a state known as a quantum superposition, as a result of being linked to a random subatomic event that may or may not occur. The thought experiment is also often featured in theoretical discussions of the interpretations of quantum mechanics. Schrödinger coined the term Verschränkung (entanglement) in the course of developing the thought experiment.' https://en.wikipedia.org/wiki/Schrödinger%27s_cat

Figure 3.1: The flip-clock, explicitly slicing moments with physical and metaphorical regularity into pieces of *now*. This retro-style clock may be explicitly what Kevin Birth calls a 'necromantic device'. A cognitive artefact designed in the past doing some part of our thinking for us.

or effects of time. The approach to this range of studies, of examining the perceptions and representation of time, has several levels as a holistic, practice-led research approach. Consideration has been paid to:

- The nature of constructed media, specifically time-based media, its history and its cultural properties and implications.
- The philosophy of time and what it means to conceive of time, and to be aware of the nature of the passing of time. How we may represent time, and what it means to represent such an intangible idea.
- The impact of differing cultural, linguistic and perceptual factors and their influence on time as a lived experience.
- The mathematical usage and descriptions of time, both as a theoretical measure and in its application to everyday lived experience.
- The current state of arguments within physics of the nature of time, and by direct implication, space, the universe and causality.
- What exactly is it that we are attempting to represent when we talk of representations of time, as Le Poivin (Poidevin, 1997) asks: 'does time pass in reality, or is the division of events into past, present, and future simply a reflection of our temporal perspective - a result of the interaction between a 'static' world and minds capable of representing it'.
- The personal and socio-economics of time. When we talk of time having value, of spending time, of saving time, how and where is this transference occurring?
- Artistic interpretations and interventions in the arena of time perception and experience.

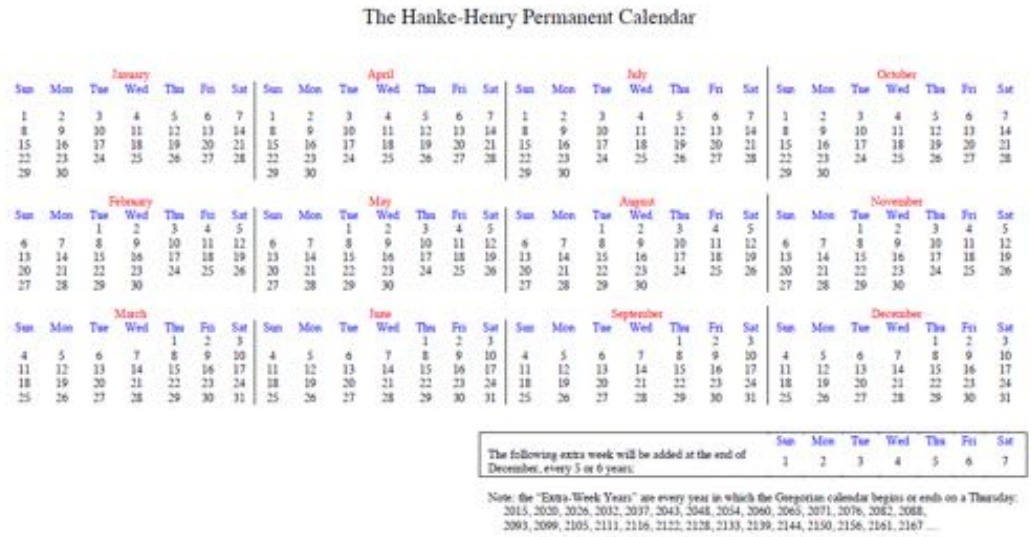

Figure 3.2: The Hanke Henry permanent calendar, each day and date of each year remains consistent and constant. Contrasted with the current Gregorian calendar this reinforces the notion of calendars as cognitive artefacts. Presenting pre-calculated reasoning about the world in convenient, but arbitrary, measures. This and other similar, historical, calendar experiments reveal the artificial, structured calculations contained in artefacts we often take as 'natural'.
Image, by Steve Hanke and Richard Henry at en.wikipedia [Public domain], via Wikimedia Commons

Within the literature relating to mathematics, physics and philosophy concerned with time, often referred to as 'Time Studies' there appears to be a strong consensus on the validity of the Minkowski Space-Time model. This model, popularised by the work of Einstein, treats time as an additional dimension alongside depth, width and height. Making a *block state* universe of x, y, z and t, allows time as a dimension that can be sliced at any point to reveal the spatial arrangement of matter in its entirety at any instant. It is sometimes argued that this leaves time only appearing to 'flow' as one moves through successive slices of the time axis, like pages of a book. This model can be argued as negating the ideal of *'now'* as a special moment particular to humans. It changes the notion of the 'unfolding' of the universe and shows time as a static continuum. Convention may dictate how we travel along this because, as Augustine of Hippo postulated in 400AD, humans have fallible perception and cannot see the world as it truly is. This block state or 'static universe' is also a popular and well reasoned end conclusion, in the arguments of many current philosophers of time, answering many of the ancient paradoxes of time. Not least of which also comes from Augustine, when he asks:

> 'How can that which is not real *(the Future)*, become real *(the present)*, and then become unreal again *(the past)?*'

Augustine asked this in the context of a strong religious belief, with a need to reconcile this with the evidence that he found in the physical world. His question hinged on the assumed

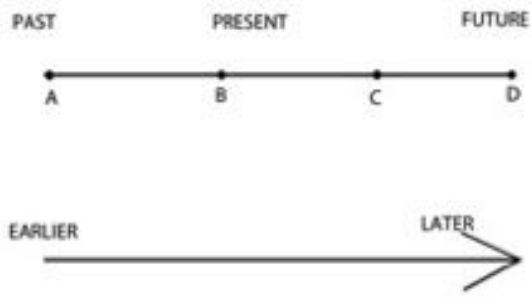

Figure 3.3: McTaggart and the dualities of time. Above: A-series, below B-series of time. Showing the argument between a tensed and tense-less universe.

infallibility and omniscience of God and the question of what caused his/her decision to create the universe as we perceive it. Put broadly, his conclusion was that the universe has always existed in all space and time, with God seeing all times at once. Humanity, being flawed of vision and able to see only the 'now' of the universe, only seeing a small portion of an unending reality across all time. This dilemma was more recently described by McTaggart (McTaggart, 1908) in his postulation of A series vs B series time as a way to encapsulate the argument for and against a tensed versus tense-less universe (see figure 3.3). The main tenet of McTaggart's argument is succinctly put by Kris McDaniel in the Stanford encyclopedia of Philosophy thus; (McDaniel, 2015):

> 'McTaggart distinguished two ways of ordering events or positions in time. First, they might be ordered by the relation of earlier than. This ordering gives us a series, which McTaggart calls the B-series. A second ordering is imposed by designating some moment within the B-series as the present moment. This second ordering gives us a series that McTaggart calls the A-series. According to McTaggart, in order for time to be real both series must exist, '

The adoption of the Static universe vs the Dynamic - where now is a real moment and the future is unwritten - solves many problems and provides a common and easily comprehended model for time. The Static universe model however, brings problems in a tense-less block state universe. In such a universe every event and position of everything is predictable, and from a tensed perspective, has (or is currently) already happening/happened.

Everywhere and nowhere is now.

This model of Euclidean space and time, formed into one, has been a highly successful framework that is supported by much experiential evidence, such as the experimental work of Hafele and Keating, investigating time-dilation by transporting caesium clocks around the globe at supersonic speed (Hafele and Keating, 1972) (see figure 3.4). From a philosophical and

Figure 3.4: One of the actual cesium beam atomic clock units used in the 1960's 'flying clocks' experiment the synchronise time around the world. And later in the Hafele-Keating experiment to prove relativity theory. Currently kept at Agilent (formally Hewlett Packard) Melbourne headquarters.
Image CC BY-SA 3.0 https://commons.wikimedia.org/wiki/File:HP_5061A_Cesium_Beam_Frequency_Standard.JPG?uselang=en-gb

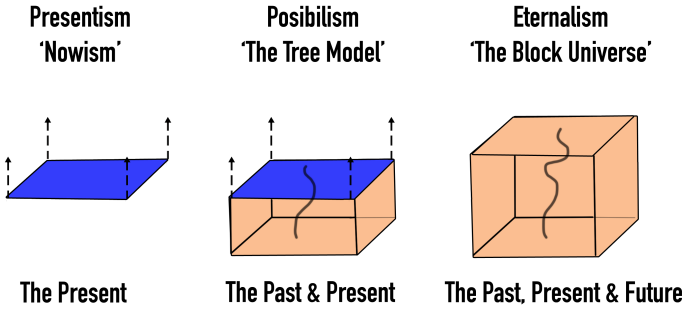

Figure 3.5: Three metaphysical philosophies of time, showing the three main conflicting views of how time is constructed.

personal perspective it could appear to negate concepts of free will, leaving only determinism and fate. The three philosophical models, believing in the now *(Presentism)*, the past and now *(Possibilism)* and the unending block universes of past present and future *(Eternalism)* (see figure 3.5) are still essentially unanswerable.

From a scientific perspective any adoption of a block state approach (Eternalism) could be argued to call causality into question, leaving only correlation available for any theory or experiment. Commonly these two points are not received well in either community. To enable science, as we generally conceive of it, to continue to work, and individuals to continue to live understandable, functional lives, both physics and philosophy appear, at the culmination of many arguments, to adopt the idea of a dynamic universe. This adoption is seemingly from a pragmatic, work-ability point of view. After-all, who is able to stretch their philosophical convictions to find comfort on the death of a loved one to be told:

> 'why are you crying? you should be happy, they are still alive yesterday'

There are new arguments occurring in the fertile ground between physics and philosophy. Figures such as Smolin and Barad, are looking to the work of both quantum physics and philosophers such as Bergson - and his ideas of time and life as indescribable as other than duration (Bergson, 1910). They question the current orthodoxy of the fundamentals of being, and of our view of what the universe is. Seemingly pivotal in this discussion is a re-evaluation of the relevance of the Newtonian notion of experimentation *(in a box)*, and the implication that time is a phenomena rather than a fundamental force. Smolin argues (Smolin, 2013) that the current arrangement puts time external to experimentation and thinking in science. His conclusions bring a new approach to the idea of *now* as fundamentally real. These underlying arguments, and potential scene changers, bring into question what it is we perceive and attempt to represent when, we talk of 'time' in any meaningful way. As Smolin writes:

> 'How we think about the future and the past determines everything about how we think about our situation as human beings.'

3.2 Temporality, visualisation and representation

When investigating visualisation and perception of time, discrete media arts practice is an ideal companion research tool to more formal methods (Boyd Davis, 2012). The practice and theoretical discourse around media art, and particularly contemporary digital media creation is intimately concerned with the manipulation of time, with representation, identity, perception and temporality.

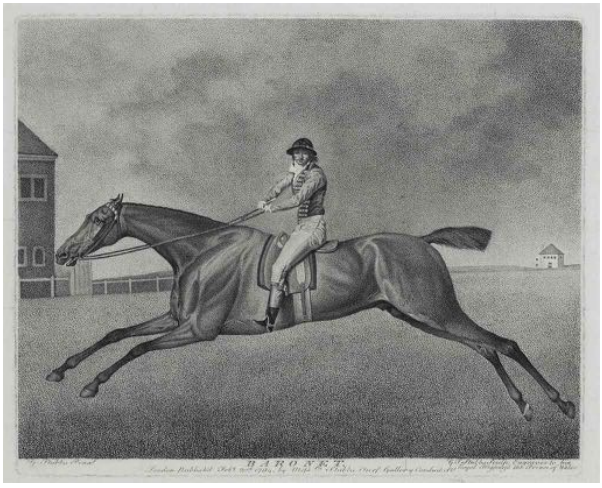

Figure 3.6: Baronet, engraved by George Townly Stubbs. Published, London, 20 February, 1794. The horse in motion in what was known as 'The flying gallop'. The representation of speed and motion is informed by understanding we could now call *pre-camera*.
Image: [Public Domain]

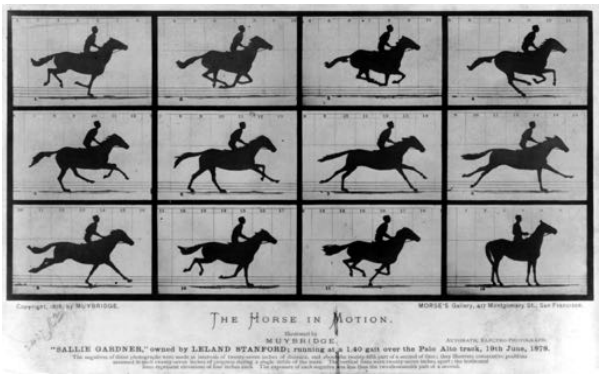

Figure 3.7: The Horse in Motion by Eadweard Muybridge. 'Sallie Gardner', owned by Leland Stanford; running at a 1:40 pace over the Palo Alto track, 19 June 1878. Less than 100 years after Stubbs (see figure 3.6), works such as this from Muybridge opened the general consciousness to new representations of time and conversely new perceptions of how time may be.
Image: Library of Congress Prints and Photographs Division [Public Domain]

The balance of temporalities in digital media, as distinct from analogue media, brings to the fore what Le Poidevin (Poidevin, 1997) points to as the *intimate collision of the problems resolving subjective and egocentric representation when 'recording' time*. This collision underpins the argument that modern media taunts us with its illusion of reality, capture and permanence. Illustrating an unresolvable conflict between McTaggart's A series vs B series model of time (McTaggart, 1908), the example of recorded digital media giving an excellent example of the abstraction of mechanical time vs the actual realisable, lived experience of time. According to McTaggart (pp. 9-10) (McTaggart, 1927):

> 'Positions in time, as time appears to us prima facie, are distinguished in two ways. Each position is Earlier than some and Later than some of the other positions. In the second place, each position is either Past, Present, or Future. The distinctions of the former class are permanent, while those of the latter are not. If M is ever earlier than N, it is always earlier, But an event, which is now present, was future, and will be past.'

Centred on the use of digital lens-based media and the processes of interaction design, my practice-led approach, works in concert with reading and writing to investigate, evaluate and present concepts and ideas. The formal aspects of representation of time in digital media has clear roots in information visualisation and visualisation of time series data. The examples of investigations into visualisation techniques for time series data abound in the worlds of art and design. From the pioneering work in information visualisation of Edward Tufte (Tufte, 2001), to the documentation of temporal cartography by Daniel Rosenberg (Daniel Rosenberg and Grafton, 2010), cubist visions of time and space in paintings such as Marcel Duchamp's, 'Nude Descending a Staircase, No. 2' (1912) (see figure 3.9), the exploratory photographic work of Eadweard

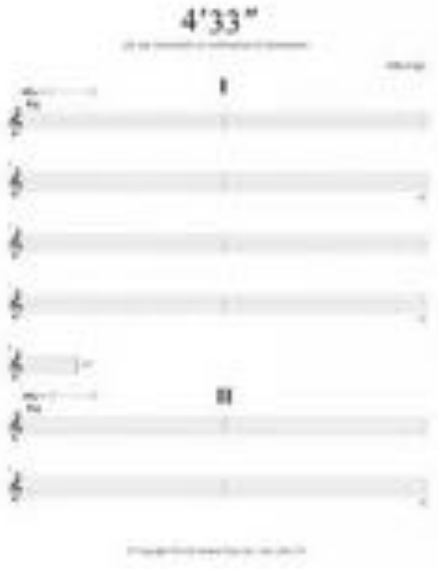

Figure 3.8: The score by John Cage for the seminal composition 4:33. *This composition with no notes, only pauses* is explicity bound by time, where the audience hear the sounds of the environment, has been performed around the world. interviewed in 1982, Cage stated that 4'33" was, in his opinion, his most important work. (Brooks and Kostelanetz, 1989)

Figure 3.9: Nude Descending a Staircase, No. 2 (French: Nu descendant un escalier no. 2). Marcel Duchamp 1912. From the Louise and Walter Arensberg Collection of the Philadelphia Museum of Art. Image: Guillaume Apollinaire, Les Peintres cubistes, Méditations esthétiques, Eugéne Figuiére & Cie, Èditeurs, 1913 [Public Domain]

Muybridge (1830-1904) (see figure 3.7), to avant garde composer John Cage (see figure 3.8) et al. have all questioned, challenged and investigated the notion of the temporality, and found diverse means to discuss their findings, in research, literature, design, art, music and musical score. E. Ray Lankester (1847-1929), at that time Jodrell Professor of Zoology at University College London, notes the impact of the Muybridge photographic studies. Particularly in relation to 'the flying gallop', less than 100 years after Stubbs (see figure 3.7 3.6) the representation is transformed by the visual comprehension of the camera and new language of time Muybridge brings (see figure 3.7)

> 'Two very interesting questions arise in connection with the discovery of instantaneous photography of the actual positions successively taken up by the legs of a galloping horse. The first is one of historical and psychological importance, viz. why and when did artists adopt the false but generally accepted attitude of the 'flying gallop'? The second is psychological and also physiological, viz. if we admit that the true instantaneous phases of the horse's gallop (or of any other rapid movement of anything) can not be seen separately by the human eye, but can only be separated by instantaneous photography, ought an artist introduce into a picture, which is not intended to serve merely as a scientific diagram, an appearance which has no actual existence so far as his or other human eyes are concerned....? And further, if he ought not to do this, what ought he to do...?' (Lankester, 1915)

Duchamp spoke about his painting 'Nude Descending a Staircase' (see figure 3.9), and directly acknowledged its relation to the photographic work of Muybridge and the new language for representation it afforded:

> 'In 1912 ... the idea of describing the movement of a nude coming downstairs while still retaining static visual means to do this, particularly interested me. The fact that I had seen chronophotographs of fencers in action and horse galloping (what we today call stroboscopic photography) gave me the idea for the Nude ... And of course the motion picture with its cinematic techniques was developing then too. The whole idea of movement, of speed, was in the air.' (Kern, 1985)

I would argue that all these ideas and approaches, to comprehending and describing the experience of time, may be only the latest theories and observations that filter through to common parlance. Taking the argument of the Sapir-Whorf hypothesis (Lucy, 2015); that our language, and our ability to describe phenomena, shape our perception of the phenomena, we may be seeing our ability to experience time expanding. As our language and subsequent ability to describe and represent time increases, so too does our capacity to give shape to our ideas of what may be elusively unknowable from a human, lived experience.

CHAPTER 4

DISCUSSION OF PUBLISHED PAPERS PART 1: FOUNDATION AND MAPPING WORKS

Against the background of cross disciplinary, diffractive reading in physics, philosophy, art, design, data visualisation and critical thinking, there is a clear thread of using research through design to examine the context of how people experience interacting with systems explicitly associated with time and temporal representation. Often these were the functions of what Birth in 'Objects of time' (Birth, 2012) refers to as *cognitive artefacts*. Using design as an explicitly generative process allowed diverse experiments, exploring the temporal aspects of a contextual design approach [1], one of explicitly seeking to understand users in their *context of use*, technical, social, spatial and *temporal*. This process allowed me to address some of the design questions and challenges of the complex issue of what time is and what it means to experience it, in a technology and interaction design context.

The focus of the work has been to utilise everyday designs as a point of analysis and intervention, re-imagining existing representations and conventions in order to question and subvert them. This concentration on the embodiment of concepts of time in everyday objects and systems, allows a more direct dialogue with which to address aspects of trans-epistemological theory through a process of critical making.

[1]The Contextual Design approach is broadly to understand users in their *context of use* in order to discover their intents, desires and needs, and to build system that are sensitive to those contexts. This definition differs subtly from that of Beyer and Holtzblatt (Beyer and Holtzblatt, 1998), who describe Contextual design as a process which "...incorporates ethnographic methods for gathering data relevant to the product via field studies, rationalizing workflows, and designing human-computer interfaces ... this means that researchers aggregate data from customers in the field where people are living and applying these findings into a final product." These tools are valuable for User Experience design but they discuss designing *in* context rather than *for* context. `https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/contextual-design`

The practical design work pursued distinct threads addressing;

- Visualisation of time dilation
- Calendar representations and interventions
- Time-lines, time-scales and temporal organisation of media
- Moments, attention, memory and temporal narrative

The work sought to investigate and challenge, by *subverting existing tools*, metaphors, language and processes, to create subtle but provocative re-evaluations of preconceptions and *received wisdom* on time. The works and papers are discussed here in a brief overview showing a development through three distinct phases, each divided into a separate chapter. The published papers and works are included in full in appendix a.

Published works and peer reviewed papers organised by chapter

Chapter 4: Foundation and mapping		
Lost Time Never	2013	Conference Paper
The Shape of Time: Reconsidering Time in the Context of Pervasive Media	2013	Conference Paper
Chapter 5: Design led investigations		
Time Travel - Time Dilation	2014	Conference paper
Designing for the Impossible: Creating a Mobile Application to Track Time Dilation	2015	Conference paper
Time Travel software for AndroidOS	2015	Open source software
Time Travel: Time Dilation and a Year of Airflight	2014	Artist book
Not all Days are Equal: Investigating the Meaning in the Digital Calendar	2014	Conference paper
Chapter 6: Deeper study and conclusions		
'What do we Know of Time When all we can Know for Real is Now'	2016	Video installation
'Making a Time Machine'	2017	Video installation
Perfect days. A Benevolent Calendar to Take Back your Time	2016	Conference paper
JourneyMap: Visualising the Time-bound Student Journey	2016	Conference paper
Arguing for Temporality in HCI: A Guide for User Centred Temporal Design	2017	Journal paper

Table 4.1: Papers and works discussed in this portfolio, organised by chapter and theme and included in full in appendix a.

The investigations of internal vs external experiences of time, time dilation and calendar interventions, has produced a body of designs, artefacts and publications created over several years.

The work is rooted in embodied temporal and emotional value and in time-lines and timescales. The experiments investigating moments and attention have been led by media making and creation of a series of media artworks. These media-led experiments are supported by investigation and interpretation of research material from the world of cognitive, neuro-psychology and temporal perception. The work is driven by an iterative process of research, design, development and evaluation; the formal outputs, publications, artefacts, etc are used as exploratory tools toward deeper investigation. Amongst the overall body of work are also numerous unpublished explorations, where hypotheses were not proved, where results showed no statistical significance, or where there was not specific final *impact* but they, nonetheless, contributed to the selected work included here.

4.1 Lost Time Never: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Lost Time Never	Buzzo	Conference paper	2013	Proceedings of the 2013 Inputs-Outputs Conference: An Interdisciplinary Conference on Engagement in HCI and Performance

The first published paper collected in this body of work came from the investigation of areas of language and preconceptions we bring to notions of time. It forms a series of papers outlining some of the questions and issues as they relate to digital media and representation. In part this is a response to the work of Lera Boroditsky within linguistics (Boroditsky, 2011b, Boroditsky and Gaby, 2010), and to both Aigner, in the area of time-series data visualisation (Aigner et al., 2007), and Callender (Callender, 2000, 2008, 2010), within contemporary physics. These three writers exemplify three entirely different epistemological approaches to the question of what time is, opening up a rich world of nuance and interpretation to me in the arena of perception and representation of time in digital media. The paper "Lost Time Never" presented at the Input-Outputs conference in Brighton in 2013 represents the beginning of a train of investigation and argument in the **Foundation and Mapping** in this body of work. The paper begins with a quote from Napoleon, via Nam June Paik. (Paik, 1976):

> 'Strategy is the art of making use of time and space. I am less concerned about the latter than the former. Space we can recover, lost time never.'
> Napoleon Bonaparte (Paik, 1976)

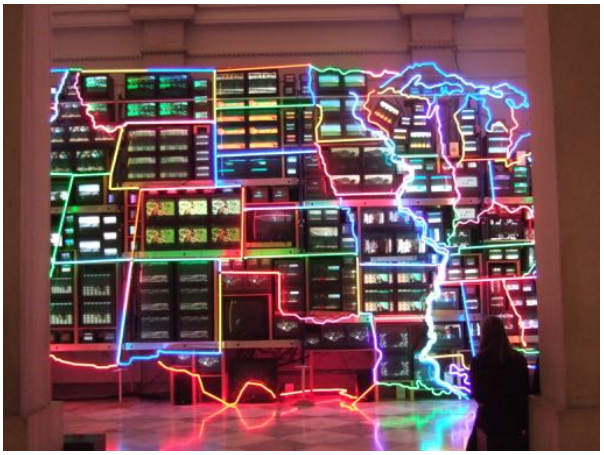

Figure 4.1: 'Electronic super Highway' by Media artist and theoretician Nam June Paik. Paik's observations of the dualities of time, particularly as they are expressed in contemporary media, were an early inspiration and access point to alternative readings of media temporalities.
Image CC BY-SA 3.0 https://commons.wikimedia.org/wiki/File:Electronic_Superhighway_by_Nam_June_Paik.jpg

This paper discusses the asymmetry we see in time and the perception of it and argues that the roots of this symmetry lie in our acts of creation, and specifically in production of media. The paper argues:

> '... our experience and expression of time and events are not connected to each other in a linear fashion ... the incidents that create what we decide to express can have little or no relationship to each other ... where a momentary incident of childhood takes a lifetime to express. In this sense input-time Vs. output-time in our expressions and our creative acts is necessarily unequal.'
>
> 'If we take these experiential aspects of time, and lay them side by side against the abstracted tempo of technology and time-based media, we see a deepening contrast. The sensations of input in a given experience are balanced against the expression of the effects of the engagement into the interaction itself. The rules of temporality at the fundament of digital media cross changes in contemporary language when considering and comparing representations of time. This presents new challenges to researchers and artists seeking to create digital experiences while allowing for representations and expression of personalised time. From Lifelogging to notions of the Quantified Self (qua, 2014) we see these contradictions and collisions becoming increasingly apparent and we ask with Martin and Holtzman (Martin and Holtzman, 2011):'
>
> > "If everyone says time is relative, why is it still so rigidly defined?"

The paper is an early exploration of the language of time and its relationship to HCI and digital media. It forms a foundation for exploration and presents the argument for a re-consideration

of the importance of time in design for digital media and interactivity. In its conclusion the paper is a heart felt appeal to bring time back into media, and to acknowledge the lived experience of time.

> 'Considering time in pervasive media as an abstracted attribute that can be applied to or stripped away from human experience and the representation thereof is essentially a regressive step. This reductionist approach delivers scatter diagrams of data points that describe rhythms in the data but not rhythms in peoples lives, experiences or perceptions. Using machine generated abstractions of time to organise media changes the nature of what is recorded. With the manipulation that occurs when our experiences are organised in an alternate taxonomy, our experiences are reframed and essentially changed and we are at risk of becoming spectators of the remediated versions of our own lives.'

4.2 The Shape of Time: Reconsidering Time in the Context of Pervasive Media: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
The Shape of Time: Reconsidering Time in the Context of Pervasive Media	Buzzo	Conference paper	2013	Proceedings of the 1st Fascinate Conference Thoughtful Technology and Beautiful Interfaces

Following this first paper, which outlines the theory and the mapping of territory, of the perception and representation of time, came a second foundation paper. "The Shape of Time: Reconsidering Time in the Context of Pervasive Media" (Buzzo, 2013b). The paper investigates aspects of the language and spatial metaphors in descriptions of time in HCI and digital media: framing them specifically in the discourse of ideas in pervasive media. It appraises some of the complexities encountered when designing for relatively straightforward temporal representations and leads the way to later design led research in specific instances of representation and visualisation. The paper begins:

> 'Within contemporary research discussion in interaction design, HCI and pervasive media the word time is commonly used to represent a wide variety of meanings, concepts and dimensions. Often this is without differentiation between contradictory interpretations of the simple word that belies complex relationships with our world and increasingly with media. The discussion or the experience of time can be traced to many sources, from Heraclitus and the river of time, Husserl's phenomenological

Figure 4.2: Visualising spatial dimensions to time, building *cognitive artefacts*. Here illustrating temporal, two dimensional representations of a three dimensional space, through which explicit, time bound, lines are drawn.
Image: Erik Streb, CC BY-SA 3.0 https://commons.wikimedia.org/w/index.php?curid=14681419

> concepts and the Bergsonian (Bergson, 1910) interpretations of time to empirical measurements of the swinging pendulum of Captain Clock (Griffiths, 2002) conflicting concepts of time are freely used to discuss media and interaction. As Chen and Boroditsky (Boroditsky, 2011a, Boroditsky and Gaby, 2010, Chen, 2013) argue even the languages we speak influence how we conceive of and verbalise our ideas of time and the effects this has on our lives.'

The body of the paper considers the issues of how to describe, compartmentalise and resolve the seemingly conflicting concepts of time. Using the consideration of time as a volume orthogonal to three dimensional space, it takes examples from digital culture, pervasive media, lifelogging and the quantified self; and argues for a new analysis of concepts of time within contemporary digital media research and HCI practice.

These two papers together represent a foundation and mapping of the elements, thoughts and motivation for the next two stages of investigation. The central point here that developed is of acknowledging time as an important, but often omitted, element in media design and a fundamental element in lived experience. The papers establish a base of argument, describing evidence to support the proposition of a need for time in design and provide suggestions of approaches to investigate these themes further. These further stages, of investigation, experimental visualisation and re-combining of the experience of time in HCI and media, are pursued in a series of subsequent experiments and works. The associated published outputs from this next experimental phase are discussed in more detail in chapters five and six.

CHAPTER 5

DISCUSSION OF PUBLISHED PAPERS PART 2: DESIGN LED INVESTIGATIONS

This chapter introduces a discussion of the middle section of work in this portfolio. The work, and subsequently published papers, are built on investigations from the foundation papers, discussed in chapter 4. At this stage, my work moves forward into an investigative, experimental making phase, where I pursue a single theme that investigates representations of time, using experimental making in two main areas:

- Illustrating unseen but real temporal phenomena described by modern physics.
- Investigating provocative or critical design for calendar and diary visualisations.

Chapter 5: Design led investigations		
Time Travel: Time Dilation	2014	Conference paper
Designing for the Impossible: Creating a Mobile Application to Track Time Dilation	2015	Conference paper
Time Travel software for AndroidOS	2015	Open source software
Time Travel: Time Dilation and a Year of Airflight	2014	Artist book
Not all Days are Equal: Investigating the Meaning in the Digital Calendar	2014	Conference paper

The first area of work in this chapter came from insights and new understandings from reading of physics and special relativity, and of temporal visualisation. This relates to what contemporary physics has to say about time, often conflicting with what we understand of: from mainstream consciousness; the largely Newtonian approach; that time is fixed; that time is clock like; and that time is universal. Whilst flying over the Gobi desert on a long-haul flight

from Asia to Europe, it came as a sudden realisation (in the strange but wonderful moment where *knowledge* of a thing or theory translates into *realisation*), that the effects of time dilation from special relativity were acting on me, and everyone around me. After rough sketches and calculations, on the back of the proverbial (airline) cocktail napkin, it transpired that I had flown for over 88 hours at more than 500mph, and that the 'year' that I had experienced was a subtly different length to the one my partner had experienced. The quest to visualise this effect, one that affects everyone, no matter how fast they move, began in earnest.

The time dilation project is an investigative thread comprising two published papers, a published photographic essay and a prototype software application for smart-watch, wearable computing devices and smart phones:

- 'Time Travel: Time Dilation'. Published in the Proceedings of the British Computer Society Conference on Electronic Visualisation in the Arts BCS EVA 2014. (Buzzo, 2014a)
- 'Designing for the Impossible'. Published in the Proceedings of the British Computer Society Conference on Electronic Visualisation in the Arts BCS EVA 2015 (Buzzo and Jonas, 2015)
- 'Time Travel'. Artists Book, Published 2014 (Buzzo, 2014b)
- 'Time Travel'. Software for Android OS. [1] [2] [3]
- 'Time Travel'. Workshop presentation at ACM SIGCHI, San Jose, CA (Buzzo and Jonas, 2016)

5.1 Time Travel: Time Dilation: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Time Travel: Time Dilation	Buzzo, Jonas	Conference paper	2014	Proceedings of British Computer Society, Electronic Visualisation in the Arts

Outputs from the time dilation project were also presented at the ACM SIGCHI2016 workshop symposium *'Attending to Objects as Outcomes of Design Research'* on the use of design and objects in design research (Buzzo and Jonas, 2016). The focus of the workshop was on evaluating the contribution and validity of artefacts as outputs from significant efforts of research enquiry. The time dilation software prototypes, running on Android OS smart watches, were presented and shared, with other researchers in the field, as a contribution to the discussion on the ongoing methodology of research through design.

[1] `http://timetravel-app.com`
[2] `https://github.com/danbz/timetravel`
[3] `https://www.youtube.com/embed/MGbGSHMkcu8?autoplay=1&rel=0`

Figure 5.1: The Hafele Keating Experiment of 1971, showing a caesium beam clock aboard a commercial jet airliner. This simple but pivotal experiment gave concrete evidence to the predicted effects of time dilation.
Image: Original publication: From Popular Mechanics, January 1972, p. 30.

The first paper, 'Time Travel: Time Dilation' (Buzzo, 2014a), discusses the theory and actuality of the effects of Time Dilation, as predicted by Einstein's Special Relativity. Alongside this discussion the research investigates the visible, experiential effects of time dilation from a phenomenological perspective, illustrating this effect through digital media. The body of work, papers and an accompanying book of aerial images (Buzzo, 2014b), recalls the Hafele-Keating (Hafele and Keating, 1972) experiment of October 1971: the first practical experiment to show time dilation, with atomic clocks experiencing and recording different amounts of time dependent on their speed of travel (See figure 5.1).

The work collated personal data from 12 months of air travel and an associated auto-ethnographic photographic record, comprising hours of video and thousands of still images. This was the starting point of the quest to build a practical illustration of the physics and mathematics behind time dilation. The research combines the interdisciplinary worlds of computer arts with data and scientific visualisation to create a deliberate collision between the visualisation of the personal and illustration of theory.

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Time Travel: Time Dilation and a Year of Airflight - Recent Photographic Work	Buzzo	Artists Book	2015	Forlaegger Fabrik20

5.2 Time Travel: Time Dilation and a Year of Airflight - Recent Photographic Work

Observations were documented in an auto ethnographic, photographic essay. Featuring images from a year of airtravel (over 88 hours in the air). These formed a non-verbal investigation that is an accompaniment output to the other works, using situated imaging, presented as a practice-led body of work, to communicate the abstract world of very small time periods, and the direct relevance of Einstein's work on the personal and perceptual world we inhabit. Contrasting the legacy ideas of Newtonian mechanics and the strange, malleability of Einsteinian space-time the work seeks to:

> 'illustrate the personal nature of how the reality of *time travel* influences every aspect of the interpersonal.'

Figure 5.2: Clouds over Oxford, UK. Still from artists book 'Time Travel' 2014: The book produced as a research output from the project, based on a year of photographic observation from air-planes.
http://www.blurb.com/b/5405590-time-travel

The book is a visual essay of the journeys that formed the data for the time dilation project, and seeks to re-connect readers to the context of realisation, bringing the theory and actuality of time dilation together. That we are all sliding past one another, experiencing unique, individual durations as we choose to walk, cycle, drive or take a train is an example of how our differing velocities cause us to move past each other in time, as we do in space.

5.3 Designing for the Impossible: Creating a Mobile Application to Track Time Dilation: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Designing for the Impossible: Creating a Mobile Application to Track Time Dilation	Buzzo, Jonas	Conference paper	2015	Proceedings of British Computer Society, Electronic Visualisation in the Arts
Time Travel software for AndroidOS	Buzzo, Jonas	Open source Software	2015	`http://timetravel-app.com` & `https://github.com/danbz/timetravel`

Following these two publications, a collaborative project with David Jonas Castanheira, a researcher and developer from University of Utrecht (HKU) and The PatchingZone, Rotterdam began. The project 'Time Travel' designed and built a mobile application for tracking and visualising personal time dilation (Buzzo and Jonas, 2015). Prototype software is available under an open source license through the github online code repository [4] and a demonstration video can be seen online [5]. The paper begins by discussing the development of TimeTravel, a mobile application for visualising personal time dilation. Time dilation is the effect on time that movement in space produces. Predicted by Einstein's Special theory of relativity (1905), and verified by practical experiment: Time dilation affects all things in motion and calculations for the effect of velocity (and of gravity, via altitude) is included in the calculations for GPS receivers. The project developed an application for Android OS based wearable devices, that visualises the imperceptible effects of time dilation on a user's everyday activities in an easy to understand, meaningful way. We described the development, and considered what would happen if we were to attempt to *visualise the imperceptible*, but real, effects of time dilation.

The collaborative work was conducted to investigate a socially orientated application that would illustrate and allow comparison of an individual's personal account of time dilation experience. Developed initially for the Android mobile platform - with a focus on watch and

[4] `https://github.com/danbz/timetravel`
[5] `https://www.youtube.com/embed/MGbGSHMkcu8?autoplay=1&rel=0`

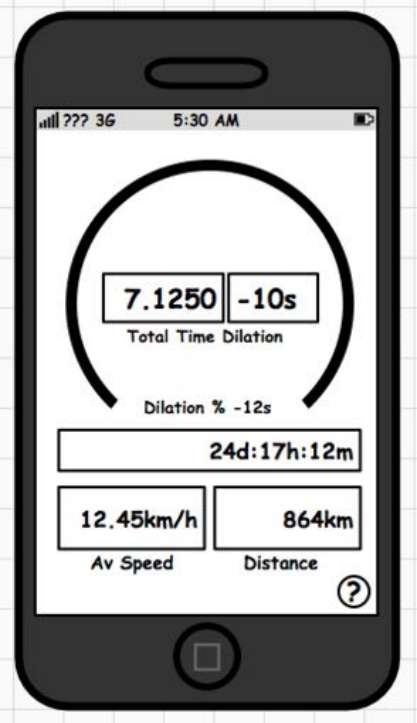

Figure 5.3: Refined design visualisation showing velocity implicitly linked to instantaneous dilation. Showing speed, distance, elapsed time, instantaneous dilation (compared to theoretical norm), etc.

wearable devices, the application uses geo-location to calculate [6] velocity and duration, and thereby calculate potential temporal dilation effects on a personal level. We designed a simple game-style element to the application, with high score orientated indicators encouraging the easy comparison of relative temporal dilation between one individual user and another. The key purpose was to make it easy to illustrate the influence of speed on time duration on personal and interpersonal level, visualising time dilation at a micro-personal level.

The paper, published in Electronic Visualisation and the Arts (Buzzo and Merendino, 2015) presented the results of our work so far. We were also invited to present a separate workshop demonstration session describing our working process and the visualisation problems we encountered. Our objective was to track the velocity and timing of an individual via geo-location techniques on a mobile platform. Then we would use the data to calculate time and velocity, and visualise subsequent dilation effects relative to a (theoretical) fixed basepoint. The effect of time dilation is non-linear in nature. The range of dilation related to motion - from static to walking speed, and to modern air transportation, generates a wide range of data. At low speeds the effect is extremely small.

[6] Due to the processing delays in the hardware stack of target devices affecting timing accuracy, this is approximated by back calculation of location changes of the host device.

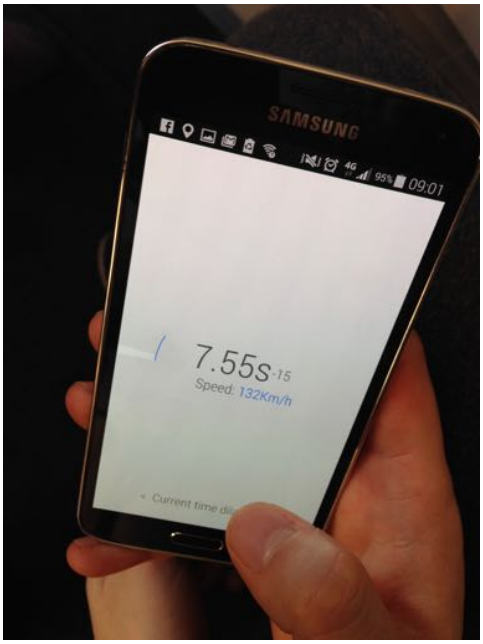

Figure 5.4: Time dilation tracking software prototype running on Android smartphone hardware, visualising instantaneous dilation, accrued dilation and velocity. See video of the prototype in action: `https://www.youtube.com/embed/MGbGSHMkcu8?autoplay=1&rel=0`

The design and presentation of on-screen graphics was iterated in constant review with a series of early user consultations. Subsequent designs adopted metaphors from real-time physical displays in the style of a classic audio VU meter combined with an approximation of an automotive speedometer. Users were able to connect the imperceptible changes in their subjective experience of time directly to their speed of motion, walking or travelling by train etc.

Further refinements adopted new AndroidWear UI guidelines more closely, making a more seamless integration into the overall wearables context. Anticipating the personal and physical nature of what we wanted to convey, we incorporated visual references from the styling of quantified self, and health and fitness tracking software. Early feedback from alpha test users indicated a *'sense of wonder'*, with a small number conveying a *'sense of disorientation'* when considering the challenge that the concept of personal time dilation brings. The response to this deliberate process of design for 'defamiliarisation' (Bell et al., 2005), was considered a particular success in presenting techniques that Shklovsky (Shklovsky, 1986) would call 'making strange'.

The work is rooted in the arena of making the invisible immediate, where we are augmenting our senses through technology, eg. experiments such as making wi-fi signals perceivable (Timo Arnall Jørn Knutsen, 2011), or detecting magnetism (Nagel et al., 2005), changes the context of how we live and how we may comprehend our world. We see this project as a bridge between the lived and theoretical worlds and present it as a practical investigation into what happens when we attempt to visualise the imperceptible.

5.4 Not all Days are Equal: Investigating the Meaning in the Digital Calendar: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Not all Days are Equal: Investigating the Meaning in the Digital Calendar	Buzzo, Merendino	Conference paper	2015	Proceedings of the SIGCHI conference on Human factors in computing systems

The proprioceptive nature of the calendar and the cycle of the seasons and years is fundamental to our external view of the world. Intertwined with this cyclic view is the lived, phenomenological experience of time, as described by Bergson et al. The modern calendar as a tool and a cultural afterfact is underpinned by the socio-economic value propositions of time. As discussed by Marx, Smith and Booth (Booth, 1991, Smith, 1776), the calendar is both measure of time *exchanged* for monetary gain or other value and status generated. There is an implicit pressure in a calendar for it to be filled, irrespective of time of day. Each denoted hour apparently available and equal in value, despite the contrasts with the human experience of things such as the need for sleep. A full calendar indicates personal or business worth and status, an empty one idleness and disorganisation.

This paper (Buzzo and Merendino, 2015), presented in Seoul, Korea in 2015 and published in the proceedings of ACM SIGCHI, takes an experimental-making approach to investigations of the subtle elements and pressures in a calendar, and possible new designs for alternative purposes. The paper begins:

> 'The electronic calendar is a common tool used by large numbers of people to reflect and shape their daily activities. It's function and structure is rooted in legacy representations dating back thousands of years. Collaborating with designers and engineers our project seeks to re-consider what the calendar does for us and how we may perceive and represent our time, personally and collectively. This paper investigates the background to 'the calendar problem' and documents design-led research. Seeking to identify some of the key problems with the current representation and to establish criteria for new interpretations of the meaning of calendar.'

The digital calendar as a focus brings together an area of study with readily communicable grounding and boundaries. It is also an arena in which to make small interpretations of the wider discussion on the themes drawn from Time Studies. The project as a whole encompasses a range of research approaches in two broad camps:

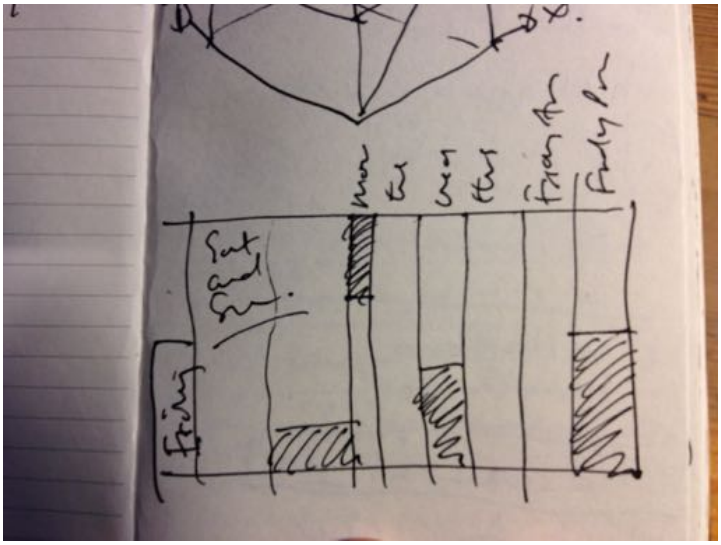

Figure 5.5: Early sketch work for experimental calendar development in the 'Not all Days are equal' project showing days of the week from a personal perspective. Monday is the thinnest day of the week, Friday afternoon and Monday morning are blank and the weekend represents the largest area of all.

- Semi-structured and structured interviews with selected participants about their time and calendar use. This was combined with participant observation and ethnographic study.
- Ethnographic study via video interviews on personal visualisations of time and of calendar usage. It contains interviews and video work, detailing an individual's calendar usage, systems, techniques and personal reflections on time perception, visualisation and representation.
- Calendar specification and making sessions with collaborators.
- A short specification, detailing the problems and possible areas of intervention in the current digital calendar paradigm was created. This was then used as a primer for a series of workshop format investigations, using collaborative making sessions to create novel calendar re-visualisations. Solutions were based upon a subset of items from the calendar specification and were the product of working with makers from architecture, technologies, performance and product design.

Experimental design work on revisualisations of the digital calendar allowed me to address questions on the nature of the time representations they contained: philosophical, scientific, mathematical, economic and political. There are also clear embodiment issues of personal/cultural norms on perception and representation of time, from a classic HCI/ Data visualisation perspective but also from a research-led design/critical design perspective. To address some of the issues raised, the project conducting a series of experiments based on the calendar problem, conducted as

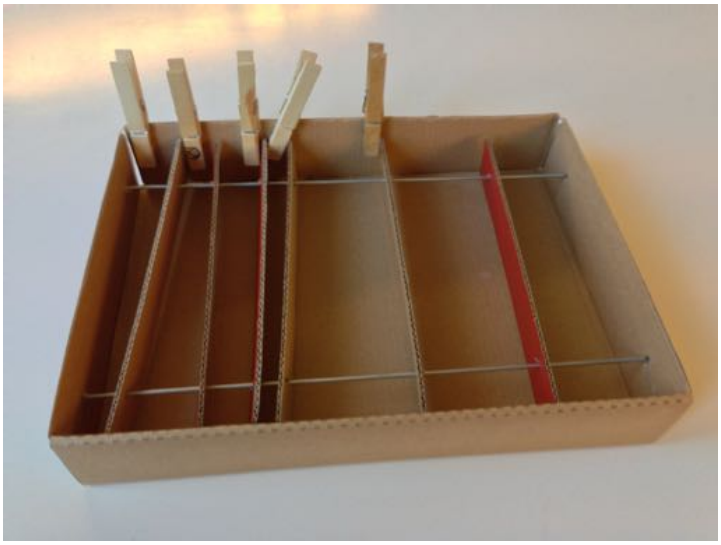

Figure 5.6: Physical prototyping work for experimental calendar development. Creating physical models with movable day divisions allowing days of the week to assume different and changeable sizes.

workshops. From these workshops and various making sessions, a number of physical prototypes were produced: a long research paper, (presented at ACM SIGCHI 2015 in Seoul, Korea); and a number of exploratory lens based media pieces, primarily incorporating time-lapse and processed video.

Grown from ideas of representation of value in time, and conventions of language, the paper 'Not all Days are Equal: Investigating the Meaning in the Digital Calendar' was the culmination of several months of work in this extended, design led, project. The insights from interviews and observations, and from re-framing design challenges and opportunities transformed my understanding of the problem domain when designing temporally. The complex, manifold nature of how we talk, imagine, visualise and represent time gained a greater clarity, and it began to become clear how one may be able to talk about the issues of an approach to *user centred temporal design*.

CHAPTER 6

DISCUSSION OF PUBLISHED PAPERS PART 3: EXPERIMENTAL TESTS FOR DEEPER STUDY

Chapter six introduces areas of deeper study and outputs, presenting some of the outcomes from this body of work.

The papers discussed here build on the foundation papers in Chapter 4 and the experimental and exploratory work in Chapter 5. Applying explicit and implicit knowledge gained to a variety of outputs; artworks, designs and finally a new theoretical framework with which to consider time when designing experiences in HCI.

Chapter 6: Deeper study and conclusions		
'What do we Know of Time when all we can Know for Real is Now'	2016	Video installation
'Making a Time Machine'	2017	Video installation
Perfect Days. A Benevolent Calendar to Take Back Your Time	2016	Conference paper
JourneyMap: Visualising the Time-bound Student Journey	2016	Conference paper
Arguing for Temporality in HCI: A Guide for User Centred Temporal Design	2017	Journal paper

6.1 What Do We Know Of Time When All We Can Know For Real Is Now? A Generative Video Installation

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
'What Do we Know of Time When All we Can Know for Real is Now'	Buzzo	Generative Video Installation	2016	'Digital Futures' British Computer Society and Victoria and Albert Museum

Figure 6.1: Details of dual screen generative installation "What Do We Know Of Time When All We Can Know For Real Is Now?" London, July 2016. https://vimeo.com/181406611

Moments [1] a video project investigating the perceptual and philosophical duration of a 'moment'. The project asked:
What is it to *notice* something? How long is that moment of noticing? How does a moment feel? Opinions across the worlds of art, perception, philosophy and cognition often disagree widely on what we perceive when we perceive time passing. Phenomenology posits that we can perceive only durations, and that any moment we notice, is not a point in time but a time-span. Neuro-cognitive estimates of what a perceptual 'moment' is, often range between three and four seconds (Elliott and Giersch, 2016) (Bitbol, 1994).

The project recorded instances of noticing, and moments of attention, recording them as 3-4 second video clips. Collating this video since early 2014 the project recorded close to a thousand separate video clips. Contrasting this huge library of intimate moments of *attention* and *presence*

[1] http://buzzo.com/what-do-we-know-of-time-when-all-we-can-know-for-real-is-now/

are a series of extended walking self-portrait video 'dérives' inspired by Guy Debord, the French situationist and *some-would-say* father of *psychogeography*. Extended walks through the streets of Hong Kong and Kowloon were filmed over a two week period in 2015. In the video material the viewer sees a central character, the walker, moving through the neon metropolis city-scape and crowded back alleys in continuous framed shots. These extended pieces of linear video have been treated, graded and finally their core data re-processed to allow each individual frame to be re- played in real-time in any order, at any speed, in any direction. Presenting the viewer with the direct visual equivalent of the universe as a zero energy quantum block state. Where each of us passes through our individual time-lines, experiencing them in random, disconnected order. Unaware that in the next instant we may be 5 years old again or that in our previous moment we were reflecting on our lives from old age.

The work investigates the challenge, laid down by McTaggart (McTaggart, 1908) over a century ago, of how we decide if we live in a tensed, or tense-less universe. Using real-time generative algorithms to select, edit, compile and present each discrete *moment* this dynamic dual-screen installation situates the viewer in the centre of the emotional, philosophical and phenomenological debate on the existence and substance of time and lived experience (Lorenz and Bevernage, 2013). On one screen, discrete moments of sense and attention, on the other, a continuous central figure surrounded at every moment by a maelstrom of temporal shift, in one of the most complex cities in the world. Creating a temporal deepmap, in the style of William Least Heat-Moon's Psychogeographic Cartographies (Gregory-guider, 2004), both a place and a time. At the same time, weaving the challenge of input-output time, where author, actors, reader and audience's timelines circle each other.

Figure 6.2: Video still from 'Walks' recorded over the period of 2 weeks in Hong Kong
https://vimeo.com/album/3101717/video/117094667

The installation has been shown as part of the *'Digital Futures'* exhibition in conjunction with the Victoria and Albert Museum, and the British Computer Society, London, July 2016 [2]. More recently it has been displayed in the gallery of the *5th Computer Art Congress* [3] in Paris, October 2016, and as part of the Association for Computing Machinery (ACM) Special Interest Group on MultiMedia (SIGMM) [4], show at the Municipal Library in Amsterdam, October 2016 [5].

A separate artist book detailing the work and content is published under the same title *'What Do We Know Of Time When All We Can Know For Real Is Now?'* through personal imprint Forlaegger Fabrik20 (Buzzo, 2016b).

6.2 Making a Time Machine: A Multiscreen Generative Video Installation

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
'Making a Time Machine'	Buzzo	Generative video Installation	2017	'Digital Futures' British Computer Society and Victoria and Albert Museum

'The Time Machine' is a multi-screen, generative video art installation based around multiple low-cost computer platforms. Presented in conjunction with British Computer Society, Electronic visualisation in the Arts, and Victoria and Albert Museum 'Digital Futures', London. June 2017. The work uses looping time-lapse video shot in locations around the world to engage the viewer in the discussion on the experience, rhythm, repetition and flow of time. Running across multiple monitor screens, the installation creates palindromic video loops from high resolution time-lapse video, and uses machine selection of the video material, to contrast the external, *clock* perception of time, with our internal, *lived* experience of it. As Birth says of how clocks distort our perception of the world:

> 'Clocks and calendars are necromantic devices - tools by which the dead think for the living, and the dead's thoughts deflect the living's attention from the cycles in the present. This is a consequence of the mediation of cognition by artefacts, and it is a feature of how artefacts can distribute cognitive models across time, culture and space' (Birth, 2012)

[2] http://www.vam.ac.uk/blog/tag/digital-futures
[3] `http://www.computer-art-congress.org/`
[4] http://sigmm.org/
[5] `http://www.digicult.it/design/data-aesthetics-the-interactive-art/`

Figure 6.3: Technical installation detail of 12 screen installation of 'Making a Time Machine' of time-lapse generative video work. Each palindromic video clip is chosen through generative selection by one of 12 separate processors.

The piece 'Making a Time Machine' is a companion piece to the successful 2016 dual screen generative installation 'What Do We Know Of Time When All We Can Know For Real Is Now?' (Buzzo, 2016a). Exhibited internationally at events such as; 'Digital Futures' with British Computer Society and the Victoria and Albert Museum (London), Computer Art Congress 5, Paris and ACM Multimedia at OBA in Amsterdam. The work comes from extensive investigation in the lived experience and perception and representations of time.

The installation presents fiction of mechanical clock time direct to the viewer: by folding multiple, differing, types of time, together in a multi-screen video form. Time-lapse video from different time zones are shifted and collated together, juxtaposing sunshine alongside moonlight, and dawn with the fall of dusk. The video loops (back and forth) on each screen of the installation, creates a large, polyrhythmic clock of high-definition, full-colour motion, where each screen details a passage of time from around the world: captured, frozen, forward and reverse. The time-lapse loops slowly switch, selected from over a thousand separate pieces by generative algorithms on each host computer, creating a slowly evolving and changing *Time Machine*. Gently rocking back and forth with a myriad of sub cadences, these loops confront the viewer with the unanswerable challenge of comprehending time.

6.3 Perfect Days. A Benevolent Calendar to Take Back Your Time: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Perfect Days. A Benevolent Calendar to Take Back Your Time	Hassenzahl, Buzzo, Neuhaus	Conference paper	2016	Celebration and Contemplation, 10th International Conference on Design and Emotion

The 'Perfect Day' (Hassenzahl et al., 2016), project came from exploratory workshops investigating temporal designs for well-being. These were held at the studio for experience design, at the University of Essen in Germany, with Professor Marc Hassenzahl, and researchers based at the Folkwang Design School. The workshops were aimed toward fostering well-being and identified a number of basic concepts, that looked at interventions into common digital calendar formats. The primary function being to develop prototypes, deploy them and perform user trials to evaluate and build a body of knowledge. This is a particular focus of the work centred around well-being, and ideas of 'time poverty' from the social science orientation of the Experience Design studio. 'Time poverty' describes a substantial tension for people in modern societies between the ever increasing time demands of work, and the time needed for engaging in additional, intrinsically meaningful, well-being-enhancing activities. At the heart of this is the digital calendar. While often only seen as an innocent and useful tool, its functionality and representation quite subtly enforces certain ways of dealing with time. As a contribution to 'designing for well-being', we explored how a first concept of a benevolent calendar, i.e., a calendar, which explicitly cares about well-being-oriented activities, has impacted the life world of five quite busy individuals. The majority experienced the calendar as positive and acknowledged its goal to change time use. After a phase of initial irritation, the participants found a renewed sensitivity towards their personal time use, adopted new well-being-enhancing activities, and in part, even internalized these activities.

Subjective well-being is the consequence of having positive and meaningful experiences. Such experiences result from engaging in activities (Lyubomirsky et al., 2005) which fulfil essential psychological needs (Ryan and Deci, 2000). For this, enough time is essential. Unfortunately, many people in modern societies suffer from what can be best described as 'time poverty'. Feelings that *'one's life has been too rushed'* or that *'there have not been enough minutes in the day'* are common and substantially related to reductions in well-being (Kasser and Sheldon, 2009) (Kroll and Pokutta, 2013). In our experiments we used data about how much people enjoy particular day-to-day activities to create a "perfect day", that is, a scheduling, which would maximize well-being. It assumes 16 hours (=960 minutes) available per day, and recommends to spend,

Figure 6.4: Details of single-calendar-day example a 'Perfect Day', showing a balance of pre-planned activities alongside 'work'

for example, 106 minutes with intimate relations, 82 minutes with socializing, 78 minutes with relaxing, 75 minutes with eating, 73 minutes with praying/meditating and 68 minutes with exercising, but only 36 minutes with working. Wryly, the authors note that *"somebody who only works for 36 min each day is of course most likely to have problems making ends meet. [...] Hence, the optimal day schedule may be more realistically applied to a Sunday rather than a Monday"* (p. 215) (Kroll and Pokutta, 2013). This blatantly points toward peoples' constant need to negotiate between time for work and all else required to be happy (i.e., maintaining work-life balance). This is not easy, since "busyness" seems to have become a deeply internalised moral value (at least in the US). At the same time people experience conflicts, anxiety and guilt concerning the way they distribute their time in favour of work (Leshed and Sengers, 2011).

Figure 6.5: Details of a 'Perfect Day' -influenced calendar showing a balance of pre-planned activities alongside 'work' in a 7 day view.

6.4 JourneyMap: Visualising the Time-Bound Student Journey: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
JourneyMap: Visualising the Time-Bound Student Journey	Buzzo, Phelps	Conference paper	2016	Proceedings of British Computer Society, Electronic Visualisation in the Arts

A student's view of higher education is often talked about as 'transformative' and as a 'journey' or 'pathway'. The student experience of university is time-bound, covering a clearly specified duration. From a learner's perspective, the Higher Education journey begins at induction and ends at graduation. Through discrete and highly personal steps, students move from one state (fresher) to another (graduate). This personal journey is explicitly linear, as opposed to than the, often, cyclic, annualised time-perspective of the university. The paper investigates how to visualise, in a temporal sense, this transformative journey, that incorporates necessary time-bound events that appear in a students academic calendar, and time-table. This is dealt with in a student-centric way that illustrates directly the journey the student takes, and reinforces the time-bound, delineated nature of the student's Higher Education experience. This work was undertaken in conjunction with University of the West of England researcher, Phil Phelps,

and was supported by students of the Digital Media BSc program as participants and research subjects. The paper documents the results from research, prototype development and early trials, and presents recommendations for future work.

From a temporally-orientated perspective a student's term-times, lectures, exams, assignments and other learning-related temporally-fixed events are way-points on a journey. Each formative milestone passed will never be revisited. Along this journey reflective vistas and moments of self- evaluation frame the educational dialogue between student and institution. These moments can be vital in assisting a student in self-evaluation, identification of progress and generating meaning- making and sense of achievement. All too often these important and instructional moments are lost to students, particularly when mid-way through a learning journey. They risk losing sight of the metaphorical hill they climb; unable to see how far up they have come; and that each step forward is one step closer to their goal.

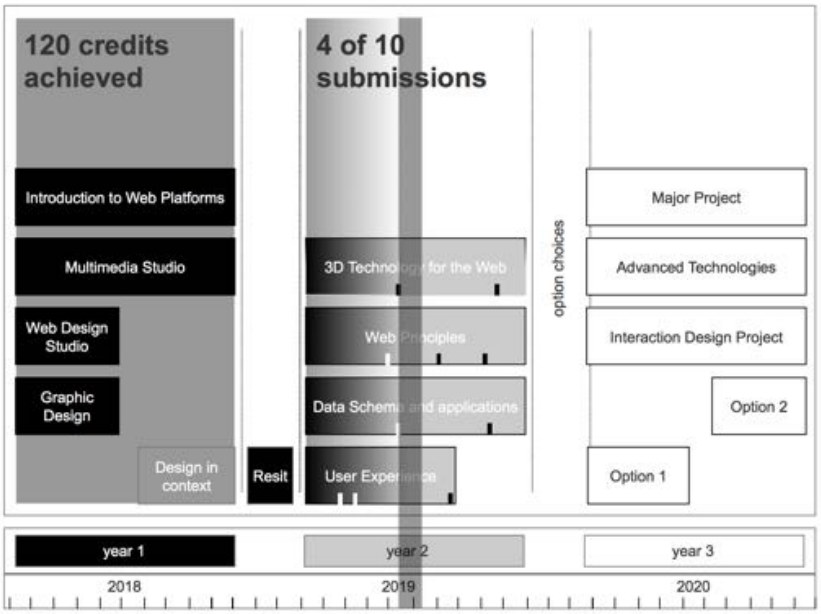

Figure 6.6: Details of early wireframe of data and temporalities in the student journey. Illustrating the visual change as events pass through the *moving-now* point, centred in the display

The temporal representation seen by students of their academic lives is often of a calendar that repeats year after year, and is implicitly, institutionally focused. It deals with the cyclic rhythms of the university as an organisation. The temporal perspective of both institution and academic staff could be considered to be at odds with the perspective of the student. The staff see repeating classes year after year with induction after induction to programmes. The organisation sees infrastructure and planning, decades into the future with a past stretching back even further. We proposed that the standard academic calendar/timetable may not be conducive to reflective learning. The unique temporal perspective of the learner is transitional and transformative whereas the institution is grounded and cyclic. Our project worked with students to develop a

range of alternative calendar (time event) representations to help learners think about the past, and prepare for the future.

Figure 6.7: Details of early timeline prototype of data and temporalities in the student journey, built using HTML, CSS, JavaScript and the JS Calendar framework and extracting live iCal timetabling data.

As we tested and evaluated prototypes we began to find greater clarity on the types of time events that students 'felt' in their lives at university. Time events ranged between what we term 'macro-scale', i.e. events or situations such as each individual year of study, a run of a course or module in that year of study, longer term assignments or projects of coursework. These may cover eight weeks or more and include other long but time-bound events such as holidays. These contrasted with 'micro-scale' events. The emphasis of macro-time events was that they were seen by students more as loosely defined durations. The micro-time events that were considered, included things that the students felt were explicitly pinned in time, appearing to 'punctuate' macro-events. Macro-events were felt more as a duration than a specific point, with beginnings or ends that were described as being more 'gradual' or 'fuzzy': Micro time-events, on the other hand, were discussed by students using far more precise language and detail. Example events listed by students included the beginning and ending of lectures, scheduled events on weekly timetables, meetings, and especially details of assignment submissions with hard deadlines.

Macro time events	**Micro time events**
year to year transition	lectures
module runs	timetables
assignments - preparation and execution	meetings
holidays	assignment submissions

Table 6.1: Macro- and micro- time events discovered during participant observation and interviews

From our initial consultation, design work, testing, and evaluation of prototypes we found three objectives we hoped to reinforce within the student-centred, temporal visualisation.

1) Linking

- Mentally and visually linking micro- and macro- time events,
  e.g., to clearly relate an individual lecture to the wider goals of a course or programme of study, rather than it being a discreet 'disembodied' activity

2) Reflecting

- Reflective progress through the journey of Higher Education -
  to clearly display how each day was a day further forward toward a goal.
- Reflection on improvement and transformation, personal growth and actualisation
  Allowing students to look back in time and see past achievements

3) Awareness of agency and control

- Reflection on agency and control with student at the centre of process and situated action.
  By putting the student at the centre of the temporal visualisation we sought to reinforce the perspective of the student being in control of their own learning within their own educational journey.
- Reinforcing purpose and linking micro- actions to macro- results
  To continually reinforce the idea of progress and change, and to visually associate how daily decisions made by students affected larger-scale goals and longer-term activities.

The research, experimental co-created designs and direct evaluation of prototypes provided rich information on how a temporally user-centred approach to systems design could aid in reflection and cognitive identification on the part of the user. This user-centred temporal design approach appeared to enable a subtle transfer of personal identification, from a users' perspective. Moving from a state where information and functions are orientated toward and 'owned' by the system, to a state of personal identification and feelings of ownership by the user.

6.5 Arguing for Temporality in HCI: A Guide for User Centred Temporal Design: Paper

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Arguing for Temporality in HCI: A Guide for User Centred Temporal Design'	Buzzo	Journal Paper	2017 (in press)	Interacting with Computers, Oxford University Press

Concerns and questions on the influence, importance and status of time in design were highlighted for me when participating in the 2013 ACM SIGCHI workshop 'Changing Perspectives of Time' in Paris, France (Lindley et al., 2013). The workshop included influential researchers and designers from around the world presenting their works and ideas on temporality in HCI to the assembled group of specialists. I was vividly struck through the various presentations at the repeated use of the word *time* to describe some effect, affect, value, object, issue or context, each instance of which was employed to denote a discrete and separate idea. Whilst there was unanimous agreement on the importance of time and temporality when considering interaction there appeared little consensus on what was being meant by the use of the word *time*. Each presentation clearly articulated an approach toward temporality from a particular perspective, and also, perhaps more importantly, from a particular epistemological standpoint. However, each standpoint only appeared robust when considered in isolation from a wider perspective reflecting on time. Crucially, each standpoint hinged on their being some absolute measure or definition of time, often leaning to clock-time as the foundation for design, development or observation of experiments or theories.

Leading from this experience, the final journal paper presented here (in press) is a culmination of the research and investigation detailed in previous materials and publications. It analyses the background to user temporality; it discusses the theoretical, trans-disciplinary and trans-epistemological environments; and it contributes to the broad debate on temporality and design within HCI, with a proposal for a framework for designers, to approach design for temporality in their own work. The article discusses how user-centred design is a well understood and commonly used approach to systems design in a Human Computer Interaction context. Within the approach is the placement of the experience of the user at the centre of the design process, as opposed to a system-centred design process. Whilst this approach has yielded significant benefits and advances in the of design of efficacious systems the understanding and incorporation of temporality in the design discussion is often conspicuously absent. The lived experience of time and the reality of a processional or narrative, causal, temporality for users is evident in day-to-day life but is not accommodated in current models of user-centred design approaches. This article discusses the background to user-centred design, and investigates what temporality means in the context of a user's lived experience of interacting with computer systems. Finally we propose a framework with which to evaluate the temporal experience of users and to assist in fostering user-centred temporal design.

When coming to this central idea, that there is a lived experience of time, it is again important to see this in a trans-epistemological, trans-disciplinary context. Norman, Neilsen, et al. all talk extensively on the user experience; and Wright and Mccarthy explain lucidly the argument for the 'experience of technology'. To this I would add that although the cognitive artefacts we are surrounded by measure and record time, the time they present us with is a kind of time they make themselves (Birth, 2012, Poidevin, 1997), and that from a human perspective we experience

time as part of the process of living.

What is clear is that acknowledging the lived experience of time is central to understanding the user's conceptual model (UCM) of any system or process that we can design. This means not only the temporal framework with which the user is looking, i.e. short term, long term, now, retrospectively, prospectively, but also whether they frame time egocentrically or objectively. How this relates to system-centric or user-centric representations would depend on: how they temporally frame the systems they are interacting with; how they frame their interactions; what evidence or representation is there of the history of the interactions; what temporal data is presented to the user, and how this is presented; and what the time-scape or time-bound arena is for the interactions.

6.5.1 Ten points for designers

The framework approach contains a number of steps, considerations and provocations. These are posed as questions or considerations to be undertaken during research, testing or evaluation. They can be considered to be congruent to the questions posed to designers from other frameworks such as the Garret 5 layer model, or the spatio-temporal aspect of Wright and McCarthy's *technology as experience* framework. Here they may explicitly ask the question 'What effects do place and time have on our experience?' (McCarthy and Wright, 2004); The framework presented here (see figure 6.8 and 6.9) extends from this opening statement and asks more, both of the designer and of the system.

The framework structure, and visual presentation in diagrams deliberately follows the experience design framework diagram from 'Technology as Experience' (McCarthy and Wright, 2004). Similarly the temporal framework goes through four themes centred around a common concern, temporality, shown in the centre of the diagram as a hub or central theme, to generate insights into the temporal worlds of the user of a proposed system or design.

There are 4 broad themes to the framework:
***understanding, translating, framing* and *representing*.**

6.5.1.1 Understanding time

The iterative process of working with user temporality can begin with understanding and insight into manifold temporal aspects of the problem domain, system, data, users and intended use. Temporal metaphors are entrenched in language and culture, and as Chen and Boroditsky have shown can also be highly, culturally specific. Setting aside pre-conceptions and received wisdom, and seeking deeper understanding of temporal contexts, can generate significant insights for designers and researchers.

In my own practice this need to understand aspects of the temporality of users can be seen in the work with students in the *JourneyMap* project (Chapter 6.4) and with working professionals in *Perfect Days* (Chapter 6.3). The insights from analysing time-use, temporal-framing, and the

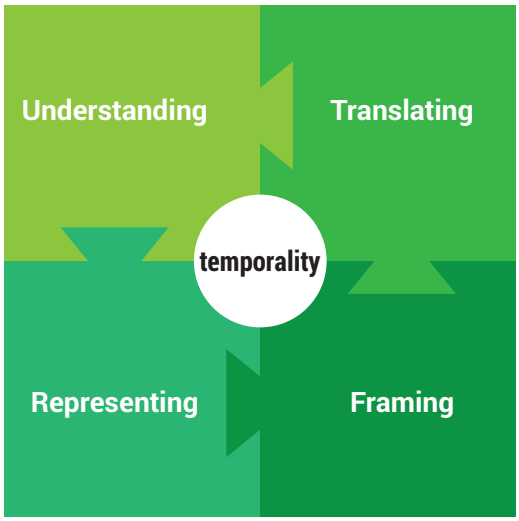

Figure 6.8: How can designers address temporal elements of a proposed experience and fit them together to form a coherent whole? Explicitly following the experience design framework diagram from Wright and McCarthy, the framework goes through four themes centred around a common concern (temporality) to generate insights into the temporal worlds of the user of a proposed system or design

time-perception of users was central to the experimental designs that were developed in the projects. The investigatory process was instrumental in highlighting this first step, achieving some understanding of what temporal aspects are involved in the problem domain.

Some of the key parts to an ***understanding*** phase are:

- **Understanding the temporal context**
  What are the aspects of time involved with the problem domain, users, proposed intervention or modes of use?
  What are the commonalities or conflicts of temporalities between users and stakeholders, system and context?
  Investigating the aspects of time that are relevant to the users, stake-holders or problem domain, can reveal useful insights in understanding of temporal contexts. Defining what kind of *time use* is involved in the problem or activity can be of great help. The definitions of time use (Aas, 1986) are of great help in defining the context for designers (is the user's *used time* personal time, contracted time, committed time etc?)

- **Understanding the narrative and procession of use**
  In what order will users engage with the system, and what temporal path will they take through the its content and functions?
  Can the action be modelled, not as a system diagram but as a linear narrative of actions

spaced in time?
The use of emotional time-lines, as an investigative tool to the problem domain, but specifically as an evaluative tool of any proposed design or system, can reveal areas of conflict, frustration and identify where users spend most of their time. Examples would suggest many systems sign-up, login and preferences functions are used sparsely, sometimes only once; key functions may be used repeatedly for extended periods. Mapping representation as a layered information exercise can be enhanced by adding calculations of time spent in each activity, function or information area.

- **Understanding the temporal data involved**
  What time series, temporal data is represented in the system or design? What metaphors are used and what time-scales are referenced or inferred?
  What information or functionality is presented to the users of the system?

  What is the temporal aspect of each element? How is the time series data presented and represented? Is the temporal aspect of this data explicitly system-related or user-related? Are presented time-scales system-generated, or produced by actions of, or for, the user? When metaphors or abstracted representations are used do they support or conflict with information gleaned from investigations in (1) or (2)? Is the data based upon internal or external expressions of time?

6.5.1.2 Translating time

After a discovery and understanding phase, comes explorations of translating the exposed elements into user-orientated interpretations. This translating phase encourages a shift of perspective toward that of the user as the central hub of the data or temporal elements involved in the design or system being proposed. This focus on translation is designed to re-inforce the analysis of temporal data as explicitly fluid and multi-dimensional and hence translatable to formats and contexts that better server the situation of the user.

The work in the experimental projects, *Time Travel* and *Designing for the Impossible* (Chapter 5.2, 5.3) and in *Not all Days are Equal* (Chapter 5.4) investigated the importance of translating metaphors and visualisations of time into user-orientated ones. Seeking to focus on finding ideas of time that are intrinsic to users rather than extrinsic. This translation process was also a significant part of the *JourneyMap* project. Where the re-framing and re-presentation of data that was structured explicitly in terms of the university as a physically based, quasi-corporate entity needed to be translated into terms and data structures that were immediately familiar and intrinsic to the understanding of students in the study.

The key elements of the ***translating*** phase are:

- **Translating the user's temporal framework**
  What is the bounding time-scale or time-scape from the users perspective? is the activity

single use, annual, sporadic, monolithic or other?
What is the users' engagement with the system?
The user will have a first use of the system, what could be considered to be their last ? How does the user conceptualise the duration of activity or action, that the system enables or engages them within?

Is the system constant from a use perspective? (such as email), with the same functionality needed everyday, or transitional (such as training to learn a skill - like language) where the system is intended to become redundant? Every system will have a first and last use, investigating how, when and for how long the system will be used, can reveal useful insights into alternative ways of framing the system for users.

- **Translating the user's lived temporal experience**
  What is the temporal context of the user? What is the temporal lived-experience for the user when using the system? How does time feel and what is time like when the interactions are taking place? What character would you want this 'use-time' to have?
  Where does use of the system fit into the user's everyday lived experience, and where does it fit in with their overall lived experience, in a longer term sense?

- **Translating relevant temporal data into user orientated temporal space**
  What is the epistemology of the temporal data involved in the design or system?
  Can it be translated into time-series data relevant to the user's temporal perspective or position?
  How does the passage of time for the user affect their relationship to their data or the system's data?

  When attempting to translate temporal information into a user-centred context we can observe how the passage of time for the user also changes the nature or relevance of the data for them. This *translation in use* will be influenced both by the narrative procession of the users actions, and by their increase in knowledge of the system and by changes in their goals and objectives.

6.5.1.3 Framing time

After investigating ways in which designs can translate temporal elements we ask whether they can be framed or re-framed to suit the temporality of the experience or the user? This framing and re-framing process can be pivotal in bridging the gap of comprehension for users. Well formed temporal framing can allow users to 'sit within' the interaction and information as a central participant in the system, rather than as an external observer.

The necessity of framing and re-framing time, temporality and temporal data is discussed in many of the projects presented in this thesis. Chief among them are the *JourneyMap* project,

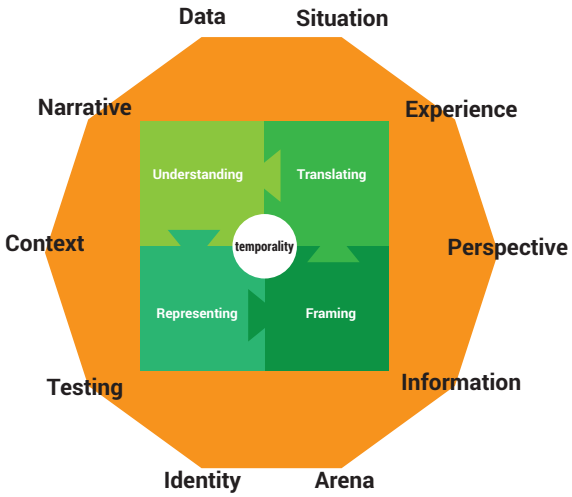

Figure 6.9: Temporal design themes follow the central process of the framework, identifying subjects or contexts to investigate in each of the four main phases.

Designing for the Impossible and the *Perfect Days* project. These works show most clearly how the main objectives were to allow users of the designed systems to 're-inhabit' their time in a new, more familiar way. The end result being to allow them a greater feeling of agency over their time with the implicit re-connection and identification that engenders. The students in JourneyMap saw their timetable as uniquely theirs, centred on their journey through higher education. The users of the Time Travel app saw their time (and time dilation) as their own unique experience and the study subjects in the Perfect Days project talked of regaining control over their work/homelife.

The key elements of the ***framing*** phase are:

- **Framing relevant user lived temporal data or information**
  What temporal information is relevant to the user?
  Is the system-orientated temporal information actually relevant or necessary?
  Many systems present excessive temporal data solely because it is relevant to the system, or that it is an available attribute of system elements, rather than because it is of relevance to the user.

- **Framing the lived experience**
  How can the temporality of the experience or system be framed in a user-centred way - is there a definable time-limited arena that can be used as a metaphor in which to contextualise the interaction? What is the period of use of the system? Can the metaphors in the system be re-orientated to suit the overall period that users will engage with the system for? For example, presenting data for school children framed by the period that they

will actually be at any specific school.

6.5.2 Representing time

How can the temporal elements of the system or the user's world be represented in the design?
After the system has been constructed how can the temporality within it be exposed to a suitable testing or evaluation process?
What temporal cultural norms or peculiarities are familiar to users?
What suitable temporal visualisations or metaphors can be discovered or implemented?
It must be remembered that the representation phase is not a goal, but rather, a part of continually iterative cycle. Just as users comprehend systems in a narrative procession, with each previous action or piece of information informing the next, so too are representations and design decisions that we must make. Changes in representation will have subsequent effects on the temporal perceptions that users have of a system or design. This does, of course, introduce the added complexity that users will see these changes as part of a temporal narrative.

Representing time is the point where the efforts in the previous stages of the framework become apparent. In the papers and projects presented here the design and artistic outputs illustrate differing approaches and interpretations. The design work in *JourneyMap*, *Not all Days are Equal* and also in the media art installations *'What do we Know of Time...'* (Chapter 6.1) and *'Making a time Machine'* (Chapter 6.2) show most clearly how different representations affect how users perceive temporality.

The essential parts of the ***representing*** phase include:

- **Representing the user in a temporally framed perspective**
  What represents the user within the temporal framework of the design, is there an element that can be identified as the temporal identity of the user within the system?
  What metaphor is used for the temporal journey of the user through the system? Does the user move though the system, *objectively*, or does the system move past the user, *egocentrically*?

- **Representing the user in temporally sensitive analysis tools**
  What user-0centred tools or processes can be employed to analyse the experience of the users' temporality, *from the perspective of the user*.
  When attempting to observe and refine designs and systems, testing is often seen as a temporally static process. It is often a single goal to be achieved with the results of tests having no temporal component to them. Where tasks have a temporal component the narrative procession in the task is commonly removed, reducing the complexity of the users' experience to single dimensions of data.

This approach and line of investigation is not completely unfounded and the importance of it has been noted by many learned researchers before, as Lundgren and Hultberg (Lundgren and Hultberg, 2009) note:

> 'there may be a benefit in *actually questioning* the temporality - or lack of in one's design' (emphasis in original)

The main argument presented in the paper is that *all artefacts have a temporality and temporality is fundamental to the experience of living*, and therefore, for all users of systems. The concluding contribution of the paper is a novel, experimental framework that designers can utilise to bring user-centred temporality into their own work.

CHAPTER 7

REFLECTION, CONCLUSIONS AND FUTURE WORK

7.1 Reflection

This body of work has investigated numerous aspects concerned with the perception and representation of time within HCI. The works, represented in a series of papers, articles, books and art works, illustrate many of the complex aspects of the discussion on temporality, and its representation in digital media. The studies and works have discovered important links between different disciplines in their description of temporality. It is clear that, *describing time is complex*, and there is little agreement between disciplines on exactly what time is or what it means. Through my work, I have, however, established a set of guiding principles for the discussion of time in an HCI context, and an experimental framework for including temporality into user centred design. This framework extends the idea of contextual design into the temporal arena by presenting key principles for understanding and working with the temporality of users of interactive systems. These principles are discussed in detail in the paper 'Arguing for temporality in HCI' (Buzzo, 2017) in chapter 6, and pivot around four framing approaches;

- Understanding users' temporal perspectives.
- Translating user's perceptions of time in the design.
- Framing timescales in the system.
- Choosing representations for time and time series data.

The work represents a sustained study of user-centred temporality within HCI: building on previous work examining user experience and the ideas of contextual design, particularly that of Dourish, and Wright and McCarthy; and expanding on studies examining aspects of temporality of users, for example, that of Lindley, Karapanos, Lundgren et al. Through analysis and discussion

of practice and language, experimental design works, and through critical artefacts, media art and publications, I discuss a new perspective on temporality in design and representation. The discussion extends and combines two main threads, that of technology as experience, and that of temporality: culminating in a published framework for user-centred temporality, 'Arguing for Temporality in HCI: A Guide for User Centred Temporal Design' (Buzzo, 2017).

The work compares and contrasts *system-centric* temporal representation with *user-centric* temporal representation, and proposes a new design methodology showing how awareness of temporality can aid in creating genuinely user-centred interactive experiences. The framework approach can be used as a toolkit, supporting designers in gaining understanding of the temporality of users or situations of use; and translating and re-framing these insights into practical outputs for design of interactive systems. This study has been wide ranging and necessarily trans-disciplinary, and as such has covered a large area of theory and practice; however, the limited resources available to me has curtailed the depth of some areas that could benefit from continued investigation. In particular, further practical experiment employing in-depth studies of the responses of users to differing visualisations, could generate useful data to refine elements of the framework and theory.

The key findings to highlight, from the studies and works, are centred on the complex relationship between time perception and time representation in HCI and design. The opening challenge that I have discussed shows that, for many people the subject of time is hermetic; an area seemingly impossible to unpack, that commonly is believed 'solved'; where the clock time approach appears as the 'gold standard' and definitions of time are used flexibly and interchangeably. This slippery linguistic flexibility and hidden uncertainty creates a complex landscape within which to work. As I write in my opening paper 'The shape of time' (Buzzo, 2013b):

> 'Time is considered using several definitions simultaneously: it is a duration, an event marker, an experience, an economic unit and also an experience and perception. This creates a free for all where the various definitions of time are ranked by their apparent authenticity and the ideal of incontrovertible 'real time' is moulded and adapted to suit whatever aspect of 'human' or 'computer' needs to be analysed at any particular moment.'

The works presented here relate to the studies of Dourish et al concerning situated or embodied interaction. Subsequent works by Wright, McCarthy et al. investigate the turn to practice within HCI, by expanding on ideas of ethnography: seeking to understand the methods people use for comprehending and creating order in the technological environments in which they live. The works follow the studies of Dourish and others within HCI to propose the question of *technology as experience*. I also build on smaller studies, and frame them into different aspects of temporality for users in HCI. These studies often focus on investigating single aspects of time, as opposed

to becoming entangled in the multiple, and often complex, range of temporal interpretations that can occur simultaneously. The individual studies and works I have undertaken unpack and examine these different types of time, in relation to HCI. I illustrate the main questions, expose the conflicts, and emphasise the importance of time when designing for interactions with computers. In concluding my argument, I assemble the evidence and present a framework for designers to use when designing for user-centred temporality.

7.2 Future work

Further research around the main themes presented in this thesis, could be further pursued in two distinct areas:

- The practice-led making of deeper, and more complex, critical objects: Particularly investigating experimental cognitive artefacts for recording or representing time. e.g. Clocks, calendars and other measures of how people record or use their time.
- Development and evaluation of the central theory presented in the framework for temporal design through applied use. By using the framework in real-world design projects and in applied processes, such as development workshops and design sessions, the process and categorisation embodied in the framework can be refined, and its effectiveness analysed, and objectively evaluated.

My personal work will continue in a practice-led methodology, by using further experimental making to investigate the strangeness I see in the world around me. In keeping with the ideas from linguistics, particularly those of linguistic determinism, and how the language we use shapes the world we perceive: I am intrigued by the prospect of investigating the tools we use to observe and record time. Amongst the cognitive artefacts such as clocks and calendars, I foresee fruitful strands of research exploring cameras and other recording tools that, at their core are machines grasping and storing up time, capturing duration. Alongside this possible avenue of experimental tool building I believe there are interesting avenues for reflecting on the theoretical and philosophical aspects of how the existence of this recorded media, the captured past, affects our present/now. This thread of work builds on material presented at ACM SIGCHI in Seoul, Korea in 2015 (Buzzo, 2015) where I ask:

> 'Just as electronic and digital technologies have freed musical instruments from the physical constraints of the acoustic, so have digital technologies freed lens-based media from the constraints of analogue film and chemistry, allowing the potential of using data sampling and processing as means of expression. What if we could instead broaden our understanding of, what a camera might be? What will the disappearing computer mean for media art? How can intelligent agents be integrated into tools and processes for visual work? How (or why) can we collaborate with the intelligent

agents, emerging and already present, within our systems, and what would be the nature of such a collaboration?

The nature of recorded digital media, that there is no physical structure to age, to develop patina and decay, gives it a strange quality with respect to time. A copy of a digital file can be indistinguishable from the original. The conceptual electronic space that lives inside a computer creates its own distinct type of time. Every file can be written and unwritten, every operation can repeat, forward and in reverse. Perceivably, it could be timeless, static space, with only the observance of a user cap[able of providing change by projecting forward as imperative. Experiencing media that lives on in this environment appears to project a mocking of our time-bound lives. Digital Media perhaps presenting us with the clear conflicts presented by McTaggart's A vs B series argument of time. A new series of work is planned investigating this time(less) spirit within media, the first project provisionally titled *'Modern media mocks us: Why Napoleon is still riding his horse and your calendar shows you things you can't see'*

7.3 Conclusion

The initial intent for this body of work was that of an investigative recording of the complex and contradictory nature of time and representation. A practice led adventure into the powerful nature of temporal representations and their influence on health, well-being and the framing of lived experience. (the past, present and future in digital media). Throughout I have used lens-based media, and media arts practice as a non-verbal means of investigative recording of alternative framing of temporal processes. Using the ideas and techniques of research through design, and experimentation to explore alternate representations. From the time-dilation software for wearables, to the student journey calendar, I have worked from the basics of space and time, to mapping of media art, psychology and mathematics. Taking assessments of representation and perceptions of time within HCI into applied prototypes, such as calendars and cognitive artefacts. Translating ideas into generative media installations and published visual works and books. Finally I presented a reflective framework theory of how and where temporality intersects with perception and representation in human computer interactions.

There has been a well documented turn to practice, and a move to embrace ethnography to improve design that opposes the systems-orientated, rationalist model. I propose that there is an additional step we can take to clarify the complexities of, understanding and designing, what happens when human interact with computers. As has been shown in this body of investigation and publications, temporality and the lived experience of time is common to everyone and fundamental to our experience and understanding of the world. We have see how awareness of design for temporality, and the idea of use-orientated temporality of data, can aid in creating interactive experiences that genuinely are user-centred. From the wide analysis of established and contemporary literature across many disciplines, and from practical experiments in the

design and creation of artefacts: A number of points emerged that together establish a structured design approach, that we are using successfully in new and ongoing projects investigating user-centred temporal design.

This new framework, for analysis of user experience from a temporal perspective, is intended to build on the excellent work that exists in many quarters of the rich HCI and RtD world. Notably, the work of Lucy Suchman (Suchman, 2006, 1985), whose ideas of situated action and changing and evolving goals in the decision processes for users, inspired and gave grounding to much of this work. Lastly to Wright and McCarthy whose clarity of argument for technology as experience, has guided my attempts when conveying the results of my own research. At its early stage, the framework allowed a re-evaluation of the constraints and priorities of proposed systems. As an awareness of the 'when' of user experience and of application of the various elements and stages. By highlighting the temporal nature of all interactive systems and designs and their evaluation-in-use becomes a fluid, dynamic thing, not fixed and monolithic but ever-changing and always-becoming.

In the arena of user-centred design, the work has shown how it contributes to an understanding of the framing of user-centred temporal representation, rather than system-centred temporal representation. I discuss and contrast the importance of human proprioceptic temporal representations for health and well-being - as opposed to machine level representations. I also illustrate the importance of temporal framing for reflection of progress through time-bound activities. Emphasising our temporal lived experience as a design concern: I propose a design approach that uses a shift in temporal representations - from system-centred to user-centred. Phenomenology represents the primacy of practice over abstracted cognition, in everyday lived experience. More recently, Dourish, building on the foundational work of Suchman, asks *where the action is* and his work and ideas explicitly make people, rather than machines, the centre of the process of design. Considering awareness, intimacy, and emotions when designing for living and acting in a digital world. He talks of interaction "organised in terms of the creation, manipulation and communication of meaning ... Rather than embedding fixed notions of meaning within technologies ... based on the understanding that users create and communicate meaning through their interaction with the system'.

As Suchman writes, the purpose of *Situated Action*:

> '...is not to produce formal models of knowledge and action, but to explore the relation of knowledge and action to the particular circumstances in which knowing and acting invariably occur.'

And Dourish goes on to say:

> 'Meaning arises in the course of action. The ... observation that we are led to ... is that the meaning of a technology is not inherent in the technology, but arises from how that technology is used.' (Dourish, 2001)

I argue that not just where, or how, but *when*, is pivotal in understanding context in the design of interactive systems. In this portfolio I have asked *when the action is*, and highlighted how the **temporal** experience of the user is the foundation of their experience of the world. Time is at the base of any possible system that users may interact with. I believe the significance is of simultaneously asking *what the 'when' is?*. This dual awareness of the fundamental nature of *time as experience*, and of *time as strangeness*, is both a closing point of this body of work and the starting point for my future investigations.

APPENDIX A

Papers and publications included here for consideration. The papers are included in their original, published format and contain the page numbering as per their original publication. Where appropriate the page orientation has been altered to suit original formatting.

		Published works and peer reviewed papers		
Title	*Author(s)*	*Type*	*Year*	*Publication*
Lost Time Never	Buzzo	Conference paper	2013	Proceedings of the 2013 Inputs-Outputs Conference: An Interdisciplinary Conference on Engagement in HCI and Performance
The Shape of Time: Reconsidering Time in the Context of Pervasive Media	Buzzo	Conference paper	2013	Proceedings of the 1st Fascinate Conference Thoughtful Technology and Beautiful Interfaces
Time Travel: Time Dilation	Buzzo, Jonas	Conference paper	2014	Proceedings of British Computer Society, Electronic Visualisation in the Arts
Designing for the Impossible: Creating a Mobile Application to Track Time Dilation	Buzzo, Jonas	Conference paper	2015	Proceedings of British Computer Society, Electronic Visualisation in the Arts
Time Travel software for AndroidOS	Buzzo, Jonas	Open source Software	2015	`http://timetravel-app.com` and `https://github.com/danbz/timetravel`
Not all Days are Equal: Investigating the Meaning in the Digital Calendar	Buzzo, Merendino	Conference paper	2015	Proceedings of the SIGCHI conference on Human factors in computing systems
Time Travel: Time Dilation and a Year of Airflight - Recent Photographic Work	Buzzo	Artists Book	2015	Forlaegger Fabrik20
'What do we Know of Time When all we can Know for real is Now'	Buzzo	Generative Video Installation	2016	'Digital Futures' British Computer Society and Victoria and Albert Museum
Perfect Days. A Benevolent Calendar to Take Back Your Time	Hassenzahl, Buzzo, Neuhaus	Conference paper	2016	Celebration and Contemplation, 10th International Conference on Design and Emotion
JourneyMap: Visualising the Time-bound Student Journey	Buzzo, Phelps	Conference paper	2016	Proceedings of British Computer Society, Electronic Visualisation in the Arts
'Making a Time Machine'	Buzzo	Generative video Installation	2017	'Digital Futures' British Computer Society and Victoria and Albert Museum
Arguing for Temporality in HCI: A Guide for User Centred Temporal Design'	Buzzo	Journal Paper	2017 (in press)	Interacting with Computers, Oxford University Press

Table A.1: Peer reviewed papers and works included in full in this appendix

Lost Time Never

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"Strategy is the art of making use of time and space. I am less concerned about the latter than the former. Space we can recover, lost time never." Napoleon Bonaparte [3]

ABSTRACT

As Nam June Paik intuits in his 1976 article "input-time and output-time" [11] our experience and expression of time and events are not connected to each other in a linear fashion (fig. 1). As a result the incidents that create what we decide to express can have little or no relationship to each other, illustrated in the example of Proust, where a momentary incident of childhood takes a lifetime to express [12]. In this sense input-time vs. output-time in our expressions and our creative acts is necessarily unequal.

Figure 1: Nam June Paik with TV's

If we take these experiential aspects of time and lay them side by side against the abstracted tempo of technology and time-based media, we see a deepening contrast. The sensations of input in a given experience are balanced against the expression of the effects of the engagement into the interaction itself. The rules of temporality at the fundament of digital media cross changes in contemporary language when considering and comparing representations of time.

This presents new challenges to researchers and artists seeking to create digital experiences while allowing for representations and expression of personalised time. From *Lifelogging* to notions of the *Quantified Self* [13] we see these contradictions and collisions becoming increasingly apparent and we ask with Martin and Holtzman: "If everyone says time is relative, why is it still so rigidly defined?" [10]

Categories and Subject Descriptors

H.3.1 Content Analysis and Indexing, H.5.1 Multimedia Information Systems

General Terms

Design, Experimentation, Human Factors, Theory.

Keywords

Time, Media, Lifelogging, Quantified Self.

1. PERSPECTIVES OF TIME

Time is often considered to be a constant, immutable ever-flowing inevitability with a single direction, external and uncontrollable, but there are many varied and sometimes conflicting notions of time [5]. (fig. 2) What we may term as *natural time* is based on observations of physical phenomena, the transit of the sun across the sky overhead, the motion of celestial bodies, and of notions of space and distance, a journey of many days or a walk that takes a morning. *Rational time* relies on the mechanical measurements of time, and finally in conflict with *natural* and *rational time*, *experiential time* is related to the individual and personal experience of the passage of events.

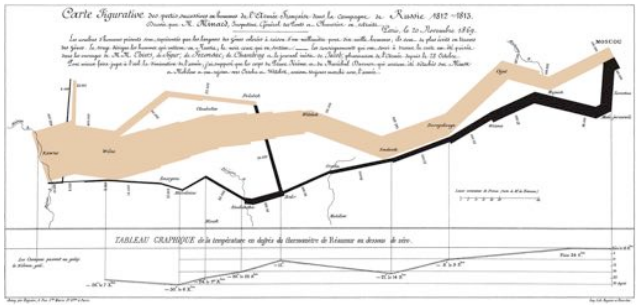

Figure 2: Napoleon Bonaparte 1812 invasion of the Russia illustrated over time by Charles Joseph Minard

In China, time is commonly conceived of vertically, as a spring or seed with time issuing forth from a point of singularity [5] whereas western tradition, dating back to Heraclitus views time horizontally as a continuous river flowing by the individual [8]. Though critical of Boroditsky's work on linguistic concepts of time [4] Chen's recent work [6], though controversial itself, has show evidence of behavioral changes in speakers of languages with different tense constructions, with different approaches to describing time.

Through the historical rise of universal mechanical time, personal and the experiential concepts of time became relegated to notions

of dreams and fancy. The Algonquin people of North America on meeting the chronologically obsessed Europeans referred to this new notion of time as *Captain Clock*, the mechanical device that ruled the actions of everyone [7]. Since industrialisation the European representations of time have been based on the framework of mechanical time with the timeline or equidistance chronology being the most apparent of these.

2. DIGITAL REPRESENTATIONS OF TIME

Within contemporary interface design for digital media, the timeline is almost exclusively used as the basis of temporal representations. Despite strong discussion and dissent within the field of (time-based) media, the timeline with its fixed, equal, mechanical increments is almost totally dominant. Representations of personal or experiential time, which relates more directly to how we actually experience time, remain relegated to sub-surrealist dreamlike collisions of discrete events or symbols.

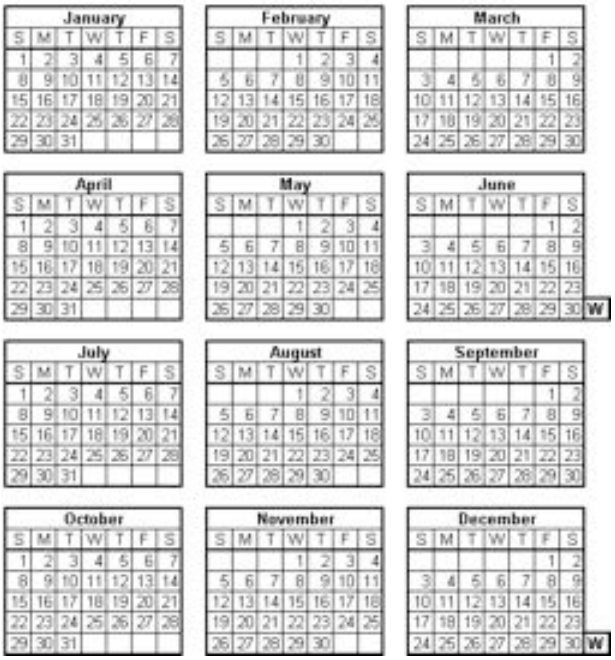

Figure 3: Standard Calendar Layout

As an example, even with the flexibility of digital calendars it is rare to find representations beyond one day, seven days (one week starting on Sunday) and one month or five weeks laid linear fashion on top of one another (see fig. 3). The underpinning data and software constructions have no predisposition to the Romanesque legacy of weeks and months and whilst almost everything else in current digital discourse is available for 'disruption', as Martin and Holtzman point out, time it seems is not on the menu [10].

3. LIFELOGGING THE NOW

Gordon Bell's pioneering early experiments with *Lifelogging* [1], the social act of storing and often subsequently sharing one's life events in public fora, and the *Quantified Self* measurement of Stephen Wolfram [15] can be considered some of the more extreme examples of recording and storing the minutiae of everyday life (See fig. 4). However this practise is now a recognisable trend with a plethora of recording devices and technologies readily available. Modern life caching is considered a form of social networking and typically takes place on the internet. The Quantified Self movement, to incorporate technology for data acquisition in manifold aspects of a person's daily life in terms of inputs, states, and performance is seeing commercial acceptance from purveyors of the physical products and software services alike. Brands such as Reebok and Nike to aggregators and disseminators of data such as Facebook, Twitter and Google to new entrants with specialised products such as Microsoft HealthVault are all assisting with the increased capture and storage of huge amounts of people's daily lives.

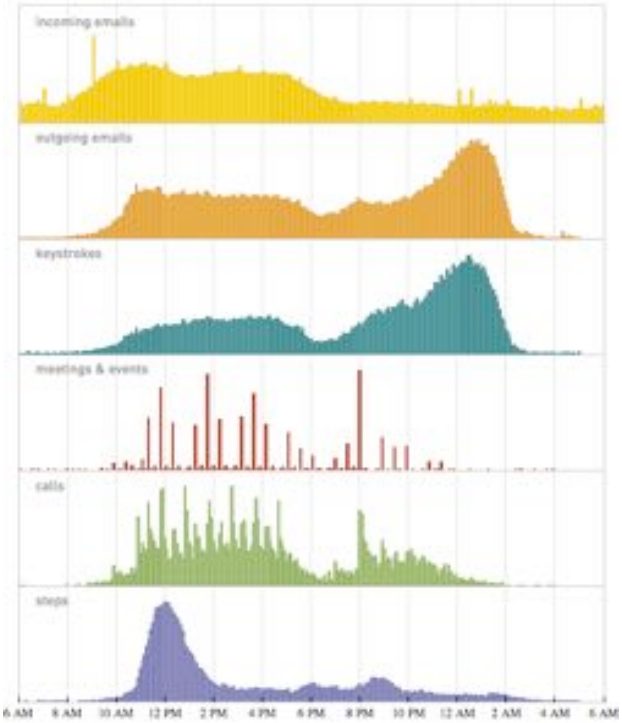

Figure 4: Stephen Wolfram's Daily Rhythms

When considering the idea of inputs and outputs in the context of data and emotional effect, this reinforcement of external mechanical time may actually be diminishing our ability to make sense of or otherwise effectively curate time-based media. Even new developments such as the specially designed Memoto *Lifelogging* camera are posed as recording devices but offer little beyond brute storage for the engagement they capture, mechanistically, every thirty seconds. (See fig. 5 and fig. 6)

Figure 5: Memoto Lifelogging camera

As we create more and more recordings and representations of our daily engagement (those moments where we are present, actualised and focused) we find that the data produced from intensely subjective personal activities such as *Lifelogging* or engaging in the increasing variety of recording under the banner of the actualised self, is just that, data.

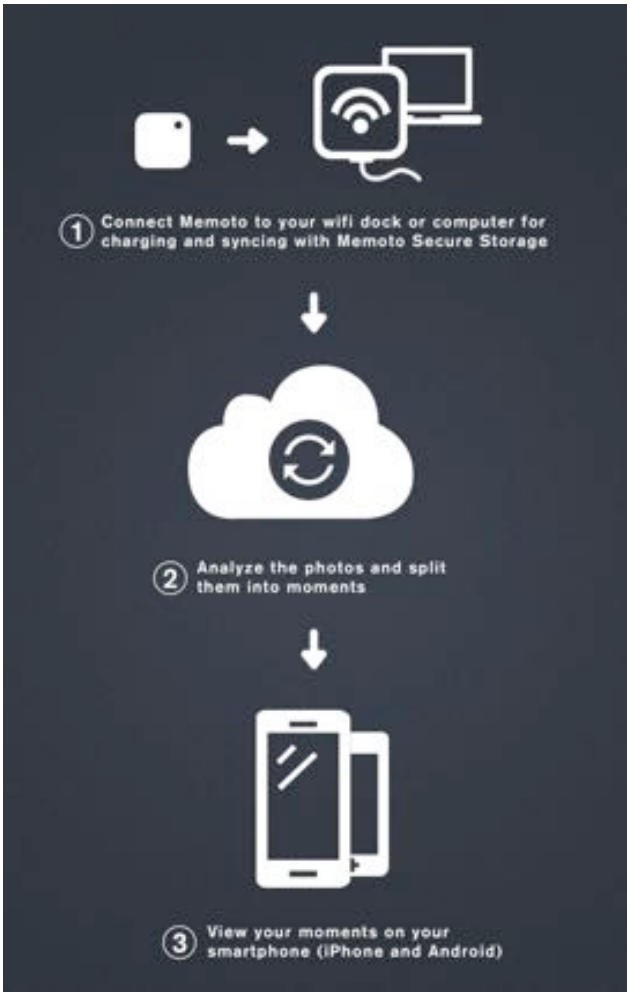

Figure 6: Memoto Lifelogging

4. TEMPORAL REPRESENTATIONS OF EMOTIONAL OUTPUT

In literature the inherent temporality of the novel is almost uniquely based upon the subjective experience of the characters within a story, chronology is neither fixed, nor flat, nor contiguous but occupies a supporting role to provide context and links between events of importance, events of engagement, for the characters, the writer and the reader. Even from the viewpoint of the author or artist temporality is often unlinked. As with the classic example of Proust [12], a momentary incident in childhood as input takes a lifetime of work to describe as output.

A work of fiction can be said to hold at least three notions of time: The time of writing (the duration of the writing process), the elapsed time within the narrative and finally the time of reading (the duration required to read the text). As such the movement through the text places the reader is multiple simultaneous timeframes as memory in the definition of Susan Stewart "at once impoverished and enriched, presents itself as a device for measurement, the "ruler" of narrative." [14] It is tempting to propose that *Lifelogged* events of social media could possibly be regarded in a similar fashion.

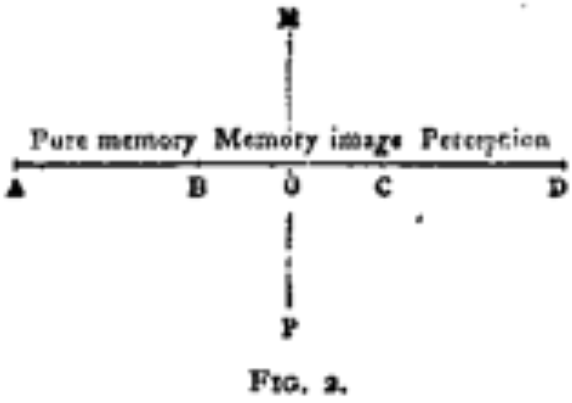

Figure 7: Henri Bergson. Illustration from "Of the Survival of Images. Memory and Mind"

The French philosopher Bergson developed his theory of time as a response to the perceived dominance of ideas of mechanical and rational time. [2] He became convinced that time eluded science since the instant one attempted to measure a moment in time, it was gone: He maintained that one can only measure an immobile, complete line, whereas he considered time as mobile and incomplete. From the perspective of the individual, time may speed up or slow down, whereas, for science, it would remain unchanged. Bergson explored the inner life of man, which he saw as a kind of duration, neither a unity nor a quantitative multiplicity. Duration is then ineffable and can only be shown indirectly through images that can never reveal a complete picture. It can only be grasped through a simple intuition of the imagination (See fig. 7*)*.

As we move from systems-orientated mechanistic models of computation, of accounting, of record keeping, or tabulation of statements of fact, toward ubiquitous computing, pervasive media and a social model of computing the notion of engagement changes emphasis. The computer has finally disappeared and receded into the *internet of things* [9]. This constitutes an important challenge as we begin to address the question:

How do we represent the experience of embodied and engaged moments over time?

Figure 8: Logging the Now on Facebook

5. PERSPECTIVES FOR MULTIPLE DIGITAL TIMES

The media we create is evidence of engagement (present, actualised, focused) but after-the-fact analysis ie curation of these discrete pieces of evidence of our engagement is limited to timelines of engagement, mechanical rather than personal. Without a coherent approach to curation we have a mechanistic chronology or a simplistic catalogue that lends nothing to re-experiencing the *experience* of being *actualised* at the moment of recording. Our intimate engagement is transformed after the fact to a Fordian production line of mechanical time where the nuance, subtlety and poignancy of being *present in the moment* is stripped of its temporal context and re-ordered to the tune of *Captain Clock* [7].

Analog media was originally created as to subvert our common understandings of time and space: at twelve frames per second and above we believe in motion. Film freezes and plays back live action in a different timeframe; radio transmits presence in time across space. Both forms play at displaying these modified experiences as if they were *here* and *now*. It can be argued that all media exist solely as manifestations of altered time and as such the experience of both traditional analog and new emerging digital media types is deeply rooted in the distortion and warping of our perception of time. This is of course only possible because chronological time itself is a technological definition, measured and defined by mechanical and chemical processes.

Traditional media has given us the power to control chronological time; can new media strategies give us the power to control our perception of time?

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Proceedings of the 1st Fascinate Conference **28-30 August, 2013**
Thoughtful Technology & Beautiful Interfaces **Falmouth University, Cornwall, UK**

The Shape of Time: Reconsidering time in the context of Pervasive Media

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ABSTRACT

Within contemporary research discussion in interaction design, HCI and pervasive media the word **time** is commonly used to represent a wide variety of meanings, concepts and dimensions. Often this is without differentiation between contradictory interpretations of the simple word that belies complex relationships with our world and increasingly with media.

The discussion or the experience of time can be traced to many sources, from Heraclitus and the river of time, Husserl's phenomenological concepts and the Bergsonian interpretations of time to empirical measurements of the swinging pendulum of Captain Clock conflicting concepts of time are freely used to discuss media and interaction. As Chen and Boroditsky argue even the languages we speak influence how we conceive of and verbalise our ideas of **time** and the effects this has on our lives.

This paper considers the issues of how to describe, compartmentalise and resolve the seemingly conflicting concepts of time using the consideration of time as a volume orthogonal to three dimensional space. Taking examples from digital culture, pervasive media, life logging and the quantified self the paper argues for a new analysis of concepts of time as discussed within contemporary digital media research and HCI practice.

Keywords: Multimedia, Time, Interaction Design. Representation, Lifelogging, Quantified Self

1. Some thoughts on Representation

In religion, philosophy and science there are a myriad of measures and concepts of **time** that are used interchangeably. **Time** is described by Bergson as being only perceivable as duration, the moment itself is intangible and can only be experienced as **that which began and ended** [1]. This is in contrast with Marx and the interpretation of capitalism as time having a measurable value, that can be traded and exchanged.

Within the discourse of Interactive Media and Human Computer Interaction **time** is considered using several definitions simultaneously: it is a duration, an event marker, an experience, an economic unit and also a a experience and perception. This creates a free for all where the various definitions of time are ranked by their apparent authenticity and the ideal of incontrovertible 'real time' is moulded and adapted to suit whatever aspect of 'human' or 'computer' needs to be analysed at any particular moment. In contemporary interface design for Digital Media, the timeline is used almost exclusively as the basis of temporal representations. Despite strong discussion and dissent within the field of time-based media, the timeline with its fixed, equal, mechanical increments is almost totally dominant. Representations of personal or experiential time, which relates more directly to how we actually experience time, remain relegated to sub-surrealist dreamlike collisions of discrete events or symbols. (Buzzo, 2013)

2. The Clockwork of Time

Contemporary European perspectives and representations of time can be traced to a framework of mechanical time metaphors, with the equidistant divisions in a timeline or chronology being the most apparent of these. In the case of digital media interfaces the fixed, equal timeline increments are almost totally dominant, creating a wholly artificial grid applied to human experience. From a subjective human perspective, this is equivalent to the abstraction of the equidistant stations of the London underground map contrasted with the experiential understanding of the actual distance between them.

Fig 1: London Underground map

Considering the political aspects of time, and subsequently of representations of time, the argument for a new imaginative reframing of mechanistic time as the single true representation becomes even more compelling. As we move from systems orientated mechanistic models of computation: accounting, record keeping, or tabulation of statements of fact, toward ubiquitous computing, pervasive media and a social model of computing, the notion of engagement changes emphasis. The computer with it's internal clock determining the pace and sequencing of all of its functions is in itself built on the concept

of mechanical time, but a version of time that is local and changeable. Your computer can be overclocked, it can be **slow**. The roots of the computer, in clockwork, in mechanical timekeeping, is as a computational engine is driven by it's own internal rhythm. The representations of interface time are naturally remnant of this machine measurement of time, an artificial grid of measurement intricately linked to the mechanical roots of computational devices.

However, as the possibly apocryphal but widely cited example of the Algonquin peoples so neatly illustrates, the mechanical description of time has seemingly always been at odds with the human experience of it [4]. The work of Chen and Boroditsky on the influence of language on health and even economic outcomes illustrates this [2,3]: Before the mechanisation of the language of time, our experience, perception and descriptions of time and duration might have been more subjective, fluid and variable.

3. The Timeline and the Experience of Being Alive

The early Lifelogging experiments from Gordon Bell [5] and the Quantified Self measurement of Stephen Wolfram are extreme examples of monitoring and recording the minutiae of everyday life [6]. Lifelogging is the recording and sharing one's life events in public, typically via the internet. Recording inputs, states, responses and interactions is central to the Quantified Self movement, where incorporating data acquisition technology in every aspect of ones' daily life is commonplace [7].

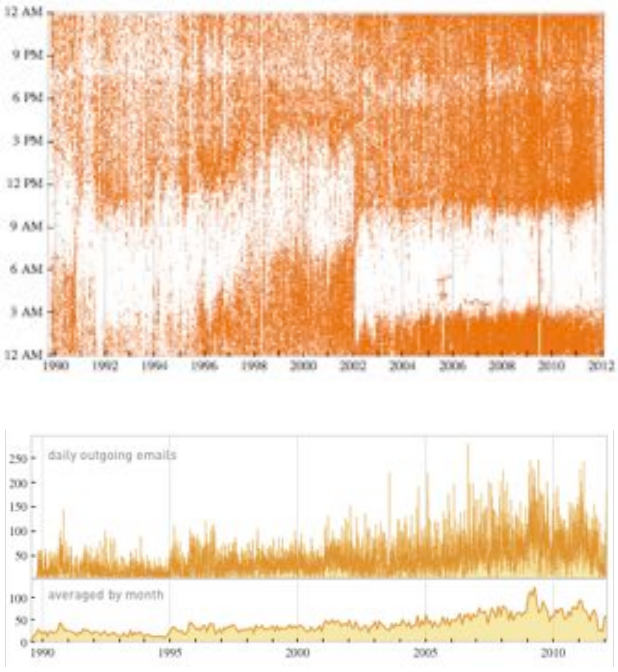

Fig 1: Outgoing mail diurnal and daily

In these examples the experience of self or of being 'present' is distilled in a reductionist fashion to create data, data that are all temporally situated. However upon review this data apparently describes little of the actual life events or experiences that created it, providing little more than revelations about the data itself. It takes human re-interpretation, applying the real world back on top of the data, to change it back into information with emotional meaning. Stephen Wolfram's illustrations of personal analytics, whilst being impressive in their obsessiveness and detail tell us little about the experience of being Stephen Wolfram, despite the data apparently having the deepest rhythms of his life embedded in it.

After centuries of being under the influence of empirical measurement of events and mechanical metaphors in language, our thought processes still carry this intimate and fluid set of relationships between events, perception and what we latterly call **time**.

We think of a person - a birthday party, a location, Devon, - summer, an evening with bright, warm light, on a weekend, a Saturday, a month, a year. Then finally (perhaps after some searching and possibly head scratching) we can apply an external, mechanical definition, Saturday 12th June 2011.

This process illustrates how we think of the past as a series of events first and then apply a chronological grid to them. Our internal experience is situated in our subjective perception of time and is then in turn validated by expressing our inner reality in an approved, codified external system of categorisation.

4. Exif, Metadata and Experiential Memory

A look at chemical film photo albums, created before the automatic chronological tagging of digital photography, reveals images arranged and sorted by emotional relevance: by subject, family, the beach, baby pictures etc. These albums hold less information than a digital photo interface but the information that is there is actively and deliberately created using subjective taxonomies and perceptions of time, order and association. As a result they appear as complex and rich in association and meaning beyond simple definitions of nostalgia.

Fig 3: Antique Photograph Album

In digital photography it is only a recent development that information other than the actual pixel level picture data is recorded and associated with each picture. Whenever such digital media entities enter into a computer system they are time-stamped as events in an artificial digital construct, that has a chronological event tree wholly separated from any perceived reality of the media creator. The time component has so far only been applied to the actual file rather than the digital image

contained within, thus allowing the timedata to change as the file is duplicated and rewritten. However, in the last few years Exif and other media metadata standards has introduced the notion that media such as digital images may contain more than just pixels [8]. A digital photograph also contains a date, a geographic location by latitude and longitude, a location by placename, the camera manufacturer and model, exposure and capture settings, names of people present in the image, name of the author of the image etc. The subsequent proliferation of mobile phone based photography where accurate time and locative data is readily available has boosted the use of image metadata massively.

Without these additional elements the digital image is akin to remembering a picture but having no recollection of when, where or what it is, nor even how it came to be in one's conscious memory at all. Though as in the case of Vice Magazine and the 'secret' photographs of John McAfee, accidentally revealing his location as a fugitive via GPS data embedded in photographs posted on the web, this is still something even the most media aware of us are still coming to terms with [9].

In examples such as live mapping, GPS navigation, Google maps, open street map etc, the user is placed at the centre of everything and the world whirls around re-orientating to suit the perceptions of the traveller. When taking a less immediate walk through the digital world of pervasive media the content is commonly laid out end to end, with the user being able to do little more than slide along a line where the relationships between events are dictated by one abstracted attribute, **time**. To fast forward or rewind, we must traverse this computer centered view of events rather than a human view. Having been separated, distilled and sorted into a simple tabulation reinforcing the view that all events, experiences, media, and meaning are equal, and therefore potentially interchangeable.

If instead we can move towards a place where we can consider a picture as the sum total of the pixels *and* attendant metadata locked together then these entities may begin to enrich the pervasive digital media that we create. This would allow them to move beyond single dimensional facsimiles of experience to deeper representations, that can begin to mirror our internal experiences of time and events in the world we inhabit.

Fig 4: Live GPS mapping

5. No Time Without Space

Examples from social media may help us describe the process of an personal event and the subsequent systematic narrowing from the personal through to the empirical applied grid of chronology. We can all imagine how to arrange our social contacts in more sophisticated and useful ways than being listed alphabetically, rather than by relationship. Can we also arrange media by the strength of the relationship we have to it from ***the now*** rather than merely the artificially rationalised divisions of distance?

Considering time in pervasive media as an abstracted attribute that can be applied to or stripped away from human experience and the representation thereof is essentially a regressive step. This reductionist approach delivers scatter diagrams of data points that describe rhythms in the data but not rhythms in peoples lives, experiences or perceptions. Using machine generated abstractions of time to organise media changes the nature of what is recorded. With the manipulation that occurs when our experiences are organised in an alternate taxonomy, our experiences are reframed and essentially changed and we are at risk of becoming spectators of the remediated versions of our own lives.

As we move on to broaden our investigation into other ways of making sense of the endless streams of media we generate, it may be useful to bear the contradictions of time in mind: Time in a physical sense is always intrinsically linked to space, as is our experience of it. Einstein proposed that we cannot have space without time and cannot have time without space - and in a strange way your grandparent's photo album knows this too.

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Time Travel : Time Dilation

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Abstract

In this paper I discuss the theory and actuality of the effects of Time Dilation, as predicted by Einstein's Special Relativity. Alongside this the research investigates the visible, experiential effects of most personal form of Time Travel from a personal, phenomenological perspective, illustrated through digital media.

The body of work, this paper and an accompanying book of modified digital images, recalls the Hafele-Keating experiment of October 1971 and parallels the Quantified Self experiments of diary photography and personal analytics in a holistic, interconnected way.

The work tracks 12 months of air travel and illustrates with practical data the physics and mathematics behind the theory and actuality of Time Dilation. The research combines the interdisciplinary worlds of Computer Arts with Data and Scientific Visualization to create a tangible collision between the visualisation of the personal and illustration of theory

The observations are documented in ethnographic, photo essay illustrations as an investigation into the mathematics and physics of personal and interpersonal time. Using situated imaging presented as a practice based body of work to communicate the abstract world of very small time periods and the direct relevance of Einstein's work on the personal and perceptual world we inhabit. Contrasting Newtonian mechanics and Einsteinian space-time the work seeks to illustrate the personal nature of how the reality of time travel influences every aspect of the interpersonal

Key Words: Time Dilation. Time Travel. General Relativity, Special Relativity, Visual Thinking, Photography, Visualisation, Practise based research, Art.

1. INTRODUCTION

In 1971 two American researchers, J.C. Hafele and R. E. Keating, conducted an experiment.

They placed two caesium atomic clocks on passenger airplanes and flew them in opposite directions around the globe to test a hypothesis first posited in Einstein's theory of special relativity.

Their aim was to measure the effects of relativity on these highly accurate devices - the predictions indicated that the eastward flying clock would lose 40ns and the westward gain 275ns. A nanosecond is equal to one billionth of a second (10^{-9} or $^{1}/_{1,000,000,000}$ s). To compare, one nanosecond is to one second as one second is to 31.7 years.

"During October, 1971, four cesium atomic beam clocks were flown on regularly scheduled commercial jet flights around the world twice, once eastward and once westward, to test Einstein's theory of relativity with macroscopic clocks. From the actual flight paths of each trip, the theory predicted that the flying clocks, compared with reference clocks at the U.S. Naval Observatory, should have lost 40+/-23 nanoseconds during the eastward trip and should have gained 275+/-21 nanoseconds during the westward trip ... Relative to the atomic time scale of the U.S. Naval Observatory, the flying clocks lost 59+/-10 nanoseconds during the eastward trip and gained 273+/-7 nanosecond during the westward trip, where the errors are the corresponding standard deviations. These results provide an unambiguous empirical resolution of the famous clock "paradox" with macroscopic clocks." (Hafele & Keating 1972)

The results showed that compared to stationary clocks in the laboratory the eastward clock lost 59ns and the westward gained 273ns. Whilst there has been discussion of the accuracy and therefore reliability of the measurements the experiment is commonly held up as one of the first to give practical evidence of the physical effects of time dilation.

2. Special relativity and time dilation

In special relativity Einstein States that the duration of time will pass at different rates when comparing an object at rest versus an object in motion. The greater the velocity of the object in motion, the closer to the speed of light, c, the greater the effect of what is known as 'time dilation'

The effect of this phenomenon is significant at speeds close to the constant of light speed but becomes exponentially less as the object in question approaches rest.

$$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Figure 1*: The mathematical relationship of time, velocity and the speed of light describing Time Dilation*

Unless our velocity is a substantial fraction of the constant speed of light the dilation effect (γ) is approximately 1. This, combined with our extremely limited lifespan is why we don't immediately notice time dilation at ordinary speeds. The fastest speed most humans will achieve, an airplane travelling near the speed of sound, gives a time dilation where γ = 1.0000000000005.

In other words, 1 second for a passenger on the plane would pass as 1.0000000000005 seconds for a stationary observer.
Time effectively passes more slowly for the traveller relative to the observer.

3. The reality of the effect

Whilst there is discussion of the validity of the results of the 1971 Hafele & Keating experiment, particularly around the 'corrections' made to their data at publication, their initial observations are clearly aligned with the predicted results to be expected from the mathematics for time dilation.

As Reinhardt et al (2007) note;

> "Time dilation is one of the most fascinating aspects of special relativity as it abolishes the notion of absolute time"

In their 2007 paper they investigate the effects of time dilation with even more accurate atomic clocks, adding more experimental evidence consistent with special relativity. There are also numerous other experiments, such as those into muon decay, that provide additional practical evidence that the effect described is real and measurable.

Figure 2: *Over Dorset: Duration 55 minutes*

4. Implications for everyday life

The practical implications for everyday life at first appear intangible when one considers the seemingly miniscule time periods being discussed. Even taking some of the most extreme examples one can imagine being feasible, such as that of a cosmonaut living in a fast low earth orbit, circumnavigating the earth every 90 minutes gives γ of approximately 1.0000000003.

If one considers our astronaut in orbit for two years, the Time Dilation due to special relativity would give an increase in lifespan of approximately 20 milliseconds. A millisecond is a thousandth (10^{-3} or $^{1}/_{1,000}$) of a second.

This gap of 20 milliseconds, or two hundredths of a second, are suddenly well within human scale perception and understanding. This is a common measured gap in motor racing and fast sports like downhill skiing. Even the record for the 100m sprint is now is 9.58 seconds, run by Usain Bolt at the World Athletics championships in Berlin in 2009.

Scales in milliseconds are spaces and durations that even humans with our modest lifespans can perceive and understand.

As Ed Lu, Science Officer on the International Space Station writes, from orbit, in his blog post on experiments in 'Relativity';

> "After our 6 months in space, we will have actually aged slightly less than everyone else on the ground because of an effect called time

> dilation. It isn't by much (about 0.007 seconds), but it is one side benefit of flying in space!"

Though the effects of time dilation at human scale speeds are often imperceptibly small they are nonetheless real. Seeing the implications of this reflected in everyday life reveals the truly personal nature of the time travel that we undertake in everything we do.

The realisation that time dilation is a tangible and observable phenomena that affects ourselves and everything around us was given heightened poignancy by spending large amounts of time flying at altitude and high speed. Observing the curvature of our planet and seeing the dark sky at the edge of space overhead, watching the mountains and deserts as they slid effortlessly under the wings of successive aeroplanes. Being able to observe the size of the individual against the backdrop of a macro-cosmic scale all the while reflecting on the fact that to a subatomic particle travelling near the speed of light, the universe is about four weeks old and it can be crossed in a matter of months.

> "Nature can produce even larger particle energies. Some particles striking the Earth's upper atmosphere have energies that exceed 2*1020 eV. If such particles are protons (with mass of about 1 GeV), their speeds would be 0.999 999 999 999 999 999 999 995 c. For them, γ is 1011. Now the age of the universe is about 13 billion years for us, but for such particles, the age of the universe would be about (13 billion years/1011), ie about a month. Such a particle could cross the visible universe in a matter of months (their time)."

This twist of perspective, the deliberate 'making strange' that Shlovsky (1917) describes occurs when translating the abstract of the macrocosmic to the intimacy of the personal. The act of comparing and contrasting macro-scale physics and mathematics with recordings of human scale observations evidence reveals useful and potentially significant insights into the nature of the world we actually inhabit.

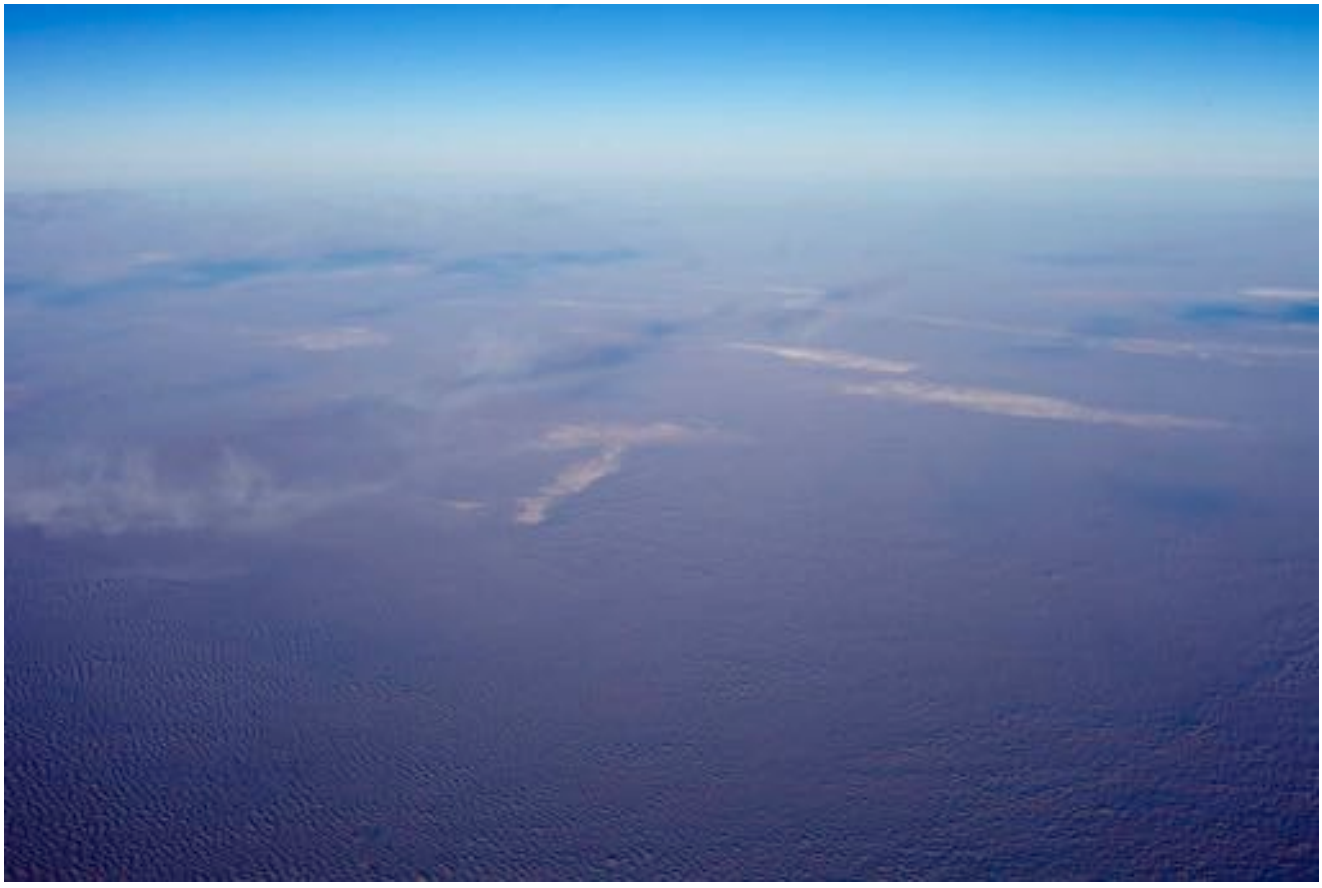

Figure 3: *Sunset over Northern China. Duration: 10 hours 50 minutes*

5. The pictorial as practice based research

As Blevis (2011) so eloquently puts it, as an introduction to the extensive list of uses of digital imagery in design thinking.

> ***"Visual thinking** is the use of imagery and other visual forms to make sense of the world and to create meaningful content. Digital imagery is a special form of visual thinking, one that is particularly salient for HCI and interaction design"*

Alongside the descriptions of digital imagery as a *'form of information'* and a '*shared and externalised memory and cognition'* (Blevis 2012) I would argue that Practice based research, when used as an investigative tool, can assist in revealing and documenting subtle but important non-verbal evidence and also provide compelling and persuasive arguments within presentation of research findings and conclusions. The research approach taken in this area is explicitly practice based, rooted within contemporary lens based digital media and video art. The investigative material presented as the counterpart to this research paper was collated from hundreds of minutes of digital video and several hundreds of digital still images taken while airborne on commercial passenger aircraft during January - December 2013. Taken over the course of 44 flights, totalling over 80 hours airborne the visual material is published as a 42 page visual essay, also containing text elements and descriptions taken from this academic paper.

***Figure 4**: Sunset over London. Duration: 55 minutes*

6. Realisation of effect on the personal

Having recorded the number of flights, durations and distances the calculations based upon the mathematics of special relativity, as discussed earlier show that.

Given 44 flights totalling 85 hours and 20 minutes or approximately 5120 minutes flying time.
gives 307,200 seconds of travel per year.

and if γ = 1.0000000000005 when travelling at or near the speed of sound.

gives a dilation of 0.0000001536 seconds.

To slip one second from base reference, such as the clock sat on my kitchen table I need to travel at my present annual rate for 6,510,416 Years.
Or to put it a different way, travel for a little over 260,000 years to slip one frame out of sync on a standard rate video camera.

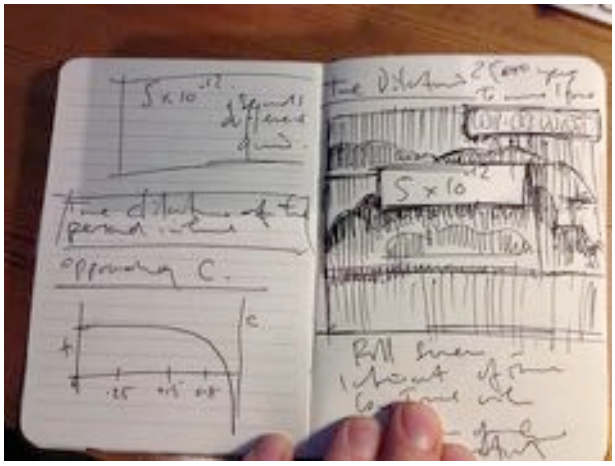

***Figure 4:** An airplane travelling near the speed of sound gives a time dilation where γ = 1.0000000000005*

7. Considering photography in evidence

When collating the increasing amounts of video and photographic material recorded whilst airborne, travelling at or near the speed of sound, the overwhelming sensation of velocity, of speed, of travel is ever-present. Viewed at a macro scale the visual material illustrates this distancing, sliding nature of objects moving in a larger framework. It supports the realisation that the terra firma so often taken as a baseline for observation is in itself only a small part of a larger perspective. The perspective that the proprioceptive nature of our observations of time, informed by the physicality of the form we have evolved and the life span perspective we consider as a norm and useful context are challenged by the linking of these measurable effects. The effects of the micro-scale variations in time seen in contrast to the macro-scale movement around the curve of the earth.

The visual material, when presented as an adjunct to the evidence of the universal but intimately

personal nature of the effects of time dilation help communicate the simple fact that we are all time travelling. Pursuing our own clearly delineated paths and durations relative to each other. Rather than there being one universal time that exists everywhere, for everyone, all at the same moment the personal implication that there is real evidence to prove that this is an illusion is both moving and compelling.

Sitting in an airline seat riding at the edge of space, looking down on the oceans, seas, cities, forests and deserts, seeing terra firma for the illusion that it is. Not a constant underlying grid of space and time - the universal yard stick and the universal clock, such as Newtonian physics promised as it replaced the Aristotelian events-make-time view of the world that had reigned before in popular consciousness.

Figure 5: *Frost over Mongolia. Duration: 10 hours 55 minutes.*

Realising that the H&K caesium clock from 1971 could be sat beside me, ticking away in it's own little timetrack, ticking to a completely separate rhythm than it's counterpart clock sat on my kitchen table at home. Realising that the slipping and sliding of our lives against each other is our own intimate version of time travel, we all move forward as future becomes present becomes past but the durations we experience, and that actually occur, and when ***now*** happens is subtly different for everyone. The time we each experience actually does expand and contract as we move in space.

The illusion of the Newtonian ideal of a universal timescale, the idea of a 'universal now' is disappearing and being replaced by the ideas of general relativity. Of a universe full of individual 'nows' all unique and all moving independently. This change is akin to seeing the universe of unique, individual 'nows' at a human, personal scale and seeing a life travelling, sliding, back and forth in time against the 'nows' of those around one.

The important element this body of work seeks to describe is not physics or even a discussion or physics but an explanation of physics and the revelatory moment of seeing it in 'real' experienced life. This work seeks to relate that revelatory moment and articulate it with the artifacts, the book and the paper, telling the story of seeing how each and everyone of us is travelling in time, independently, uniquely, every day.

> "To see a World in a Grain of Sand
> And a Heaven in a Wild Flower,
> Hold Infinity in the palm of your hand
> And Eternity in an hour."
>
> William Blake

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TIME TRAVEL: Time dilation and a year of airflight

This document has been modified to show multiple pages of the original publication per sheet.

For an airplane travelling near the speed of sound, γ = 1.0000000000005

This work investigates the visible, experiential effects of Time Dilation, as described by Einstein's theory of special relativity.
Arguably the most personal form of Time Travel it is illustrated from a personal, phenomenological perspective, through a body of work.
A written paper and this accompanying book of modified digital images, recalls the Hafele-Keating experiment of October 1971 and tracks 12 months of air travel and illustrates the physics and mathematics behind the theory and actuality of Time Dilation

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TIME TRAVEL

Daniel Buzzo

TIME TRAVEL

TIME DILATION AND A YEAR OF AIRFLIGHT

recent photographic work by Daniel Buzzo

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Daniel Buzzo is an artist, designer, researcher and educator working with new media and creative technologies. He works primarily in the areas of media art, interaction design, and interdisciplinary research in arts and technology.

As an alumnus of the Royal College of Art his work has been shown widely including; BBC Television, ISEA, Artists Television Access, San Francisco. Act Up, New York. LSE, London and appeared in publications as diverse as The Face, The Guardian and Revolver. He writes, lectures and presents internationally on art and creative technologies.

His practice based Doctoral Research investigates the Perceptions and Representations of time in Digital Media.

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Special relativity and time dilation

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"After our 6 months in space, we will have actually aged slightly less than everyone else on the ground because of an effect called time dilation. It isn't by much (about 0.007 seconds), but it is one side benefit of flying in space!"
Though the effects of time dilation at human scale speeds are often imperceptibly small they are nonetheless real. Seeing the implications of this reflected in everyday life reveals the truly personal nature of the time travel that we undertake in everything we do.

The realisation that time dilation is a tangible and observable phenomena that affects ourselves and everything around us was given heightened poignancy by spending large amounts of time flying at altitude and high speed. Observing the curvature of our planet and seeing the dark sky at the edge of space overhead, watching the mountains and deserts as they slid effortlessly under the wings of successive aeroplanes. Being able to observe the size of the individual against the backdrop of a macro-cosmic scale all the while reflecting on the fact that to a subatomic particle travelling near the speed of light, the universe is about four weeks old and it can be crossed in a matter of months.

"Nature can produce even larger particle energies. Some particles striking the Earth's upper atmosphere have energies that exceed 2*1020 eV. If such particles are protons (with mass of about 1 GeV), their speeds would be 0.999 999 999 999 999 999 999 995 c. For them, γ is 1011. Now the age of the universe is about 13 billion years for us, but for such particles, the age of the universe would be about (13 billion years/1011), ie about a month. Such a particle could cross the visible universe in a matter of months (their time)."

This twist of perspective, the deliberate 'making strange' that Shlovsky (1917) describes occurs when translating the abstract of the macrocosmic to the intimacy of the personal. The act of comparing and contrasting macro-scale physics and mathematics with recordings of human scale observations evidence reveals useful and potentially significant insights into the nature of the world we actually inhabit.

The pictorial as practice based research

As Blevis (2011) so eloquently puts it, as an introduction to the extensive list of uses of digital imagery in design thinking.

***"Visual thinking** is the use of imagery and other visual forms to make sense of the world and to create meaningful content. Digital imagery is a special form of visual thinking, one that is particularly salient for HCI and interaction design"*

Alongside the descriptions of digital imagery as a *'form of information'* and a *'shared and externalised memory and cognition'* (Blevis 2012) I would argue that Practice based research, when used as an investigative tool, can assist in revealing and documenting subtle but important non-verbal evidence and also provide compelling and persuasive arguments within presentation of research findings and conclusions. The research approach taken in this area is explicitly practice based, rooted within contemporary lens based digital media and video art. The investigative material presented as the counterpart to this

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In 1971 two American researchers, J.C. Hafele and R. E. Keating, conducted an experiment.

They placed two caesium atomic clocks on passenger airplanes and flew them in opposite directions around the globe to test a hypothesis first posited in Einstein's theory of special relativity.

Their aim was to measure the effects of relativity on these highly accurate devices - the predictions indicated that the eastward flying clock would lose 40ns and the westward gain 275ns. A nanosecond is equal to one billionth of a second (10−9 or 1/1,000,000,000 s). To compare, one nanosecond is to one second as one second is to 31.7 years.

"During October, 1971, four cesium atomic beam clocks were flown on regularly scheduled commercial jet flights around the world twice, once eastward and once westward, to test Einstein's theory of relativity with macroscopic clocks. From the actual flight paths of each trip, the theory predicted that the flying clocks, compared with reference clocks at the U.S. Naval Observatory, should have lost 40+/-23 nanoseconds during the eastward trip and should have gained 275+/-21 nanoseconds during the westward trip ... Relative to the atomic time scale of the U.S. Naval Observatory, the flying clocks lost 59+/-10 nanoseconds during the eastward trip and gained 273+/-7 nanosecond during the westward trip, where the errors are the corresponding standard deviations. These results provide an unambiguous empirical resolution of the famous clock "paradox" with macroscopic clocks."
(Hafele & Keating 1972)

The results showed that compared to stationary clocks in the laboratory the eastward clock lost 59ns and the westward gained 273ns. Whilst there has been discussion of the accuracy and therefore reliability of the measurements the experiment is commonly held up

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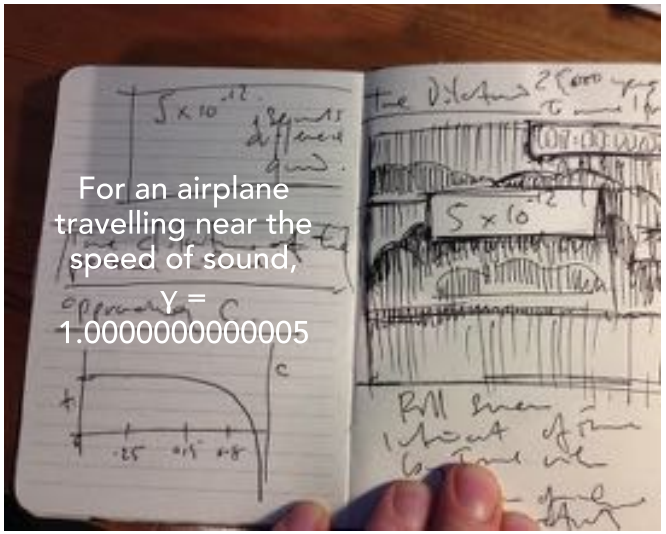
all move forward as future becomes present becomes past but the durations we experience, and that actually occur, and when ***now*** happens is subtly different for everyone. The time we each experience actually does expand and contract as we move in space.

The illusion of the Newtonian ideal of a universal timescale, the idea of a 'universal now' is disappearing and being replaced by the ideas of general relativity. Of a universe full of individual 'nows' all unique and all moving independently. This change is akin to seeing the universe of unique, individual 'nows' at a human, personal scale and seeing a life travelling, sliding, back and forth in time against the 'nows' of those around one.

The important element this body of work seeks to describe is not physics or even a discussion or physics but an explanation of physics and the revelatory moment of seeing it in 'real' experienced life. This work seeks to relate that revelatory moment and articulate it with the artifacts, the book and the paper, telling the story of seeing how each and everyone of us is travelling in time, independently, uniquely, every day.

"To see a World in a Grain of Sand
And a Heaven in a Wild Flower,
Hold Infinity in the palm of your hand
And Eternity in an hour."

William Blake



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research paper was collated from hundreds of minutes of digital video and several hundreds of digital still images taken while airborne on commercial passenger aircraft during January - December 2013. Taken over the course of 44 flights, totalling over 80 hours airborne the visual material is published as a 42 page visual essay, also containing text elements and descriptions taken from this academic paper.

Realisation of effect on the personal

Having recorded the number of flights, durations and distances the calculations based upon the mathematics of special relativity, as discussed earlier show that.

Given 44 flights totalling 85 hours and 20 minutes or approximately 5120 minutes flying time.
gives 307,200 seconds of travel per year.

and if γ = 1.0000000000005 when travelling at or near the speed of sound.

gives a dilation of 0.0000001536 seconds.

To slip one second from base reference, such as the clock sat on my kitchen table I need to travel at my present annual rate for 6,510,416 Years.
Or to put it a different way, travel for a little over 260,000 years to slip one frame out of sync on a standard rate video camera.

"An airplane travelling near the speed of sound gives a time dilation where γ = 1.0000000000005"

Considering photography in evidence

When collating the increasing amounts of video and photographic material recorded whilst airborne, travelling at or near the speed of sound, the overwhelming sensation of velocity, of speed, of travel is ever-present. Viewed at a macro scale the visual material illustrates this distancing, sliding nature of objects moving in a larger framework. It supports the realisation that the terra firma so often taken as a baseline for observation is in itself only a small part of a larger perspective. The perspective that the proprioceptive nature of our observations of time, informed by the physicality of the form we have evolved and the life span perspective we consider as a norm and useful context are challenged by the linking of these measurable effects. The effects of the micro-scale variations in time seen in contrast to the macro-scale movement around the curve of the earth.

The visual material, when presented as an adjunct to the evidence of the universal but intimately personal nature of the effects of time dilation help communicate the simple fact that we are all time travelling. Pursuing our own clearly delineated paths and durations relative to each other. Rather than there being one universal time that exists everywhere, for everyone, all at the same moment the personal implication that there is real evidence to prove that this is an illusion is both moving and compelling.

Sitting in an airline seat riding at the edge of space, looking down on the oceans, seas, cities, forests and deserts, seeing terra firma for the illusion that it is. Not a constant underlying grid of space and time - the universal yard stick and the universal clock, such as Newtonian physics promised as it replaced the Aristotelian events-make-time view of the world that had reigned before in popular consciousness.
Realising that the H&K caesium clock from 1971 could be sat beside me, ticking away in it's own little timetrack, ticking to a completely separate rhythm than it's counterpart clock sat on my kitchen table at home. Realising that the slipping and sliding of our lives against each other is our own intimate version of time travel, we

Northern China: Duration 10 hours 50 minutes

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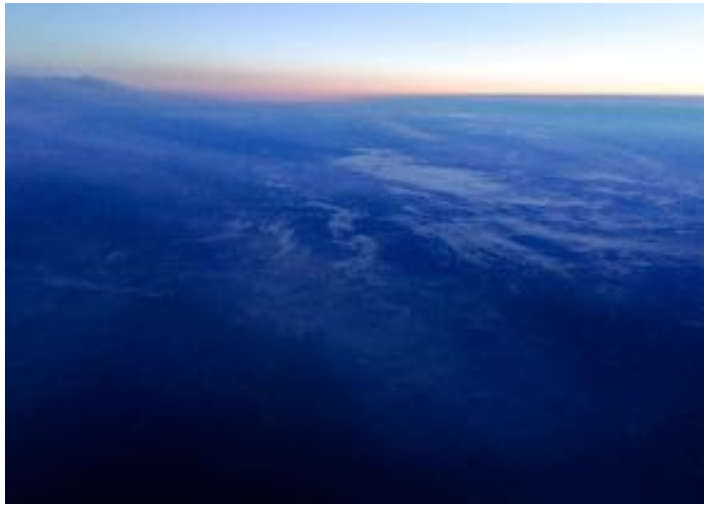

North of London: Duration 1 hour 10 minutes

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Hong Kong: Duration 10 hours 50 minutes

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Near Chengdu: Duration 10 hours 30 minutes

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South Bristol: Duration 1 hour

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Clouds over Oxford: Duration 90 minutes

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Belgium: Duration 55 minutes

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Goteborg: Duration 1 hour 40 minutes

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Outskirts of London: Duration 90 minutes

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South of Leiden: Duration 55 minutes

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Paris: Duration 45 minutes

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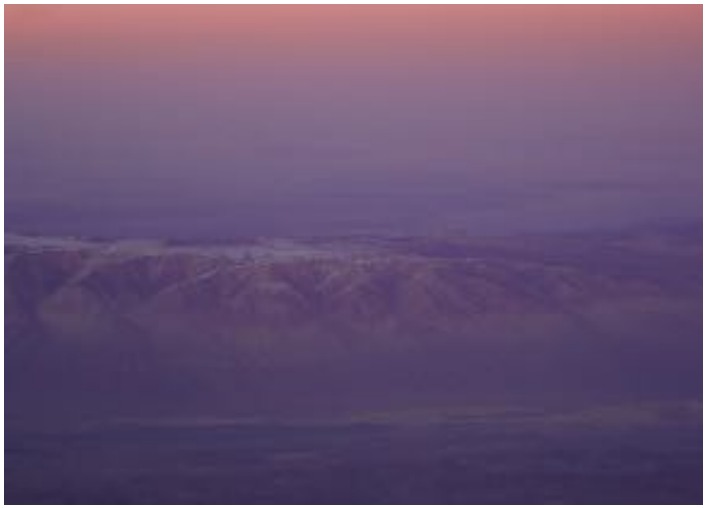

Mongolia: Duration 11 hours 30 minutes

Frost over Mongolia: Duration 11 hours 50 minutes

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Irish Sea: Duration 1 hour

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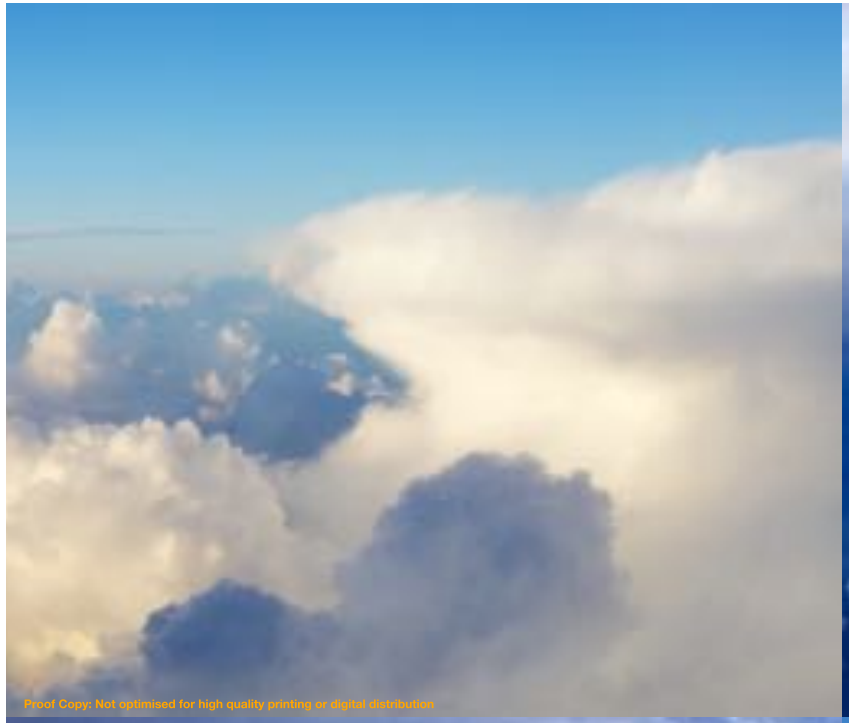
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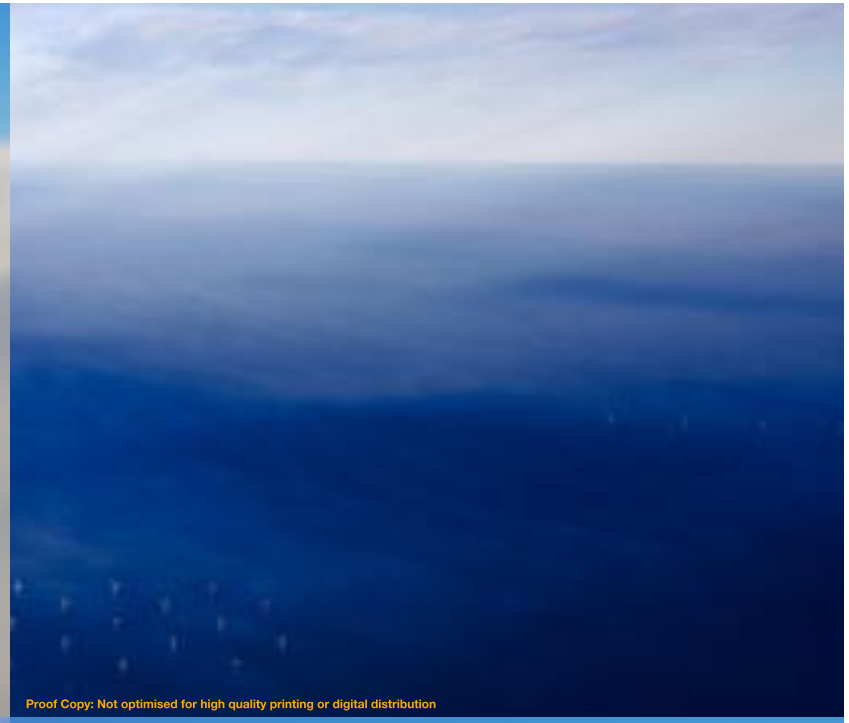
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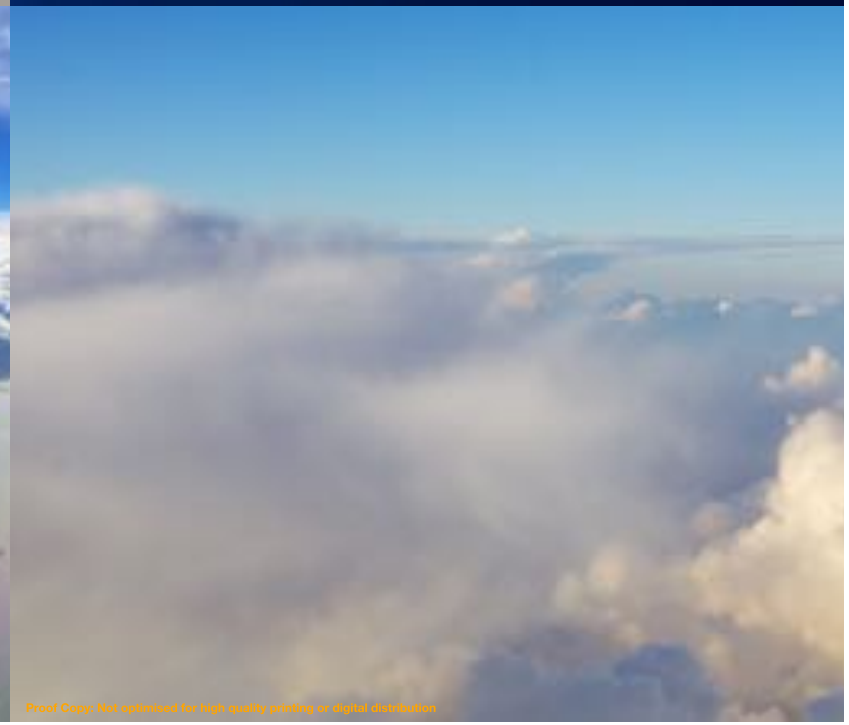
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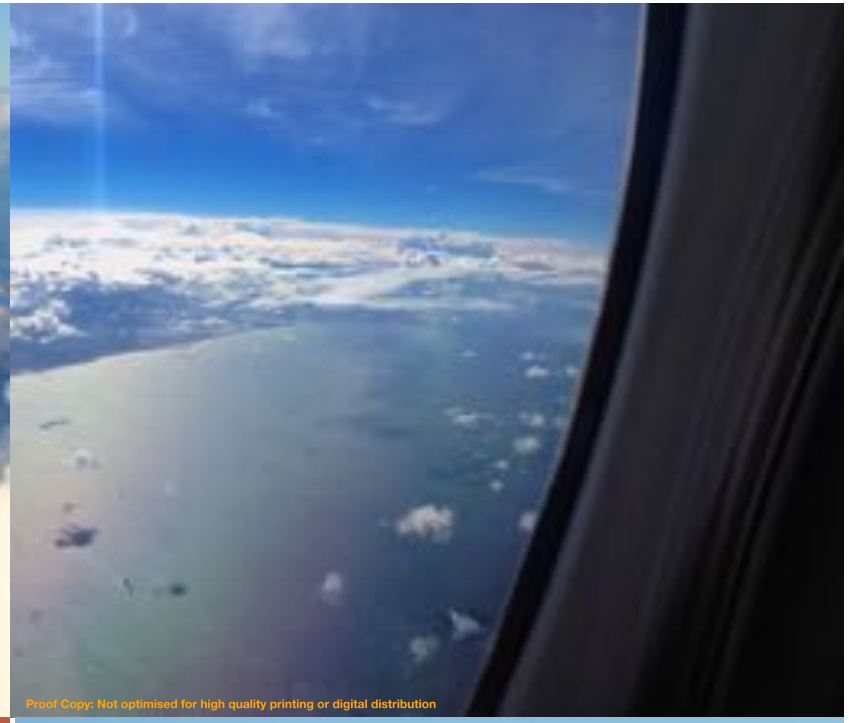
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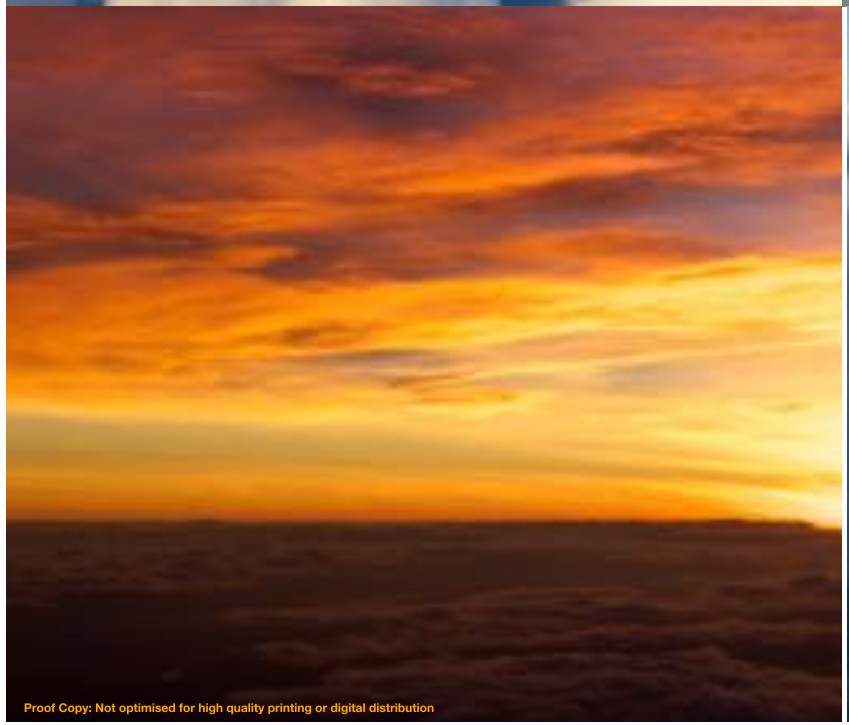
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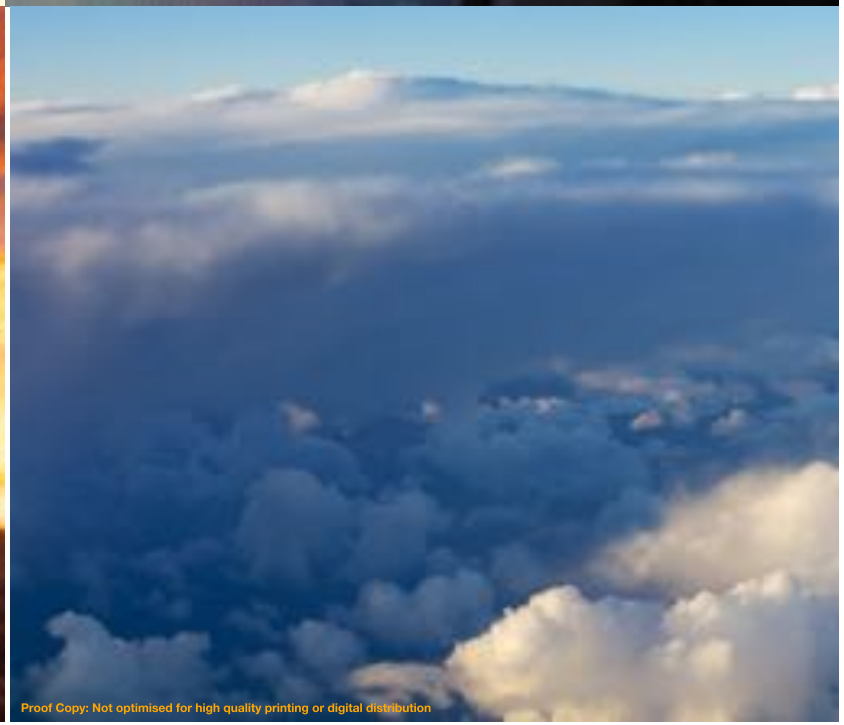
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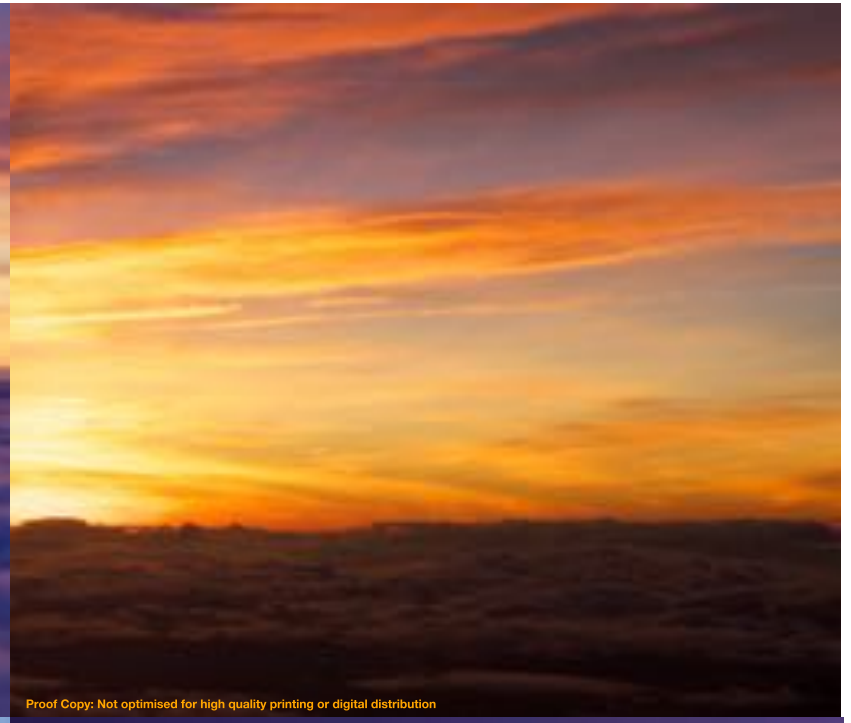
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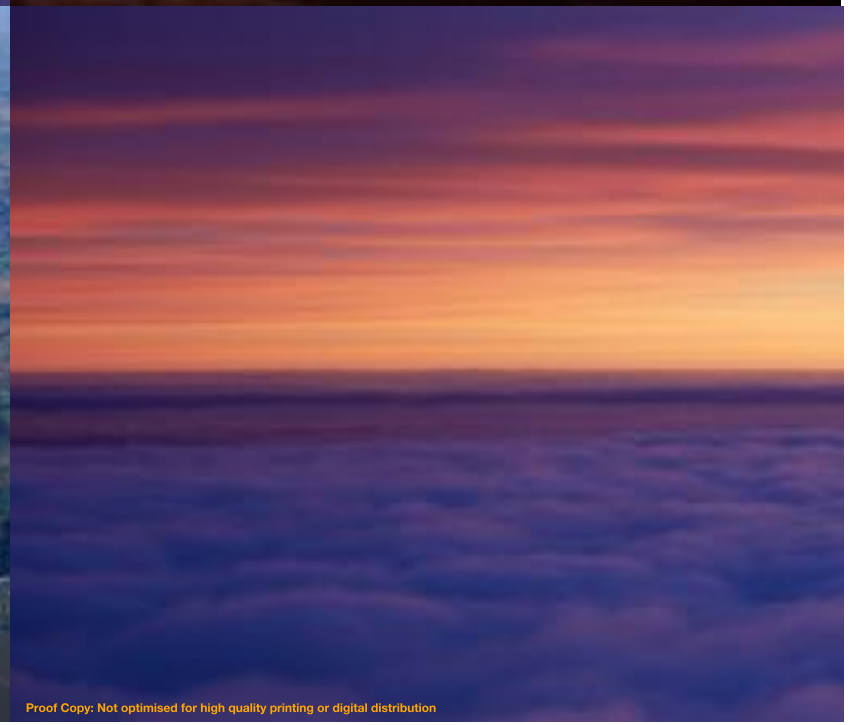
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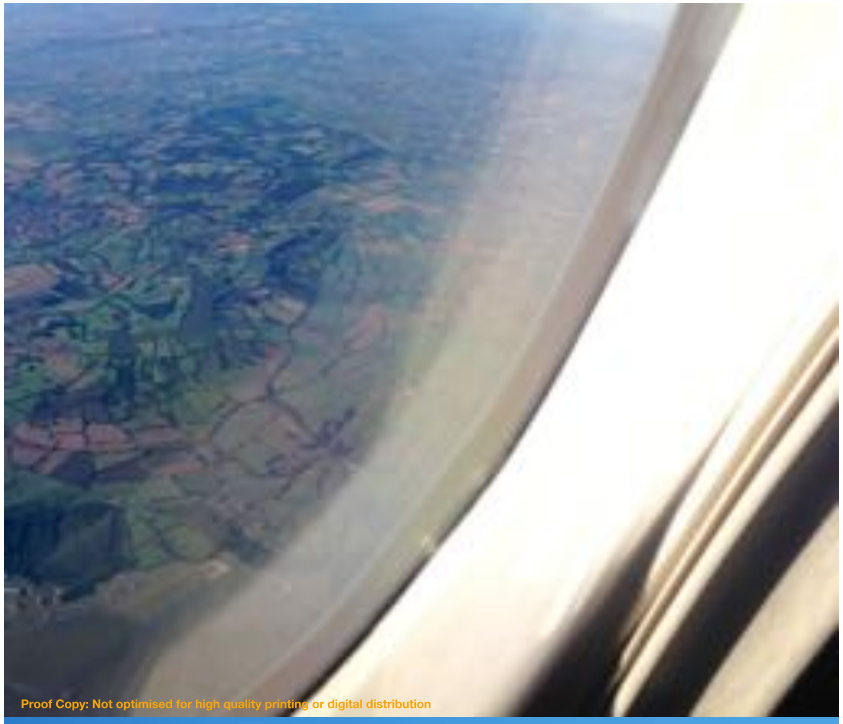

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Copenhagen: Duration 1 hour 20 minutes

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Gobi Desert: Duration 11 hours 30 minutes

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Amsterdam: Duration 55 minutes

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Somerset: Duration 55 minutes

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Street lights of Bristol: Duration 55 minutes

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North Sea: Duration 1 hour 10 minutes

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http://dx.doi.org/10.14236/ewic/eva2015.12

Designing for the Impossible: Creating a mobile application to track time dilation

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In this paper we discuss the development of TimeTravel, a mobile application for tracking personal time dilation. Time dilation is the relativistic warping effect on time that velocity and gravity produces. Predicted by Einstein's Special theory of relativity (1905) and verified by practical experiment, (Hafele and Keating 1972) time dilation affects all things in motion, anywhere in the Universe (Reinhardt 2007). Our project was to develop a simple application aimed at smart watches that could communicate the imperceptible effects of time dilation on a user's everyday activities in an easy to understand, meaningful way. We describe the development and consider what happens when we attempt to visualise the imperceptible

Interaction design. Time. Temporality. Visualisation. User experience. Usability. Making.

1. INTRODUCTION

The interface and UX design processes contained challenges in our quest to communicate this highly abstract concept in an engaging, easy to understand way. We employed an iterative process, considering conceptual, functional and visual design. Alongside this we encountered technical challenges in tracking and calculating timescales in the trillionths of seconds or less (ten to the minus twenty or smaller durations) and of programming for an uncertain execution stack.

***Figure** 1: A caesium beam timepiece used in the US space program occupies a first-class seat aboard a TWA flight from London to Washington on November 23, 1966; this formed part of the famous Hafele-Keating experiment published in 1972 (Photo: Jackson, Getty Images)*

Underpinning the design and technical challenges our developmental progress moved from wireframes and functional demos in high-level web technology based (HTML, CSS and Javascript) application development environments (Calvium's AppFurnace and the IntelXDK) to the decision to migrate to native Android development in AndroidStudio. At the end we consider the development of our project and discuss the ideas of representing information to an individual about themselves that would not ordinarily be detectable. Contrasting with many other visualisations, heat, light, speed, effort etc that an individual can ordinarily perceive we conclude that we are visualising the imperceptible.

We approached the exercise as a design led arts research project. Specifically situated in the arena of media art and critical design, as popularised by Dunne & Raby (2007) and discussed in detail by Shankin (2002). We also borrowed ideas from the exploratory design techniques of Gaver et al (1999) and Research Through Design as a means to gain insights on the core objective of the project.

Although the project is focussed on generating usable, commercially available software for mass consumption this is not it's primary goal. Working in a making/arts/exploratory technology context we seek to ask the question as to how we live, temporally, and what the nature of the modes of personal data visualisation may be. This project seeks not to create a scientific tool or a teaching

aid to explain a theory from the world of physics but to propose a question about how we perceive the world. Asking what may happen when we visualise seemingly impossible or contradictory things.

The research project is a continuation of previous research efforts (Buzzo 2014) combining practice led media art and theoretical research (Buzzo 2013) in the field of perception and representation of time. Our design is at pre-release stage and as an on-going project will iterate further in the run-up to wide-scale release and, we hope, in subsequent revisions. We wish to share our work so far to engage in a dialog to improve our next stage user testing processes.

Our project has developed a simple mobile application in an attempt to communicate an abstract concept to users of the application. This research through design approach is used to investigate and demystify an esoteric concept from theoretical physics with the aim of lay communication through practical example. At the same time as designing we were also investigating in an ethnographic way what awareness of time dilation may feel like.

Previous work in the field of physics such as Hsuing et al (1990) has investigated visualisation of time dilation, in a general sense, but this has primarily been for an expert audience rather than aimed at personal visualisation. There are several functional applications that operate as 'calculators', allowing users to enter velocity, duration etc and have dilation figures calculated for them. None of these actually make any attempt to link this to personal lived experience, nor make calculations based on live sensed data. It is this point of the live and personal nature of the application and visualisations and calculation that is central to the project.

This project builds on previous work investigating the personal micro-scale effects of relativity whilst attempting to communicate a macro-scale context.

Previous work visually documented extended periods of air flight and investigated the subsequent effects of time dilation at a personal level. In this project we change the focus to everyday effects and are deliberately targeting a wider user group with an interactive project.

2. PROJECT OUTLINE/ AIMS

Time dilation is described in Einstein's Theory of Relativity and is the difference between the elapsed time measured by two observers moving relative to each other. The fundamental aspect of the recording and visualisation of time dilation is the effect in relation to other things. How one's movement in space and time changes relative to a common base or a fixed point, considered an observer; or in our case, other individuals, friends moving separately in time and space at differing speeds.

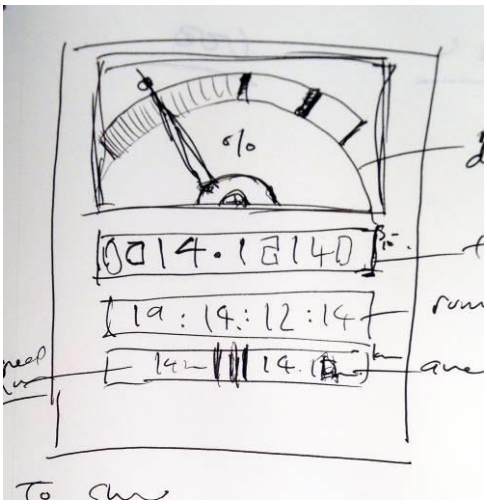

***Figure 2**: Original sketch ideas for physical equipment styled visualization showing instantaneous time dilation effect, elapsed time, and accumulated dilation*

In many of the popular science explanations of time dilation the example of two twins is often used; one departing on a rocket ship and the other remaining on earth. After a few years of space-flight the cosmonaut twin returns to earth to be reunited with his or her now elderly sibling. The velocity of the travelling twin has dilated time, as a function of travelling through space.

This illustration is on one hand easy to grasp but on the other still is rooted in a very abstract set of circumstances. Unless you have a twin sibling, and one or other of you possesses a functional interstellar vessel capable of achieving velocities close to the speed of light it is still in the realm of fantasy.

The first practical experiment demonstrating evidence of time dilation was the Hafele-Keating experiment of 1972. Simply put this involved flying highly accurate caesium atomic clocks around the globe and comparing the time they recorded with a previously synchronised stationary clock. (see figure. 1) The experiment showed the moving clocks experienced different amounts of time compared with the stationary one. The resulting time differences were in line with Einstein's predictions of the effects of time dilation. Subsequent experiments have illustrated the phenomenon in numerous different ways.

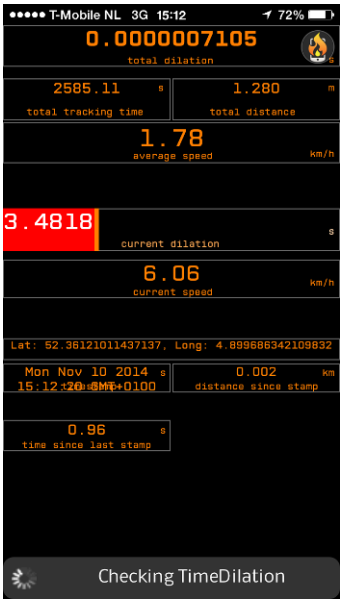

***Figure 3**: prototype iterations in Calvium's Appfurnace IDE showing extensive debugging data. Latitude, Longitude, velocity, time since last geo-location event, instantaneous dilation, etc.*

Time dilation is affected by both gravitational and velocity effects. For our approximation we make the decision to discard the gravitational effects of altitude and concentrate on dealing with the effects of velocity. Although we could anticipate some users engaging in air-travel when using the application without leaving the planet for orbit and beyond the effect of varying velocities is by far the larger.

Previous research projects on the time dilation aspects of airplane flight, 'Time travel: Time dilation' [2] sought a better way to communicate the individual nature of time travel. We hoped to continue the investigation of a lay understanding and conceptualisation of the personal applicability of time dilation. The quest to generate a key personal understanding of the actuality of the effects of time dilation on every individual led us to a design for mobile platforms.

Mobile computing devices, mobile, phone, tablet and particularly the new generation of 'smart watches' were considered the ideal platform on which to create a simple intervention to convey the core idea. The common incorporation of GPS for geo-locative purposes into these devices was central to the potential success of the design. Ironically the calculations involved in the working of the GPS, Global Positioning System, incorporate calculations for time dilation due to velocity and gravitational effects, in part informed by the experimental work of Hafele and Keating.

3. PROJECT DEVELOPMENT

Our core design proposition was straightforward, to track the velocity and timing of an individual via geo-location techniques on a mobile platform. Then use the geo-data to calculate time and velocity and display any subsequent dilation effects relative to a (theoretical) fixed basepoint.

The possibility of encouraging users to compare their own dilation with others was seen as an important additional feature. We hoped this would be a step toward reinforcing the realisation of the actuality and intrinsically personal nature of time dilation that the project sought. Sharing details of the amounts of accumulated time dilation by users and articulation and comparison of the reality of time dilation and comparison is key to this concept.

Our research and development process went through several simple steps;

- initial conception, discussion, translating the physics into math and then code;
- concept and interface iterations;
- prototype iterations across platforms;
- analysing and solving timing and performance issues;
- discussion of design for AndroidWear;
- discussion of success criteria and specification;
- collaborative iterative working.

4. INTERACTION DESIGN

Starting from basic functional investigations, discussion (see Figure 2) and visualisations the project generated key requirements. Through iterations of the requirements and visualisations a first version minimum viable product (MVP) was arrived at, comprising;

- Geo-Locative Tracking;
- Calculation of instantaneous dilation effect;
- Readout of total dilation (since reset; similar in design to an automobile trip meter);
- Readout of average speed (as above).

Secondary functionality that was felt to be desirable included

- Tools to share total and/or weekly dilation in with other users;
- A high score style table to create the ability to compare totals with friends.

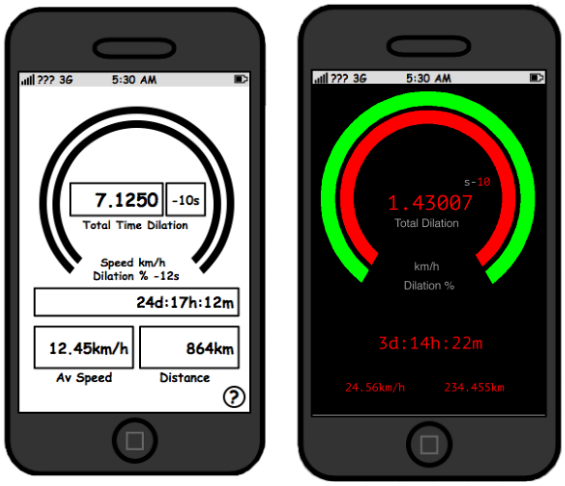

***Figure 4**: Iterated sketch designs for interface showing speed and instantaneous dilation readouts and curved/circular displays.*

***Figure 5**: Early high-resolution wireframe interface example including elapsed tracking time and elapsed dilation factor – compared to theoretical fixed basepoint*

4.1 Software and Platform Development

The software platforms considered were Android and iOS, Android being chosen as the initial development platform for reasons of programming, testing and deployment convenience. The Android OS running on a watch styled device was targeted as an ideal candidate hardware platform. This was felt to be effective both from a form and interaction factor but also given the intimate link to ideas of time that a watch styled device evokes. From a mathematical and software point of view the base calculation for time dilation is relatively straightforward.

The effect of time dilation is non-linear in nature. At low speeds the effect is extremely small. However, as the velocity, v, approaches the speed of light c, (3×10^8m/s), the dilation effect increases dramatically from $t^1/t = 1(v = 0)$ toward $t^1/t =$ infinity at v = c, where in theory, time ceases to have relevance.

Figure 6 Illustrates the calculation for time passed at origin, considered to be a static observer, compared with the time that passes for the object in motion.

$$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$$

Figure 6: Calculation of time dilation compared to a fixed observer

Due to generally low speeds we were anticipating to measure extremely small intervals of time would need to be considered from the outset. The accuracy of the target equipment and the measuring process we decided to employ necessitated a very high degree of approximation within the measurements and subsequent calculations. As a result it must be emphasised that the visualisations we are seeking to create for users are indicative but highly generalized. We are only attempting to account for the effects of velocity on time dilation and not that of gravity.

As expected, early iterations of the code to calculate dilation were found to be returning extremely small quantities. The relative dilation we were observing being in the region of 10^{-15} to 10^{-20} and so small that there were initially problems returning results that were not truncated as zero by the precision depth of the languages used. The range of dilation related to motion, from static to walking speed to modern air transportation gives an issue with our chosen style of linear readout. By manipulating the readout results by varying logarithmic scaling factors we were able to consistently generate usable results from our original core time dilation calculation functions.

We analysed the efficiency of timing functions in the target software platform. Unfortunately it quickly became apparent that the variability of processing time and system lags could introduce significant errors in the calculations and processing stack. Given that we are investigating extremely small durations requiring high levels of accuracy this was revealed to be a significant problem.

After much consideration it was decided to opt for an alternative strategy that would regularly sample the velocity of the host mobile device and from this data build a 'best guess' approximation of the actual time dilation. As GPS usage increases power consumption on mobile devices the velocity sample rate can be increased and decreased from seconds to minutes to increase accuracy or preserve battery life. Incidentally it is worth noting that the geolocation API system samples data at rate determined by the host device, in our case a relatively slow rate (>0.5s per sample). Additionally GPS has a generally acknowledged accuracy of between 7.8m (with a confidence of 95%) up to 3.5m for high quality GPS SPS receivers (http://www.gps.gov). These two factors combined mean that small body movements, such as the swinging of a users arm, have no influence on the accuracy of our measurements.

Whilst the approach of back calculation based upon velocity is significantly less accurate and less desirable than a mathematically more accurate approach it was felt to be an acceptable compromise to achieve the end goal. That of

making a first-order intuitive system, that uses an approximate idealization, Since we are using GPS speed measurement, our reference frame is the 0 m/s gps reading, meaning a stationary point relative to the latitude and longitude coordinates on earth's surface; a system that reinforces awareness of the personal nature of dilation rather than being an accurate scientific tool.

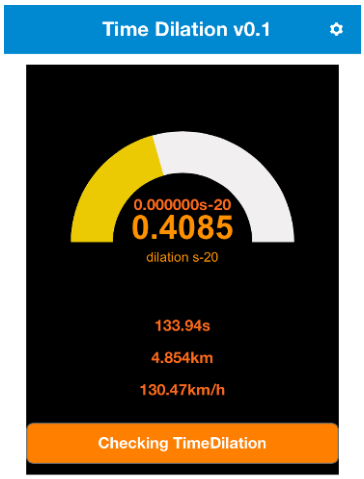

***Figure 7**: Screenshot from prototype developed in intelXDK IDE showing use of dial graphing libraries and immediate dilation feedback*

4.2 Design Iterations

The visual interface went through several iterations and the core functions were refined at each iteration. The prototyping progressed across three different frameworks, Starting with web-based technologies in the Appfurnace rapid prototyping tool from Calvium (see Figure 3) then progressing to the IntelXDK development environment (see Figure. 7).

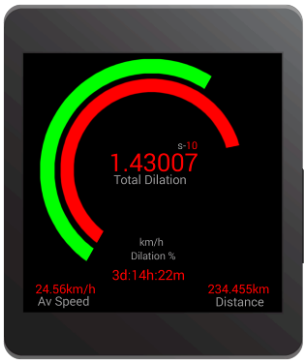

***Figure 8**: Early prototype design for AndroidWear form showing current dilation and velocity as arc readouts, accumulated dilation, average speed and distance travelled (since last reset)*

The particular advantages of beginning work in the Calvium environment is the speed with which simple interfaces can be assembled with the capability to easily incorporate custom code routines, In this instance in JavaScript. The speed with which a simple prototype of the sketched code routines and simple interface can be generated is mirrored by the speed of deployment of prototypes to Android and iOS mobile devices. Using cloud based repositories for the prototype designs allows 'through the air' deployment into test player applications on various mobile devices.

Following initial designs of interfaces we sketched out descriptions of code routines that would be needed to calculate the core functions. From this base a working prototype was produced extremely quickly. Iterations to the interface and code calculations were similarly deployed over the air making testing and development an efficient process. Initial testing was based on self observation of traveling with devices, iOS and Android, running early versions of software. Improvements to code routines and information presentation came from early ethnographic testing. Modifications to interface elements and interaction behaviour came from informal testing and interviews with a variety of technology literate early users.

After some iterations a custom JS (JavaScript) library of core time dilation calculation functions was created. This allowed a test-bed using a variety of calculations from percentages of light speed to observer's time to be performed.

***Figure 9**: Prototype revisions for Android watch interface illustrating current velocity and dilation factor compared with theoretical fixed observer*

Subsequent to successful testing and verifiable results the project moved to the AndroidStudio IDE and was re-coded in Java. AndroidStudio, whilst having a larger development overhead allowed development of applications with access to more native platform resources, principally the ability to continue to execute on the target device when the application was running in the background. Both AppFurnace and IntelXDK have clear routes to commercially deployable applications but their current lack of AndroidWear players and the advantages of native coding were the main factors in the decision to move to AndroidStudio.

Having proved the code functions, architecture and interface in the initial prototypes re-coding in Java in the AndroidStudio IDE was a relatively straightforward process. Initial testing was on Android smart phones using a variety of travel methods, walking, cycling, tram, car and train. This gave a variety of real world velocities to test calculations against.

***Figure 10**: Prototype testing on Android based phone showing actual dilation calculated whilst travelling at speed on an intercity train*

After obtaining a number of AndroidWear smart watches, Sony SmartWatch 3 model SWR50 (See Figure 11) we were able to do initial deployment into the smart watch format. Certain elements of the application packaging at compilation time are different within the AndroidStudio IDE. These are mostly associated with the deployment context, usually via a tethered Android phone where our application would be unpacked and the AndroidWear context subsequently loaded to the smart watch via Near Field Communication (NFC) tethering or Bluetooth.

4.3 Deployment and Testing

Initial deployment of early prototypes was immediately helpful in providing feedback and field testing to the iterative design process. Early iterations of the design displayed greater amounts of information relating to the geo-locative tracking process, displaying latitude, longitude, elapsed time between geo-tracking updates etc. (see Figure 3) It quickly became apparent that much of this information, whilst interesting from a development and debugging perspective, was irrelevant and unnecessary to convert the key message of the project.

4.4 An Awareness of the Personal Nature of the Relativity of Time

The design and presentation of information on screen was reconsidered in constant review with a series of early user consultations. Initial feedback indicated the designs presented a scientific instrument, (see Figure. 4) that once explained to users had initial novel interest but lacked the personal connection the project aimed to evoke. Subsequent designs adopted metaphors from real-time physical displays in the style of a classic VU meter combined with an approximation of an automotive speedometer (see Figure 5).

***Figure 11**: Sony SmartWatch 3 model SWR50 chosen for testing contains in-built GPS capability which allows our application to work without the necessity of a tethered Android phone*

The adoption of a moving indicator giving real-time visual feedback rather than just textual feedback of the instantaneous subjective time dilation yielded particularly positive feedback. It appears that users were able to connect the imperceptible changes in their subjective experience of time directly to their speed of motion, walking or travelling by train etc. After moving from prototypes deployed in small numbers to the target development platform, AndroidOS, A wider circle of testers were used in advance of deployment to the Android application store for release version 1.0 (see Figure 8)

Further refinements adopted new Android UI guidelines more closely, making a more seamless integration into the overall wearables context. Anticipating the personal and physical nature of what we wanted to convey we also incorporated visual references from the styling of quantified self and health and fitness tracking software. (see Figure 9)

5. FEEDBACK FROM USERS

Early feedback from alpha test users is positive, with subjects reporting emotional responses to the information communicated from the application. Several users indicated a 'sense of wonder' with a small number conveying a 'sense of disorientation' when considering the challenge that the concept of personal time dilation brings. This response was considered a particular success.

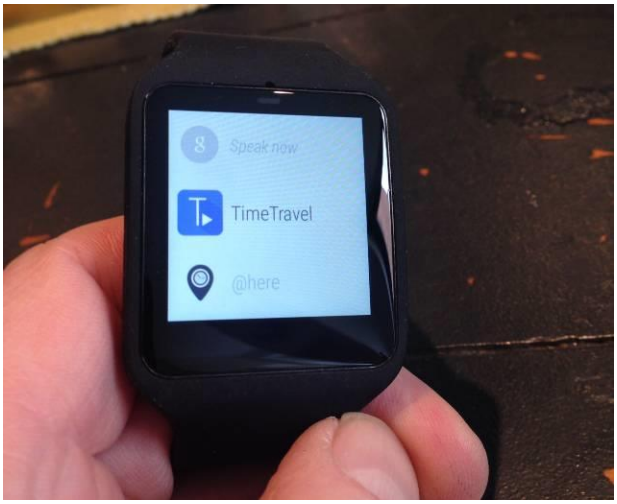

***Figure 12**: Prototype testing of our application on Sony SW3 SWR50 AndroidWear smart watch*

6. FURTHER DISCUSSION

So far the project is at the end of the first stage and though we have viable working prototypes it is anticipated that there will be several more cycles of work. We are attempting to visualise something usually considered abstract and intangible. Our next goal is to engage a wider discussion and greater user numbers to allow statistically significant research to be undertaken on how the application affects the perceptions of users.

Our next stage is to conduct an adoptive user study (n =< 10) with a small number of users with Android smart watches devices. In the adoptive strategy we ask users to engage with the application for an extended period of time. We are primarily interested in studying what if any changes occur when we present seemingly impossible concepts such as the speed of light and the warping of time in visual form to users. Following this adoptive process we will engage in user interviews and evaluate the findings with a view to both further design iterations and reporting of research findings.

At this point in our research we wish to engage in a wider discussion as to the best process to evaluate the next stage of our project. We are working in the arena of making the invisible immediate. The arena where we are augmenting our senses through technology – such as experiments in making wi-fi signals perceivable (Arnall & Knutsen 2011) or detecting magnetism (Nagel et al. 2005) – changes the context of how we live and how we may comprehend our world.

We see our project as a bridge between the lived and theoretical worlds and present it as a practical investigation into what happens when we make the imperceptible perceivable.

7. ACKNOWLEDGEMENTS

We wish to thank Dr Graham Meaden at the University of Bristol School of Physics for assistance with mathematical interpretation and Emily Buzzo for graphic design guidance.

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Not all Days are Equal: Investigating the Meaning in the Digital Calendar

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CHI'15, April 18–23, 2015, Seoul, Republic of Korea.
Copyright © 2015 ACM 978-1-4503-3146-3/15/04:.$15.00.
dx.doi.org/10.1145/2702613.2732512

Abstract
The electronic calendar is a common tool used by large numbers of people to reflect and shape their daily activities. It's function and structure is rooted in legacy representations dating back thousands of years. Collaborating with designers and engineers our project seeks to re-consider what the calendar does for us and how we may perceive and represent our time, personally and collectively.

This paper investigates the background to *'the calendar problem'* and documents design-led research. Seeking to identify some of the key problems with the current representation and to establish criteria for new interpretations of the meaning of calendar.

Author Keywords
HCI, design, time, user interface,Experience; places; time; calendars; temporality; events; design; user experience; usability; making.

ACM Classification Keywords
H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

Figure 1: Typical digital calendar interface: Apple iOS

Introduction

The proprioceptive nature of the calendar and the cycle of the seasons and years is fundamental to our view of the world. Intertwined with this cyclic view is the lived, phenomenological experience of time, as described by Bergson et al. Underinned by the socio-economic value propositions of time as discussed by Marx, Smith and Booth. The traditional grid calendar can be seen to enforce industrial and commercial assumptions on both the representation of time and our perception of time (see figure 1). These assumptions, or affirmations, make the ongoing usage of the traditional metaphor inherently calendar-orientated rather than user-orientated.

The introduction of the vCal and the iCalendar format [15] and the interoperability and portability of data these standards enable has increased the reliability, uptake and usage of electronic calendars. Despite the increasing sophistication of the users and usage of digital calendars the layout, functionality and usability appears little changed from traditional paper and print calendars of 18th and 19th C. The near seamless interoperability of the underlying data between standards and platforms, such as calDAV [14] and iCalendar [15] appears to contrast with designs where some extreme skeuomorphic examples even mimic the stitched, leather bound volumes and wrapped page edges of their historical forebears. [24] Our aim is that our design led research and the design ideas generated contribute to the growing discussion on the representation of time in HCI and interaction design.

Process and Method

We set out to investigate the assumptions and conventions the calendar metaphor brings to our perceptions and representations of time. Through research and user interviews we generated criteria to guide a making process. Through the subsequent process we aimed to find some provocative alternative visualisations that would help reconsider the subtle personal, shared, economic and perceptual cues that are embodied in a calendars structure.

We employed a 'diffractional' reading and research approach, as popularised by Barad and van der Tuin [26] as a way of coping with epistemological problems of representation. We found this approach particularly useful in our specific case where we explicitly avoid attempting to solve all aspects of what could be considered a *wicked problem*. Attributed to Rittel and Webber, *'wicked problem'* [22] was a description of seemingly intractable problems within their field of social planning. Much has been written of how wicked problems may also occur within design [17] and the field of Human Computer Interaction. [27] In this instance we find a challenge containing the multi-layered problems of language, politics, perception, representation and cultural-historical aspects with no specific straight line to a single 'efficient' solution. [18]

We used a combination of user interviews, design workshops, physical making and fast prototyping in the project to investigate traditional calendar designs. Analysing their meaning and use and and imagining critical design provocations. We present a variety of ways in which our perceptions and representations of time, in a calendar context, may be re-imagined and consider new ways of thinking about planning and recording personal activities.

Calendar structure and time perception :

Time Series Data

In daily use the visual calendar metaphor and its implicit structuring of time appears to create a number of interesting collisions between different types of lived time. The calendar simultaneously represents the personal and the public, work and home, value and scarcity and mechanical and experiential time. The digital calendar in its common form creates a mechanical grid of equidistant hours, days, weeks, months and years, divided into convenient slots or spaces into which to insert pre-booked activity. On initial evaluation this appears at odds with the lived time it represents.

Calendar representation of time is rigid in its measure and in its quantity. A user can view a block of 24 hours, starting at 00:00 and ending at 23:59. He or she can view 7 days, starting on Monday or (optionally) on Sunday. A user can view a grid of 5 rows of seven days, commonly starting only with the first week of the month or they can see a sometimes overwhelming array of 12 blocks of 5 rows of seven days. Beyond these standard options this is commonly the limit on the flexibility of digital calendar visualisations.

When compared to other time series data visualisation tools and methods, such as the wide rage of approaches described by Aigner [3], the standard viewing arrangements for calendar based time-series data appear inflexible. As a metaphor for representation of the personal in a work or shared timespace environment it appears particularly rigid or gives less contextual information when compared to other data visualisation scenarios.

Spatial bias in time perception

The common calendar structure shows days of the week laid left to right with time processing from left to right in all areas. In the week view and month view this left to right metaphor is generally reinforced. From a linguistic perspective this could be considered particularly euro-centric. As the work of Chen and Boroditsky [8] [12] has uncovered, native language structuring influences most notably the comprehension but also the mental spatial structuring of time. Bonato et al 2012 working in a similar field investigating the influence of subconscious spatialisation and visualisation of time found evidence to support this idea. Saying that; "Humans represent the subjective time flow on a spatially oriented mental time line that is accessed through spatial attention mechanisms" [6]

The economics of time

Many kinds of time are represented in calendar usage. Literature reveals time as an area of potential mystery and disagreement in almost every avenue of research. Leaving the A series vs B series argument of McTaggart (1908)[21] to one side and working from the 'B' perceptual basis of time as an actuality, reveals numerous other interpretations of *'time'* to consider. Though not exhaustive by any means the ideas influencing our investigation ranged from the concepts of life as duration from the phenomenology of Bergson to the attention based expansion and contractions of time from neurophysiological time-perception studies and the socio-economics of time. The economics of time is large area of study with several prominent works discussing time. Such as Smith's view of the Labour Theory of Value (LTV) and Marx's "Time of production" "Time of circulation: and "Organic time" [25] In his 2013 book Tombazos analyses the three volumes of Marx's *'Capital'*

and goes so far as to pose the idea of *economic capital* as a specific form of organising *social time*.

As Booth says in his extensive analysis of the political economies of time. "Time is thus analyzed as one of the goods over which a person disposes" underlying the repeating theme of the *value* of time. He goes further and adds that "The freedom of time is accordingly understood as its non-coercive transfer from one person to another"[7]

Time, as the old adage goes, *is money*. The calendar in this situation can be seen as both purchase order and invoice for the transactional economics underlying that well known statement.

Classifying time use
When classifying time-types the work in the area of time-use studies is particularly relevant. The time use classification series first proposed by Dagfin Aas in 1982 [2] and subsequently used by the New Zealand Statistical survey [19] is useful in our case and defines used time in the following ways;

- Contracted time
- Committed time,
- Necessary time
- Free time

As is becoming clear, calendar recorded time events may have multiple meanings and reference multiple *'time types'*. It must be noted that all these uses of time are recorded in almost identical ways. Leaving the nuance of or the explicit usage of time indicated to be inferred from the surrounding contextual data, if it is available.

Body time
The calendar, at its core, is a micro-scale map of the rhythms of the solar system we see from where we stand on planet Earth. The oldest roots of the calendar and the notion of recording past and future events are based upon, and measured against, our experiential observations of our world around us. Ancient earthworks works such as StoneHenge in Salisbury Plain, UK through to systems such as the Mayan Haab dating from 5th Century pre-Columbian Mesoamerica (Bricker 1982)[9] all reflect our solar precession.

The experimental psychological work of Berkovich-Ohana, Goldstein et al (2013) [5] investigating altered states of consciousness indicates clearly the correlations between a phenomenological sense of time and body in a variety of test subjects. "Hence, we hypothesized that an altered sense of time and space would be related to an altered sense of body ... A possible candidate mediating this connection is the insula, related to both proprioception and the sense of time" [5] In this context the notion of calendar carries within it the pattern of forces that have shaped our bodies and our sense of time and of self.

This proprioceptive experience of time, situated in the circadian and in evolutions response to our particular developmental location, 150 million km from the nearest star, roots us directly in the phenomenology of time. An area that Husserl described as the most important and difficult of all phenomenological problems [20]. Whilst the calendar is immutably based upon our immediately local physical conditions, 24 hour diurnal cycle, 365 diurnal cycles to an orbit of our home planet the visual calendar appears so abstract as to reflect little of this.

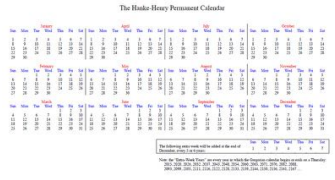

Figure 2: Hanke Henry Permanent Calendar

Calendar structure
Historically there have been many attempts to reform the traditional Gregorian Calendar. This calendar model structures time series data into 12 months, with mixes of 28-31 days each, encompassing 52 weeks of 7 days each. This model necessitates the inclusion of an occasional leap year as a corrective measure to bring the year length back into line compared with the solar mean.

The International Fixed Calendar or Cotsworth plan is a solar calendar designed in 1902.[13] It records a year of 13 months each containing 28 days, with one or two days a year belonging to no week or month. It is a perennial calendar, where every date is always fixed on the same weekday. Whilst it was never officially adopted in any country it was the official calendar of the Eastman Kodak Company from 1928 to 1989. [23] The Hanke-Henry Permanent Calendar was a proposal that aimed to reform the current Gregorian Calendar by making every year identical (see figure 2). In it every date always falls on the same day of the week.

Additionally there have been approaches to normalize the shifting cyclic nature of date and days in the Gregorian calendar by normalization and standardisation. Other approaches such as internet time and the briefly popular SwatchBeat universal time, [1] launched in 1998 seek to define a universal clock time for calendar. This approach of a universal time use also alleviates, to some extent, the problems encountered when one moves the calendar model into a world context with time-zones.

Alternative calendar structures
The calendar metaphor deals primarily with duration. Every event has a length and every experience recorded in the calendars description of the past or the future also had a person, a place and a temporality to it. This parallel is at the heart of the modern nature of Calendar, that it records the personal, that it implicitly relates to the experience of time whilst translating that into its own abstracted model of mechanical time divisions. From a philosophical perspective all is calendar, from the seasons to the diurnal, all is a representation of the experience of duration. Onto this lived record of possible past and possible future an abstract grid is applied.

In some sense the calendar could be considered a representation of B Series time, where every moment 'is', existing continually and always happening. With our relationship to it - removed as we are from the structure of the calendar and divorced by its mechanistic impossibility - forced into a position of an A series view, of future, present and past. Trapped outside an impossible abstraction watching events pass us by. Our experience is forward only and conflicts with the calendar, as it changes reality, as recorded events change from unreal future to real present to unreal past, just as Augustine of Hippo wrestled with.

A making experiment: It did not have to be like this:

Issues we identified with current calendar implementations are considered in both practical terms of current ideas in the visualisation of time series data [3] but also in terms of the implicit meaning of the structures underpinning data and types of representation. The research through design approach utilised in the project is rooted in the same arena of critical design popularised by Dunne and Raby [16] and evaluated as an effective design approach by many commentators and discussed at length by Bardzell and Bardzell (2013) [4] and others. Following our research into the key problems identified with the usability and data representation in common calendar interfaces we

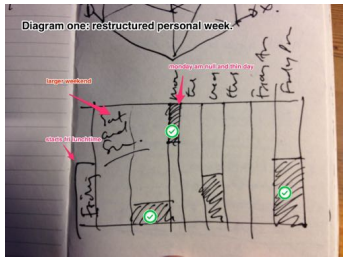

Figure 3: Initial sketches showing personal perspective on time allocation on a day basis
©Daniel Buzzo

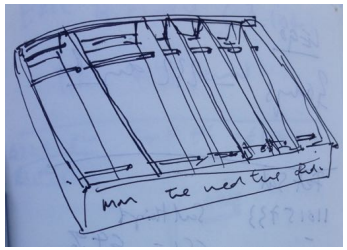

Figure 4: Sketch expansions of variable time allocation mechanism
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approached a free making phase, generating guidelines for design collaborators and co-investigators.

Making Brief to collaborators:
At its core a calendar is Time-Series Data. Inside it the perception of time and the metaphors used to represent it impose or reinforce societal and cultural norms. Affirming what is and is not time and how our ideas of time are structured. The Calendar metaphor contains a number of elements that could be considered problematic or limiting. Especially in how it's structure represents time and subsequently forces us to consider time.

The Calendar model of time is infinite and lived time is not. As noted in our previous work [11] [10] this arguably becomes a case of A series representation vs B series experience. Each moment recorded in a calendar always is - with no past, present or future. Our view onto the calendar translates these tense-less moments from a perspective of directional movement through B series existence. Against this background how can we design mechanisms that enforce or illustrate the experience of B Series time and represent scarcity in calendars and interact and represent more fully the lived experience of time?

We distilled commonly discussed problems that we encountered. We found that the Calendar often does not;

- Show resource (time) limits on allocation
- Present a human/proprioceptive cycle of time
- Present season or climate restrictions
- Differentiate work vs personal division of time
- Indicate financial or resource value of time
- Indicate geospatial issues in event allocation
- Allow alternative working structures and patterns, providing alternatives to what Dunne and Raby refer to as an 'affirmative' design.[16]

From this analysis a set of priorities or key specification criteria were created and collaborators were requested to choose one of the criteria/ requirements and to develop a new or novel calendar intervention. The design or intervention they were asked to come up with needed only to address a single criteria and could be in any media or any form.

Design a calendar to;

- See any time period/range in any combination
- See any duration/event by any search criteria
- See priorities and tasks
- Prevent inappropriate or over booking of time
- Indicate geospatial issues between duration events
- Reflect proprioceptic (human physical) experience
- Differentiate between industrial and personal time availability
- Differentiate between monetary and personal value

The shorter specification/provocations were prepared and shared among a range of collaborators that included artists, interaction designers, product designers, software engineers and visual designers. Many of the design exercises started in workshop style discussion and quickly progressed to iterations of drawing and physical making.

Investigations: The design projects

A range of design interventions were developed during the second phase of this project. Each dealing with different aspects of the problem and requirement list and seeking a critical insight into the wicked problem presented by the calendar.

Figure 5: Physical making to illustrate variable time allocation on day basis

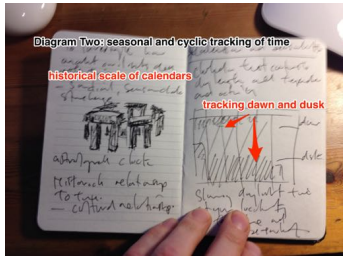

Figure 6: Sketch examples tracking dusk and dawn, proprioceptive data ©Daniel Buzzo

Investigation One: Drawing out the shape of a week
Gives examples of proposed and lived alternative shapes to the calendar against the narrative description of a week.

A simple workshop exercise began the first of the design interventions. Beginning with the development of a narrative of an individual lived week. We then considered how the values and balances expressed between differing types of time implied in the narrative could be displayed within an existing calendar paradigm. (see figure 3)

We investigated the value structure of the personal week, with discussion of the relative merit, accessibility and utility of different days. In a western European context personal time, i.e. commonly Saturday and Sunday, were considered of more intrinsic personal value than that of weekdays (Monday-Friday).

In initial design sketches Friday afternoon was reclassified to be part of the weekend and Monday morning removed from the calendar altogether. The justification being that from a work and productivity perspective Monday morning was always allocated to other tasks and as such was not a time that additional events could or should be scheduled into. The remainder of Monday was considered to be the smallest part of the week perceptually. Represented by being the thinnest in area compared with other days and forming an area less than a quarter of Saturday and Sunday - these days now combined and re-designated 'the weekend', with Friday morning close behind. (see figure 4)

Reflecting on this simple visualisation of the experience nature of time led to a series of physical making exercises as exploratory steps toward practical interactive solutions. (see figure 5)

Further investigation and iterative design work on this individual project considered the historical nature of calendars in a macro context with the cyclic nature of the seasons and dawn and dusk. These natural environmental factors being acknowledged to be of significant influence on the structure of personal experiential and commercial time. Consideration was given to indication of daylight, based upon location as was the problem of the cyclic changes created by the passing of seasons and their influence on perceptions and usage of time. (see figure 6)

Annual cyclic events entered into the calendar were proposed to have the ability to warp and change the structure of days or weeks. Such as recurring personal or family birthdays influencing time before and after the identified event. Changes in the availability and kind of activity that are suitable for different seasons. E.g. refraining from starting new projects in December or before summer vacations in July. Researching purchases in March before the (UK based) financially year end in April etc.

Investigations were made into giving events both a distorting weighting that would warp the fabric of the calendar but also a taste' or flavour' that would influence the activities that were suitable for different calendar seasons. When approaching travel and collaborative working, with events involving other people, the issue of locality and timezone became highly visible.

Investigation two: The calendar as 3D topography
We considered the additional dimensions of information implicit in the kind of calendar designs we were proposing. The requirement to add additional dimensionality in our time series data prompted investigations of three dimensional representations of basic combined calendar data.

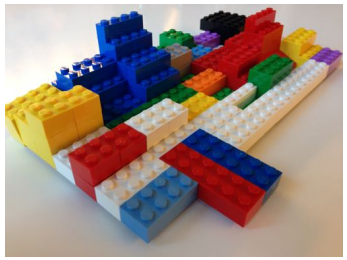

Figure 7: Physical making investigations of 3D time series data

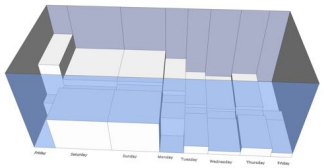

Figure 8: 3D calendar data visualisation

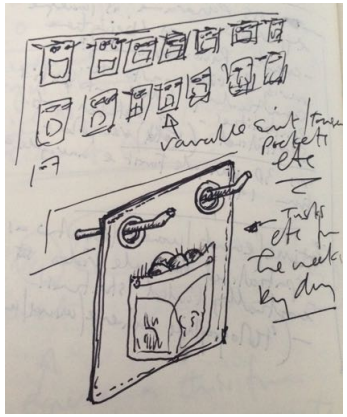

Figure 9: Pocket calendar early sketches ©Daniel Buzzo

Allowing additional value to be placed upon slots, days and time through a calendar cycle, be it day, week, month or year allowed representation of complex relationships between differing types and needs of time.

In this instance it was a specific investigation of activity. With work and task allocation 'effort' tracked in a z axis, with x and y representing a grid of days and hours. This gave an immediately comprehensible view of the activity, 'busyness' or work throughout a time span. Early designs focused on the standard week by week work allocation. (see figure 7)

The X (height) value afforded to individual blocks of time or days indicated additional dynamic value on a day by day basis. Friday afternoon evening being the literal and metaphorical high point of the week with Wednesday being the opposing low point.

Physical prototypes moved into 3d visualisations and then interactive prototypes in the Unity3D environment. Data from the iCalendar format was parsed via JavaScript to JSON format and incorporated into the Unity3d development environment.(see figure 8)Placement of events in the week occurs via a variety of mechanisms. Experimental methods of generating events, particularly meetings, are arranged by representing the meeting as a sphere of various types and materials (dependent upon the value, type and importance of the meeting). These are dropped or fired onto the terrain of the week with simulated gravity and elastic collision. The *'meeting sphere'* then finds its own suitable location driven by simulated physics forces in the calendar model (gravity, elastic collision and friction).

In initial testing it was discovered that in the majority of cases meetings rolled downhill to Wednesday lunchtime.

Intervention three: The trouser pocket calendar
The trouser pocket calendar is a physical proposal that tracks activity type and available resource matched to task;

Rear pockets from trousers of different types are hung onto a 7 day calendar grid. Differing designs and materials of the garment segments indicating the 'kind' of day to be anticipated. Formal, athletic, summer, winter etc. Tokens representing tasks and task amounts are placed into the pockets of each day/garment. (see figure 9) There are a fixed number of tokens available each week, corresponding to the anticipated time/emotional resource available.

This tracks and reflects the type of activities one may be undertaking and allows an estimate of how much work can be done in a week. The simple metaphor illustrates the formal/informal activity orientated rhythm of the week and imposes finite resource limits on a rolling weekly basis.

Calendar as indicator of cost
When viewing a calendar as a tabulation of work and cost, when engaging in the exchange of time as value *not all days are equal*. Requesting my expertise to design or problem solve on a Tuesday afternoon is an easier exchange for me than the same task requested on a Sunday evening. The standard calendar, however makes no distinction and give no indication to the potential client that I value my days as anything other than equal. Hence they appear surprised at my reluctance to discuss the problems with their website on a Sunday afternoon while having dinner with my family. Living like that:the view of a colleague's calendar thing all scrunched up letting you know it is not a good time to call,

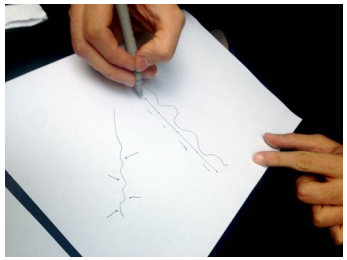

Figure 10: Early sketches of an intertwined calendar.

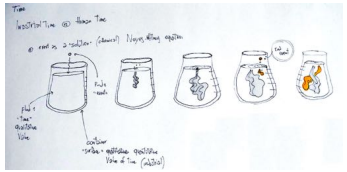

Figure 11: Industrial vs human time. An illustration of contained intertwined event visualisation. ©Nicolo Merendino

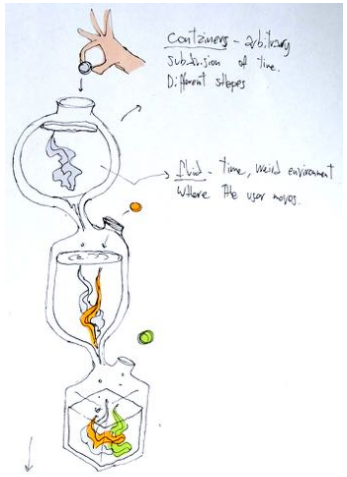

Figure 12: Week by Week intertwined events ©Nicolo Merendino

The intertwined timelines
Working with industrial designer Nicolo Merendino from STEIM, a series of visualisations based on ideas of intertwined interpersonal events were created.

Stemming from descriptions of the relationship with the designer's family members, the metaphor of intertwined timelines was extended into practical treatments for an intertwined calendar. Through iterative ideation an investigation into possible treatments for synchronising and relating differing tasks was drawn up. (see figure **??**) The calendar was visualised as a series of pools, tubes, jars and receptacles into which 'events' could be inserted.(see figure 11) These events were suspended and enabled to grown through fluids of different viscosity. The fluid in the vessels representing available time. Events encountered temporal requirements of other participants and intertwined, creating areas of separation and of confluence as arranged by the participants. (see figure 12)

Further development

Our project has combined wide ranging enquiry and crafting design together to consider how we represent and are influenced by representations of time. We discovered how the representation and measurement of time changes our perception and subsequent experience of calendar based time. We have used the personal as an entry point into playing with the experience of time recording and organisation in the digital realm.

Many things we live with every day are lingering paradigms that have ceased to make sense. The issues of moving beyond historical metaphors are seen in many contexts; the qwerty keyboard, the equirectangular map. These representations are often the hangovers of a mechanical age and older societal metaphors and concepts. As has been seen in the slow change in digital scheduling representations, we carry the old into the new, often with out question.

The making criteria developed in the research phase of the project can be seen as solid grounds for future investigation into the area of representations of time. Not only limited to specific calendar contexts but more widely applicable in any lived scenario. We argue that as users become more data literate possibilities for new directions are available.

We believe that not all days are equal and propose that the evenly spaced digital calendar is ready for change.

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What Do We Know Of Time When All We Can Know For Real Is Now?

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1. INTRODUCTION

This How long is a moment ? How does a moment feel ? What is the past, what is the future ?

The Moments project investigates the perceptual length of 'a moment' of attention and of the historical tension between the argument for and against time in the universe.

2. THE PROJECT

With scientific estimates of what a perceptual 'moment' of- ten hovering between three and four seconds but opinions across the worlds of art, perception, philosophy and cognition often disagree widely. (Bitbol 1994) The project investigated just how long a 'moment' might be and then asks the question;

'what is it to see the now, remember the past and anticipate the future, though we can conceive of the things are they truly real, do we truly experience them ?'

The 'moments' project recorded instances of noticing, moments of attention, and records them. Collating video since early 2014 the project has so far recorded close to a thousand separate video clips. Contrasting this huge library of intimate moments of 'attention and 'presence' is a series of extended walking self-portrait video 'derives' inspired by Guy Debord, the French situationist and would-be father of psychogeography.

This project builds on previous temporal visualisation projects (Buzzo 2014) (Buzzo & Jonas 2105) using interactive wearable technology and transmedia publishing. In the moments project extended walks through the streets of Hong Kong and Kowloon were filmed over a two week period in 2015. In the video material the viewer see a central character, the walker, moving through the neon metropolis city-scape and crowded back alleys in continuous framed shots.

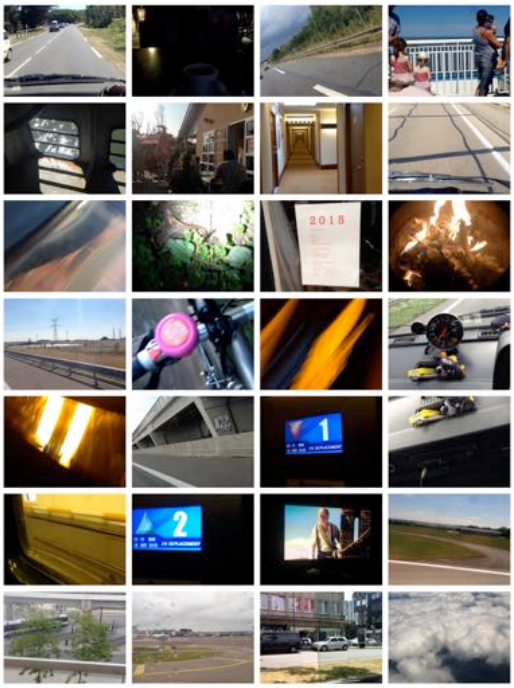

***Figure** 1: moments*

These extended pieces of linear video have been treated, graded and finally their core data re-processed to allow each individual frame to be re-played in real-time in any order, at any speed, in any direction. Presenting the viewer with the direct visual equivalent of the universe as a zero energy quantum block state. Where each of us passes through our individual time-lines, experiencing them in random, disconnected order. Unaware that in the next instant we may be 5 years old again or that in our previous moment we were reflecting on our lives from old age. The work investigates the challenge, laid down by McTaggart (1908), over a century ago, of how we decide if we live in a tensed or tense-less universe.

Figure 2: *Derive through Hong Kong*

Using real-time evolutionary algorithms to select, edit, compile and present each discrete 'moment' this dynamic dual- screen installation situates the viewer in the centre of the emotional, philosophical and phenomenological debate on the existence and substance of time and lived experience. (Lorenz & Bevernage 2013)

On one screen discrete moments of sense and attention, on the other a continuous central figure surrounded at every moment by a maelstrom of temporal shift in one of the complex cities in the world. Creating a temporal deep map in the style of William Least Heat-Moon's Psychogeographic Cartographies (Gregory-Guider 2004) of both a place and a time. At the same time weaving the challenge of input-output time. Where author, actors, reader and audience's timelines circle each other. (Paik 1976) (Buzzo 2013 a, b)

Time, connected and fractured confronts the viewer with the challenge of participation, a challenge of narratives of perception encased in visible temporal flux.

3. TECHNICAL DETAILS:

- Motion video captured via various Digital stills, video and DSL camera sources
- Individual clips graded and edited in Final Cut Pro
- Algorithmic real-time image assembly routines written in Processing environment (Java)

Playback/installation hardware.

- 2 x Mac OSX Mini or latop computers,
- 2 X HDMI or similar display screen (size variable)
- 2 x suitable stands or hanging for screens at eye height to viewers
- Audio reinforcement (suitable for low volume, ambient, audio track, such as powered extension speakers)

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Perfect days. A benevolent calendar to take back your time

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Abstract "Time poverty" touches upon a tension between the ever increasing time demands of work and the time needed for people to engage in further, intrinsically meaningful, wellbeing-enhancing activities. At the heart of this drama is the digital calendar. While often only seen as a useful and quite innocent tool, its functionality and representation subtly enforces certain ways of dealing with time. To counter this, we developed the concept of a benevolent calendar: *Perfect Days* explicitly cares about the wellbeing-oriented activities of its user. In a study with five quite busy individuals over three weeks, we found that the majority experienced *Perfect Days* as positive and acknowledged its goal to change time use for the better. After a phase of irritation, participants felt more aware of their personal time use, adopted new wellbeing-enhancing activities, and in part even already internalized these activities.

Keywords *Wellbeing, Experience design, Time use, Digital calendar, Productivity tools*

Time use, wellbeing, and the digital calendar

Subjective wellbeing is the consequence of having enjoyable and meaningful experiences in everyday life. Such experiences result from engaging in activities (Lyubomirsky, Sheldon, & Schkade, 2005), which fulfill psychological needs (Ryan & Deci, 2000). For this, sufficient time is of essence. Unfortunately, many people suffer from what can be best described as "time poverty". Feelings that "one's life has been too rushed" or that "there have not been enough minutes in the day" are common and related to reduced wellbeing (Kasser & Sheldon, 2008). Kroll and Pokutta (2013) used data about how much people enjoy particular day-to-day activities to create a "perfect day", that is, a scheduling which would maximize wellbeing. It assumes 16 hours (=960 minutes) available per day and recommends to spend, for example, 106 minutes with intimate relations, 82 minutes with socializing, 78 minutes with relaxing, 75 minutes with eating, 73 minutes with praying/meditating and 68 minutes with exercising, but only 36 minutes with working. Wryly, the authors note that "somebody who only works for 36 min each day is of course most likely to have problems making ends meet. […] Hence, the optimal day schedule may be more realistically applied to a Sunday rather than a Monday" (Kroll & Pokutta, 2013, p. 215). This blatantly points at peoples' constant need to negotiate between time for work and all the other activities they require to be happy (i.e., maintaining work-life balance). This is not easy, since "busyness" seems to have become a deeply internalized moral value (at least in the USA). At the same time people experience conflicts, anxiety and guilt concerning the way they use their time mostly in favor of work (Leshed & Sengers, 2011).

Our tools of time, clocks and calendars, play an important role in this daily drama, because they heavily influence the way we perceive, use and experience time (e.g., Lindley, 2015; Leshed & Sengers, 2011, p. 912). Take the lack of representation of free, personal time in work calendars. Currently, in a work calendar, free time is just "unused", undedicated time. The implication is clear. If a calendar is full, one is a busy, hard-working person; if the calendar is empty, one is not. An empty calendar is a luxury; a full calendar a necessity. The digital calendar not only mirrors societal or economic trends. It also enforces them by shaping our perception and use of time.

Obviously, calendars can take many different forms (Buzzo & Merendino, 2015), each ripe with its own meanings. In the present paper, we empirically explore the idea of a benevolent calendar, designed to support people in taking back (at least some) of their time to increase wellbeing. We place this in the context of designing for wellbeing (e.g., Desmet & Pohlmeyer, 2013; Hassenzahl et al., 2013).

Specifically, we first "constructed" a perfect *work* day by prompting people to explicitly allocate time to meaningful personal and social activities on a work day, such as "putting the children to bed", "playing music", "exercising", or "meditating". Of course, the resulting perfect day was idealized. However, it remained dominated by work, while at the same time people seemed to more consciously consider how much time to spend with work and what to do best in their free time. We then transformed the individual perfect days into a set of daily calendar entries. These were added automatically to the already used calendars. The design rationale was simple: The calendar extension aimed at taking over work time and replacing it with well-being time by using the codes and habits borrowed from work. Undedicated time is now not just free to be filled with more work, but already occupied with personally relevant activities. By confronting its user with their own idealized

behaviour, the calendar was supposed to create friction and to prompt the conscious renegotiation of time and activities (Hassenzahl & Laschke, 2015; Laschke, Diefenbach, & Hassenzahl, 2015). To make the superimposed activities more distinguishable, we gave them unusual labels. They consisted of a verb (i.e., an activity) followed by direct speech related to personal goals (e.g. *sleep – "now off to bed!"* for a person, who has problems in calling it a day and getting enough sleep). We tried to let these activities appear more like time-based suggestions than fixed calendar entries, to signal sympathy for the difficulty of implementing the activities in everyday life. In the following, we report detailed quantitative and qualitative findings from a three week field exploration of Perfect Days with five people.

Perfect Days in the wild

Participants, procedure, and analysis

A convenience sample of five individuals participated in the study (3 female, ages: 27, 35, 40, 41, 45 years). They were recruited by members of the research team. The crucial requirement for being included as a participant was a busy work schedule and the routine use of a digital calendar in everyday (work) life.

Table 1 shows brief characterization of the participants. All were quite busy, with most of them (except P4) feeling not entirely happy with their current use of time. Their relationship with the calendar was mostly bittersweet: It appears to be a necessary, but sometimes harsh master.

The study started with an approximately thirty-minute interview conducted via phone or *Skype* by the third author. Some introductory remarks and a general conversation about individual time use and the role of the digital calendar served as ice-breaker and provided some background information about the participants (Table 1). The interviewer then asked the participant to reconstruct a *typical* work day by creating prototypical calendar events (e.g., meetings, work, lunch) and placing them on a typical 24-hour grid (Kahneman, Krueger, Schkade, Schwarz, & Stone, 2004). After this, the participants were asked to imagine a *perfect* working day and were prompted to include activities, which would improve their wellbeing, but do not seem to fit into their day. The interviewer proposed thinking about activities from the categories sleep, meals, personal hygiene, social contacts, physical activities, contemplation and maintenance/housekeeping. The resulting personal blueprint of a perfect day was again drawn up on a 24-hour grid.

We then created a *Perfect Day* .ics-file for each participant, which contained *only* the selected personal activities, e.g., "12:00 lunch" (meal) or "20:00 going for a drink with my husband" (social contacts). The .ics was emailed to the participants together with instructions of how to import the file into their main calendar. After the import, the personal perfect day activities became regular entries for the next three weeks.

Participants were instructed to use their calendar as usual. We explicitly told them to adapt perfect day activities to the particular requirements of the day at hand, i.e., to delete the activities, if they did not find the time or to move activities, if done earlier or later etc. We asked them to make sure that for each day the calendar most closely matched what they actually did.

Table 1. Brief characterizations of the participants.

Participant	Time use and calendars
P1, female, 41 married, two children, employed manager	P1 works from home. She feels challenged by balancing time for her work, her family, and herself. For her, time has a negative connation since the lack of it seems so apparent. On weekdays, nearly 100% of her time has to be planned in a relatively fixed manner. In general, she experiences the calendar as a supportive tool. Now and then, she gets annoyed, since it tends to be too full
P2, female, 35 single, self-employed	P2 works from home. The digital calendar is her most important tool, because structuring time and ensuring productivity is very important to her. She is an "expert" in using her digital calendar with all its available features. For example, she uses the calendar to keep up with social and cultural activities through different calendar subscriptions. Her relationship to the calendar is in general positive. However, now and then she can't keep it updated. The calendar ends up being not representative of how busy she really is and this tempts her to take on even more work and appointments
P3, male, 40 married, two children, university researcher	P3 works in an office. He suffers from lack of time and inflexibility. The day is heavily structured by routines, e.g., taking care of the children. Personal time is mostly in the evening, but he feels too exhausted to do something meaningful then. He describes his relationship to the calendar as a forced marriage. While it plays an important role in planning time at work, the calendar is perceived as dominant. It puts P3 under pressure and "pushes him around". Because of this he is reluctant to use his calendar for private activities
P4, female, 27 single, doctoral candidate, self-employed	P4 works in an office and from home. Her relationship to time is quite relaxed. It all seems a matter of how to prioritize to make everything fit in. She feels a responsibility to organize her time into clear rhythms and enjoys this. She also looks for "cracks" within these structures to indulge in free time. She has a very positive relationship to her calendar. It contains both business and private activities
P5, male, 47 married, three children, employed manager	P5 works in an office. Time management and the calendar plays an important role in work, but in his private life, P5 doesn't make use of the calendar. He enjoys his works, but admits that his family does not get as much time as he wishes for. Over the years, however, he has improved the balance between his work and private life, e.g., through prioritizing. His relationship to the calendar is neither clearly negative nor positive. The calendar creates pressure, but at the same time P5 is very proficient in making the calendar work in his favour. He, for example, creates "appointments" to block time, he needs to work on a task, important to him

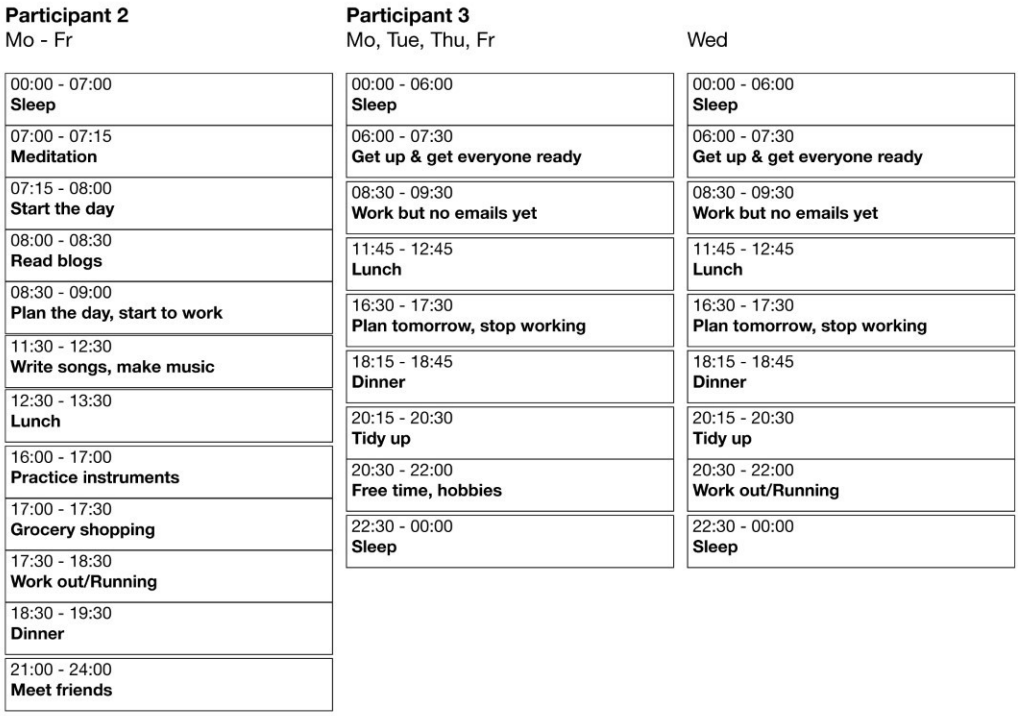

Figure 1. Example of perfect day activities and their scheduling.

At the end of the three week period, we asked participants to export the *Perfect Day* calendar and send it back. This enabled us to analyse the difference between the originally envisioned perfect day and real days. A second interview was conducted via phone or *Skype* and took place on the last day of the study phase (plus four days). The second interview was an open conversation (run by the third author) about the three-week period. The participants were prompted to talk about topics, such as how they used the Perfect Day calendar, how well it worked, if the calendar changed some of their routines, if they would like to keep on using this calendar or aspects of it.

The first interview served as introduction for the participants and was used to compile brief characterizations of the participants (Table 1). The .ics-files were analyzed quantitatively (Section "Findings: Activities "). The second interview was transcribed and submitted to a thematic analysis (Braun & Clarke, 2006). Emerging themes were discussed among authors and further refined (Section "Findings: Eight emerging themes").

Activities

Each participant defined at least one perfect day, some even more (up to three different versions for different days of the week). Of course, days differed in the number of daily activities defined. Figure 1 shows three example days from P2 and P3.

On average, the number of activities planned for a single day was 8.4, with substantial variation among participants (6.6 to 12) (Table 2). Of 8.4 activities, participants realized 5.2 per day on average (62%). Since available time on a day is finite, the more events participants planned for the more difficult it should be to realize the ideal. However, this was not apparent: P5 (6.6 events per day) had about the same realization rate as P2 (12.0 events per day).

We correlated the relative number of realized activities for each day (real/ideal) with the order of day per person to estimate change over time (Table 2, column "change"). The results were mixed. While for P1 and P4 the percentage of realized activities did not change at all over time, P2 revealed a slightly negative, but insignificant trend to realize less activities over time. P3 and P5 revealed a positive trend, with P5 reaching statistical significance. In fact, P5 realized only 55% of activities in the first week, 58% in the second week, but 76% in the final week.

Eight emerging themes

Theme 1: Overall impression is positive

Overall, our *Perfect Day* calendar extension (PD) was received positively (all P's except P4). A prominent explanation for the positive impression was that PD

Table 2. Number of ideal and realized activities for each participant, relative frequency, and change over time.

P	Ideal per day (sum)	Realized per day (sum)	Relative	Change[a]
1	7.0 (105)	3.5 (52)	50%	-.06
2	12.0 (180)	7.7 (115)	64%	-.36
3	8.0 (120)	6.6 (96)	83%	.28
4	8.6 (129)	4.3 (65)	50%	.03
5	6.6 (99)	4.1 (62)	63%	.53*
Mean	8.4	5.2	62%	

*Notes: a) Spearman's Rho; *) p<.05*

helped with gaining control over personal time. P2 explained: *"[…] the best […] was to experience that it is really not so hard to integrate all the work-unrelated activities, all the activities I really want to do, into everyday life."* P5 said: *"A valuable support, although I did not slavishly obey."*

An important precondition of control is insight. P3, for example, reflected that PD made him *"aware of things, about the 'hooks and eyes' of daily scheduling."* It prompted the conscious negotiation of his own needs with those of others: *"[…] there is a need to coordinate with my wife, who does the baby-sitting […], who already has an appointment? [PD helps] to make a conscious effort to integrate it [perfect day activities]"* (P3). P1 perceived the PD as especially caring. She said: *"I had this feeling, there is somebody worrying about me [laughs]. The calendar is worrying about me and this felt good […] A little like saying 'Be careful to do all the things, you wanted to do'."* And further: *"If it is in the calendar, I don't have to choose anymore. This is good."* Of course, P1 did not slavishly obey the calendar, too, but rather creatively responded to its prompts. However, for her PD became something active, a "thing with attitude", while the majority of participants still emphasized its tool-like qualities.

P4 was outright negative about PD. She was annoyed, showing "reactance". While she couldn't quite explain this, the negative response seems to emerge from the same qualities as the positive experiences described by the others. Reactance (Brehm, 1966) is a response to perceived external restrictions of autonomy. What P1 framed positively as "caring" is experienced by P4 as an unwarranted intervention. A reason for this may be that she perceived herself as already quite thoughtful and successful in managing her time.

Theme 2: Carefully blurring the line between work time and private activities
Some participants felt reluctant to schedule their private time in a similar way to work time (see also Table 1). P4 said that through PD free time *"lost its playful lightness"* (P4). In the same vein, P3 said, while acknowledging the positive powers of PD, that it seems *"stupid to 'clock' off-hours, but there seems no way around it"* (P3).

Conceptually, PD tries to take over work time and to replace it with wellbeing time by using the codes and habits borrowed from work. This blurs the line between both. In a way, it spoils peoples' ideal of free time as something being spontaneously filled with relaxing and stimulating activities. At the same time, P3 acknowledges that this ideal may be hard to attain in everyday life, since free time is likely to be "sucked-up" by contracted time. This is a tension deliberately designed into PD.

To make this more bearable, we employed a particular way of presenting activities to distinguish them from the work related entries: short funny, slightly ironic labels, which could be understood as comments made by the calendar itself. All participants experienced this as positive. P1 pointed out that *"it made very clear that this [a PD activity] is not a work appointment"* (P1). To her, it was important that the communication was *"friendly and not lecturing"* (P1). She said: *"[PD] is just there and nicely says 'That's enough now'"* (P1). P2 also perceived a difference between PD activities and work entries: *"[They appear] definitely not like a meeting"* (P2). She also liked the motivational nature of the phrasing. P5 summarized: *"It stood out. I found it charming. […] It's a different way of thinking. The colour and the linguistic distinction helped to perceive, it [PD activities] as something different"* (P5).

By making the events slightly strange, participants were better able to grasp the difference between PD and their "normal" calendar, while using the same technology. However, this still might have been too subtle for some participants and future work should explore additional strategies.

Theme 3: Being overwhelmed by the large number of additional activities
Conceptually, we chose to overlay the existing calendars with the self-selected, wellbeing oriented activities. This overlay was meant to induce friction, a certain tension between how time use is, and how it could or should be. Of course, an average of 8.4 additional fixed activities per day can be quite overwhelming and invasive.

In fact, feeling overwhelmed was a common theme. P1 said: *"I felt stressed out the first two days, because of all the events in my calendar […] I thought: 'Oh wow, I can't manage this'"* (P1). P2 explained: *"The first thought crossing my mind was: Goodbye to that, you can't use that anyway"* (P2). She filled her perfect day with activities she would like to do, but confronted with it, it dawned upon her that she still *"had to work […] super unrealistic […] I had only four to five hours left for work"* (P2). P3 was overwhelmed as well, but immediately understood the denseness of his calendar as an *"impulse for certain things [changes]"* (P3). P5 did not feel overwhelmed, since he knew that *"everything that is yellow [the PD activities] has a low priority anyway, to be honest. But it is a hoped-for reminder […]"* (P5).

Theme 4: Playing with time
The friction induced by superimposing real days with perfect days can only be productive if participants resolve the tension, that is, start to actually "work" or "experiment" with their schedule. P1 started to approach her calendar a little more "creatively" after a while. She now "juggled" and tried for a fresh start by reconsidering each activity: *"[…] because of the calendar, I discovered that it is better for me not to exercise midday, but rather in the afternoon or early evening"* (P1). Likewise, P2 consciously adapted PD to her needs: *"And then I restructured the calendar a little, some events got shortened and then I used it"* (P2). She also coped with the pressure by re-framing her notion of the private activities: *"It became totally easy, because I just cancelled [deleted] events, I could not fit in in a day. Tomorrow is just another day"* (P2). She lowered her expectations and simply tried to fit in as much private activities as feasible. In fact, while PD uses the same element (i.e., an event) as the work calendar, activities (i.e., appointments) are better seen

as suggestions. They could be treated a little more generously: *"[…] priority was not so high that I had to slavishly obey. I took a look, acknowledged the suggestion, and tried my best"* (P5). This is basically what participants discovered: to take their free time seriously, but not being too strict with themselves. To work with their schedule every day, rather than to blindly submit themselves to it.

Theme 5: Day or week?
A concrete problem that emerged already in the first interview was the unit (here: days) we chose. People have different notions of a perfect day for different days of the week. P3 said that he is not planning the *"perfect day, but […] his week"* (P3). In fact, a number of participants insisted on defining two or three perfect days. At the heart of this is their desire to actually spend a day as closely to the ideal as possible. However, without further differentiation this seems impossible. Most activities have "rhythms". For example, P1 put "seeing friends" in her PD, but later said that it is of course unrealistic to go out every night. A week as a unit seems to stand a better chance to serve as a realistic blueprint compared to a day.

Theme 6: Irritation, sensitization, and internalization
Only three out of the five participants, P1, P2, P5, explicitly reflected on different phases in their relationship to PD. In general, using PD started out negatively (see Theme 3). P1 felt "irritated" in the first two days. P5 tried to "ignore" PD in the beginning. P2 was a little more positive by pointing out that the first week required *"working with the calendar, in the sense of experimenting with what fits when"* (P2) (see Theme 4). P2 further said: *"I tried to carefully avoid irritation, which worked out and there were many days I deleted a lot and I moved around events"* (P2).

This "working with time" led to sensitization. P5 explained: *"I have a sensitization, I feel it. It can't express it in numbers, but I intensely thought about, how to actually spend my free time"* (P5) and further: *"The calendar made me aware of certain elements in my daily routines"* (P5). P1 feels more *"well-arranged."*

Finally, participants reported a certain internalisation. P1 said: *"In the third week, I haven't thought much about it [the perfect day activities], but moved, deleted, tried to make it happen […] it was already in my head, somehow"* (P1). P2 explained: *"At the beginning, I spent more time looking at the calendar. I needed it. […] in the last week, it was like I already knew all the things important to me, such as writing songs. I did not need to look at the calendar. It was already in my head. I learned: 'Hey, it is supercool, I can use breaks throughout the day to write a song'"* (P2).

Theme 7: What is in a day?
Of course, change differed from participant to participant in terms of content. P1 said that she *"still engaged in more or less the same activities, but on different times"* (P1). Since she worked from home and mixed private (especially exercise) with work activities throughout the day, her perceived major problem had been "disrupted" days. PD helped with the transition from work to free time: *"[When MPD showed the first private event] I said to myself: 'Okay, this had been eight or nine hours, now I stop, and just have a look what the calendar offers'"* (P1). She also worked late less often, because *"we [she and her partner] had to go out [laughs]"* (P1) the calendar told her so. In addition, she felt as if she used *"the free time […] really for the activities, I've put in [PD]. I don't hang about and ask myself: 'What are you actually doing right now?'"* (P1). PD helped P1 to establish a better separation between work and private time (both at home) and to be more conscious about the activities, she cares about.

For P2 it was all about establishing rhythms and routines. For example, she defined a morning meditation as an element of her perfect day, an activity she rarely got around to do. Prompted by PD she said to herself: *"Okay! I need to set the alarm, to get up, and to just do it. […] I found it really great and pulled through. […] a great example of how to build a habit"* (P2). For another precious activity, namely writing music, being prompted by and working with PD helped her to identify breaks throughout the day to fit it in: *"It [PD] helped me to play music more often"* (P2).

Although cautious about the changes instilled by PD, P3 was able to identify two concrete situations. Similarly to P1, PD helped him with the transition from work to private time: *"What was good, was the event which prompted me to wrap-up work, to have a last look at the to-do list and to call it a day"* (P3). Another transition was going to sleep: *"[…] in the evening, 'It's time for bed' at least it was a reminder to wrest myself free [of whatever I was doing] to get seven hours of sleep"* (P3).

P5 explained that there are many obstacles in realizing a perfect day. He engaged in the suggested activities only if there hadn't been *"catastrophes at home"* or other *"duties."* He pointed out that PD cannot actually remove obstacles, but supports him by reminding *"that I actually wanted to do something different"* (P5). In fact, PD helped him: *"Yes, I even exercised. Maybe not the sports I wanted to do, but at least some sports"* (P5). The most important suggested activity (*"100% super"*) was putting the children to bed.

Theme 8: Scaffolding for a more well-being oriented use of time
P1, P2, P3 and P5 reflected about whether they would be willing to continue using PD or not. P1 would like to use PD further, but mainly because it removes choice: *"To let [PD] decide […] If it is in the calendar, I do not need to make a choice"* (P1). P5 just plans to keep important private activities in the work calendar, such as putting the children to bed. For P2 and P3 it was more about keeping up newly established practices. P2 was curious about the future, since she did not plan "to put anything [private] into the calendar." She stated: *"[I] hope that my new routines are so strong already that I just do it"* (P2). However, if she felt like "relapsing," she *"would put it [important activities] back into the calendar"* (P2). To prevent

relapse may also be the reason for P5 to keep important PD activities in the calendar. P3 plans to further engage in subtle rearrangements of his schedule. He mentions the transition from work to free time in the afternoon, and concentrating work a little more in the morning to have more free time. Similar to P2, he worries about his ability to maintain his newly acquired routines and would use PD in the case of relapse: *"[PD] relates to one's 'weaker self,' which is made conscious and which needs to be eliminated [laughs]"* (P2). In this sense, PD is understood by the participants as "scaffolding technology" (e.g., Fritz, Huang, Murphy, & Zimmermann, 2014). It provides insight, structure, and motivation for those who feel incapable of implementing their intentions.

Summary and conclusion

For most of our participants the benevolent calendar was a worthwhile, wellbeing-enhancing experience (Theme 1). It prompted rethinking personal time use and promoted the integration of wellbeing-oriented activities into everyday life (Theme 6, 7). Participants reported sensitization towards personal time use und a certain internalization (Theme 6). Already at the end of the three week period, the perfect day calendar became a "scaffolding technology" – a means to prevent relapsing into old habits (Theme 8).

Of course, our findings are limited since they mostly reflect how participants subjectively experienced the perfect day calendar. While an average of 5.2 realized wellbeing-oriented activities per day seems promising, this number is not easy to interpret, since we neither had a control group in the study nor individual baseline measurements. In other words, we neither know how many wellbeing-oriented activities per day are normal nor how many activities each of our participants had before they used the calendar. The change over time within the three weeks was rather mixed. While two participants increased their number of wellbeing-oriented activities over time, for two no change was apparent, and one even decreased the number. Future studies will create a more complete picture. Nevertheless, at least the study shows, that "productivity tools" can play the role of a Trojan horse in wellbeing-oriented design.

From our point of view, *Perfect Days* is already a viable conceptual design. Thought of as a product-service-system, a "wellbeing coach" could explore time use with an individual in a "counselling interview". In dialogue with the participant, the coach could construct a perfect week (see Theme 5). To lower irritation (Theme 6), only a fixed number of wellbeing-oriented activities (e.g., 4) should be allowed – at least in the beginning (Theme 3). The friction created by the superimposed activities needs to be apparent, but bearable. The coach can now prepare a "calendar extension" and ask the participant to import it into her or his calendar, similar to what we did. The activities themselves should be clearly distinguishable from typical work entries (Theme 2), yet occupy the same space to create bearable irritation and then sensitization. A fruitful strategy to distinguish wellbeing-oriented activities from work activities was humour and a little irony. Most participants found the slightly strange labelling of the wellbeing-oriented activities "charming". In general, we assume that humour and irony can make necessary friction more bearable (Hassenzahl & Laschke, 2015). Another important aspect is being understanding (Hassenzahl & Laschke, 2015). In the present case, this could be achieved by framing the activities as suggestions rather than fixed appointments and by stimulating people to play around with the activities and to gradually adapt their perfect week to their individual interests and abilities (Theme 7). Of course, the conceptual knowledge gained through the present case can also be used to create a more self-contained version of our benevolent calendar, where, for example, the conversation with a coach is replaced by a prompted self-analysis. In this respect, *Perfect Days* is a conceptual design inviting many different concrete materialisations.

All in all, the present study shows that a mere "productivity tool", such as a digital calendar, can be transformed into a caring technology, which is just – as one of our participants expressed it – *"there and nicely says 'That's enough now!'"*. This, however, requires explicit rethinking of our all too ubiquitous, innocent, and supposedly "useful" tools in terms of the impact they currently have and could have on psychological wellbeing.

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JourneyMap: Visualising the time-bound student Journey

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A student's view of higher education is often talked about as 'transformative' and as a 'journey' or 'pathway'. The student experience of university is time-bound, covering a clearly specified duration. From a learner's perspective the Higher Education journey begins at induction and ends at graduation. Through discrete and highly personal steps students move from one state, fresher, to another, graduate. This personal journey is explicitly linear, rather than the cyclic, annualised, time-perspective of the university.. The paper investigates how to visualise, in a temporal sense, this transformative journey. Incorporating necessary time bound events that appear in a students academic calendar and time table but in a student centric way that illustrates directly the journey the student takes and reinforces the time-bound, delineated nature of the student's HE experience. We document the results from development and present recommendations for future work

Time, temporality, interaction design, experience, research through design, visualisation

1. INTRODUCTION

From a temporally-orientated perspective a student's term-times, lectures, exams, assignments and other learning related temporally fixed events are way-points on a journey – each formative milestone passed will never be revisited. Along this journey reflective vistas and moments of self-evaluation frame the educational dialogue between student and institution. These moments can be vital in assisting a student in self-evaluation, identification of progress and generating meaning-making and sense of achievement. All too often these important and instructional moments are lost to students. Particularly when mid-way through a learning journey they risk losing sight of the metaphorical hill they climb. Unable to see how far up they have come and that each step forward is one step closer to their goal.

The temporal representation seen by students of their academic life is of a calendar that repeats year after year, and is implicitly institutionally focused. It deals with the cyclic rhythms of the university as organisation. The temporal perspective of both institution and academic staff are at odds with the perspective of the student. The staff see repeating classes year after year with induction after induction to programmes. The organisation sees infrastructure and planning decades into the future with a past stretching back even further.

We proposed that the standard academic calendar/timetable is not conducive to reflective learning. The unique temporal perspective of the learner is transitional and transformative whereas the institution is grounded and cyclic. Our project worked with students to develop a range of alternative calendar/time event representations – to help learners think about the past and prepare for the future.

2. TIME AS A LIVED EXPERIENCE

The idea of time as a 'lived experience' has been discussed at length within mathematics, philosophy and physics and meta-physics for thousands of years. From the early thoughts of Parmenides (late sixth or early fifth century BC), though now surviving only in fragments of poems it appears that for him the phenomena of movement and change were simply appearances of a changeless, eternal reality. In the paradoxes of the Greek philosopher Zeno, (Ca 490–430 BC) we see this tension between our lived experience of the world and what logic may dictate of what underpins what we perceive. Nowhere is this tension more apparent than in the study of time, particularly in studying the lived experience of time and representations of time. More contemporary philosophers, in particular Husserl (1991), when he writes on the 'consciousness of internal time', and more recently Barad (2007) and the physicist Lee Smolin (2013)

have argued about new interpretations of what time is and what it means to experience it. Le Poidevin (2009) when addressing the question 'how do we represent time' asks 'what is a representation and how do we perceive it'. Whilst an in-depth discussion of the complex and often competing theories of temporality, existence and perception are beyond the scope of this particular paper there are grounding arguments on visualisations of time, timelines and chronographs that have been of particular use. Notable as background to the design direction and theory of our project is the work of Aigner et al. (2007, 2011) Stephen Boyd Davis (2012, 2013) and in particular the large body of work from Edward Tufte (1983).

Rosenberg and Grafton (2010) allowed us insight into the history of temporal visualisation and of the changeable and often culturally specific nature of temporal representation. The work in the area of linguistics, temporality and spatiality (Fuhrman & Boroditsky 2010, Boroditsky 2011) have been of particular use, supporting decisions on visualisation based on the western European student base we were designing with and for (Hendriks & Boroditsky 2015). Whilst these references are not exhaustive by any measure as we have discussed in previous work in this area of temporal visualisation, and particularly calendar design projects (Buzzo & Merendino 2015, Buzzo & Jonas 2015, Buzzo 2014, 2013) it must be remembered that the problem of time visualization is a *'wicked problem'*. Originally identified by Rittel & Webber (1973) the idea of a wicked problem that contains many factors, commonly human and cultural, that eludes a single solution, and that has many diverse possible resolutions has been documented extensively within the area of design. (Frankel & Racine 2003, Buchanan 1992)

Several designers and researchers identify that the methodology of *research through design* is explicitly generative in nature and particularly suited to challenging, seemingly intractable problems. (Zimmerman, Forlizzi & Evanson 2007, Gaver 2012) Taking this methodological approach of research through design we began with an exploratory investigation of how students visualise their individual journey through Higher Education. A guiding theory to our work was also provided by the ideas of *technology as experience* (Wright & McCarthy 2004) and of *situated action* (Dourish 2004)

2.1 Initial investigations: students

The project began by conducting semi-structured interviews students at levels 1, 2 and 3 of an undergraduate Batchelor's degree in Science. The students were predominantly studying in the field of digital media and interaction design and so could be considered to have experience of the subject area. The initial interviews centered around the investigation of linguistic and spatial metaphors used by students. The Interviews prompted students to reflect on the time-limited period that they would spend within higher education and to investigate this as a progressive journey from one point to another rather than a cyclic activity**.** The reasoning behind this approach is based on the observation that the timescales used in discussion and representation of temporal activity from the university's perspective are often based upon permanent or long-term cyclic activities and repetition of events such as exams, evaluations, modules and courses. This is presented against the background of institutional timescales stretching back tens and in some instances hundreds of years. We contrasting these timescales and the temporal epistemology that underpins them with the lived student times-perspective and understanding. We felt this illustrated clearly how the idea of a time-limited student journey from induction to graduation may often be at odds with the language and representations they are presented with when institutional timescales and temporal-references are used.

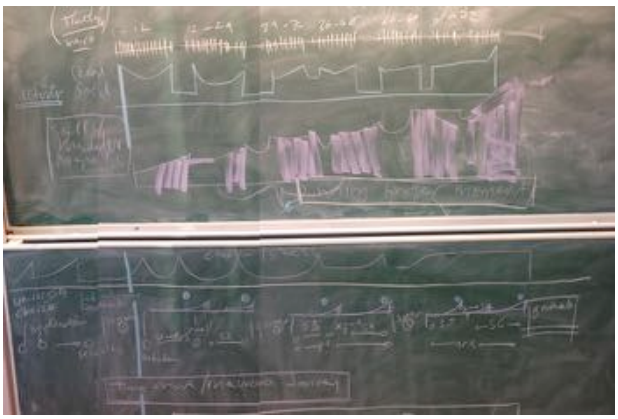

Figure 1: *early collaborative work illustrating varieties of time events over the student HE journey, showing skill, emotion, chronology and events*

The semi-structured interview questions also investigated students perceptions about educational transformation and improvement, particularly based upon ideas of progress. Language, metaphors and concepts that the students conveyed indicated that individually they understood the broader concept of higher education as a transformational journey of skills progression and personal development on a day-to-day scale. However it was apparent they found little to link their lived experience to temporal representations and activities with the broader idea of journey and educational progression.

When asked about repetition, activity, meaning and purpose within temporal activities, several students

expressed surprise when confronted with the realisation that each workshop, seminar, session or lecture would only ever happen for them once in their educational journey. This realisation contrasted strongly with the language use where students expressed that much of what they did was repetitive, located in a cyclic educational process rather than a linear progressive one. When asked about calendar usage the answers from students were mixed, some regarding digital calendar usage as essential, helping them organise and plan their time around university, lectures and assignments. Other students appeared to do little in the way of formal temporal planning, occasionally referring to online timetables for information around scheduled activities such as room numbers for lectures. Some students appeared to reject, at an emotional level, structured temporal planning, seeing it as an authoritarian construct of the university and not something over which they had agency or input. Commonly students with less structured planning reported relying on their cohort for information about activities and also anecdotally for a sense of reflection or progress on their learning.

In more focused discussion on temporal planning students reflected that information about activities, events, and engagement was fragmented across many systems and presented in many different ways. Students also appeared to face challenges effectively reflecting on work they had done and learning goals they had achieved. This appeared reinforced by several student's apparent inability to visualise learning experiences such as seminars and lectures with subsequent coursework submission, assessment, and feedback as a connected series of events. This lack of connection with the elements in subject-centered learning appears to reinforce the disconnection between a subject of learning and the individual lectures, workshops, coursework, feedback and assessment related to the subject. This reinforced a feeling in some students of confusion and lack of purpose in their day-to-day and week to week activities. Some students appearing to struggle to see individual learning activities as leading towards any specific goal.

When considering the evaluation of educational learning objectives we used Bloom's Taxonomy (Bloom 1956) as a background to help investigate student achievement in terms of levels of complexity and mastery. Whilst Bloom's is not without it's critics it is widely regarded as a useful starting point for evaluation of learning. We were primarily interested in supporting *Cognitive* (knowledge based) and *Affective* (emotive) in self-evaluation and reflection through are also keen to investigate measures of *Psychomotor* (action based) in future work.

- **Cognitive**: mental skills (*knowledge*)
- **Affective**: growth in feelings or emotional areas (*attitude or self*)
- **Psychomotor**: manual or physical skills (*skills*)

2.2 Student-centered, time-bound information

When investigating the variety of data and information sources that carry time-bound or temporal information we discovered that almost every element the students come into contact with has macro or micro temporality. *We discuss this distinction in greater depth in the section 'types of time events.* When investigating the kinds of temporal data students deal with we were generally contrasting durations measured in hours at the micro scale and durations of months or tens of months at the macro scale. The primary temporal data we became interested in to visualise for Students included;

- Term and holiday dates
- Assignment dates
- Feedback on submissions, coursework and examinations
- Lectures, Workshops, and Seminars as part of programs of study (modules or courses)
- Special events such as guest lectures

In addition to this temporal data, we saw additional content that was explicitly tied to temporal events, e.g.

- Assignment coursework specifications
- Audio, video and textual feedback on submitted work
- Lecture slide sets, worksheets, example files, and video recordings
- Descriptions and additional material for special events (speaker descriptions, links etc)

2.3 Design Exercises

In our formal interview stage and investigation of some of the issues raised and discussed by students we researched the actuality of their temporal lived experience in their day-to-day and week to week study activities. We assembled a range of data types and associated content orientated information as core materials to be incorporated into possible prototypes. We engaged in a series of small, semi-structured participatory design exercises with small numbers of students. We presented students with a variety of temporal information we had identified alongside the temporally-linked content and asked them to go through a number of exercises generating spatialisations, hierarchies, affinities and

associations between the elements. Of particular interest to us was how the students might structure the events and content in a linear or progression orientated fashion. Particularly if we felt these were specifically student-centered or perceptually orientated, reflecting the temporal lived-experience of students.

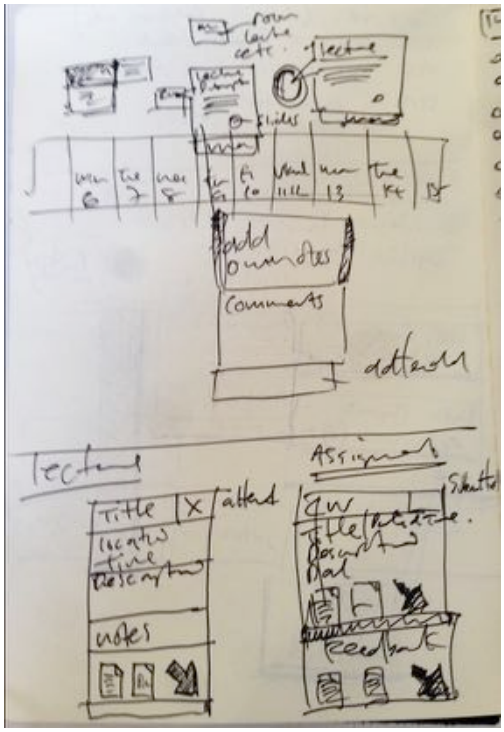

Figure 2: *We generated a number of simple prototypes, commonly starting on paper. This illustrates ideas of how to visually associate 'micro scale' events and linked information and resources.*

2.3.1 Prototypes

We generated a number of simple prototypes, commonly starting on paper and using iterative design processes and fast informal testing. This allowed us to develop ideas and analyse associations between durations, temporal events, reflection and linked informational content. During prototype generation we found that existing temporal representations were still extremely useful to students for orientation and sense making (perhaps due to their familiarity more than any other reason) and could potentially work effectively alongside other more adventurous or experimental illustrations of the student journey.

2.3.2 Types of time events

As we tested and evaluated prototypes we began to find greater clarity on the types of time events that students 'felt' in their lives at university. Time events ranged between what we term *'macro scale'. i.e.* Events or situations such as each individual year of study, a run of a course or module in that year of study, longer term assignments or projects of coursework. These may cover eight weeks or more and include other long but time-bound events such as holidays. These contrasted with 'micro-scale' events.

The emphasis of macro time events was that they were seen by students more as loosely defined durations. The micro time-events that were considered included things that the students felt were explicitly pinned in time and that appeared to 'punctuate' macro events. Macro events were felt more as a duration than a specific point. With beginnings or ends that were described as being more 'gradual' or 'fuzzy'. Micro time-events were discussed by students using far more precise language and details. Example events listed by students included the beginning and ending of lectures, scheduled events on weekly timetables, meetings, and especially details of assignment submissions with hard deadlines.

Macro time events
- year to year transition
- module runs
- assignments - preparation and execution
- holidays

Micro time events
- lectures,
- timetables
- meetings
- assignment submissions

From our initial consultation, design work, testing, and evaluation of prototypes we found three objectives we hoped to reinforce within the student centered temporal visualisation.

1) - Linking
- Mentally and visually linking micro and macro time events
  - e.g to clearly relate an individual lecture to the wider goals of a course or programme of study, rather than it being a discreet 'disembodied' activity

2) - Reflecting
- Reflective progress through the journey of Higher Education -
  - to clearly display how each day was a day further forward toward a goal.
- Reflection on improvement and transformation/personal growth and actualisation
  - Allowing students to look back in time and see past achievements

3) - Awareness of agency and control

- Reflection on agency and control with student at the centre of process and situated action.
    - By putting the student at the centre of the temporal visualisation we sought to reinforce the perspective of the student being in control of their own learning and on their own educational journey.
- Reinforcing purpose and linking micro actions to macro results
    - To continually reinforce the idea of progress and change and to visually associate how daily decisions made by students affected larger scale goals and longer term activities.

3. PROTOTYPE

Having analysed data sources, content and also technical scope of delivery we developed an early operational prototype using live data sources. The prototype visualisation built upon efficacy and clarity we saw in the early stage design work using time-line orientated spatial structures. Working with predominantly European, English speaking subjects the design presented time running on a two-dimensional x-axis from left to right. (Rolke et al 2013, Fuhrman et al 2011) The user's perception of *now* being centered within the view with the past and performed events being to the left and future events goals and un-completed tasks to the right.

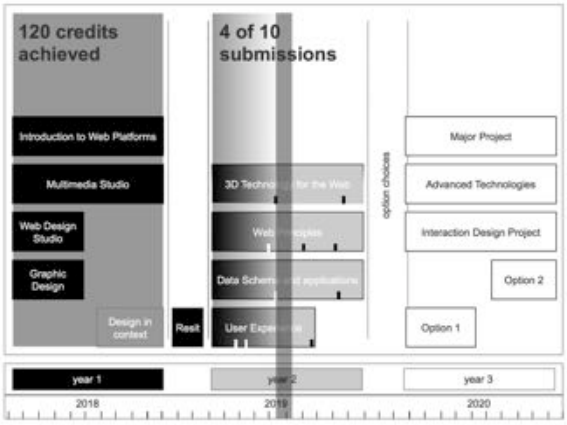

Figure 3: *Early prototype using x axis timeline showing wide (3 year) view of activities, illustrating the left/right future/past visualisation scenario.*

Using time-line metaphors and map-style interactions allowed us to move away way from some of the restrictions of more traditional grid based, calendar style visualisation. The time-line and map metaphors allow background time-scales to be expanded and compressed to present greater or lesser granularity of durations and events being represented. This appeared to follow the language students had used to structure, navigate and describe the interrelation between macro and micro time events in their education experiences.

Figure 4: *Medium resolution prototype timeline showing events grouped by course of study and indicating attendance: past events (red or green on dark grey background) on left and future/unresolved attendance (white on pale grey background) on right. 'Today' is indicated by grey bar with red highlight on day-name*

3.1 Using bounded time-lines

Our approach to the design explicitly hinged on the students lived-experience of time in the context of a journey through higher education. To reinforce this the calendar was specifically time-bound to the length of study (usually three years) starting at the point of induction at level 1, continuing to the day of graduation at level 3 and then stopping. The expectation is that should a students study be interrupted or extended the calendar would reflect this change in the length of the 'journey'. This linear, time-bound representation was seen to be crucial in communicating the base context of the design work, and of the subtle but important conceptual shift underpinning the project itself. One of shifting the centre of the representation to a student centered one rather than an institutionally focused one.

Figure 5: *Example of individual event showing time, location, description, externally linked content and indication of attendance*

The time-line data representation we have investigated seeks to work with current theory discussing the apparent contradictions in temporal representations. Specifically in the A series vs B series time argument McTaggart (1908) proposes two views. One, of a tenseness universe (B series), one where all things are happening all the time and the idea of today, tomorrow and now is only relative and 'non-real' – as commonly represented by

calendar view. This is juxtaposed with the lived experience of time, seen like a spotlight sweeping over events as they pass (A series). Robin Le Poidevin (2009) discusses these contrasting views in the context of asking what a perception or representation actually is. He contrasts the distinction between an egocentric and an objective representation and the problems when applying this view specifically to temporal perception. On the face of it our perception of time appears initillay *egocentric*, similar to spatial statements such as 'it is hot in here' or 'that mountain is further away than that tree'. Whilst the *objective* perception of space appears easy to do, 'the mountain is in this location, the tree is in this different location' he claims that the same cannot be said so easily of time, where ones own temporal perspective does not so easily appear to determine whether events are in the future or the past.

Traditional calendar representation appears to construct an objective representation of time. One where events written for a certain date do not change when the subjective or *egocentric* perception says that they have moved from the future to the past. The calendar may be more akin to a map in this sense. It's representation of space is appears an objective one within which we must clearly orientate ourselves, aware of our passage through the represented landscape. Tackling this simple but thorny philosophical and representational issue was a recurring theme in many of the early prototypes in our project.

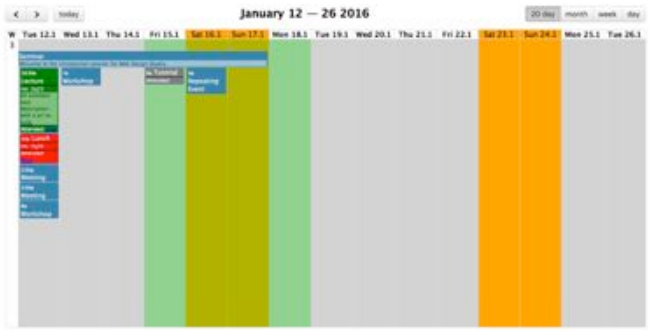

Figure 6: *Early prototype built using HTML, CSS and JavaScript. Showing example data sources and active event attendance (shown as red and green events, events without recorded attendance showing in blue)*

In our main development we addressed this issue in a simple fashion by changing the colour of all days and events that were objectively in the past. We indicated the viewer's location in a 'current' position in the temporal time-line and we also investigated the language used to describe future events. This attempt at *strong-framing* of the passage of time and progression of events through the bounded time-line was further reinforced by adding an extra data category to 'attendable' events - e.g. lectures seminars, workshops, and assignment submissions. Allowing us to record what the outcome was of events now in the past and leaving explicitly unresolved events in the future the outcome of which was yet to be resolved. This was an explicit attempt to address Objective 2) - that of encouraging reflection of progress though the educational journey and of Objective 3) linking micro-action to macro-purpose - linking attendance at individual events that were part of a longer process of small incremental stages rather than discrete events.

3.2 Development

The functional prototype student-journey time-line was built using client-side web technologies (HTML,CSS and JavaScript) to allow speed of development, standardisation and easy deployment to a variety of operating systems and platforms - desktop, mobile etc. The fullcalendar.io JavaScript library was incorporated to provide simple calendaring operations and parsing of data in JSON (JavaScript Object Notation) retrieved from a remote Google Calendar. Fullcalendar.io is itself built on moment.js, an open source library designed to handle the complexities of low level date, event, timing and duration data. It also provides support for time-zones and a variety of events related to the iCalendar 'Internet Calendaring and Scheduling Core Object Specification' (RFC5545) for electronic calendaring data. Simple extensions within the ISO standard can accommodate event related information - e.g.; event type, event location, links and URLs of related information (slide-sets etc.). In addition to these properties we added a property to indicate whether the event had the capacity to be 'attended' and what the status of that was - attended, not attended (for events in the past), or yet to be determined. (for events in the future). These additional data elements were written into the existing non-standard property extension to the specification *'x-'*. In future development there appears to be the possibility to use the existing *'partstat-event'* participant status with a new *'x-'* status event of *'x-attended'*. With 'null' indicating the event has not yet occurred and '*true'* or '*false'* indicating attendance status after the event has passed. It may additionally be possible to use the '*PERCENT-COMPLETE'* properties of the *'partstat-todo'* property of calendar events, however the '*PERCENT-COMPLETE'* property is explicitly associated with the '*TO-DO'* event type and was originally specified to deal with tasks and activities rather than temporal/calendar events.

3.3.1 Initial Testing

Early evaluations of the functional prototype by students were conducted by short usage sessions and semi-structure reflective interviews. As of writing there have not yet been extend trials and

results are based upon initial appraisals. The results have been used to form guidelines for future development.

3.4 Future Development

Future development includes options to switch to other, more traditional, calendar style or event-list displays. The may be a useful development for students, particularly in organising and visualising time-scales of days and weeks when integrating other tasks and activities such integrating study events with e.g. social engagements. This is currently available using modification to the code resources in the fullcalendar.io JavaScript library but will need some development work concerning which additional data and information sources will be displayed and how they may be visualised effectively in these more traditional formats.

An important part of the original motivation for the project was to encourage reflection and self awareness within students undertaking the higher education journey. From early design exercises it was proposed that students could add personal notes directly into calendar events, both for themselves, e.g. for making contemporaneous lecture notes and also for sharing such as asking questions or sharing additional resources that other attendees to the event would be able to see. Additional ability to make comments or notes in the form of diary style functionality was raised in early design sessions. Given the range of current practice and existing tool use it is suggested that linking to existing external sources be an easily investigated option - e.g. diary entries and note taking saved in Evernote and Google Docs software and social sharing via Facebook or twitter posts. These various 3rd party services all have web focused APIs (Application Programming Interface) that can be used to write and recall information with relative ease. This step of continuing to integrate with external resources has a two-fold benefit. It integrates with user's existing systems and behaviour rather than attempting to introduce new work practices and it keeps the system being developed light and flexible.

Future technical development of the project should include closer integration with existing data sources. These include data from a number of disparate systems within the current university environment. Many systems exposed over the internal and external networks predominantly have some instance of a *web service end point* (A web service is a function that can be accessed by other programs over the web. A *web service*, as opposed to a *web site* is targeted at other programs rather than at humans) and given the correct configurations and, if necessary, security tokens the data can be integrated into the student JourneyMap project in a straightforward manner. The exposed web service endpoints serve a range of data formats and containers, usually XML (extensible markup language) or JSON (JavaScript Object Notation), that are easily accessible using standard web technologies. This will also help the project to be linked to university data sources such as the existing Virtual Learning Environment (VLE) from BlackBoard Inc., the internal timetabling and assignment system, and the submission and feedback systems. This would allow students to see, or link directly to, the bulk of data, content and information that has a temporal aspect or is related to temporal events. All of which is expressed in a time-bound, explicitly student entered visualisation that is designed to support the lived experience of the student journey.

3.5 Conclusion

Following these proposed developments we advocate a long-term adoptive study for more extensive testing of a robust stage 2 prototype. By combining a number of different measures, qualitative and quantitative we would hope to see where, why and how the temporal visualisation assists students in more clearly comprehending their time-bound journey through Higher Education. We would also hope to see clear areas for improvement and refinement, both in technical efficacy and functionality and in quality and effectiveness of the visual representation.

Figure 7: *Iterated functional web based prototype. Showing live JSON data sources over 30 day range.*

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The Time Machine:
a Multiscreen Generative Video artwork

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'The Time Machine' is a multi-screen, high-performance, generative video art installation based around multiple low cost computer platforms. Using algorithmic selection of palindromic loops of timelapse video the work contrasts the external, machine perception of time with our internal, phenomenological experience of it. The video feeds, recorded from around the world, tick and tock backward and forward creating a polyrhythmic, 12 screen time-piece. The images loop back and forth on each screen of the installation, creating a large polyrhythmic clock of high definition, full colour motion. Each screen detailing a passage of time from around the world, captured, frozen, forward and reverse. The time-lapse loops slowly switch, selected from over a thousand separate pieces by generative algorithms on each host computer. Creating a Time Machine reflecting the world, gently rocking back and forth with a myriad of sub-cadences, confronting the viewer with the unanswerable challenge of comprehending time.

time, temporality, media art, generative video, time lapse, installation, phenomenology

1. INTRODUCTION

'The Time Machine' is a multi-screen, high-performance, generative video art installation based around multiple low cost computer platforms.

> "Clocks and calendar are necromantic devices - tools by which the dead think for the living, and the dead's thoughts deflect the living's attention from the cycles in the present. This is a consequence of the mediation of cognition by artifacts, and it is a feature of how artifacts can distribute cognitive models across time, culture and space" (Birth 2012)

2. GENERATIVE VIDEO

The work uses looping time-lapse video shot in locations around the world to engage the viewer with a discussion on the experience, rhythm, repetition and flow of time. Running across multiple monitor screens the installation senses the audience and in response creates palindromic video loops from high resolution time-lapse video. The video feeds, recorded from around the world, tick and tock backward and forward creating a polyrhythmic, multi-screen time-piece, a video-clock locked in receptive, slowly evolving loops. A Time Machine reflecting the world. The backward and forth looping of the video feeds engage the viewer with both the re-assurance and the discomfort of seeing the world as 'clock-time'. The mechanistic vision that time is something created and measured, governed and ruled externally to ourselves and external to our experience.

The piece '**The Time Machine**" is a companion piece to the successful 2016 dual screen generative installation "**What Do We Know Of Time When All We Can Know For Real Is Now?**". (Buzzo 2016) Exhibited internationally at events such as 'Digital Futures' with British Computer Society and the Victoria and Albert Museum (London), Computer Art Congress 5, Paris and ACM Multimedia at OBA in Amsterdam the work comes from extensive investigation in the lived experience and perception and representations of time.

The work "The Time Machine" contrasts the external, machine perception of time with our internal, phenomenological experience of it. The notion of 'clock time' is a powerful and extremely widely adopted metaphor for what can be argued as the most fundamental element of experience (Munn 1992). Time links all things we see and perceive, from our earliest awareness of our own physical growth and mortality to more subtle realizations of the narrative procession of events and even the concept of causality (Garcia and

Prender 2014). The complexity of dissembling what this experience means has been wrestled with for millennia, as Augustine of Hippo asked in 400AD

> "What then is time? If no one asks me, I know: if I wish to explain it to one that asketh, I know not."

The evidence and the balance of the philosophical argument is for procession and flow. What Heraclitus, and subsequently Nietsche described as *all is chaos and becomin*g . However, clock time, an external mechanical, industrial notion of time, has become dominant since the turn of the last century. (Martineau 2015) The patterns and rhythms seen are considered cyclic, oscillating and reciprocating like the cogs and gears in a clock. Even the movements of stars moon and planets around us are considered as an orrery, a childs instructional toy to describe the universe.

This work presents this mechanical clock fiction direct to the viewer. Folding half a dozen different types of time together in a multi screen video form. Time lapse video from different time zones shifted and collated together, sunshine alongside moon light, dawn next to the falling of dusk. The video loops back and forth on each screen of the installation, creating a large polyrhythmic clock of high definition, full colour motion. Each screen detailing a passage of time from around the world, captured, frozen, forward and reverse. The time-lapse loops slowly switch, selected from over a thousand separate pieces by generative algorithms on each host computer. Creating a slowly evolving and changing time machine. Gently rocking back and forth with a myriad of sub cadences, confronting the viewer with the unanswerable challenge of comprehending time.

2.1. TECHNICAL REQUIREMENTS

The Time Machine generative video installation utlilises 12 separate monitor and computer pairs. Each independently sensing the environment around them and dynamically controlling and presenting palindromic (looping back and forth) time lapse video shot on locations around the world. Screens and computers can be supplied. The installation therefore requires 24 240v AC power sources. Due to the low power requirements of the screens and computers there are no special requirements for power delivery other than access to sufficient mains electricity points. Multi-gang extension blocks are an ideal solution for power requirements.

Setup one: In the round

The installation of computers and screens can be adapted to suit available space but the arrangement is commonly ‘in the round’, i.e. the screens and monitors are bunched together allowing visitors and viewers of the work to view from 180-360 degrees of the installation. With the screens addressing all sides of an installation space. This commonly uses a floor space of approximately 2m x 2m.

Setup two: Flat

If space or arrangement is a suitable the work can also be exhibited ‘flat’ on a single wall with each screen arranged in an interlocking grid. If this option if requested then suitable wall fixings or stands will need to be arranged to support all 12 screens.

Figure 1: *Standard ‘ flat’ installation using matric of 12 monitors showing Raspberry Pi driving computers.*

2.2 TECHNICAL BACKGROUND TO THE WORK

When approaching the technical architecture for ‘The Time Machine’, the latest in a series of generative video art installations, for purposes of both cost and flexibility, the computing platform required to run a multi screen installation required great thought. Previous generative or interactive multiscreen works had required high-performance and subsequently high cost computer platforms to run software and reproduce high frame-rate, high-quality video. For the latest piece of media art work, The Time Machine, based around extensive, high quality, time-lapse video material, the intention to run the installation on as many as 16 separate screens, and therefore computers, simultaneously, forced a re-think of the

choice of platforms. Previous works had utilised high performance Macintosh mini-computers running custom software written in C++. These platforms performed well with both video CODEC and software execution, enabling efficient high frame- rate playback of premium quality video material and near seamless generative or interactive functionality.

When considering a new installation work the cost of including significant numbers of these high-performance but high-cost computing platforms was prohibitive, running into tens of thousands of pounds for computing hardware alone. To enable the production of the proposed new work alternative platforms and modes of delivery needed to be considered. After numerous comparisons and testing the Raspberry Pi (www.raspberrypi.org) low-cost, high-performance computer was selected as the platform of choice. Having a price advantage of approximately 20x versus previous high-cost computer platforms and the ability to execute custom C++ applications this hugely successful low-cost platform gave significant advantages over other devices. With a small form factor, low power consumption and a wide range of supporting software and peripherals the Raspberry Pi platform provides great opportunities for low cost, high performance custom media art installations.

Background to this work details the challenges, decisions and subsequent production processes behind the making of a new high performance, generative, multiscreen video installation using a large number of interlinked Raspberry Pi mini computers. Giving insights into artistic, design and technical decisions the paper contributes to both the creative process of artistic computer visualisation but also of the technical negotiations that must be undertaken when repurposing new technologies toward artistic goals.

The C++ application library openFrameworks (http://openframeworks.cc/) was used as the staring point for programming using the Xcode Integrated Development environment (IDE) on MacOS computers to generate core code. This code was then ported by SSH remote connection to wifi connected Raspberry Pi target platforms for testing and native compilation. The extensive amount of video assets were managed in Aperture media library on MacOS and edited and colour graded using Final Cut Pro. The selection and editing process was extremely labour intensive both in the selection process for clips and the editing process.

The time-lapse video clips contained in the project were shot over a period of approximately 36 months across many locations including UK, France, Portugal, Netherlands, Belgium, Hong Kong, Korea, Toronto and California. Primary video capture equipment included Canon 5D MkII and EOS-M DSLR cameras running Magic Lantern firmware modifications and HeroIV GoPro video systems. Assembly, selection and processing was primarily via MacOS with text code executed on MacMini computers.

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doi:10.1093/iwcomp/xxxxxx

Arguing for temporality in HCI: A guide for user centred temporal design.

REMOVED FOR BLIND REVIEW[1]

[1]*removed for blind review*

User centred design is a well understood and commonly used approach to systems design in a Human computer interaction context. Within the approach is the placement of the experience of the user at the centre of the design process, as opposed to a system centred design process. Whilst this approach has yielded significant benefits and advances in the design of efficacious systems the understanding and incorporation of temporality in the design discussion is often conspicuously absent. The lived experience of time and the reality of a processional or narrative, causal, temporality for users is evident in day to day life but is rarely accommodated in current models of user centred design. This article discusses the background to user centred design, and investigates what temporality means in the context of a users lived experience of interacting with computer systems. Finally we propose a framework with which to evaluate the temporal experience of users and to assist in fostering user centred temporal design.

Categories and subject descriptors:

Keywords: Temporality; Interaction design; User experience

Responsible Editorial Board Member:

1. INTRODUCTION

User centred design is commonly seen as focused around the needs, priorities, desires and goals of the user. Design processes associated with user centred design seek to divine, clarify, prioritise and contextualise these needs to create better specifications, goals and evaluation methods for designs. Utilising these processes allows an insight into the framework of content, functions and interactions that may be required to address problems or support users. Common artefacts from these processes include affinity diagrams, sorting activities, flow and structure diagrams and other spatially orientated descriptions of the design problem and subsequent prototypes. Whilst each of these elements are often the product of serious observation, research and ideation, faithfully recorded in great detail, they commonly lack a vital element of every users experience of any system.

The experience of time.

Putting aside the deep question of whether time exists, or what time is Callender [2010], describing the experience of it is complex, trans-epistemological and trans-disciplinary. This can sometimes make it a controversial subject to include in many research publications. The commonly agreed norms are that we live in a temporal world, where time passes and is experienced in only one direction. We live in a world where the procession of events in order is the root of causality, and time travel, whilst the subject of much debate in theoretical physics, is not available to humans in any real or usable sense. In everyday living time is woven into every element of experience, our language is steeped in time, waiting, pausing, catching up, next, today, tomorrow, now. As the widespread work of Chen and Boroditsky shows Boroditsky [2011]Chen [2013], even the language we use to describe time shapes our future outcomes and our cultural heritage shapes the metaphors and spatialisation we use to describe time Hendricks and Boroditsky [2015]. Additionally, as Kevin Birth describes so eloquently, Birth [2012] the cognitive artefacts of time that surround us, watches, clocks and calendars, all shape how we think of time and how we experience it.

> "The Specific form of the materialisation of time is important for how it shapes and constrains how the immatreiality of time is conceived"

(K birth objects of time pg 20.)

1.1. Considering Temporality

When we stop to look, we see we are immersed in temporal data, opening times, closing times, timetables, schedules, appointments, meetings, time spans, time lines, describing events and durations. Even simple processes and instructions are temporal, with activities punctuated by varying temporal elements, as Vallgårda et al. [2015] Huang and Stolterman [2011] Pschetz [2015] amongst many others note, this complex temporality can be translated into the design of the experience of artefacts in a variety of ways. Particularly when looking at the temporal imperative that systems place users within.

These approaches appear largely centred on the relation of the user to the system and vice versa in a contextual sense, rather than a broader appraisal of the temporal experience of the user in a phenomenological sense. The element of temporality is still predicated on the temporality of the system, of a system centred view of time. These system mechanics often have no inherent sense of time nor comprehension of the experience of it.

These various approaches, detailed in literature, go a long way toward raising the question, or even existence of temporality for users but can be argued to not go far enough in their opposition to a rationalist, solutions approach to systems. One that could be considered to be following a reductionist, idealised model and approach to systems, users, intent, context and interactions. One where time, whilst introduced as a new factor to consider, is still an external, abstracted element, divorced from the lived experience of time. This emphasis on the *lived experience* of users, perhaps even borne out of a desire to change the narrative from users toward people that use systems, has been related McCarthy and Wright [2004b] eloquently in arguments for research methodology and the in the ethnomethodological turn to practice in HCI Kuutti and Bannon [2014]

I would argue that whilst a positive step forward there is a common element that could be considered in a different light that can deepen and richen both the experience of interactive systems and potentially bring benefit to far wider areas of Human Computer Interaction design.

To illustrate I will use a simplified example from the world of physics. It can be argued that there have been three great stages of understanding time, albeit an externalised *'clock time'* version of time, in the world of natural sciences;

- In the era of Aristotle time was a product of change or activity, the more things changed the more time was produced.
- In the era of Newton time was universal and immutable, underpinning all things equally like a temporal graph paper with a universal *'now'*. Newton went so far as to propose a rejection of observable environmental cycles as a measure of time Newton [1687]
- In the era of Einstein time was flexible, malleable and relative for each and every individual, even when those differences were tiny we each were experiencing our own relative version of time.

In the present there are arguments in the world of quantum physics where the way we think about time, of its direction, even its existence are being questioned. One of the large ideas from this debate is presented well by Smolin [2013] when he talks of the shift from the Newtonian model of physics, of conducting experiments on models of the universe - what he refers to as a *universe in a shoe box* where time is abstracted out of the model (and the universe) to an external, imaginary, mechanical clock. Allowing the models of the universe to be wound backward and forward, like Newton's (inspired but flawed) models of gravitation of planets. In this respect it is similar to a mechanical, heliocentric orrery. Engaging, informing and charming but evidently not a true representation of the universe. Smolin proposes a move toward one where time is considered a fundamental force, perhaps the most central element to be considered in a new physics. As he points out, even the laws of physics exist in time and may well have changed over time to give us the laws we experience today.

The parallel we can take from this within HCI is that the system designs, diagrams of users interactions, of models of use, are akin to the Newtonian model of physics. We abstract the world down to a shoebox and remove time to be able to observe and understand behaviour. However we often forget that we cannot expect to scale these models back up to the size of the universe and have them behave accurately. We omit the understanding that time is *IN* the universe, fundamentally woven into every element of it, and cannot be removed and placed outside our models. As attractive as flow diagrams, structure charts, wireframes and other design artefacts are, they omit time. Every human experiences time as a fundamental, central element in their lived experience. However, the models and systems we present to them, and of them commonly have all temporal elements removed. Time is abstracted away leaving only an external, mechanical, system-centred temporality in it's place.

1.2. Related work

When addressing this central theme, that *there is a lived experience of time*, it is again important to see this in a trans-epistemological, trans-disciplinary context. Norman, Neilsen, et al all talk extensively on the user experience and Wright and Mccarthy explain lucidly the argument for the 'experience of technology'. From a human perspective we experience time as an integral part of the process of living rather than the result of an idealised external mechanism. The cognitive artefacts we are surrounded by, clocks, calendars etc. measure and record time, but as Birth discusses so clearly Birth [2012],the time they present us with, and immerse us in, is a kind of time they *manufacture themselves*.

Lindley, in her analysis of temporality of users Lindley [2015] focusses on the notion that technology is implicated in the speeding up of everyday life. The work looks at how the adoption of the clock and 'clock time' coincided with shifts in ways of conceptualising and using time. It suggests that digital technologies shape experiences of time and need to be understood in the context of the routines of the modern Western world. It argues for a broader approach to dealing with the temporal aspects of social life. She writes on how this approach to temporality and temporal identity in a social context is deeply rooted in the lived experience;

> "Research in HCI has illustrated how this notion of immediacy is upheld through the social conventions associated with technologies, as well as through their design. For example, Harper et al. Harper et al. [2012] have described the lived experience (or durÃľe, following Bergson Bergson [1910]) of Facebook as being located firmly in the now, ...
> ...They observe that interactions privilege the present and underpin an impression of events unfolding as they happen...
> ...Because of this, the performance of identity is one of the moment..."

The *lived experience of time* as described in this way is perhaps part of what James might call *the specious present*

> 'the prototype of all conceived times is the specious present, the short duration of which we are immediately and incessantly sensible'

James [1890]

However, this specious present is only one of a range of what PÃűppel would call 'elementary time experiences' Pöppel [1978] all of which are relevant and pertinent to our goal of understanding user temporality.

Le Poidevin in the Stanford Encyclopedia of Philosophy [1] describes these elementary time experiences thus;

- (i) duration;
- (ii) non-simultaneity;
- (iii) order;
- (iv) past and present;
- (v) change, including the passage of time.

What is clear is that acknowledging the lived experience of time is central to understanding the users conceptual model (UCM) of any system or process that we may attempt to design. This means not just the temporal framework with which the user is looking - i.e. short term, long term, now, retrospectively, prospectively, but also whether they frame time *egocentrically* or *objectively* Poidevin [2009]. This influences how they then temporally frame the systems they are interacting with, how they frame *their* interactions and what evidence or representation there is of the history of their interactions. One must also consider what temporal data is presented to the user, how it is presented, what the time-scape or time bound arena is for the interactions and how this relates to system-centric or user-centric representations.

2. METHODOLOGY/EXPERIMENTS AND EXAMPLES OF TEMPORAL DATA

2.1. What is it we talk of when we talk of time?

> "What then is time? If no one asks me, I know: if I wish to explain it to one that asketh, I know not."
>
> St Augustine's Confessions, Book IX

In any discussion that begins 'What is time?' it must be remembered that the question itself pre-supposes that time exists in some 'real' sense. Amongst the many disciplines and areas that address the many complex aspects of time central to my research and underpinning much of this project have been; Chen and Boroditsky Boroditsky [2011] Chen [2013] and the complex world of how culture and language shape the metaphors and subsequently the cognition and expression of the lived experience of time.

Marx, Booth et al. Booth [1991] and the discussion of the socio-economic and cultural factors involved in the exchange of a personâĂŹs time for monetary or social gain or value. Husserl and the complex discussion of phenomenology and how one can describe and quantify the lived experience of being.

Over a period of years a series of research experiments and experimental designs have been produced, investigating the influence of system-orientated temporal representations. From a user-centred design context, investigation of the temporal data presented to users in many systems was found to be almost exclusively *system orientated* rather than *user orientated* Buzzo and Philip

[1] http://plato.stanford.edu/entries/time-experience/

Phelps [2016]. In the **JourneyMap project** we investigated novel temporal visualistaions of information for students engaged in a journey through Higher Education. In our study we observed subjects engaged in an activity with a time-limited scale of 3 years (actually 33 months for many students). However, these students were regularly being presented with data in a system oriented context (the university) of several decades. In many cases the temporal context presented to young students was three times the actual lives of the intended users. With the extended cycles of the university being the context in which temporal data was created, and subsequently presented to students.(see figure 1)

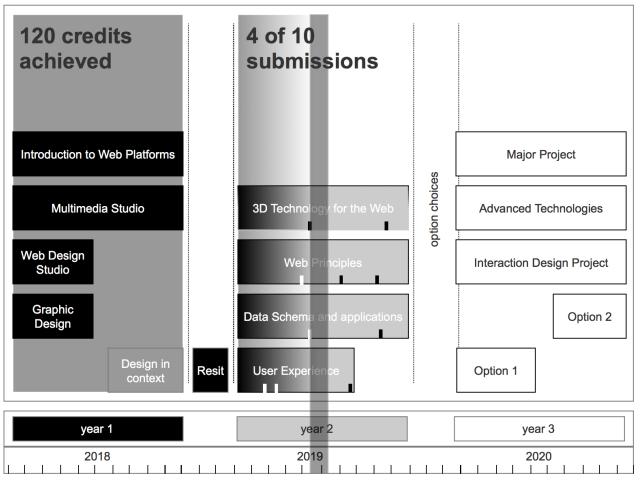

Figure 1. Details of early timeline prototypes of data and temporalities in the student journey. Illustrating future and past events current temporal frame and temporal procession through a 3 year time-period,

The project investigated the issues affecting students with the intention of reinforcing a sense of progress through a time-bound journey. Locating phases and important points as a unique, personally structured temporal cartography. The aim of the project was to support reflection and aid indications of progress through the events and durational activities. These were classified as *macro* or *micro* time-scale events. Showing lectures, examinations, presentations, holiday .etc as the unique events, from the individual student perspective, that they are.

The key findings centred around the usefulness of strongly framing a time-bound experience and presenting the time series data explicitly as past or future. This temporally contextualised information was designed to illustrate clearly the student's progress through events toward a future goal. The effectiveness of the prototype designs was based upon the potential of perceptual shifts of the subjects. Transforming from being an element amongst many moving through the activities of the University to one of moving through activities and timescales unique to the individual.

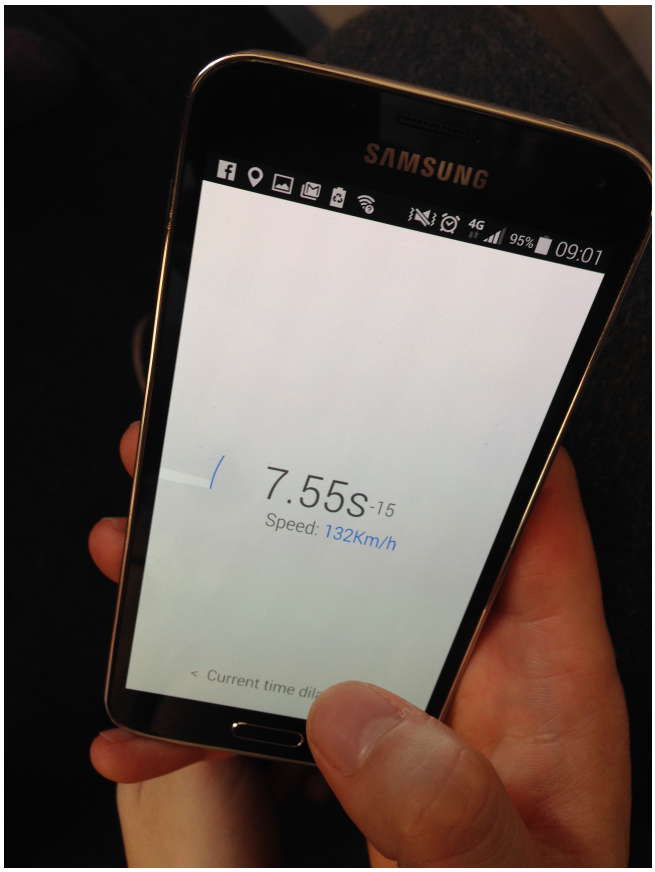

Figure 2. Prototype personal time dilation tracking software running on android mobile device

2.1.1. Time dilation and illustrating the impossible

In other research we investigated the actual effects of time dilation (as predicted by Einstein's theory of relativity and confirmed by experiment) and proposed experimental designs for wearable devices to help people understand the microscopic changes in time and duration that occurred to them everyday as they travelled at differing speeds. Buzzo [2014] (see figure 2)

The project aimed to illustrate a kind of temporality that is invisible from a human scale perspective. Considering the cognitive and design challenges faced when attempting to illustrate the microsecond differences physical movement (velocity) produces in different individual's experience of time. The project developed

software for mobile devices (see figure 2) that back-calculated time-dilation based on velocity and illustrated to the user their instantaneous and accumulated time dilation.

2.1.2. Some days are not equal - an experimental calendar project

In other design led investigations we conducted a series of experimental making activities. These were aimed at interrogating the non-explicit pressures and constraints, social, cultural, political and economic invested in the standard digital calendar model. Early research identified a series of effects or deficiencies current designs were felt to exhibit. Making sessions then generated experimental, critical interventions in attempts to illustrate the unspoken challenges current designs and artefacts were felt to present. The designs proposed novel solutions to temporal framing, work life balance, task allocation and of the conflict of clock (external) versus phenomenological (internal) experiences of time. Discussion proposed future directions and the challenge of creating visual or physical representations that combine both experiences of time.

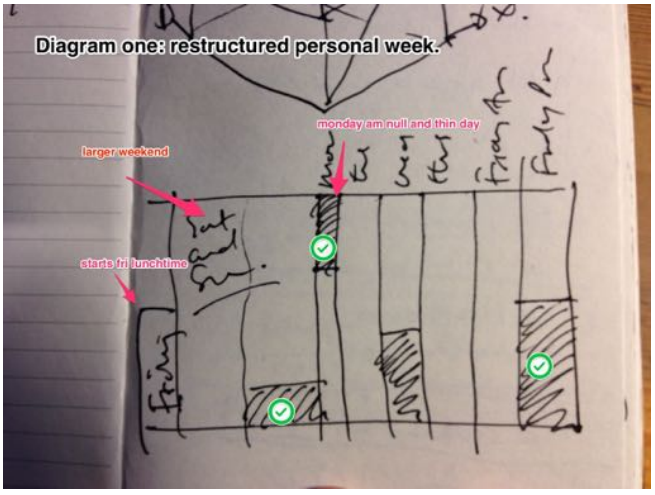

Figure 3. Early sketch explorations for alternate views of personalised week

2.2. Perfect day - a calendar to promote well being

From the experimental calendar designs a further extended project addressed one particular issue regarding well-being. That of personal time management and work life balance. The project investigated designs for a pro-active calendaring process that would effectively 'defend' it's user or owner and support or promote well being. The design and prototype process and subsequent adoptive user study brought insights into the subject's relationship with the personal grammar of their time use and ontology. The project also discovered evidence that this also encouraged reflection on activities and temporal recording leading to higher levels of well-being.

Figure 4. Example of an idealised day pre-configured in a test subject's calendar: from Perfect Day project showing pro-active temporal activities.

Out of this extended body of experimental work, interviews, research, and observation a number of themes

related to temporal representation and perception were found to commonly recur. The outputs of this work combined with research of other work in the field. There has also been extensive and generous discussion with other researchers working in the field that gave rise to the proposed design guides included here.

3. SITUATED TEMPORALITY AS A DESIGN APPROACH

As has been shown in this paper, temporality and the lived experience of time is common to everyone and fundamental to our experience and understanding of the world. We have seen how awareness of design for temporality and of the idea of *use orientated temporality* of data can aid in creating interactive experiences that truly are centred on the user's context.

From the analysis of established and contemporary literature across many disciplines and from practical experiment in design and creation of artefacts a number of points emerged that together establish a structured design approach that we are using successfully in new and ongoing projects investigating user centred temporal design.

This new framework for analysis of user experience from a temporal perspective is intended to build on the excellent work that exists in many quarters of the rich HCI and research through design world notably the work of Dourish Dourish [2004] whose ideas of situated action and changing and evolving goals in the decision processes for users inspired and gave grounding to much of this work, also to Wright and McCarthy whose clarity of argument for technology as experience has been kept in mind when attempting to convey the results of this research.

4. POINTS FOR DESIGNERS

The framework approach contains a number of steps, considerations and provocations. These are posed as questions or considerations to be undertaken during research, testing or evaluation. They can be considered to be congruent to the questions posed to designers from other frameworks such as the Garret 5 layer model or the spatio-temporal aspect of Wright and McCarthy's *technology as experience* (ibid) framework. In which they explicitly ask the question 'What effects do place and time have on our experience?'McCarthy and Wright [2004a], the framework presented here extends from this opening statement and asks more, both of the user and of the system.

There are 4 broad themes to the framework, that of *understanding, translating, framing* and *representing.*

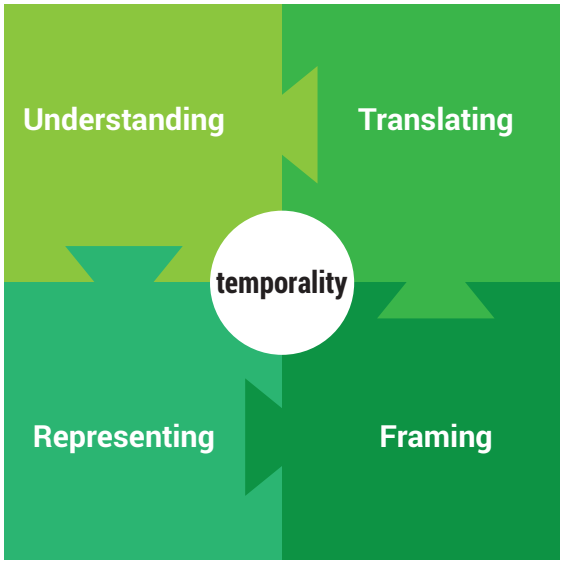

Figure 5. How do temporal elements of an experience fit together to form a coherent whole?

4.1. Understanding time

The iterative process of working with user temporality can begin with understanding and insight into the manifold temporal aspects of the problem domain, system, data, users and intended use. Temporal metaphors are entrenched in language and culture, and as Chen and Boroditsky (ibid) have shown can also be highly culturally specific. Setting aside pre-conceptions and received wisdom and seeking deeper understanding of temporal contexts can generate significant insights for designers and researchers.

Some of the key parts to an ***understanding*** phase are;

- **Understanding the temporal context**
  What are the aspects of time involved with the problem domain, users, proposed intervention or modes of use?
  What are the commonalities or conflicts of temporalities between users and stakeholders, system and context?

  Investigating the aspects of time that are relevant to the users, stake-holders or problem domain can reveal useful insights in understanding the temporal context. Defining what kind of *time use* is involved in the problem or activity can be of great help. The definitions of time use Aas [1986]are of great help in

defining the context for designers (is the user's *used time* personal time, contracted time, committed time etc?)

- **Understanding the narrative and procession of use**
  In what order will users engage with the system, what temporal path will they take through the system?
  Can the action be modelled, not as a system diagram but as a linear narrative of actions spaced in time?

  The use of emotional time-lines, both as an investigative tool to the problem domain but also specifically as an evaluative tool of any proposed design or system can reveal areas of conflict, frustration and identify where users spend most time - for example in many systems sign-up, login and preferences functions are used sparsely - sometimes only once but key functions may be used repeatedly for extended periods. Mapping representation as a layered information exercise can be enhanced by adding calculations of time spent in each activity, function or information area.
- **Understanding the temporal data involved**
  What time series, temporal data is represented in the system or design. What metaphors are used and what time-scales are referenced or inferred?
  What information or functionality is presented to the users of the system?

  What is the temporal aspect of each element? How is the time series data presented and represented? Is the temporal aspect of this data explicitly system related or user related? Are time-scales presented system generated or produced by actions of or for the user? When metaphors or abstracted representations are used do they support or conflict with information gleaned from investigations in (1) or (2)? Is the data based upon internal or external expressions of time?

4.2. Translating time

After a discovery and understanding phase comes explorations of translating the exposed elements into user orientated interpretations. This translating phase encourages a shift of perspective toward that of the user as the central hub of the data or temporal elements involved in the design or system being proposed. This focus on translation is designed to re-inforce the analysis of temporal data as explicitly fluid and multi-dimensional and hence translatable to formats and contexts that better server the situation of the user.

The key elements of the ***translating*** phase are;

- **Translating the user's temporal framework**
  What is the bounding time-scale or time-scape from the users perspective? is the activity single use, annual, sporadic, monolithic or other?
  What is the users' engagement with the system?
  The user will have a first use of the system, what could be considered to be their last ? How does the user conceptualise the duration of activity or action the system enables or engages them within?

  Is the system constant from a use perspective? (such as email, with the same functionality needed everyday) or transitional (such as learning a skill, like language training where the system is intended to become redundant) Every system will have a first and last use, investigating how, when and for how long the system will be used can reveal useful insights into alternative ways of framing the system for users.
- **Translating the user's lived temporal experience**
  What is the temporal context of the user? What is the temporal lived-experience for the user when using the system? How does time feel and what is time like when the interactions are taking place? What character would you want this 'use-time' to have?

  Where does use of the system fit into the user's everyday lived experience? Where does it fit in with their overall lived experience, in a longer term sense?
- **Translating relevant temporal data into user orientated temporal space**
  What is the epistemology of the temporal data involved in the design or system?
  Can it be translated into time series data relevant to the user's temporal perspective or position?
  How does the passage of time for the user affect their relationship to their data or the system's data?

  When attempting to translate temporal information into a user centred context we can observe how the passage of time for the user also changes the nature or relevance of the data for them. This *translation in use* will be influenced both by the narrative procession of the users actions but also by their increase in knowledge of the system and by changes in their goals and objectives.

4.3. Framing time

After investigating ways in which designs can translate temporal elements we ask whether they can be be framed or re-framed to suit the temporality of the experience or the user? This framing and re-framing process can be pivotal in bridging the gap of comprehension for

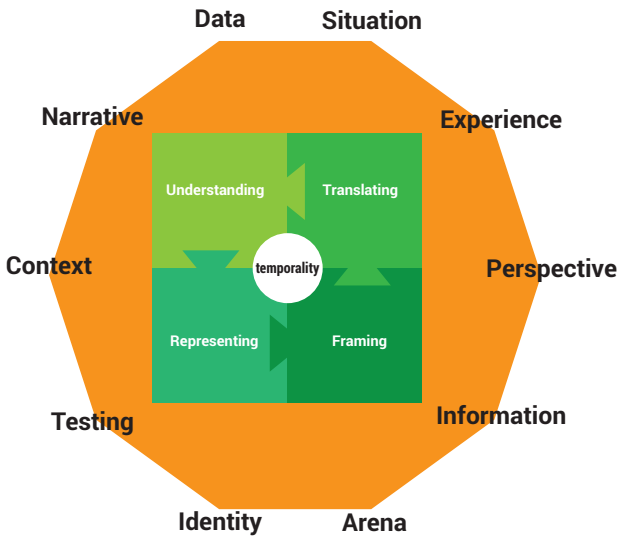

Figure 6. Temporal design themes follow the central process of the framework

users. Well formed temporal framing can allow users to 'sit within' the interaction and information as a central participant in the system, rather than as an external observer.

The key elements of the ***framing*** phase are;

- **Framing relevant user lived temporal data or information**
  What temporal information is relevant to the user?
  Is the system orientated temporal information actually relevant or necessary?
  Many systems present excessive temporal data solely because it is relevant to the system, or that it is an available attribute of system elements, rather than because it is of relevance to the user.
- **Framing the lived experience**
  How can the temporality of the experience or system be framed in a user centred way - is there a definable time-limited arena that can be used as a metaphor in which to contextualise the interaction? What is the period of use of the system? Can the metaphors in the system be re-orientated to suit the overall period that users will engage with the system for? Eg. presenting data for school children framed by the period that they will actually be at any specific school.

4.4. Representing time

How can the temporal elements of the system or the user's world be represented in the design?

After the system has been constructed how can the temporality in it be exposed to a suitable testing or evaluation process?
What temporal cultural norms or peculiarities are familiar to users?
What suitable temporal visualisations or metaphors can be discovered or implemented?
It must be remembered that the representation phase is not a goal but rather a part of continually iterative cycle. Just as users comprehend systems in a narrative procession, with each previous action or piece of information informing the next, so too are representations and design decisions that we make make. Changes in representation will have subsequent effects on the temporal perceptions that users have of a system or design. This does, of course, introduce the added complexity that users will see these changes as part of a temporal narrative.

The essential parts of the ***representing*** phase include;

- **Representing the user in a temporally framed perspective**
  What represents the user within the temporal framework of the design, is there an element that can be identified as the temporal identity of the user within the system?
  What metaphor is used for the temporal journey of the user through the system? Does the user move though the system, *objectively*, or the system move past the user, *egocentrically*?
- **Representing the user in temporally sensitive analysis tools**
  What user centred tools or processes can be employed to analyse the experience of the users temporality, *from the perspective of the user.*
  When attempting to observe and refine designs and systems, testing is often seen as a temporally static process. It is often a single goal to be achieved with the results of tests having no temporal component to them. Where tasks have a temporal component the narrative procession in the task is commonly removed, reducing the complexity of the users experience to single dimensions of data.

5. CONCLUSION

The main argument presented here is that all artefacts have a temporality and temporality is fundamental to the experience of living, and therefore of all users of systems. This approach and line of investigation is not completely novel and the importance of it has has been noted by many learned researchers before, as Lundgren and Hultberg [2009] note,

"there may be a benefit in *actually questioning* the temporality - or lack of in one's design" (emphasis in original)

In this paper I attempt to push further and establish a clear and usable framework for designing for temporal awareness that goes beyond adding or removing temporal *themes* but is at the heart of all experience. The four phase framework investigates and expands on design processes for what happens when humans interact with computers. It is explicitly contrasted against a systems orientated, rationalist model of users and interaction. This framework for temporal design is seen as building on and extending the existing body of work in the well documented turn to practice. This turn to practice embraces ethnomethodology in improving design of technology.

Based upon research observation and experimental design work over several years, I outline a process for investigating the complexities of how we perceive of time and how we may design for time. The framework approach is now being used in real world experimental design situations and yielding significant insights. The paper describes an additional step we may take in improving how we design for humans and technology. A step toward understanding the ways in which real people experience time, events and actions.

ACKNOWLEDGEMENTS

Removed for blind review.

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