

**Exploring the effectiveness of the design-led intervention
in reducing screen time and enhancing exercise for
children in the home environment**

By

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Abstract

Considering the rapid rise in obesity, this thesis suggests the notion that obesity can be tackled beyond conventional ways. It is widely reported in the literature that the epidemic of obesity is only going to get worse in the next 10 years. A change is needed to allow people to have more control over living healthier through improving physical and social environments, as these have a strong influence in shaping lifestyles. Existing research is converging on the view that modifying lifestyle behaviours is a viable approach to tackling this global epidemic. Therefore, this thesis proposes a unique intervention approach, focused on instigating sustainable behaviour through a design-led intervention. This novel approach attempted to facilitate a change in participants' sedentary lifestyles and prompt daily exercise behaviours.

Physical inactivity amongst children and young people has been identified as a serious public health concern in relation to increases in obesity, with figures on screen time reaching a worrisome peak. The current study demonstrated that making small changes to people's daily routine could result in habitualising healthier behaviours. This thesis further analysed some fundamental theories/models that have been applied in stimulating behaviour changes in different disciplines. Following a thorough literature review of a broad range of behavioural change studies, including reported case studies, a framework was developed. It proposed the stages of intended habituation of this new behaviour and informed the development of a research tool artefact which was employed for the main study of this thesis.

To evaluate the effectiveness of this intervention, a longitudinal study called the Domestic User Study (DUS) was undertaken to discover the habitual changes over time in home environments. A total of 20 households participated in DUS and used the prototype (design-led intervention) for a total duration of three months. Their behaviour change data were captured through means of monitoring, pre/post interviews, and mid/post surveys. The evaluation explored three fundamental research questions: 1) Did the design-led intervention help in building exercise behaviour? 2) Has the user's TV watching behaviour changed as a result of the design-led intervention? 3) Has Knudgbox created habitualised sustainable behaviour? Some key constructs were emerged to form the theoretical framework of this thesis and were measured throughout the DUS.

The results uncovered the key determinants that influenced participants' behaviour when exposed to the design-led intervention. After a comprehensive analysis, three main dimensions are presented that constitute the user habituation process: visual feedback, user empowerment, and regulation. The joint impact of these dimensions on sustainable behaviour suggests that, when incorporated, they can bring forth habitual changes in the target demographic and beyond. Overall, this study suggests that design-led interventions can have a positive effect on instigating exercise behaviour in the home environment. The recommended behaviour habituation model should be considered in the future implementation of design-led approaches in order to improve the chances of success.

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Finally, I dedicate this thesis to my parents Israel and Uche Nwankwo.

And, to my siblings, Chichi, Chizu, Chigo, I love you all.

The end has allowed me to truly appreciate all that I have learnt and gained from this process. I am profoundly grateful to have been part of the excellent research community here at NTU as this was edifying and fun.

Motivation for conducting this study

In the end, I remember not the tough times, but my resilience to push through to the end...

As a public health enthusiast, one of the reasons for conducting this research was my burning interest in contributing to the conversation on what families could do better whilst raising digital natives. The other reason was my desire to expand on the work I had done during my Master's dissertation, which had examined ways in which we can create interventions to reduce health inequalities. Its focus was the influence of national and local policies in tackling the issues around social determinants of health (SDOH). There is a growing consensus that social conditions have a greater influence on health than health service provision. SDOH describe the sociocultural conditions in which people are born, grow, live and age (WHO, 2008).

The general understanding from my Master's research was that multifactorial implications of health outcomes still boil down to the lifestyle choices that people make, and are exposed to, from a young age. The author sought to explore how lifestyle changes impact on people's health. This led to the initial contact with supervisors to discuss the idea and, after several deliberations, we agreed on proposing an intervention that focuses on giving people the autonomy to manage their lifestyle. And thus, my PhD was born.

List of publication and conferences

Nwankwo, F, Shin, D, Al-Habaibeh, 2020, **Alternative way to reduce the obesity crisis; a case study of design-led intervention.** *Cancelled UCL Conference due to COVID-19.*

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Nwankwo, F, Shin, D, Al-Habaibeh 2018, **Domestic User Experiment on improving children's physical activity through design-led intervention.** *ADBE College Conference. (Poster)*

Nwankwo, F, Shin, D, Al-Habaibeh 2017, **'Technology and inactivity; overcoming sedentary behaviour in the home through design-led interventions.** *HRF International Conference, London. (Conference paper)*

Nwankwo, F, Shin, D, Al-Habaibeh 2017, **Reducing Sedentary Behaviour through Design-led intervention.** *ADBE College Conference. (Conference paper)*

List of Abbreviations

AAP	Academy of Paediatrics
ABC	Autonomy, Belonging and Competence
BBC	British Broadcasting service
BCTs	Behaviour Change Technique
BHF	British Heart Foundation
BI	Behaviour Intention
BMI	Body Mass Index
BO	Behaviour outcome
CET	Cognitive Evaluation Theory
DfBC	Design for Behaviour Change
DfSB	Design for Sustainable Behaviour
DLW	Double Labelled water
DNA	deoxyribonucleic acid
DR	Design Research
DSR	Design science research
DUS	Domestic User Study
EVT	Expectancy-value Theory
FBM	Fogg Behaviour Model
FIT	Feedback Intervention Theory
GPAQ	Global Physical Activity Questionnaires
HBM	Health belief model
HPP	Human Powered Products
HUT	Home-Usage Test

IHUT	Home User Test
IMI	Intrinsic motivation inventory
IPAQ	International Physical Activity Questionnaire
LLM	Linear Mixed Model
MDA	Mechanics-Dynamics-Aesthetics
MET	metabolic equivalent
MVPA	Moderate to vigorous physical activity
NHS	National Health Service
OIT	Organismic Integration Theory
PA	Physical activity
PBC	Perceived Behavioural Control
PEOU	Perceived Ease of Use
PIA	Physical inactivity
PU	Perceived Usefulness
RCPCH	Royal College of Paediatrics and Child Health
RCT	Randomized Control trial
RtD	Research Through Design
SB	Sedentary Behaviour
SCT	Social Cognitive Theory
SDT	Self-determination Theory
SEM	Social Ecological Model
SST	Screen Sedentary Time

ST	Screen Time
TA	Thematic analysis
TAM	Technology Acceptance Model
TPB	Theory of Planned Behaviour
TRA	Theory of Reasoned action
TTM	Transtheoretical Model of behaviour change
TV	Television
UK	United Kingdom
WB	White box
WHO	World Health Organisation

Table of content

Copyright Statement	i
Abstract.....	ii
Acknowledgements.....	iii
Motivation for conducting this study	iv
List of publication and conferences	v
List of Abbreviations	vi
Table of content	ix
List of Figures	xx
Chapter 1 Introduction.....	1
1.1 Introducing the thesis	1
1.2 Rationale of study.....	3
1.3 Defining screen-based sedentary behaviour (SB).....	9
1.4 The research context.....	10
1.4.1 Design-led intervention.....	12
1.5 Research Aim	14
1.5.1 Objectives	14
1.5.2 Research Questions.....	15
1.6 Research phase breakdown	17
1.7 Positioning the research and its contributions.....	18
1.8 Organisation of Thesis	19

Chapter 2	Literature review Phase 1.....	22
2.1	Introduction.....	22
2.2	Obesity problem.....	23
2.2.1	Impact of Obesity.....	26
2.3	Drivers of childhood obesity.....	28
2.3.1	Genetic factors.....	29
2.4	Defining physical activity and inactivity in the context of this thesis.....	29
2.4.1	Measurement of physical activity.....	30
2.4.2	Contextualising sedentary behaviour.....	34
2.4.3	Trends in lifestyle.....	40
2.5	Social capital and sedentary screen time.....	42
2.6	Summary of Chapter.....	44
Chapter 3	Literature Review phase 2.....	46
3.1	Introduction.....	46
3.2	General behaviour change approach with theoretical applications.....	48
3.3	Contextual approaches to changing behaviour.....	51
3.4	Relevance of behaviour change theories in the current study.....	53
3.5	Habits.....	55
3.6	Behavioural determinants.....	58
3.6.1	Health Belief Model.....	58
3.6.2	The Theory of Planned Behaviour.....	61

3.7	Behavioural process	65
3.7.1	Transtheoretical Model/Stages of Change	65
3.8	Motivation continuum in relation to behaviour.....	67
3.8.1	Self-determination theory	67
3.9	Technology Acceptance Model.....	73
3.10	Feedback and self-monitoring strategies.....	74
3.11	Design for sustainable behaviour	76
3.11.1	Design and behavioural decision-making dimensions.....	77
3.12	Existing home interventions.....	79
3.13	Other real-world interventions	81
3.13.1	Sweat Coin	82
3.13.2	Fitness trackers.....	84
3.13.3	Gamification	85
3.13.4	Policy related interventions.....	86
3.14	Conceptualising the theoretical underpinning of the current study.....	87
3.14.1	Key constructs adopted from the above theories	91
3.15	Summary of Chapter	100
Chapter 4	Methodology	102
4.1	Introduction	102
4.2	Overview of research paradigms.....	103
4.3	Research philosophies	104

4.3.1	The positivist views	104
4.3.2	The interpretivist views.....	106
4.3.3	Design science research as a paradigm?	108
4.4	Research approaches	109
4.4.1	Deductive approach	109
4.4.2	Inductive approach.....	111
4.4.3	Abductive approaches.....	113
4.5	Research strategies	113
4.5.1	Ethnography.....	114
4.5.2	Grounded theory	115
4.5.3	Case study	116
4.5.4	Action Research.....	118
4.6	Research choices	119
4.6.1	Qualitative.....	120
4.6.2	Quantitative.....	122
4.7	Time Horizon	123
4.7.1	Longitudinal study	123
4.7.2	Cross-sectional study	125
4.7.3	Time focus of the current study	126
4.8	Technique and procedure	126
4.8.1	Literature review	127

4.9	Overall study design.....	129
4.10	Domestic User Study (DUS).....	130
4.10.1	Data analysis	131
4.10.2	Thematic analysis.....	133
4.10.3	Study population	134
4.10.4	Justification of sample size	135
4.11	Using material as a tool in design research	136
4.12	Ethical consideration	137
4.13	Summary of Chapter	138
Chapter 5	Design development of the Knudgbox	140
5.1	Introduction	140
5.2	Instrument development process	141
5.3	The Knudgbox.....	145
5.3.1	Knudging technique	150
5.3.2	Hardware selection.....	152
5.4	Improved design optimisation and metrics conversion.....	153
5.4.1	Security of data	154
5.4.2	Reliability.....	154
5.5	Building the prototype.....	154
5.5.1	Performance testing	155
5.6	Summary of Chapter	157

Chapter 6	Preliminary research	159
6.1	Introduction	159
6.1.1	Questionnaire findings and discussion.....	160
6.1.2	Snack consumption and screen time	164
6.2	Pilot of DUS	165
6.2.1	Participants' characteristics	168
6.2.2	Procedures.....	169
6.2.3	Measurement of screen time and physical activity before and after the intervention.....	169
6.3	Semi-structured interview and analysis.....	171
6.3.1	Recommendations for device improvement	177
6.4	Lessons and limitations from the pilot study	178
6.5	Summary of Chapter	179
Chapter 7	The main study – Domestic User Study (DUS).....	181
7.1	Introduction	181
7.2	The data collection process for the DUS.....	182
7.2.1	TV watching monitoring.....	183
7.2.2	Bike and device deployment and semi-structured interview	183
7.2.3	Mid study assessment at weeks 5 & 10	185
7.2.4	End of study interview	187
7.2.5	Post-study survey	187
7.2.6	User demographics.....	188

7.3	Pre-intervention data (TV usage monitoring)	188
7.4	Pre-intervention analysis	190
7.4.1	Lack of exercise	191
7.4.2	Sedentary behaviour.....	191
7.5	Behavioural Data.....	192
7.5.1	Physical activity behaviour	192
7.5.2	Attitudinal changes	196
7.5.3	Maintenance	198
7.6	End of study interview analysis	208
7.6.1	Self-regulation.....	208
7.6.2	Interest and enjoyment.....	208
7.6.3	Environmental influence	209
7.7	Post-intervention data.....	210
7.8	Summary of Chapter	211
Chapter 8	All Results and Discussion	212
8.1	Introduction	212
8.2	Intervention setup.....	213
8.3	Participant Profile.....	215
8.4	Pre-intervention Analysis	216
8.4.1	Screen time habit before the intervention	216
8.5	Behavioural archetype.....	218

8.5.1	Exercise Initialisation.....	225
8.5.2	Exercise Frequency (habit building).....	237
8.5.3	Introducing attitudinal Changes.....	241
8.6	Attitudinal analysis.....	248
8.6.1	Perceived ability.....	250
8.6.2	Social norm.....	253
8.6.3	Control beliefs.....	257
8.6.4	Interest/Motivation.....	261
8.6.5	Forced functionality.....	263
8.7	Habit Retention.....	267
8.7.1	Post study results.....	269
8.8	Statistical analysis of all results.....	272
8.9	Statistical analysis from all households.....	277
8.10	Summary of Chapter.....	278
Chapter 9	Domestic User Study Evaluation – The Behaviour habituation model	281
9.1	Introduction.....	281
9.2	Intervention evaluation in two dimensions.....	282
9.2.1	User Empowerment.....	284
9.2.2	Visual Feedback.....	286
9.3	Reflection on the intervention opportunities and challenges.....	289
9.4	Regulation.....	291

9.5	Unpacking the behaviour change process in relation to the DUS.....	295
9.5.1	Phase 1 (Behaviour initiation)	297
9.5.2	Phase 2 (Repetition stage).....	302
9.5.3	Phase 3 (Habitualisation stage).....	307
9.6	Evaluation of the Knudgbox as the research instrument.....	312
9.6.1	Did the design-led intervention help in building exercise behaviour?	313
9.6.2	Has the user’s TV watching behaviour changed as a result of the design-led intervention?	314
9.6.3	‘Design for sustainable behaviour’. Has Knudgbox created habitualised sustainable behaviour?	316
9.7	Summary of Chapter	317
Chapter 10	Conclusion	319
10.1	Beginning of the end... ..	319
10.2	Achievement of research aim and objectives.....	319
10.3	Research questions	320
10.4	Theoretical and Methodological contribution for policy and practice.....	322
10.5	Contribution to Design for sustainable behaviour research	324
10.6	Contribution to Public Health	325
10.7	Study strengths and limitations	327
10.8	Suggestions for future studies	329
10.9	Concluding remarks	330
References.....		332

Appendix 1: Participant Recruitment Flyer	381
Appendix 2: Participant Information Sheet	382
Appendix: 3 Consent Form.....	384
Appendix: 3.1 Signed consent forms	385
Appendix: 3.2 Signed consent forms	386
Appendix: 3.3 Signed consent forms	387
Appendix: 3.4 Signed consent forms	388
Appendix: 3.5 Signed consent forms	389
Appendix: 4 Questionnaire for parents regarding their children’s screen time	390
Appendix: 5 End of Pilot study semi-structured questionnaire	394
Appendix: 6 Pre-intervention Interview Guide.....	398
Appendix: 7 Week 5 and 10 Questionnaire for Empirical Study	399
Appendix: 8 End of Empirical Study Interview Guide.....	403
Appendix: 9 Post-study Questionnaire	406
Appendix: 9.1 Intrinsic Motivation Inventory Scale description.....	407
Appendix: 10 Prototype User Guide.....	409
Appendix: 11 Conceptual Sketches for Prototype	410
Appendix: 12 Technical diagram of Knudgbox.....	411
Appendix: 13 Energy Monitor reading for all houses	412
Appendix: 14 Screenshot from MATLAB showing justification for Group threshold	414
Appendix: 15 Participant Home set-up (not included in the body of the work).....	415

Appendix: 16 Snapshot of DUS thematic analysis node using NVivo 12 Pro	416
Appendix: 17 Case classifications snapshot from thematic analysis.....	417
Appendix: 18 Exemplar text frequency query from DUS thematic analysis.....	418
Appendix: 19 Weekly breakdown data.....	421
Appendix: 20 Other attempted statistical analysis.....	423

List of Figures

Figure 1 WHO report on obesity and overweight WHO, 2013 (remade by author)	4
Figure 2 Obese and overweight statistics by WHO 2017 (remade by author)	7
Figure 3 Obese and overweight primary school children in the UK Graph (Baker, 2019) (remade by author).....	8
Figure 4 Steps taken in the current study	17
Figure 5 Word cloud from literature review	22
Figure 6 Childhood obesity prevalence (Source; NHS England Statistics on Obesity in Statistics team report, 2018) remade by author	24
Figure 7 Proportion of UK children classed as either obese or overweight, (Source Millennium Cohort study, Centre for Longitudinal studies in Fitzsimons, E. and Pongiglione, B., 2017)	25
Figure 8 Chapter diagram	46
Figure 9 The Fogg Behaviour Model Fogg, 2009 (remade by author).....	56
Figure 10 Health belief model Janz and Becker, 1984 (remade by author)	58
Figure 11 Theory of Planned Behaviour, Ajzen, 1985 (remade by author)	61
Figure 12 Stages of Behaviour Change Prochaska & DiClemente 1982 (remade by author).....	65
Figure 13 Self-determination theory identified innate human need Deci & Ryan 2008 (remade by author).....	68
Figure 14 Taxonomy of human motivation (Ryan and Deci, 2000).....	69
Figure 15 TAM model Davis, 1989 (remade by author)	73
Figure 16 Three dimensions of DfSB Strategies (Shin & Bull 2019)	79
Figure 17 Tacx bike (author's image).....	80

Figure 18 Authors screenshot of the Sweat coin interface	84
Figure 19 SDT in the context of the current study.....	90
Figure 20 Theoretical framework for the current study.....	94
Figure 21 Research process ‘Onion’ (Saunders, Lewis and Thornhill, 2009).....	103
Figure 22 The ‘White Box’ (Shin, 2014).....	142
Figure 23 Label of the device components	143
Figure 24 Design process of the Knudgbox.....	146
Figure 25 Initial schematic design of the intervention.....	146
Figure 26 Initial design ideas	147
Figure 27 Knudgbox as the research tool	148
Figure 28 LED indication	151
Figure 29 Gizmo for prototype testing.....	153
Figure 30 Arduino digital pin	156
Figure 31 Children’s screen time by age	161
Figure 32 Parents’ concern about children’s general screen time	162
Figure 33 Most used device and amount of time	163
Figure 34 Eating habits while watching TV	165
Figure 35 Pilot study set-up	168
Figure 36 Flow chart of recruitment and participant involvement	169
Figure 37 Average TV watching time in hours before and after the pilot study	171
Figure 38 The word cloud shows the types of activities that respondents admitted being involved in.....	172
Figure 39 Participants’ weight concerns.....	175
Figure 40 Participants’ feelings towards continuous use of the device.....	177
Figure 41 Data collection process.....	182

Figure 42 Device home set-up and LED indication.....	184
Figure 43 Theoretical framework for current study.....	185
Figure 44 Energy monitor showing Kwh value for house 17.....	190
Figure 45 PA Week 1.....	193
Figure 46 First 5 weeks of intervention exercise data.....	194
Figure 47 First 5 weeks of PA and TV watching data.....	195
Figure 48 Responses on constructs measuring motivational changes.....	198
Figure 49 PA for week 10 - 13.....	199
Figure 50 Physical activity overview across weeks.....	200
Figure 51 Physical activity week 5.....	201
Figure 52 Low physical activity log.....	203
Figure 53 Physical activity and TV watching weekly.....	204
Figure 54 Daily average monthly PA.....	205
Figure 55 Average daily TV watching monthly.....	206
Figure 56 TV watching the lowest and highest recorded weekly averages.....	207
Figure 57 Post-intervention feedback (Participant 17).....	210
Figure 58 Study setup – Participants’ homes.....	214
Figure 59 TV watching before and after the intervention for all participants.....	217
Figure 60 Participant classification using three main variables.....	220
Figure 61 Participant classification using two variables.....	221
Figure 62 Participant classification using one variable.....	222
Figure 63 Participants’ behaviour archetypes.....	223
Figure 64 Physical activity daily average.....	224
Figure 65 <i>Responsive</i> group daily average exercise behaviour (week 1).....	226
Figure 66 <i>Responsive</i> week 1’s daily average (exercise excluding house 1).....	228

Figure 67 <i>Inert</i> group daily average exercise behaviour (week 1)	229
Figure 68 First 5 weeks of intervention exercise data (<i>Responsive</i> group)	231
Figure 69 First 5 weeks of intervention exercise data (<i>Inert</i> group).....	232
Figure 70 Weeks 1-5 daily average exercise and TV watching (Group 1).....	234
Figure 71 Weeks 1-5 daily average exercise and TV watching (Group 2).....	235
Figure 72 Daily average weeks 6-12 exercise behaviour (Group 1)	237
Figure 73 Daily average weeks 6-12 exercise behaviour (Group 2)	239
Figure 74 Survey questions addressing each psychosocial determinant measured	242
Figure 75 Behaviour change process for all participants.....	244
Figure 76 Motivational changes aggregate by participants'	246
Figure 77 Change in motivation (both groups).....	248
Figure 78 Attitudes relating to perceived ability	250
Figure 79 Attitudes relating to social norms.....	253
Figure 80 Attitudes relating to control beliefs	257
Figure 81 Attitudes relating to interest/motivation.....	261
Figure 82 Attitudes relating to forced functionality	263
Figure 83 Post-intervention feedback (<i>Responsive</i> group)	269
Figure 84 Post-intervention feedback (<i>Inert</i> group)	271
Figure 85 A scatter plot conditioned by participants' TV time against physical activity.....	275
Figure 86 A scatter plot conditioned by gender for TV time against physical activity	276
Figure 87 Behaviour habituation determinants	282
Figure 88 Identifying challenges and opportunities related to the behaviour change process.....	289
Figure 89 Behaviour habituation model.....	291

Figure 90 Intervention evaluation by phases296

List of Tables

Table 1 Summary of some behaviour interventions with theory applications.....	50
Table 2 Operational definition of constructs used in this thesis.	92
Table 3 Theoretical construct conceptualisation.....	93
Table 4 Inclusion and exclusion criteria for main study (DUS)	135
Table 5 Research methodology summary	138
Table 6 PA input and TV output value allocation	156
Table 7 Synopsis of pilot study approach	166
Table 8 Inclusion and exclusion criteria for the pilot study.....	168
Table 9 Sample of User Pre-intervention information and study duration.....	189
Table 10 User demographics	215
Table 11 Basic statistics for daily TV time.....	218
Table 12 Behavioural variables explanation.....	219
Table 13 Fixed effect parameters.....	273
Table 14 Basic statistics for daily exercise	277

Chapter 1 Introduction

1.1 Introducing the thesis

The secret to long life, according to the longest living humans on earth, is engaging in daily physical activity (Poulain *et al.*, 2004). Therefore, staying healthy from a young age is vital for the purpose of extended life. Physical inactivity, in contrast, is the leading cause of death (WHO, 2010). Lee and others (2012) in their study, suggest that inactivity kills more people each year than tobacco smoking; the invention and widespread use of modern-day technologies could be blamed for this. Similarly, inactivity alone does not account for the rise in obesity, as commercial drivers such as consumers buying more high dense food, high car usage and energy-saving technological devices are also responsible for the increase in obesity rates (Swinburn, 2008). Thus, historical accounts suggest that the environment around us has dramatically changed with the introduction of technology and its ability to do almost any and everything for us, unlike in the past. Obesity itself, according to the WHO, is also a global epidemic with which higher death rates, although most obesity-related illness has been attributed to a lack of physical activity. In a technical report published in the year 2014, obesity was labelled as an epidemic/pandemic and therefore became a global health problem (WHO, 2014). There is a need to discuss all the parameters that have contributed to this global epidemic. Therefore, the details of this thesis disclosed how body weight has been rising due to a combination of inappropriate diet and lifestyle patterns. It is evident that environment, as stated earlier, broadly affects people's behaviour and can be categorised as physical environment, economic factors, policies, and socio-cultural drivers (beliefs, attitudes and perceived norms) (Swinburn, 2008; Emley & Musher-Eizenman, 2018). Categorising these drivers has been helpful in providing a robust

framework for interventions targeted at curbing obesity. Behaviour, as one of the dependent factors of inactivity, has been researched to draw a nexus on further research encouraging ambulatory movement being one of the steps to address obesity crisis (Biddle, 2010; Silverstone & Teatum 2011). The problem with looking at laziness is that it fails to capture the fact that people are becoming active subjects of modern technology.

Moreover, there is a need to reconsider how the technology movement is transforming our everyday lives (Silverstone and Teatum, 2011). Such consideration, from the view of the current study, exposes an apparent gap: that denying people, the use of these modern-day screen devices will be counter-productive thus, the need to modify their use while restoring physical movement will be more effective. Furthermore, this marked a significant shift in the understanding of body weight and its adverse effect on health.

This thesis sets out to analyse the trends that have led to the development of this shift, such as lifestyle, and how interventions targeted at behaviour change could improve health and well-being. This introductory chapter outlines the problem this thesis is trying to address, and as a way of introducing the topic, it discusses the background of the obesity epidemic and its relationship with certain lifestyle trends. Further in this thesis are discussions around theoretical underpinnings and how applicable they are to obesity as a public health problem. It then goes on to highlight the research aim and objectives and the research questions pertinent to the study. This introductory chapter also includes an overview of the thesis structure.

1.2 Rationale of study

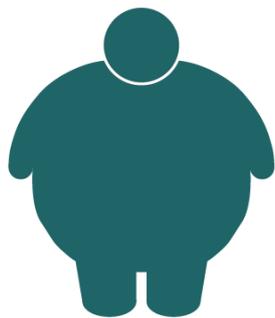
The focus of the thesis is to bring change in physical inactivity behaviour in the domestic environment. In the simplest form, physical activity (PA) describes “any bodily movement produced by skeletal muscles resulting in energy expenditure (EE) (Caspersen, Powell and Christenson, 1985). The main reason for inactivity is the changes in children and young people’s lifestyle over several decades, particularly in relation to screen-based sedentary behaviour and its association with poor health outcomes (Berkey *et al.*, 2000; Bickham *et al.*, 2013). This led the American Academy of Paediatrics (AAP) to recommend that parents should limit the screen exposure of children aged 6 or older, with consistent limits on screen time: 2-5 years of age not more than two hours per day and children under the age of 2 less than two hours a day (Bar-On *et al.*, 2001). Similar, recommendations following the AAP guidelines were issued by the Canadian Paediatric Society (2017), necessarily recommending no screen time for children under the age of two, and an hour’s limit for 2-5 years of age with no screen use before bed. The United Kingdom (UK) did not publish any recommendations on screen time until recently. But even then, the Royal College of Paediatrics and Child Health (RCPCH) in their recent guide were unable to recommend an appropriate screen time guideline for children (RCPCH, 2019). They argued in contrast that the evidence of screen exposure having an impact on health is weak. They proposed that the studies that have investigated the connection between screen time (ST) and adverse health effects may be mediated by the ST displacing opportunities for more positive behaviours such as socialising, engaging in exercise and sufficient sleep. This is the premise upon which the current study is based, despite contesting the UK’s RCPCH guidelines on not recommending a cut off time for children’s screen time. The

intervention set out for the current study will enable parents to negotiate ST limits with their children, by encouraging them to displace some of the time spent on watching TV with exercise, with the aim of instigating new healthy behaviour in children.

In the WHO/European Region



Over 50%
of people are
overweight or **obese**



Over 20%
of people are
obese

Figure 1 WHO report on obesity and overweight WHO, 2013 (remade by author)

While obese individuals appear to be at higher risk for poor health outcomes than those classed with a healthy weight, obesity has a significant impact on productivity. Also, the recent rapid increase in childhood obesity in many developed countries (Marshall et al. 2006; Reilly & Dorosty 1999; Campbell 1995), has been attributed to lifestyle behaviours such as TV viewing and other sedentary behaviours which have been argued to contribute to physical inactivity (Wijndaele *et al.*, 2010; Hoyos Cillero & Jago 2010). Experimental data suggest that clustered lifestyle behaviours varying from reduced PA, excess screen time activities and too

much sitting, are all contributors to this global epidemic (Cassidy *et al.*, 2016). WHO further supports that physical inactivity has been a predominant cause of major chronic health problems including, but not limited to: obesity, cardiovascular diseases, and diabetes (WHO, 2018). Thus, reducing the time people spend being inactive will be productive if this can be reallocated to more active behaviours. Blair and others (1992); Epstein & Roemmich (2001) suggest that this will have a significant impact on energy balance and general body fitness.

According to WHO (1948) “health is a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity” (p.100). Thus, for people of all ages inactivity has been identified as a serious public health concern (Mérelle *et al.*, 2017; Stewart *et al.*, 2017). PA is a behaviour that can favourably modify health; thus, Morris (1994) labelled it “today’s best buy in public health” more than a decade ago, with suggestions that increasing PA by at least 10% will result in significant health care savings globally (Katzmarzyk & Janssen 2004). Yet, according to the British Heart Foundation (BHF) report published in 2015, a significant amount of young people do not participate in sufficient PA to meet the Public health recommended guidelines (British Heart Foundation, 2015).

Some studies suggest that increased PA has the potential to reduce the risk of obesity and other cardiovascular-related diseases (Dobbins *et al.*, 2013; Lind *et al.*, 2017; Ostendorf *et al.*, 2018). Department of Health guidelines recommends the engagement of up to 60 minutes of moderate to vigorous PA (MVPA) daily for people aged 5-18 years (Department of Health, 2011). Despite the PA recommendations, there is a growing concern that the general population are inadequately active and therefore prone, to health risks such as obesity (Karnik and Kanekar, 2012). Moreover, the level of obesity and overweight crisis is rising

among the said population, especially within developed countries (Chinn and Rona, 2001). The obesity prevalence has seen a rapid increase in children and young people in most industrialised countries (Chinn and Rona, 2001; WHO, 2013). Figure 2 confirms the proportion of children globally (36%), who are categorised as either overweight or obese from a recent WHO report. Recent evidence suggests that in obese children, most of the excess weight accumulated tracks into adulthood with significant long-term health implications. Therefore, early childhood or teen years are vital periods for the development of interventions targeted at increasing PA to promote overall health (Suh & Kim, 2019). WHO advises authorities to create supportive environments as they are fundamental in helping both young and older people to make healthier choices whether to exercise or eat properly regularly.

COMBINED OVERWEIGHT
AND OBESITY RATE OF 10 - 17
YEARS OLDS

36%

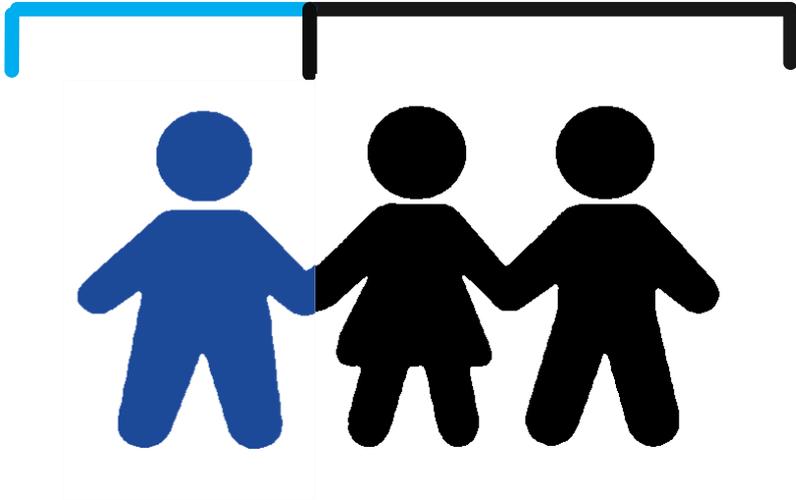


Figure 2 Obese and overweight statistics by WHO 2017 (remade by author)

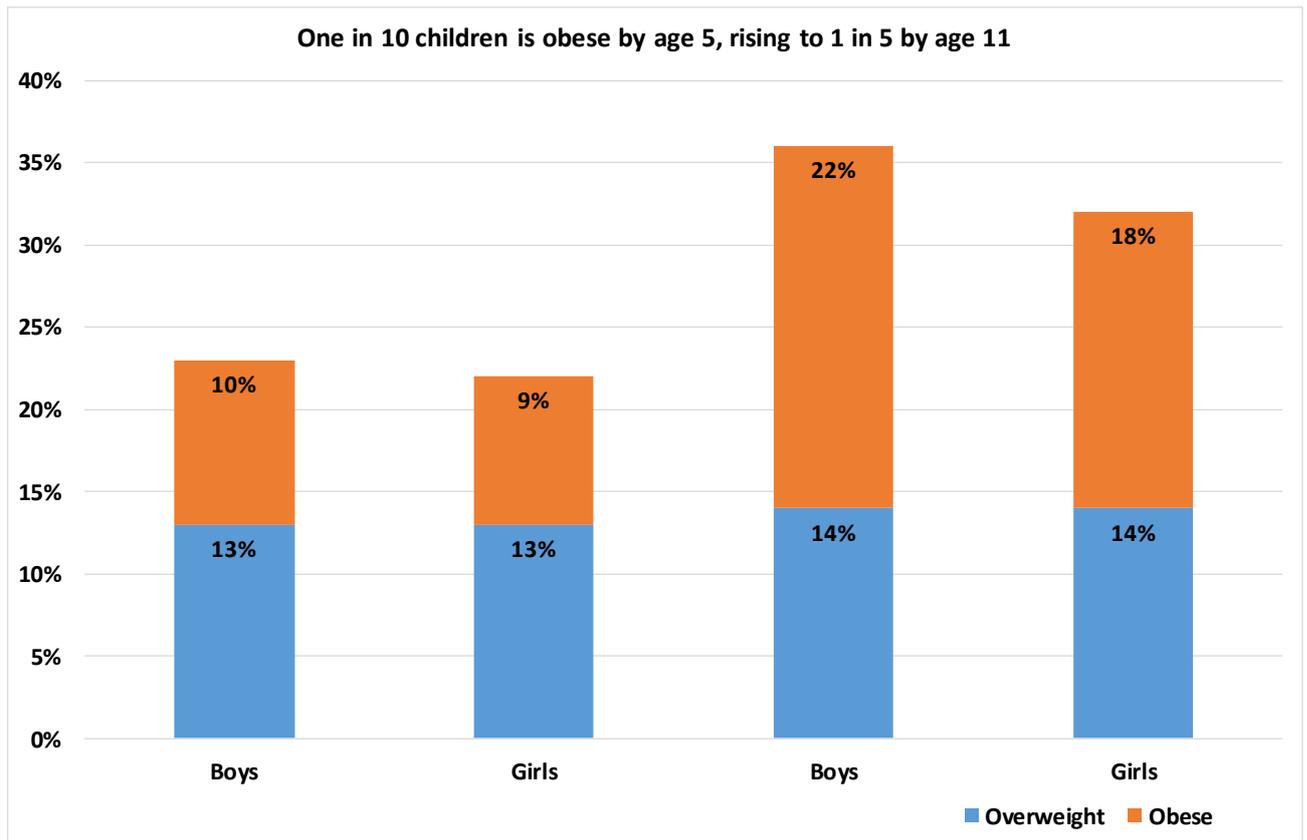


Figure 3 Obese and overweight primary school children in the UK Graph (Baker, 2019) (remade by author)

A lot of different factors are suggested to contribute to low levels of PA and energy imbalance. Some suggested examples of moderate to vigorous activities include: brisk walking, basketball, football, dance, cycling, and stair climbing. West and others (2010) reported from their randomised clinical trial that parents gained confidence in managing their children’s weight-related actions. Thus, refrained from applying force when it comes to encouraging them to exercise. Their parent-centred intervention for overweight and obesity resulted in increased confidence in managing their children’s dietary activity pattern over a year through follow up. Their study recommended that future research is required to evaluate the long-term effectiveness of interventions aimed at changing weight-related behaviour such as exercise. Other researchers suggest that to improve the health outcomes of children, it will be crucial to create sustained lifestyle patterns of regular PA that will transcend into adulthood (Lopes *et al.*, 2007). Thus, the current study focuses on not

only deploying the intervention to improve exercise habits, but also to evaluate the habituation process; and ability to sustain the changed, and new, behaviour. This calls for a crucial identification of approaches that will effectively increase and maintain activity levels of children across all ages.

There are various settings in which promotion of PA can occur. This includes outdoor or indoor home environments, school environments and recreation centres (Owen *et al.*, 2000). The home environment has often been ignored, although scholars often place emphasis on it as a domain with the capabilities of being able to create opportunities to reinforce positive behaviours in their children (Owen *et al.*, 2000). Children and young people spend a considerably high number of their waking hours being sedentary at home; some factors such as low social-economic support from parents, little PA self-motivation (Van Der Horst *et al.*, 2007) and technological advancement give rise to low levels of PA.

As established above, some of the health consequences of sedentary habits appear to be weakened when more time is spent being active (Ekelund, 2012). Consequently, it has become a public health priority to promote PA in young people (Pate *et al.*, 2016) with a focus on targeting good behaviours that could potentially reduce sedentary behaviour (SB).

1.3 Defining screen-based sedentary behaviour (SB)

Before discussing the context and the goal of exploring the measurement, perception, practices and adverse outcomes around screen-based SB, it is essential to define what is meant by SB and then screen-based SB in this thesis. This is primarily due to the term SB often interchangeably used with ‘inactivity’, ‘screen-

time’, ‘low energy expenditure’ and ‘time spent sitting or lying’ (Hamer and Stamatakis, 2013; da Silva *et al.*, 2017; Tremblay *et al.*, 2017).

SB has been recognised as a growing issue in the field of public health (Diaz *et al.*, 2017). The word ‘sedentary’ is derived from the Latin term “sedere” which means “to sit” (Magnon, Dutheil and Auxiette, 2018). By definition, SB is *any waking behaviour characterised by an energy expenditure 1.5 metabolic equivalents (METs) while in a sitting, lying or reclining position* (Chastin, Granat 2010; Tudor-Locke, Myers 2001). ST, has been argued to be the top activity in the thematic field of SB activities (Pate *et al.*, 2008). Thus, in the interest of clarity, screen-based SB, in the context of the thesis, refers to any sitting or lying inactive time spent on-screen devices such as TV, tablets, computers, video games and mobile phones.

1.4 The research context

In the UK and globally, a lot of children and young people are not meeting the current recommendations for PA (Hallal *et al.*, 2012). A BBC¹ (2018) report suggested that one in three children in England participates in less than 30 minutes of PA daily, which is less than the recommended amount in government guidelines. PA is vital for good physical health according to the WHO definition for health. Although this definition has been widely applied and accepted, the unrevised nature of this definition has been criticised; some have even proposed a change in meaning in that health should be considered ‘the capability to adapt and to self-monitor’ (Huber *et al.*, 2011). Though the disagreement about the definition of health has been emphasised, the most common reasons are due to health referring to medical, spiritual, social, societal and economic impact (Larson, 1999). There is a wellness

¹ British Broadcasting Corporation

definition which defines health as power and capability to overcome diseases, having a “reserve of health” (Larson, 1999 p. 129), which contradicts the WHO definition in that poor health can occur even in the absence of disease. Other authors who have defined health from the wellness model state that health can be viewed as “optimal personal fitness for full, fruitful creative living” (Goldsmith, 1972 p. 213). This paradigm perceives health as having an essential link between mind and body and, this can often be overlooked by the holistic WHO definition. The wellness model is more concerned with health promotion and disease prevention as it not only focuses on general improvement of health but also promoting positive aspects that encourage healthy lifestyles. The overall intention of having a measurable definition of health is to promote disease prevention in the first instance, as well as promoting better ways in which people could lead a healthy life such as encouraging proper eating habits, exercise and avoiding stress. Thus, lifestyle trends such as children and young people spending a substantial amount of their day on sedentary pursuits (Fa’ *et al.*, 2012; Hallal *et al.*, 2012) are considered unhealthy and should be tackled by fostering lifestyle changes to discourage these behaviours.

Nevertheless, the call for a national focus on increasing childhood activity is seemingly essential. Understanding the trends in PA behaviour and its practices amongst adolescents is fundamental (Marques, Gaspar de Matos, 2014). However, from previous studies, the most common activity that impacts on people’s PA lifestyle is ST and, this is seen in various populations including children and adolescents (Krebs *et al.*, 2003; Healy *et al.*, 2011). ST including TV viewing, computer use, playing of video games and use of tablets like iPads not only increase consumption of high levels of concurrent food intake but it also negatively influences people’s behaviour (Escobar-Chaves and Anderson, 2008; Wang, Lin

and Ke, 2015). Some of the adverse outcomes such, as obesity and overweight have been attributed to the above lifestyle trends (Dietz, 2004). Thus, reducing ST has been considered a public health concern over the recent years and researchers have attempted tackling it through a variety of ways: behavioural counselling (Moyer *et al.*, 2004), mobile app intervention (Lubans *et al.*, 2014), retrieving TV from children’s bedrooms (Wethington, Pan and Sherry, 2013), exergaming² (Maloney *et al.*, 2008). These interventions have yielded numerous outcomes but have had little success in reducing ST amongst the targeted population mostly, due to their participants getting bored and not staying consistent. This calls for new ways in tackling the ST issue, possibly by not only reducing the consumption but encouraging children to change their habits which is what this thesis proposed. To the researcher’s best knowledge, this thesis is the first study that has approached ST reduction from a design-led approach, whereby a specific device is developed to help users regulate their ST whilst increasing their exercise.

1.4.1 Design-led intervention

Firstly, design as a broad term has been historically defined as “*the process of planning, creating ideas, and implementing these ideas, to improve the artificial environment*” (Herbert, 1968 p 68). In a recent report, design was highlighted as an essential link between creativity and innovation in the field of design (Design Council, 2017). It was categorised into three components: ‘creativity’ as the creation of new ideas, ‘innovation’ as the effective exploitation of new ideas resulting from creativity, and ‘design’ which forms these ideas, thus linking creativity and innovation. The above coalition of three different things suggests that in today’s economic environment, design has been implemented with the use of

² Exergaming – interactive fitness involving exercise and video gaming.

technology to transform ideas into tangible products or operational processes whereby design determines the ability of these products to meet customer/user needs (Trueman & Jobber 1998).

On the other hand, the term 'design-led' is defined as "*the tools and approaches which allow design thinking to be embedded as a cultural transformation within a business*" (Bucolo & Matthews, 2011 p. 9). Arguably, design thinking illustrates how designers think and act towards creating solutions to problems from a variety of perspectives; iterative improvement of possible solutions (Dorst, 2011; Kimbell, 2011), while synthesising the needs of the intended user with considerations of economically and technologically feasible methods (Brown & Katz, 2011). Accordingly, design in this context is viewed as the consortium of form and function to create a sustainable competitive advantage to revise the customer/user proposition. Overall, designers and design companies are becoming more socially responsible in the development of their products and services in order to tackle societal problems. In the current society with numerous social problems, utilising design methods to address this social problem has been widely implemented. For instance, one study that sought to use design-led service improvement to involve older people in the use of medical outpatient services demonstrated that design-led approach which centres on lived human experience develops creative and practical possibilities to solving significant real-life healthcare problems (Wolstenholme *et al.*, 2010). Similarly, Shin and Bhamra (2016) in their study to design for sustainable behaviour change endeavoured to apply the possibility of utilising human power as the primary source of energy for everyday user use in the home. The main result from their study proposed that the human power generator was not merely viewed as an object that generates electrical power but mostly as a tool to

practise energy-saving behaviour which in turn give health benefits – the exercise routine.

Concerning the proposition to address the screen-based sedentary problem, a design-led approach may play a pivotal role in combining design thinking with the need to tackle users' lack of motivation to engage in PA, by providing a platform in which users maintain a degree of perceived autonomy.

Design-led intervention in the current research is the process of instigating 'behaviour change' through design to encourage more responsible PA/ST in the home environment. The concept of design-led intervention in the current research is linked with existing literature to fill a significant gap between replacing screen sedentary time with a more active behaviour such as PA. It uses a prototype called the Knudgbox (see Chapter 5) which has been designed to stimulate behavioural motivation for building people's exercise habit. With limited empirical data in the field of Design for Sustainable Behaviour, this study hopes to gain further understanding and provide great insights into how the role of design and its application could impact on solving a societal problem such as obesity.

1.5 Research Aim

The overall aim of this study is to evaluate the design-led intervention that is designed to reduce sedentary behaviour in the domestic environment. The primary focus of the thesis outcome is to evaluate its effectiveness in instigating habitual physical activity whilst reducing screen time with emphasis on sustaining this new habit.

1.5.1 Objectives

Below are the specific objectives that were developed following the research aim:

1. Determine what constitutes screen time sedentary behaviour and ascertain their relationships with health outcomes.
2. Establish the corresponding relationship with children's lack of PA and excessive screen engagement.
3. Determine to what extent behaviour change theories can support the initiation of new exercise behaviours.
4. Demonstrate the effectiveness of behaviour change techniques in predicting changes in usage of the research tool.
5. Establish the operating principles of the Knudgbox and its effectiveness as an intervention for reducing ST.
6. Evaluate the efficacy of design-led intervention approach in instigating exercise behaviour and, reducing TV time, highlight evidence for sustainable behaviours.

1.5.2 Research Questions

The previous sections have drawn together the study rationale and the background in which the current study is being researched. To be able to achieve the set aim and objectives, it is vital to formulate the research questions that will guide this research.

Thus, the overarching research question to be answered during the course of this PhD is *Can design-led intervention instigate physical activity behaviour and reduce sedentary screen time, specifically for children within the domestic environment?* In order to explore this question fully, this is further broken down into sub-questions.

1. What is the current background of research related to PA behaviour, and how does it indicate possible interventions to tackle the obesity crisis?
2. How can behaviour change theories create pathways for developing physical activity interventions?
3. How can longitudinal investigation identify key behavioural determinants that influences change?
4. What behavioural changes are evident as a result of the intervention?
5. What are the changes in the measured psychosocial determinants over time?
6. What are the key effects of the design-led intervention on habit formation and behavioural intention?

1.6 Research phase breakdown

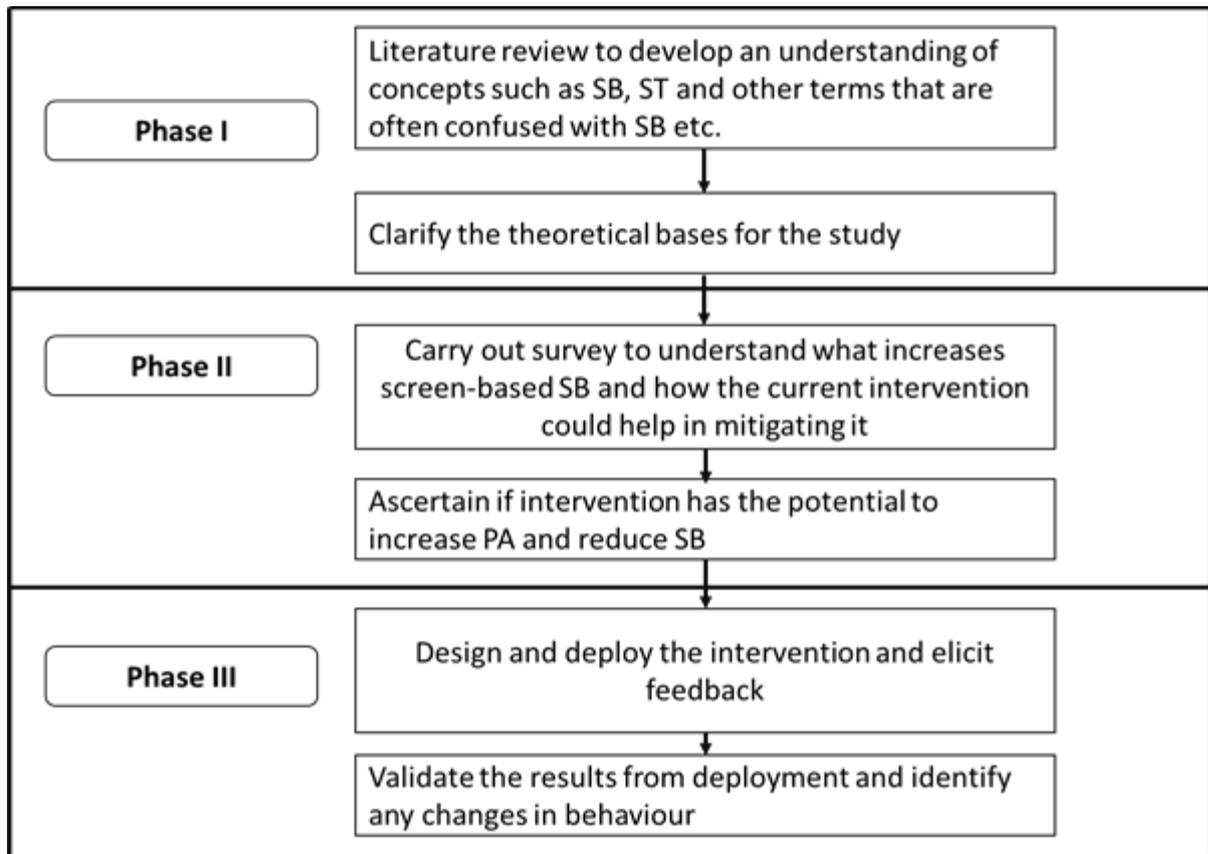


Figure 4 Steps taken in the current study

Figure 4 shows the overall structure of the study. The literature review (phase 1) prompted phase 2, whereby it was essential to understand the viewpoint of parents on the issues around ST. The outcomes of the two phases included the finding that there was a need to approach the problem of physical inactivity and excess ST using a different method. Another outcome from phase 2 was that parental attitudes and norms could be a huge factor to consider when creating interventions to address this issue. Thus, during phase 3, which was essentially a DUS, the researcher evaluated the effectiveness of the proposed design-led intervention to address the problem of inactivity as well as psychosocial determinants that may influence the participants during the study; this will be discussed in detail in chapter 3.14.1. The term ‘psychosocial’ refers to the social and wider factors that influence the individual’s

mind or behaviour (Oxford dictionary). This term is widely applied in literature in relation to health outcomes and relates to WHO's definition of health is a complete state of physical and social wellbeing (Martikainen *et al.*, 2002). Within this thesis, 'psychosocial' pertains to broader contextual and social factors that influence participant behaviour which was measured using different constructs discussed in chapter 3.14.1.

1.7 Positioning the research and its contributions

Thinking about behaviour change, design-led intervention provides significant insights into how direct observation through design can be employed, by deploying the Knudgbox as a research tool to be tested for its effectiveness in reducing screen-based SB as well as increasing PA. Although critics appreciate the fact that these devices brought about profound change in our society (Martins *et al.*, 2016). The reviewed literature showed an association between TV viewing and levels of obesity. Arguably, excessive TV viewing contributes to being overweight or obese through the displacement of activities such as structured physical activities and free play. Swinburn and Shelly (2008) in their study suggest that behaviours like TV viewing and ST are potentially modifiable behaviours, and considering its link to obesity, interventions aimed at reducing it may have a significant impact on the reduction in obesity levels. For example, the pilot phase of the study showed that children's baseline TV viewing time is 3 hours on average a day; the exposure to the Knudgbox as a tool reduced this significantly and halved this time by 70%. To the best of the author's knowledge, this is the first study of its kind utilising design-led intervention as a tool to mitigate and reduce screen-based SB and increase PA. Thus, the novelty lies in using a design-led intervention approach in combination with behavioural psychology to break bad habits (screen-based SB). The uniqueness

of this, rely on providing a healthier replacement option (PA) for the users, which in turn still offers the choice to engage in screen-related activities but at a reduced rate.

This thesis is the first to contribute to the existing research gap whereby it utilises the design approach to foster ST displacement which, is an entirely new direction within this field of study. This leads to the conclusion that, within the current research, the use of the above approach has not been researched thus this thesis brings fresh insights to this topic by viewing PA interventions in the multidisciplinary dimensions of Public Health, Product Design and Behaviour Science. The final contribution presented within this thesis demonstrates a new theoretical and methodological direction for studies of its kind. This thesis developed and implemented a practical, qualitative approach to understand the determinants of user behaviour through design-led intervention. It developed a concept that disaggregates the habituation process and how this can be applied in future interventions, potentially applying the design elements. One of the key contributions is the longitudinal investigation using a design-led approach, which uncovered the attitudes and motivation of the user behaviour, and the evaluation of the intervention.

1.8 Organisation of Thesis

The main aim of the thesis is to design and evaluate an intervention to encourage children to be physically active, accordingly, to promote sustainable lifestyle behaviours in the domestic environment. Following this introduction, whereby the author provides a clear synthesis of the research problem, the aim and objectives of the study are described. Chapter two outlines and elaborates on the review of the literature. Within that chapter, some of the key topics discussed are: the obesity trends and its association with physical inactivity, determinants of inactivity (this

includes but is not limited to technology, modernisation, and lifestyle trends), and societal influences. In addition, various interventions that have attempted to tackle the issue are discussed, with public health recommended guidelines and behaviour change models that are relevant in the intervention. Through this critical review, the highlighted limitations, gaps, and inconsistencies provided a rationale for the study methodologies designed for this thesis. The next chapter (3) presents the second phase of the literature review, where the author contextualises relevant theories by highlighting how these theories have been previously applied in different contexts. This led to the formulation of the theoretical framework that guided the empirical investigation of the current study. Chapter four further examines the methodological approaches, research paradigms and the justification for the chosen methodology. It also touches upon the framework of the present study with emphasis on the iteration process of the research tool. With chapter four, the author justifies the need for undertaking a longitudinal investigation and reason for the choice of the study demographic selected for DUS. Chapter five highlights the need for developing a research artefact with evidence from the literature on the validity of the results obtained from these kinds of material. It also discusses the choice of hardware, software and the iteration process for the artefact development. Chapter six presents the findings of the first phase of the empirical study, which aimed to ascertain the level of understanding of parents on the subject of SB/PA. This chapter also discusses the result obtained from the pilot testing employing the study prototype. This was conducted in order to examine the feasibility of the DUS. Chapter seven reports one household as a case study, providing details of the data collection process and all results obtained from that household. Chapter eight further presents all results from all participants; however, due to the large volume of data collected,

this data is presented by grouping the participant by behaviour archetype. Chapter nine evaluates the effectiveness of the intervention by presenting the behaviour habituation model with discussions on the interdependency of the identified dimensions. It also highlighted the challenges and opportunities of behaviour habituation as it applies to the current study. The final chapter of this thesis presents how the research questions, aim and objectives were met. It also presents all contributions to knowledge, such as theoretical and methodological contributions, contributions to design for sustainable behaviour research and public health, before drawing out significant recommendations for further studies. In reflection, the author also highlighted the study strengths and limitations encountered during this PhD research, with a reflective account of the entire PhD journey.

Inclusion criteria was community-based interventions, sedentary behaviour studies, policy-based PA interventions, cross-sectional and other observational studies targeting health behaviour change.

Exclusion criteria was clinical studies, Randomised control trials, studies with interrupted time-series, studies with no follow up and studies including only one gender.

Figure 5 illustrates a word cloud that emerged from the search results using NVivo, with the following search terms: obesity, childhood, television, video games, sedentary behaviours, inactivity, PA, interventions, sustainable design, evidence-based interventions, and motivation. Randomised controlled trials, longitudinal and cross-sectional and other relevant observational studies were included. An interdisciplinary approach was essential to cover the diverse range of literature that was necessary to position the study gap identified during this PhD study.

2.2 Obesity problem

In the last 40 years, there has been a rapid global increase in the popularity of people who are either classed overweight or obese, with figures in the UK and United States (US) quickly rising since the last decade. The global statistics for people under 20 years of age, suggests that around 1.4 billion are overweight with increasing numbers for adults over the stated age (Kelly *et al.*, 2008). Their studies also suggest that the total estimation indicates that amongst the global adult population, over 10% of these group is believed to be obese. In 2016, the global figures soared to 1.9 billion young adults under the age of 18 classed as overweight and of these, over 650 million obese (WHO, 2017). In 2013-2014, the US released a report that 34% of people who fell in the ages of 20-39 years old were obese (Ogden

et al., 2015). In Europe, the UK currently has the highest prevalence of obesity, with 27% of the population diagnosed as clinically obese and 36% overweight (Dearden, 2017). Although the obesity rate appears to be increasing in many high-income European countries, the UK seems to have an accelerating and more rapid rate than many other parts of the world.

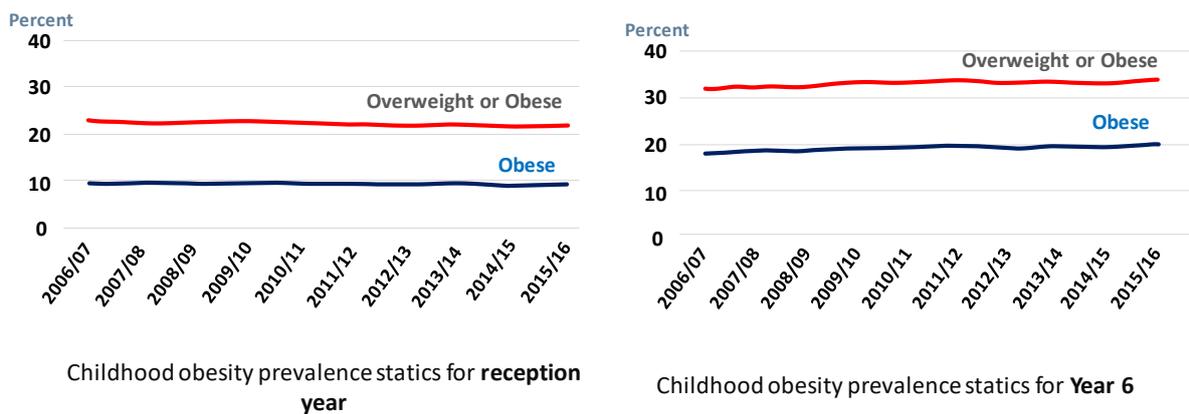


Figure 6 Childhood obesity prevalence (Source; NHS England Statistics on Obesity in Statistics team report, 2018) remade by author

One in 5 children in reception year were considered obese or overweight in a 2015/16 NHS report. Figure 6 above illustrates that in 2015/16, in year 6 20% were obese and, in comparison to the previous report in 2006, there had been a 3% increase in this figure, which is projected to rise to 20% by the year 2025. A BBC (2017) report revealed that one in every 10 young people aged 5 to 19 is obese. Also, in the same year, there was a global record of 41 million children under 5 years of age, being described as either obese or overweight, and about 340 million children and teenagers from ages 5-19 were reported to be obese (Statistics team, 2018).

Another BBC report (2017) showed that a study which included 12,000 children found that 25% were overweight or obese at by the time they were 7. This figure

continues to rise to 35% by the age of 11. From this report, it can be argued that 11-14 years is a window where a lot of changes, due to children of this age bracket's ability to make independent food choices and this became an interesting age group to explore.

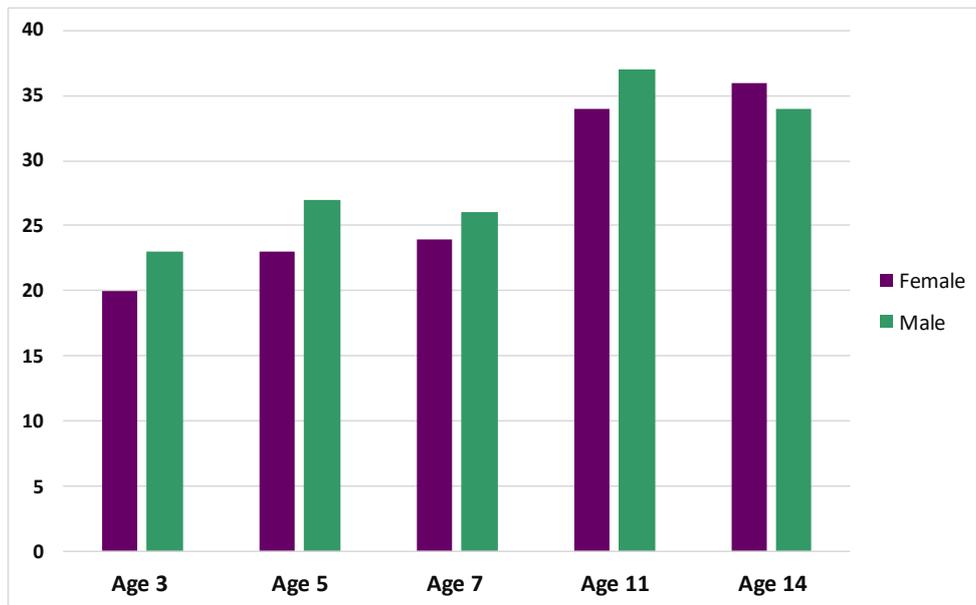


Figure 7 Proportion of UK children classed as either obese or overweight, (Source Millennium Cohort study, Centre for Longitudinal studies in Fitzsimons, E. and Pongiglione, B., 2017)

Studies suggest that children start to take control of their decisions during the early to the mid-adolescence stage; some of such decisions are choice of engagement in exercise, diet and other leisure time activities. Since this is a crucial stage, it might be worth developing interventions that give them autonomy to make the right decisions.

Nevertheless, the WHO report shows that behaviours such as PA and diet are modifiable risk factors associated with mortality and morbidity, which account for 63% of deaths globally (WHO, 2014). Traditionally, PA is believed to be beneficial to health; nevertheless, past studies have employed objective monitoring approaches to encourage PA behaviour. For instance, numerous studies found that there is an

increased health benefit from only little engagement in light PA (Healy *et al.*, 2008; Dunstan *et al.*, 2012; Carson *et al.*, 2013). In reality, according to Pratt and others (2012), there are several domains in which an individual can be physically active such as leisure, occupational, transport and household. Leisure PA could include sports participation of either structured or unstructured play (Ng & Popkin 2012). Within the active travel and household domain, cycling and housework/chores respectively contribute to people's total PA, seeing as movement is involved (Petee Gabriel *et al.*, 2012). It is therefore essential to consider that, within the various domains where PA can occur, an individual can be physically active or physically inactive.

2.2.1 Impact of Obesity

Recently, public health practitioners have shown a growing concern regarding the impact of sedentary lifestyles on people's health, particularly with regards to the increasing trends of obesity and overweight amongst young people (Marshall *et al.*, 2006). Obesity is generally associated with poor outcomes, including early mortality and cardiovascular disease (Cassidy *et al.*, 2016). In the last decade, the fast-food pattern has dramatically increased, thereby changing people's diet system, consequently resulting in the global issue of obesity. Obesity is a chronic disorder which can be linked to multiple causes and has been noted to affect an individual at either isolation or population level. In England, treating obesity and overweight related conditions costs billions of pounds each year. Estimates of indirect costs from the broader impact of obesity range between £2.6 billion to £15.8 billion, simultaneously direct costs between £479.3 million in 1988 to £4.2 billion in 2007; (Richardson *et al.*, 2011). Accordingly, obesity and overweight are as a result of the

consumption of excess calories and low expenditure of human energy (El-Sayed, Scarborough and Galea, 2012).

Scholars have further suggested that overweight and obesity contribute to global death, and has been estimated as the fifth leading risk factor (Hoogeveen *et al.*, 2017; Stewart *et al.*, 2017; Smith and Smith, 2016). Smith & Smith (2016) in their study have shown that 3.4 million deaths are recorded annually as a result of obesity. With diabetes and obesity interlinked, Ahmad (2016) sums up the figures of people suffering from both diabetes and obesity to 1.2 billion of the world's population.

Therefore, it is not a surprise that some developing countries are also on the brink of an obesity crisis; arguably due to modernisation and technological development which could be blamed for creating this problem. As discussed in chapter 1, obesity results from the accumulation of excess fat to the extent that health is impaired (Rogers and Brunstrom, 2016). Hill (2012) argues that a small fraction of energy imbalance is sufficient to put a person at risk. For instance, a negative energy imbalance of about 100kcal/day could potentially prevent unhealthy weight gain in a broad population. Typically, energy imbalance does not only arise as a result of excess calories: reduced PA and an increase in sedentary activities are also contributing factors. Nevertheless, the evidence suggests that there is an existing relationship between reduced risk of developing cardiovascular disease like obesity and leading a physically active lifestyle. Townsend and others in their review reported within BHF (2015) suggest that the statistics on children and adolescents' PA has seen a sharp decline since 2008. Their suggestion centred around the need for more interventions around determinants of this behaviour. Accordingly, this

thesis presents evidence on how to effectively increase the PA of children and young people, particularly in the home environment where most of SB occurs.

2.3 Drivers of childhood obesity

Obesity is mostly a result of people responding to the trends in the obesogenic environment they find themselves in. The prevalence of obesity increased from 15% in 1993 to 26% in 2010 (Swinburn *et al.*, 2011). This increase has undoubtedly been affected by the intensified supply of energy-dense foods and its system, resulting in more persuasive food advertising; the fast-food boom and the lack of exercise (Styne, 1999). This thesis recognises the above as one of the critical drivers of obesity. However, the focus of this thesis also puts a heavy emphasis on the role of the home where sedentary activities are predominantly seen. It is therefore important to shed some light on other key drivers of obesity.

Some studies have found positive links between PA and health outcomes; however, the optimum level of PA required to achieve and maintain good health is unclear. This may vary for different health outcomes for diverse populations. There is also an unanswered question of whether inactivity (e.g. SB) and PA are to be treated as separate constructs rather than merely as contrasting terms. For instance, one can attain the recommended levels of PA daily yet accrue long periods of SB. For children, this is widely seen due to excessive amounts of time spent on technological devices such as TV and screen-based entertainment devices (Vioque, Torres and Quiles, 2000). This notion put more emphasis on the need for a research in creating interventions to encourage more active behaviour in the home environment. Nonetheless, other aspects like genetics play a significant role in the accelerated growth of obesity (Anderson and Butcher, 2006).

2.3.1 Genetic factors

As already established in the previous chapter, obesity is a multifactorial condition. Evidence indicates that there are complex interactions between genetics, intrauterine environment and non-genetic factors (Kipping, Jago and Lawlor, 2008). However, obesity is also known to have a fundamental genetic factor contributing to its aetiology (Grant, 2014). Body mass index (BMI) is a universally applied measure of overall obesity and, according to WHO classification, a person with a BMI of $\geq 30\text{Kg/m}^2$ as obese (WHO, 2017). Herrera and Lindgren (2010) discuss the common subgroup classifications of obesity: monogenic obesity (severe obesity), syndromic obesity (clinically obese), and polygenic obesity. It is possible that polygenic obesity is the result of traits present in DNA (Hinney, Vogel and Hebebrand, 2010). In other words, any individual who harbours a high volume of polygenic variants has an increased chance of accumulating body weight (Giuranna *et al.*, 2018).

Medical scientists suggest that, although an obesity epidemic can be associated with genetic causes (O’Rahilly and Farooqi, 2006), changes in lifestyle over the past century have contributed more to the obesogenic environment. From an economic point, lifestyle changes have been hugely driven by food prices which gave people incentives to consume more with the intention of burning fewer calories (Cawley, 2010).

2.4 Defining physical activity and inactivity in the context of this thesis

PA is defined “*as any bodily movement produced by skeletal muscle that requires energy expenditure, and ‘exercise’, as subset of physical activity*” (Caspersen, Powell & Christenson, 1985). Regular PA has been attributed to improving psychological wellbeing and other numerous health benefits (Janssen and LeBlanc, 2010). Notwithstanding this evidence, inactivity has reached pandemic levels (Kohl

et al., 2012) with the majority of children and young adults spending tremendous amounts of their waking hours being inactive (Hallal *et al.*, 2012; Griffiths *et al.*, 2013). Exercise refers to any planned/structured and repetitive activity done to maintain physical fitness (Chodzko-Zajako *et al.*, 2009). The participation in exercise results in bodily movements and have been shown to improve general physical fitness, and wellbeing, and operationally has been established to reduce SB. Thus, PA and exercise are related concepts. Consistent with this logic, physical activity and exercise within this thesis can be regarded as the same concept and will be used interchangeably throughout.

Physical inactivity (PIA) on the other hand is simply not meeting the Moderate to vigorous physical activity (MVPA) guidelines (Muhajarine *et al.*, 2015; González, Fuentes and Márquez, 2017). However, the problem of PIA is the second cause of preventable death worldwide (WHO, 2016). Thus, in the field of public health, promoting PA has been a long-standing focus (McMinn *et al.*, 2013). As discussed in chapter 2.2, people of all age groups are not sufficiently active to achieve optimal health benefits, with children and young people experiencing adverse health outcomes (Sawada *et al.*, 2010). As a result, the measurement of PA has become increasingly prominent, with several tools designed to assess and capture PA adequately.

2.4.1 Measurement of physical activity

The call for action on promoting PA has led to improving ways in which it is measured and evaluated in the recent past. PA measures can be used for several purposes, such as: identifying high-risk groups either by demographic characteristics or by geographic location, determining opportunities for intervention, as well as evaluating the outcomes from these interventions and pinpointing the

problem of inactivity (Sallis, 2010). The multidimensional nature of PA has resulted in the development of numerous measures with an increasing lack of consensus from researchers and practitioners regarding which measures are considered best (Silsbury, Goldsmith and Rushton, 2015). Besides energy expenditure, PA measures are supposed to provide information about the intensity, distance travelled, volume, duration and habitual PA.

The double-labelled water method (DLW) which was invented in the late 1940s, with its first human application from 1982, has remained the gold standard way of assessing total energy expenditure (Melanson, Freedson and Blair, 1996; Westerterp, 2009; Sylvia *et al.*, 2014). Its use in research is infrequent due to its expensive, time-consuming nature with high subject burden, and it does not offer any qualitative account (Sylvia *et al.*, 2014). The principle of DLW in measuring energy expenditure relies on the difference between the apparent turnover rates of both hydrogen and oxygen of body water in function with carbon dioxide production (Westerterp, 2017). Classification of PA measurement can be grouped into two recognisable methods used by researchers: self-reports (subjective) and objective measures/direct observations. Self-report tools are usually in the form of questionnaires, diaries/logs and interviews (Prince *et al.*, 2008). Unlike DLW, the self-report measures are popularly used due to their low cost, realism, and general acceptance (Dishman, Washburn and Schoeller, 2001). For instance, questionnaires have been widely used for nearly 50 years for PA surveillance in epidemiological and cross sectional studies to understand PA behaviour (Epstein *et al.*, 1976; Sternfeld and Goldman-Rosas, 2012). Questionnaires as tools have been classified into four: International Physical Activity Questionnaire (IPAQ) (Bauman *et al.*, 2009), Global Physical Activity Questionnaires (GPAQ) (Armstrong and Bull,

2006), short-term recall (Durante, Ainsworth 1996), and quantitative history recall questionnaires (Ainsworth *et al.*, 2015). IPAQ was developed to assess total population levels of PA across domains of work, leisure, domestic and active transport environments across countries (Craig *et al.*, 2003; Bauman *et al.*, 2009). It paved the way for the GPAQ, which provided the necessary measurements to support the inclusion of risks factors associated with surveillance of PIA (Hallal *et al.*, 2012). The above studies further suggest that the IPAQ and GPAQ data enabled a global comparative assessment of global trends of PA assessment for the first time. The GPAQ is a short and simple one-to-four item assessment tool which was endorsed by WHO to provide classification on an individual's PA status and has been widely used in about 100 countries to collect information on typical week frequency and duration of MVPA³ in three domains (work, transport and leisure) (WHO, 2018). Even though self-reports are valuable in gaining understanding into population PA, they have been suggested to over or underestimate actual energy expenditure and rates of PIA (Sebastião *et al.*, 2012). Its inability to capture absolute levels of PA has often been fraught with issues around response bias which relates to social desirability (Prince *et al.*, 2008). There has been several limitations on reliability and validity of self-reports and how researchers interpret questionnaire data in a quantitative sense (Shephard, 2003), thus, objective or direct measures of PA are generally used for accuracy and results are often reliable and consistent. Chu and others (2015) suggest that self-administered questionnaires like GPAQ offer a relatively inexpensive method for measuring MVPA in various domains. This method of subjective measurement can be an advantage with its ability to measure compliance of an individual's PA with PA guidelines, since its intensities are

³ Moderate and Vigorous Physical Activity

expressed in METs (Ainsworth *et al.*, 2011). One cohort study explored the validity of both type of recall questionnaires mentioned above in an occupational sitting time amongst Finnish and Chinese subgroups (Gao *et al.*, 2017). Their results have shown that these instruments provide an acceptable measure of office-based sitting time, although these types of measurements do not provide accurate measures at an individual level due to their high variability.

Direct measures such as DLW, physiological markers (biomarkers), monitors and motion sensors (pedometers, and accelerometry devices) and other wearables are believed to give more precise estimates of energy expenditure, without the issue of response bias seen with self-report methods (Prince *et al.*, 2008). This thesis presents a PA measure in the form of a design-led intervention which will add new knowledge on habituation process, especially for PA behaviour and measurement. Some researchers argue that there is no ideal measure (Shephard, 2003; Sallis, 2010; Ainsworth *et al.*, 2015; Silsbury, Goldsmith and Rushton, 2015). In most instances, the selection of measures depends on the purpose of the assessment, the number of individuals to be monitored, time, and availability of funds. Although self-report has its limitations, some researchers consider these tools to have contributed to a substantial understanding of health risks associated with PIA (Ainsworth *et al.*, 2015). The current study utilised design-led intervention and simultaneously adopted other validated instruments (survey), to provide a more comprehensive description of PA performance measured during the course of data collection. A consensus can be made that there is no one universal method to assess all the dimensions of PA, therefore suggests the need to provide more evidence on how people perform the intended behaviours. The design-led approach can be an ideal measurement to capture the behavioural data of users, due to its ability to

reduce the subjectivity inherent in some of the above methods, and its novelty in capturing the real-time data of changing PA behaviours. This will be discussed in more detail later in the thesis Chapter 5.

2.4.2 Contextualising sedentary behaviour

As discussed in chapter 1.3, many researchers have shown that prolonged sitting can lead to several detrimental health effects at both physiological (Biswas *et al.*, 2015) and psychological levels (Falck, Davis and Liu-Ambrose, 2017). Owen and others (2011) argued that SB can be defined in many ways but is mostly distinct from lack of PA, although others suggest that SB can be said to be too much sitting (Hamilton *et al.*, 2008). Even though prolonged sitting has been consistently associated with poor health outcomes irrespective of the time spent being physically active (Hinkley *et al.*, 2014), a growing body of evidence suggests that despite meeting the national PA recommended guidelines, some people may still be at risk of premature mortality, if their energy expenditure is below 2 METs (Salmon *et al.*, 2003; Hinkley *et al.*, 2014). Some of these could include increased risk of developing chronic diseases (Hamilton, Hamilton and Zderic, 2007; Healy *et al.*, 2011; S. J. H. Biddle, 2012). Nevertheless, that criterion alone is not sufficient to clarify what SB is. Indeed, standing has been said to have an energy cost closer to that of sitting (Henson *et al.*, 2016) without causing any adverse health effect attributed to SB. For instance, some randomised and experimental studies showed that standing for a few minutes to break up prolonged sitting has a positive impact on glucose metabolism (Thorp *et al.*, 2014; Henson *et al.*, 2016; Duvivier *et al.*, 2017).

On the contrary, other studies found no unanimity with the above findings; replacing sitting with standing did not benefit postprandial metabolism (Bailey and Locke, 2015; Hawari *et al.*, 2016). Magnon and others (2018) argue that the current

definition of SB is not clear enough to reveal the complications of SB with lifestyle. To clarify, the SB definition in chapter 1.3 excludes standing as a form of SB but grants an enhanced understanding of what differentiates SB from other activities.

The focus of this study herein is screen-based SB, including using smartphones, tablets, TV viewing, and other screen engagement activities. Tremblay and others (2011) in their systematic review, found an association between excess TV viewing (>2 hours) and reduced physical and psychological health in children and adolescents. Other studies show that not only does excess time spent on-screen affect children's general health, but spending prolonged hours on these devices was strongly associated with poor vision (Bener *et al.*, 2010), anxiety and depression (Maras *et al.*, 2015). The Canadian SB guidelines recognise two distinct forms of SB: screen-based SB (smartphone/computer/tablet and TV viewing) and non-screen-based SB (sitting at work/at school, motorised transport and sitting for socialising) (Active Healthy Kids Canada, 2011). Existing literature has shown that children spend over 6 of their waking hours engage in screen and non-screen based sedentary activities (BBC, 2015). Therefore, targeting this time frame which is predominantly spent on screen-based sedentary activities, may serve as an appropriate proposition to bring a change which can potentially impact on their health and wellbeing.

2.4.2.1 TV viewing

TV has been recorded to represent the largest source of screen-based media exposure for most children (Robinson *et al.*, 2017). Subsequently, there has been a rising prevalence in urbanisation, lifestyle changes, and nutritional transition across various demographics in recent years (Bishwajit, 2015; Dennison, Sisson and Morris, 2016). Most epidemiological studies investigating the prevalence of obesity

and overweight suggest a growing trend in lifestyle-related obesogenic behaviours (Hills, Andersen and Byrne, 2011; Sikorski *et al.*, 2014; Sisson *et al.*, 2016). Some of these factors include: change in dietary choices due to the fast-food trend, sedentary living, TV viewing, use of media technologies and lack of PA (Griffiths *et al.*, 2013; Tanaka, Reilly and Huang, 2014; Bishwajit, 2015; Sisson *et al.*, 2016). This growing consensus has suggested a strong relationship between SB and inadequate PA and a high risk of developing chronic diseases (Tremblay *et al.*, 2010; Wijndaele *et al.*, 2011). Some cross-sectional and prospective studies have shown evidence of an adverse association between TV time and cardiovascular risk factors including metabolic syndrome and other biomarkers (Dunstan *et al.*, 2005; Aadahl, Kjær and Jørgensen, 2007; Burazeri, Goda and Kark, 2008). Aadahl and others (2007) in their population-based intervention study suggested that TV viewing was linearly associated with BMI and waist/hip ratio and other biomarkers, however an intense PA pattern was associated with a healthier waist circumference profile. From their findings, they further suggest that PA and PIA should be regarded as separate behaviours that may impact different cardiovascular risks. On the contrary, one longitudinal study that aimed to investigate the differences in time use and its association with PA and prolonged TV viewing amongst adults found that on the days where participants exercised, there was more record of energy expenditure due to reduction in other activities (Matthews *et al.*, 2018). The above study put forward evidence showing that there is a link between TV viewing and PIA⁴ and this opens an avenue for future research to refrain from interventions that offer compensation but rather promote activities that improve health and encourage weight loss. Drawing from the outcomes of the above study, this thesis focuses on

⁴ Physical Inactivity

the complex interaction between prolonged TV viewing and other determinants of human behaviour and how this can effectively be utilised to create an internalised motivation to engage in PA. Recognising TV viewing as a principal domestic activity, the proposed intervention for the current study will capture the flow of behaviour towards TV use as it unfolds in the daily life of the participants. It is hypothesised that the intention to displace TV viewing with light to moderate PA will fluctuate daily, weekly or even monthly. Perhaps the dynamics in the fluctuation can be modelled to show association between change in new TV habits and new PA behaviours with a person or between persons as the case may be. Based on evidence of associations of TV time and behaviour and the role of home environment in influencing these behaviours, modifications of the domestic setting could facilitate any intended behaviour change (Tabak *et al.*, 2018). Data published by the Office of Communications (Ofcom) (2019) suggests that the TV viewing of children aged 5-15 has reached 11 hours per week. Although their report indicates that this data is an average based on TV programs watched by this demographic, they, however, suggest that YouTube and video gaming using TV set seem more popular with figures reaching 19 hours per week. Their report also indicate other figures of online engagement which suggests that children are exceeding the recommended amounts of screen consumption mentioned in chapter 1.2⁵. Whilst these figures seem to be a representation of the UK children, the survey conducted amongst parents prior to the DUS showed that 33% of 140 parents reported that their children spend 6 hours or more on TV or other screen related activities. Also the participants of the current study averaged over 9 hours a day from the real time data logging carried out prior to the DUS, this will be discussed in Chapter 8.

⁵ Can be found in page 2

2.4.2.2 Socio-digital participation in the home

The roll-out of technology use in the home has become a trend especially in the lives of young children, and this has allowed them the opportunity to interact with digital media (Holloway, Green and Stevenson, 2015). Thus, some researchers have suggested that computers and other technologies have become intrinsically compelling for young children (Sigdel, 2017). Sigdel (2017) further indicates that the use of these devices can be educational, whilst others fully support that recreational screen time use (i.e., TV watching, DVD, computer gaming, tablet/mobile phone) may also support children's development (Houghton *et al.*, 2015). There is also robust evidence from empirical studies showing that children's learning trajectories are influenced by their effective use of the growing technologies that are provided in their home (Plowman, 2015). In this regard, the home environment plays a vital role in how exposure to these devices intersects with children's mental and physical wellbeing development. One cross-sectional study found a positive correlation between mobile phone use (including internet) and feelings of depression (Kim *et al.*, 2010). Although the above studies showed a small size positive effect, a more robust study that included 6000 children aged 12-18 have also found an association between general ST use and indications of depressive symptoms and misconduct (Ferguson, 2017). Another longitudinal study provided a refined perspective on the association between use of digital technology and depressive symptoms: their study presented that, for children who do not feel strongly bonded with their friends, resorting in spending significant time using the internet is prevalent and this led to changes in self-reported feelings of depression over time (Selfhout *et al.*, 2009). Vice versa, children who felt strongly bonded with their friends, there was no significant association with spending time on the internet

and depressive symptoms. Despite the impact on mental wellbeing, a cross-sectional study that investigated 1300 adolescents aged 12-18 showed that the amount of time children spent on their digital devices reduced the time they spent interacting with their parents without reducing the parent-child relationship quality (Lee, 2009).

Similarly, critics argue that despite the positive outcomes from technology such as compensating and motivating children who lack social skills to communicate, the downside outweighs these positives (Srivastava *et al.*, 2018). Some of these are the challenge of spending too much time on the devices at home, which impacts on their desire to pursue other healthy activities such as exercise, family time and social pursuits. Therefore, the result of digital technology use is negatively impacting on the declining PA, and this has received substantial attention under the hypothesis that displacement of ST has a relationship with time spent using digital technologies. A large body of evidence that drew from the survey of over 200,000 children between ages 11 and 15 observed the correlation between time spent on digital devices and spare time PA varied according to many factors including age, and culture (Melkevik *et al.*, 2010). Outcomes from their study mainly showed that two hours or more spent on screen-based SB resulted in 30 minutes less per week spent on PA, although this was solely dependent on the type of screen-based activity undertaken and strict the parents were. Very specifically, regular computer use for instance was associated with increased PA, while watching TV and video gaming was associated with decreased PA. The conclusion of the above study was that PIA⁶ is unlikely to be a direct cause of excess screen-based SB, however it observed at

⁶ Physical inactivity

not sufficiently active adolescents have additional time to spend on screens further impacting on their PA level.

Thus, from the above studies, it is evident that the amount of time spent on digital devices and its impact on PA is mixed and inconclusive. The study by Gebremariam (2013) provides a longitudinal account which suggests that by merely reducing the time spent on these devices, PA will not necessarily increase. However, the current study proposes an intervention aimed at displacing the said activity with PA to change the screen media habit and likelihood of increasing PA. This helps policymakers and researchers create the right interventions around achieving moderation of screen use. Although most researchers have looked at the increased positive influences these devices could offer children, other studies (like the current study) seek to explore how the displacement scenario could be applied to achieve a good balance. Therefore, the current study focused on the reduction of the use of these digital devices by exploring parental values and attitudes, and how they influenced their children's use of technology such as TV. This discussion extends to the trends in lifestyle and the implications of technology and how it has rewritten the way we live our lives.

2.4.3 Trends in lifestyle

The focus of the research is increasing PA and reducing SB. PA has been identified as a tool to modify health outcomes. In other words, a physically active lifestyle reduces the risk of chronic disease (Pharr *et al.*, 2018), metabolic syndrome (Durstine *et al.*, 2013), obesity (Ip *et al.*, 2017), diabetes (Äijö *et al.*, 2016) and all-cause mortality. There is an observation from reviewed literature suggesting that health-enhancing exercise habits may wear off as children enter adolescence. Therefore, these habits should not only be advocated but preserved and encouraged

to be maintained in the early stages of life (Aarts *et al.*, 1997). Lopes and others (2007), after assessing 503 boys and girls aged 6 to 18 years of age with a MTI ActiGraph⁷ model, found that boys undertook more physical activities than girls, although activity generally decreased with age. Thus, habitual PA developed in childhood may not progress through to adulthood if not sustained. There is a need to promote these habits amongst children and young people and help them understand the value and maybe this could be maintained through adulthood.

Interestingly, the report published by BHF revealed that a large percentage of boys and girls aged between 5-15 years are not achieving the levels of PA recommended in these guidelines (20% and 19%) respectively, with the highest decline found between 13-15 years of age (25% boys and 14% girls) (BHF, 2015). In England alone, 52% of children aged between 11-15 years of age participated in vigorous PA for two hours or more per week; this is notably low in comparison to Finland (70%) and the Netherlands (77%).

In children and young people, PA benefits can cut across both physical, psychological and mental benefits (North *et al.*, 1990) and increases in self-esteem result from the social interaction (Florez *et al.*, 2018). For this reason, children and adolescents have been identified as a group with the risk of low activity levels and should be targeted for intervention programs aimed at increasing activity.

According to previous research, many factors such as lifestyle contribute to low levels of PA, resulting in energy imbalance. Some of these include technological advancements that encourage motorised transport and seated activities such as TV viewing (Duke *et al.*, 2003), and low levels of PA awareness (Van der horst *et al.*,

⁷ One of the most widely accepted accelerometers for field-based PA measurement

2007). Kremers and others (2008) argue that since PA and SB can be tackled as separate constructs, and awareness for children to perceive the need to change these behaviours may lead to a better understanding of health behaviour change. However, to date, Public Health practitioners have focused extensively on increasing PA, with minimal attention to the evidence suggesting that SB has a distinct association with health outcomes (Active Healthy Kids Canada, 2011).

2.5 Social capital and sedentary screen time

The concept of social capital is linked with the value attributed to social networks and how this is essential in promoting wellbeing and increased sense of belonging. Although this has remained an intangible concept, Coleman (1988) perceived ‘social capital’ as a positive element whereby the structure inheres with the relationship between actors and among actors. His sociological stance on social capital suggests that an individual is subject to norms and rules in any given social or cultural environment. Therefore, from his sociological approach, he further argues that an actor (individual) have no “internal springs of action” if they are a product of their immediate environment. In the context of this thesis, it views children’s agency and explores how their interactions with their peers or subjective norm transform their actions. One of the productive ways to view social capital is to understand its functions in any given context, and Coleman, (1988) suggests this to be any resources individuals can utilise within the relationship with others. Putnam (1995, p.67) shares similar views with Coleman and defined “*social capital as features of social organisation such as networks, norms and social trust that facilitate coordination and cooperation for mutual benefit*”. In his view, when social capital exists amongst members of the community, there is a high engagement of mutually beneficial activities for collective action. Implicit to the

work of the above two authors, social capital can be created or formed, and this can potentially transform into other forms of capital. For instance, according to the Teens gaming and Civic engagement survey conducted by Lenhart (2008), game play experiences amongst teenagers were strongly associated with their engagement in political and civic duties. In particular, Coleman and Putnam do not feature children, notably in their work, and one can argue that they perceive children's lives are hidden to the sociological gaze.

In the context of the current study, social capital can be viewed as social interactions amongst children and their co-actors (friends and family). Again, as discussed in chapter 2.3, prolonged sitting involves excess TV watching, video gaming and time spent on mobile devices; some studies have identified these activities as beneficial for building positive relationships, accomplishment and positive emotion (Jones *et al.*, 2014). Some authors suggest that positive relationships are highly crucial for psychosocial wellbeing for children (Bagwell & Schmidt, 2011). This also supports one of the basic human needs (relatedness) as Ryan and Deci, (2000) rightly identified in their self-determination theory which will be discussed in detail in the next chapter. Children's excess engagement with screen devices has been determined to have numerous negative implications on their wellbeing. Hence, the displacement hypothesis which is proposed in the current study does not ignore the evidence that children's social interactions and capital enhance both quality and quantity of the communication between friends leading to greater relatedness. Therefore, whilst the evidence on the relevance of moderate engagement with screen devices shows positive influences and increases in social capital, there has been lack of studies on how changing these screen behaviours could be made a habit. Hence, there is a need to develop interventions on instigating a more active

behaviour and discouraging excess ST without totally taking away the value that the latter activity offers. The current study will provide a more nuanced understanding on balanced screen time engagement in relation to the national and global screen time recommendations.

2.6 Summary of Chapter

This chapter began by highlighting the background problem of obesity and how lifestyle factors such as PIA and SB contributes to the obesity epidemic. This chapter explored how obesity and its drivers have primarily been approached from a clinical perspective in combination with interventions that have approached the issue from a lifestyle point of view. Despite steady progress towards ensuring curbing obesity, this chapter discusses the various interventions and the importance of their findings. Some of the limitations identified from these studies are that there are opportunities for more proactive interventions to investigate new ways to increase adolescent PA to reduce the childhood obesity epidemic. In response to the already existing interventions, governments world-wide have called for action on behaviour change strategies relating to PA, diet and screen-related behaviours (Waters *et al.*, 2011). The increased interest for the current study spanned from current evidence showing the ubiquitous duration children dedicate to engaging in screen-related activities and clear evidence of not meeting the recommended PA guidelines. This has warranted further research to explore and understand the current drivers of childhood obesity and how focusing on increasing PA might help in tackling the issue. Sections of this chapter discuss that more than 80% (WHO, 2018) of the world's adolescents are inactive; accordingly, this chapter contextualised the definition of PA and inactivity and recommendations as well as the various measurements of PA. As there is no one accurate measurement in

assessing PA, this chapter argued that innovative ways such as design-led interventions could be considered as an evidence-based approach to understand and measure both PA and screen time usage; this will provide a more structured behaviour pattern on how future interventions adopting this design-led approach can be widely applied. This underlying premise and the trends in lifestyle identified in this chapter also explored how targeting children's screen time could infringing on their social capital. Evidence shows that when children spend a lot of time engaging in screen-related activities, there is also less time spent interacting with immediate family members, as they are often disconnected in the real world whilst connected with their virtual (real-life) friends within these activities. Therefore, this chapter presents how the current study will be addressing the limitations of the studies explored through literature and focused on combining of behaviour change theory and design-led approach, in developing novel strategy to increase children's PA.

Chapter 3 Literature review phase 2

3.1 Introduction

This chapter presents the literature review performed to understand the state of the research with regards the various discipline in which this thesis is situated. This chapter answers the second research question.

RQ2 – How can behaviour change theories create pathways for developing physical activity interventions?

Figure 8 demonstrates a schematic diagram showing the key areas that influence the current study. As the current thesis is interdisciplinary, it was necessary to merge the diverse views from all the disciplines.

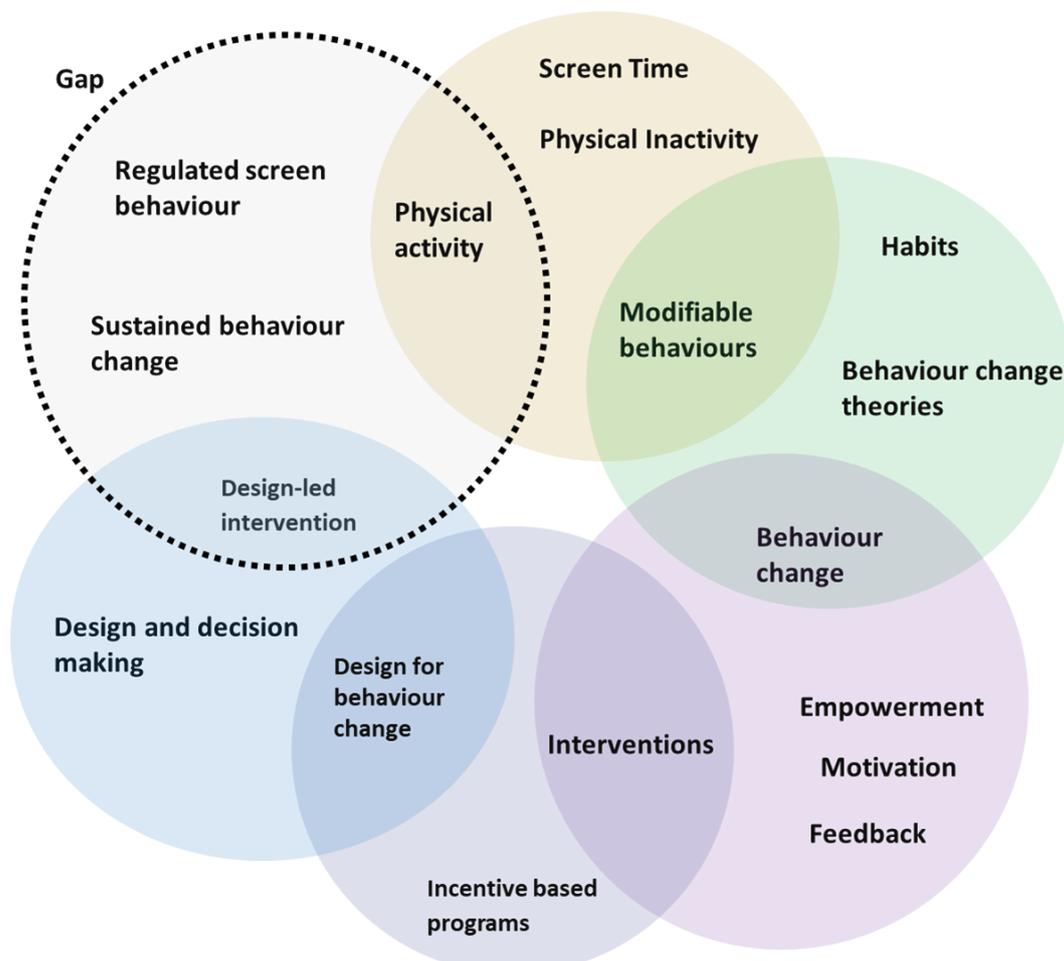


Figure 8 Chapter diagram

The previous chapter highlighted the ST and PIA challenge and how this is a problem that has been ignored in some contexts, such as the home environment. This chapter presents discussions that support the argument that the said behaviours are all modifiable with the appropriate interventions.

The discussions continue to explore behaviour change theories and habit formation. As the thesis is aimed at improving health, this chapter also highlights relevant health-related behaviour theories that have been previously applied in promoting healthy behaviours.

The next section identifies the main ingredients found in the interventions that have previously targeted changing and sustaining behaviour. It contains an account of theories and frameworks related to motivation, empowerment and feedback. There is an emphasis on how technology acceptance theory is relevant when using technological approaches to change behaviours. The current study further adopted the key constructs from these theories, which were pertinent to the current study and informed the theoretical framework.

The current study is situated within the Product Design discipline; therefore, it was essential to review existing literature around design for behaviour change and how designers are approaching the subject of behaviour change. Examples of studies involving how behaviour can be changed using design, and products based innovative frameworks, are listed and described in this chapter.

The next section focuses on design and decision making; designers often assign values to different dimensions when creating any product to ensure its users make rational choices. This is adopted from decision science which explores how people make optimal decisions in a world of uncertainty. It cites existing frameworks that

evaluate how designers should improve designing for suitable behaviour approaches.

This PhD research is positioned in the last circle of the above diagram. More research is needed to close the cycle and contribute to existing knowledge. Limited studies were identified on design-led interventions that focused on motivating children to engage in home PA, more so habitualising this behaviour. From the review of literature in Chapter 2, the majority of the studies focused on outdoor activities targeting older demographics. This indication highlights the need to foster interventions that help the younger demographics to create regular activity habits and also helping them habitualising this behaviour.

3.2 General behaviour change approach with theoretical applications

Human behaviours have often been described as complex, and this can be contextualised by several factors such as demographics, personality characteristics and domain-specific cases in which certain behaviours are investigated. Behaviour change can be required in any setting and for various reasons; this could either be individual, community or population based. Examples of various contexts that require changes in behaviour include but are not limited to: lifestyle behaviour (dietary changes, smoking & exercise habits) driving practises, and sustainable behaviour (such as switching the light bulb off when not in use, taking a shower instead of a bath to save energy and water consumption). Researchers to date have confirmed that there is no single approach to changing behaviours. One study argued that changing people's behaviour can be measured by patterns in terms of prevalence within a specified population (Michie, van Stralen and West, 2011). Fishbein and Ajzen (2011) argue that approaching different kinds of behaviour in similar ways, often using the same constructs to predict and understand any

behaviour of interest, seems like a good approach, and they advise that researchers should consider the context in which this is viewed. This led to them measuring how attitudes can impact on people's intentions, thereby resulting in determining behaviour changes. Their involvement in identifying and measuring behaviour change dates back to their formulation of Theory of Reasoned Action (TRA) which is a significant approach to measuring attitudes, intentions and normative influences in order to predict any changes (Fishbein & Ajzen, 1975). TRA forms a base for several behaviour theories used and applied across various domains today. Similarly, other social cognition models have also sufficiently predicted and explained and modified health behaviours (Sutton & Sheeran, 2003). Table 1 summarises a few examples of various areas in which behaviour change theories were applied. Behaviour change is essential in many different settings/domains for many purposes. Thus, the current study embarked on a journey to change PIA behaviour through an intervention that regulates children's ST habits. One systematic review concluded that ST behaviours are modifiable and recommended that some environmental modifications be adopted to target these behaviours (Hoyos Cillero and Jago, 2010).

Table 1 Summary of some behaviour interventions with theory applications.

Theory	Target Behaviour	Method	Intervention outcome in changing the intended behaviour	Study
<i>Health Belief Model</i>	Patient belief on physical activity and serum uric acid	Randomised Control Trial (RCT)	HBM had a significant implication on planning educational based programs for increasing physical activity and decreasing serum uric acid in patients.	(Shao <i>et al.</i> , 2018)
<i>Goal Setting theory</i>	Dietary behaviour intention	Longitudinal study	Goal priming had no significant difference in whether the pupils eat or not. The outcome, therefore, suggests that incentivising to induce behaviour might impact on goal setting.	(Lagerkvist <i>et al.</i> , 2018)
<i>Theory of Planned Behaviour</i>	Student Retention	Multivariate Modelling	All three variables of TPB proved to offer positive psychologically-based account on student retention. Identified phenomena related to retention or student dropout.	(Dewberry and Jackson, 2018)
<i>Social Cognitive Theory</i>	Smoking Cessation	RCT	Increased self-efficacy to refrain from smoking in social and stressful circumstances which implies that self-efficacy is a possible mediator of the intervention.	(Bricker <i>et al.</i> , 2010)
<i>Self Determination Theory</i>	Proposed a new technology platform to support people attempting to achieve long-term recovery from Alcohol misuse	Usability test	Provided autonomy supportiveness by sharing some motivational tips. Offer some resources to cope with cravings and provide access to social support to persevere.	(Gustafson <i>et al.</i> , 2011)

3.3 Contextual approaches to changing behaviour

There are various approaches and theories on behavioural change, which have derived from various disciplines such as psychology and sociology. The complexity of changing behaviour results in these approaches and theories focusing on many different levels of changing behaviour. Thus, behavioural change theories generally attempt to explain the changes in human behaviour in various contexts. The home context has not received a lot of attention, even though it could be a primary agent for improving health. This study suggested that parents are seeking behaviour change interventions which focus on the home context (Nwankwo *et al.*, 2019). The existence of various theories tends to cite factors such as environment and personal determinants as drivers of behavioural determination. The application of these theories has grown exponentially over the years especially in the fields of health, energy, law, climate, education and criminology, with the hope of improving services offered within these areas by understanding behavioural influences (Racheal Davis *et al.*, 2015, Nadine, 2014). The broad use of the term behaviour change has been distinguished by scholars as either model of behaviour or theories of change (Dolan *et al.*, 2011). They argue that in behavioural change two key approaches, changing minds and changing contexts are vital in implementing any theory. As much as both approaches share similar features, Dolan further argues that changing minds relates more with reasoned processes while changing context predominantly refers to an automated system of action. This interpretation suggests that models of behaviour provide a diagnostic understanding of psychological drivers aimed at explaining or predicting behaviour trends; theories of change, on

the other hand, are more process-driven constructs designed to change a given behaviour (Davis *et al.*, 2015).

As previously indicated, behaviour change is increasingly recognised as a crucial part of human wellbeing, especially in driving sustainability and social cohesion. Thus, recently there has been an emergence of interventions that are built from behaviour change science. The recognition of patterns of behaviour has been a huge driver of behaviour change interventions and has been vital in determining populations' health and wellbeing (Abraham and Denford, 2017). 47 years ago, a study was conducted in Alameda County in the US which followed the behaviour patterns of over 7000 people: it showed that factors such as sleep, dietary habits, PA behaviours and alcohol consumption predicted their mortality (Belloc & Breslow, 1972).

In the field of social and health psychology, most interventions tend to use behaviour change theories to promote and predict behaviour change. Instances, where there has been successful application of behaviour change theories in the bid to modify behaviour, including addiction, as its manifestation is primarily considered as behavioural (Webb, Sniehotta and Michie, 2010; Hagger *et al.*, 2012). The American Psychiatric Association (2013) suggested that although the mechanism by which addiction is developed depends on cognitive and emotional processes, the behavioural processes involved are maladaptive. Thus it has become apparent that changing complex behaviours can be a multifaceted phenomenon with various levels of influence, such as the social and physical environments (Buchan *et al.*, 2012).

Generally, the origins of psychological studies on goal-directed behaviours rely on rational choices (Aarts, Paulussen and Schaalma, 1997). The central premise of rational choice (choice theory) is that the behaviour of individual actors results from aggregating social behaviour, each of which is governed by determinants of individual choices/decisions (Blume and Easley, 2007). Some very prominent change models, like the theory of reasoned action, state that attitudes (i.e. the desirability of the action) in combination with subjective norms are the antecedents of behavioural intention and these are supposed to precede the behaviour (Ajzen, 1991). Having contextualised theoretical approaches to changing behaviour, the next section will focus on discussing the overview of various types and definitions of theories reviewed in this study.

3.4 Relevance of behaviour change theories in the current study

“A theory presents a systematic way of understanding events or situations” (Rimer and Glanz, 2005, p.4). These are categorised as a set of concepts, that define, describe or predict events by explaining the relationships between variables (Babbie, 2003). Ultimately, theories should be developed and tested as they provide a plan for developing better interventions. The use of theory is not limited to planners but also researchers in the context of identifying the most appropriate audience and means to bring behavioural change and critical outcomes. As discussed in the previous section, theories generally help us to understand behavioural trends and how any negative behaviour can be changed. In broad terms, theories can be classified as explanatory or change driven. For instance, understanding why employees at a workplace use the lift instead of stairs is one step to encouraging using the stairs. However, the outcome of this is more explanatory;

therefore, it will require a model for change in order to influence the employees to use stairs.

A well-known example is the health belief model (HBM) which will be discussed in detail further in this chapter; it was originally developed as an illustrative framework to explain people's engagement in one-off health-related behaviours (Jones *et al.*, 2015). Researchers recognise HBM as one of the widely utilised theories in health behaviour interventions (Glanz and Bishop, 2010). One reason is that HBM theorises that people's beliefs influence readiness to take action about their likelihood of being ill or developing a health problem and their perceived benefits of taking action to mitigate it (Glanz, K 1997; Rosenstock 1974; Tanner-Smith, Brown 2010). Generally, in health promotion initiatives, theories of behaviour change either explicitly or implicitly provide a framework on which these initiatives are based. In the field of public health, health promotion interventions ensure that people are engaged beyond education, this comprises of efforts to close the intention-behaviour gap both at individual and community levels. Orbell & Sheeran (1998) describe the intention-behaviour gap as a term used to reflect that sometimes intention does not mean that people do what they set out to do. This is how the science of health behaviour change progresses. The idea that behaviour might influence our health was first revealed in the longitudinal study conducted by Alameda County, where they followed respondents for over 10 years. The study found some key behaviours (lack of exercise, not eating breakfast, smoking, high alcohol intake) were associated with mortality and morbidity (Belloc & Breslow, 1972). Since the Alameda study, another cross-sectional and experimental studies have confirmed the association amongst health behaviours and potential health risks. For example, a randomised trial by Haines and others (2013) examined the

efficacy of a home-based intervention to enhance household routines recognised to be related to childhood obesity. The outcome of their study suggests that promoting household routines such as enhanced sleep duration and reduced ST may be a practical approach to lowering BMI among the targeted group.

Prestwich and others (2018) suggest that to foster the understanding of these behaviours, especially factors that influence them, several theories will emerge in any given study. Hence, the implementation of each model or theory vary by intervention, and there is no right or wrong theory for each study, thereby explored many theories pertinent to health behaviour change interventions. This was useful to explore the relationships between constructs (determinants) and outline the variables which the said intervention will be targeting in order to influence healthy behaviours. Various theories identify many different constructs, although the conceptualisation of these constructs is very similar. Thus, to provide a bit of context, the current study critically discusses the theories that have been considered for this study in detail below. The fitness of any behaviour change theory in either predicting or changing a specific behaviour is subject to understanding the habits attributed to the targeted behaviour.

3.5 Habits

Everyday behaviours shape people, and this becomes habitual over time. For a habit to fully form, there is an expectation that this habit is performed repeatedly over time. For lifestyle behaviours like PA and healthy eating, achieving an optimal health outcome depends on repeated performance. For instance, going for a run once will not yield the same health benefits as regular running routine (Erikssen *et al.*, 1998). The Department of Health UK in their new guideline suggests that there is no minimum amount of PA needed to reach the desired health benefit

(Department of Health, 2019). They recommend that a little exercise every day will be helpful for people to achieve a behavioural goal. In the case where these behaviours are practised regularly, the individual will ultimately reach a point of doing them automatically without deliberation. At that point, the said behaviour would likely be transformed into a habit (Orbell and Verplanken, 2010).

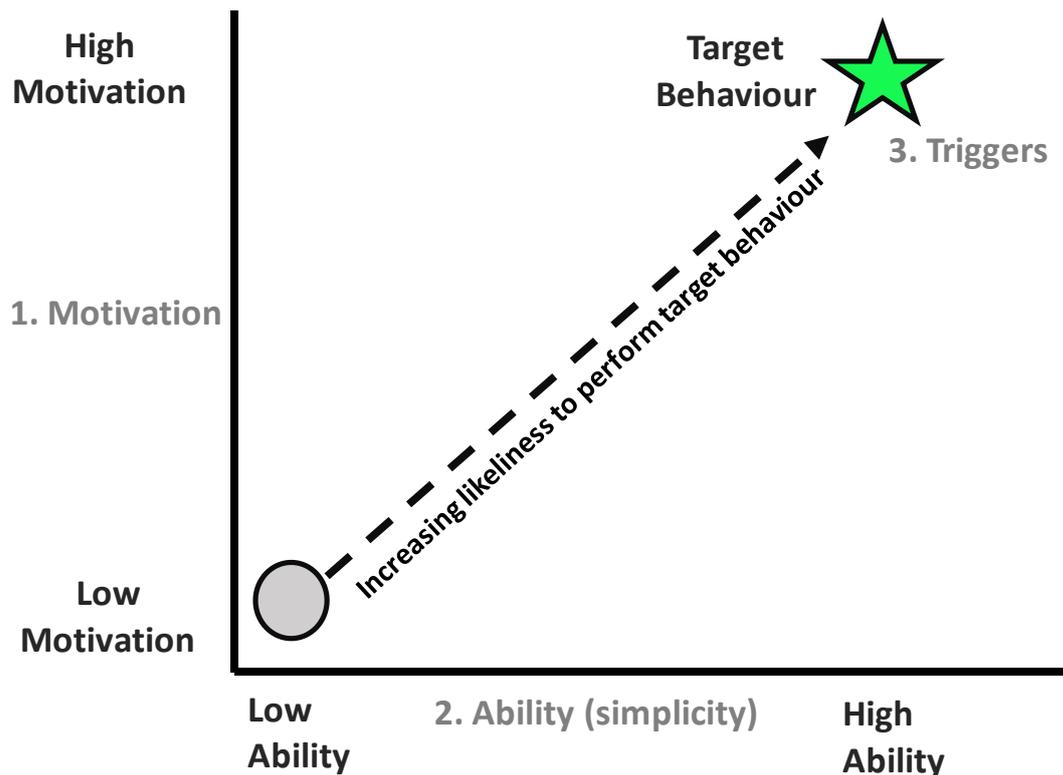


Figure 9 The Fogg Behaviour Model Fogg, 2009 (remade by author)

This health recommendation discussed above also aligns with the Fogg Behaviour Model (FBM) which is a model that focuses on understanding the triggers of people’s behaviour change process (Fogg, 2009), see Figure 9. FBM identifies that behaviour is performed if guided by these principles: *motivation*, *ability* and *triggers*. The model purports that changing simple behaviours requires lower levels of motivation to initiate these behaviours. He argues that if the initial target behaviour is not ‘small’, no amount of motivation will be enough to trigger an

individual to act. Figure 9 represents a simple and practical way to visualise FBM according to its originator.

Establishing new habits would require a sense of repetition and without having to think about it, and has taken the ‘cue-response’ approach. According to Gardner and Rebar (2019), the concept of changing behaviour by getting people to form new habits is by converging contextual cues; simply put, this is setting cues to get people to initiate this new habit. FBM would question the implication of merely setting contextual cues as the model argues that using contextual cues is similar to triggers which are events of the environment and can only elicit behaviour provided there is the right level of motivation (Fogg, 2009). Thus, he refers to his model as “tiny habits”. It is challenging to plan an intervention targeting behaviour change at the same time as being responsive to individuals’ motivation appropriately. The intervention for the current study has been designed to change the contextual cues that trigger new habits by encouraging further actions with the expectation that repetition by the participant will achieve the desired habit.

Furthermore, as FBM argues, individual motivation can be adopted during the design phase of the intervention. Additionally, for any habit changing interventions to achieve desired results, the intervention needs to prioritise understanding the determinants of the old behaviours and how habits are formed, with considerations of how motivation can support the habit process (Gardner and Rebar, 2019). Therefore, the below section has been divided into behavioural determinants, behavioural process and motivation continuum in relation to behaviour.

3.6 Behavioural determinants

3.6.1 Health Belief Model

The HBM, as shown in Figure 10, is an explanatory model which theorises that behaviour is largely predicted by four main constructs: susceptibility, severity, benefits, and barriers (Hochbaum 1958; Rosenstock 1974). The HBM has been in use for over half a century to predict health-related behaviours and structure interventions to change these behaviours. Initially developed by some American social psychologists in the 1950's, HBM explain people's widespread low participation in programmes designed to prevent and detect diseases (Rosenstock 1960;1974; Hochbaum 1958). Later, in the 1970's, the constructs within this model was improved due to people's responses and particularly adherence to medical programs (Becker, 1974).

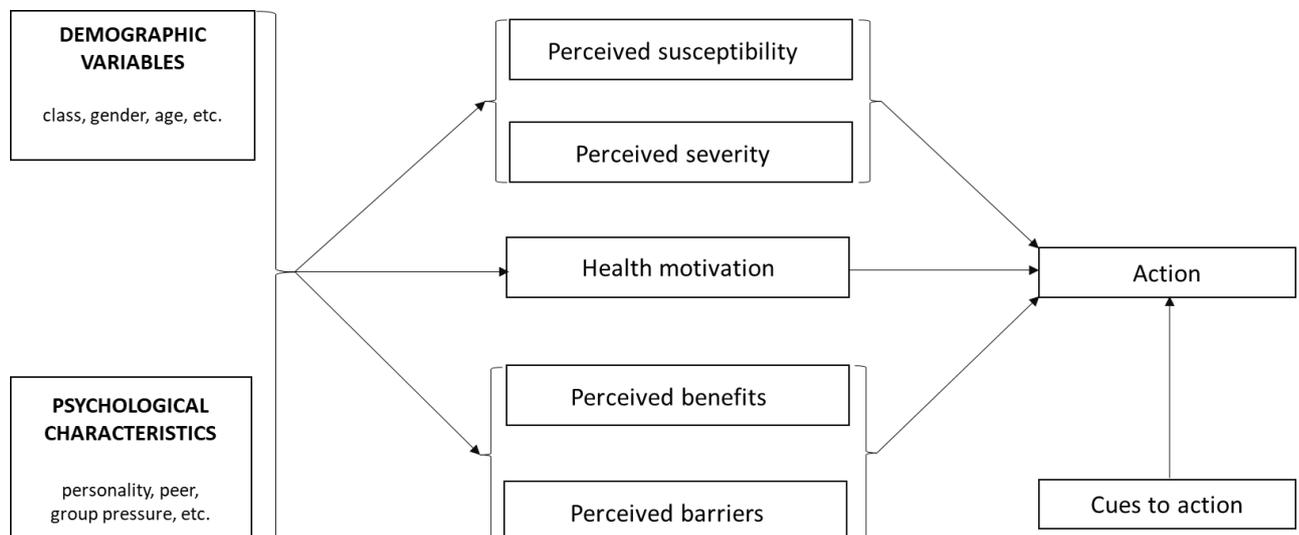


Figure 10 Health belief model Janz and Becker, 1984 (remade by author)

Over the past decade, HBM has been one of the more widely applied psychological approaches to explaining health-related behaviours. The HBM model which was consolidated by Rosenstock and others (1974) suggests that an individual's chance of performing an action is dependent on some constructs. It is a cognitive model of behaviour that indicates that, for an individual to behave in a certain way, there

must be a preconceived threat to the individual's well-being with clear outcomes for a particular action. The model was dedicated to threat perception and behavioural evaluation which are the two main aspects of individual illustrations of health and healthy behaviours (Conner & Norman, 2005).

- Perceived Susceptibility – This describes ones' beliefs about their likelihood to develop a disease.
- Perceived Severity – This refers to feelings about contracting a serious illness or the fear of leaving it untreated, resulting in either clinical or social consequences. The combination of susceptibility and severity has been classed as a perceived threat.
- Perceived Benefits – The ability of a person to transform their susceptibility into a behaviour change is influenced by their beliefs regarding the benefits of the various actions to be taken to reduce the threat.
- Perceived Barriers – Every possible impediment that hinders the individual undertaking the recommended behaviour.

Cues to action in this model represent any strategy that is employed to activate readiness. This could be reminders, prompts, personal communications and health campaigns. Self-efficacy is a recently added element on the HBM model which was adopted from Bandura (1982). Self-efficacy is defined as *“the conviction that one can successfully execute the behaviour required to produce the outcomes”* (Bandura, 1997, p.79). Therefore, whether or not one can accomplish a given goal is the judgment of self-efficacy. From the author's viewpoint, self-efficacy is interchangeable with ability, in the sense that it focuses on one's cognitive perception by putting emphasis on one's prior performance.

As figure 6 indicates, the distinct constructs specified that constitutes HBM are directly related to performing an action to change behaviour. While some scholars have questioned the level of impact of perceived threats on behavioural motivators (Abraham and Sheeran, 1994) and this is particularly relevant in the context of children's behaviours (Fingeld *et al.*, 2003). Meanwhile, other researchers have applied HBM in their studies by combining the constructs with self-efficacy from social cognitive theory. For instance, Adih & Alexander (1999) found that including self-efficacy, among other HBM constructs significantly predicted condom use among young people in their study sample. Critics of HBM, therefore, argue that as a psychosocial model, this model is limited in its accounting for individual health-related behaviour due to the relationships between the constructs in the model not being well defined. Thus, this ambiguity has led to the variability of its application. For over half a century the HBM has been applied in predicting health-related behaviours and is limited in that it is mostly a cognitively based model. It has been useful in predicting and framing HIV-protective behaviours as well as cancer screening. The author, after a critical review of this model, identified that most researchers who have applied HBM often miss out testing the outcome of 'cues to action', which is a compelling triggering mechanism within the model. For the current study, the author identified 'cues to action' as a significant construct to adopt from HBM. Cues to action will have a more substantial stimulus effect on people's behaviour as the current study focuses on regulating and limiting behaviours. Based on the above, it may not be a useful or relevant model to apply in this study, especially in predicting behaviour.

3.6.2 The Theory of Planned Behaviour

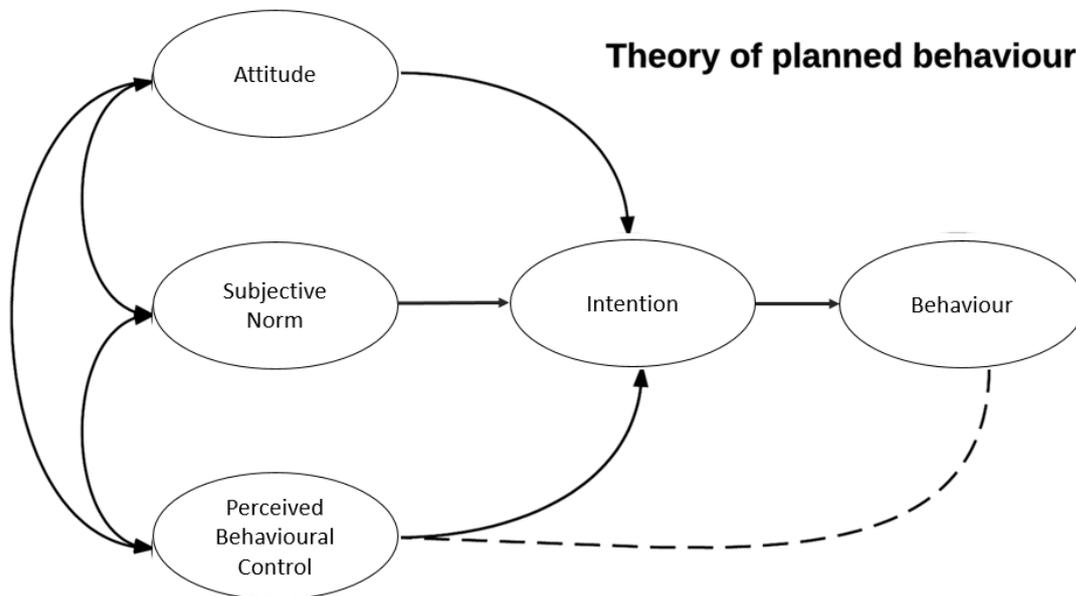


Figure 11 Theory of Planned Behaviour, Ajzen, 1985 (remade by author)

The theory of planned behaviour (TPB) was developed by Ajzen (1991) emerged as an improvement of TRA. The concept of TPB suggests that an ‘individual’s intention is most proximal to his/her behaviour’ and this will mediate the effect of the categorised perceptions on behaviour namely: perceived behavioural control, attitudes and subjective norms (Ajzen *et al.*, 1985). He proposed his TPB with an explicit goal of extending the scope of the TRA. The central principle of this theory is that intentions predict behaviours. Within the constructs of TPB, Figure 11 shows that attitude refers to beliefs on whether the behaviour (PA or dietary behaviour) will yield desirable outcomes. Subjective norms reflect beliefs about whether significant people within the individual’s environment want the individual to engage in the said behaviour. Perceived behavioural control (PBC) was later included as a new construct in the recent version of TRA. It summarises whether the person believes he or she has the necessary resources to engage in the behaviour and this is comparable to Bandura's concept of self-efficacy.

Consequently, a behaviour that is seen as easy to perform is likely be high in PBC⁸ and vice versa, if the task is seen as difficult will have a low PBC. TPB⁹ has been widely applied in many different behaviour interventions and, with the added construct of PBC, it argues that an individual with a high PBC with respect to a given behaviour is more likely to intend to perform the said behaviour, and have a higher chance of acting on the intention despite any obstacles. This thesis is focusing on instigating PA behaviour and regulating the TV watching habits of the studied participants. Within the context of TPB, if one of the participants for the current study has high PBC because of their perception of their ability to engage with the intervention, this may influence their actual behaviour to engage in PA. One of the studies that discuss the relationship between attitudes and behaviour argue that, for an individual to form an intention, they often take into considerations how much control they have over the behaviour (Manstead, 2001). His study argues that since PBC determines both intentions and behaviour, this can be seen as a joint determination of intention. The joint determination of intention, according to his study can be understood in two ways: motivation and lack of control. Motivation: a person with high PBC is more likely to try harder at performing the behaviour as opposed to their counterpart with low PBC. Lack of control: failure to engage in behaviour even with a strong intention to perform can be attributed to lack of control. Thus, PBC, in this case, is ‘non-psychological’ in the sense that the individual did not just fail to act due to perception of control but actual lack of control. One of the limitations of TPB is that it merely assumes that regardless of intention, a person can acquire the resources and opportunities in order to

⁸ Perceived behavioural control

⁹ Theory of planned behaviour

successfully perform the desired behaviour. It does not account for other variables such as threat and fear as in that of HBM, which are other factors that affect behavioural intention. One disadvantage of TPB is that it merely presumes that behaviour results from linear decision-making process; therefore, it does not account for any prolonged changes in behaviour. Whereas the Transtheoretical Model (TTM), which will be discussed in the process of behavioural changes in the next section, takes into consideration various processes of decision-making stages which account for behaviour.

The relevance of TPB in this thesis is that it highlights intentions and PBC as the two main determinants of intentions towards a behaviour. However, the theory is not explicit on the actual control over behaviour. Critics such as Wegner & Wheatley (1999) question the idea of intentions resulting in behaviour, in contrast, Sheeran (2002) suggests that for a behaviour to occur, automatic processes or intention need to be present. Another meta-analysis review of TPB showed that intentions and self-predictions were stronger predictors of new behaviour in relation to desire (Armitage and Conner, 2001). Their study presented evidence that PBC predicts intentions and behaviour in a wide array of domains. In summary, other meta-analyses confirmed the efficacy of utilising the constructs in TPB to increase the predictive power of behaviour (Armitage, Conner 2001, p. 489).

TPB and TRA, like the HBM, are value-expectancy theory models, although without the threat concept which is central in the HBM concept. Ajzen (1998) argued that the main reason behind using any theoretical model or theory is to help researchers better understand behaviour in the domain of health in order to frame effective interventions. He further suggested that TPB constructs are structurally better specified and mathematically more generalisable than the HBM. He also

admitted that TPB and TRA help to promote an understanding of volitional behaviours better than the HBM's approach, to determine the situations that may fall outside the control of the subject in instigating behaviour change. Some health promotion studies have applied TPB in exercise intention, and behaviour domains and their findings indicate that attitudes and PBC facilitate the participation in exercise and result in general autonomous motives in children (Hagger, Chatzisarantis and Biddle, 2002; Downs and Hausenblas, 2005).

PBC, as a core cognition of intention in TPB theory, will be useful in demonstrating if the intention to engage in PA has the potential to enhance autonomous motives in application to the current study. For the current study, TPB may be useful in understanding and measuring how beliefs might impact on intention. The constructs from this theory will be applied in creating a thematic guide for the qualitative interviews where the researcher would be inquiring about the role of habit formation on determining new behaviour maintenance. McEachan (2011), in their meta-analysis, explored the effectiveness of TPB dependent on methodological moderators and behaviour. They recommended that researchers intending to test TPB should endeavour to employ objective measurements rather than merely using self-reported measures of both current and past behaviour. Their study influenced the methodological moderators used in this thesis. This thesis employed the use of the objective measurement obtained from the research instrument to corroborate the self-reported information that was obtained from the semi-structured interviews, which will be discussed in chapter 4. The next theory presented helps understand the participants' stages of change.

3.7 Behavioural process

This section discusses the processes that influence people to behave the way they do.

3.7.1 Transtheoretical Model/Stages of Change

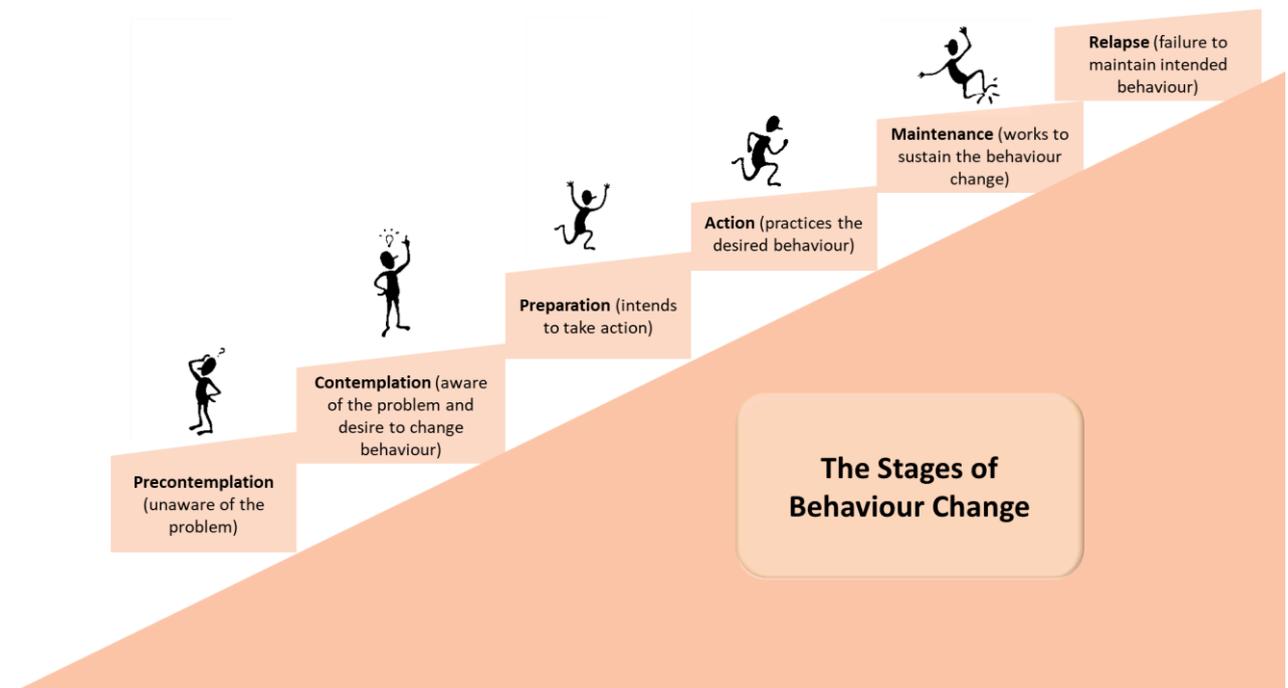


Figure 12 Stages of Behaviour Change Prochaska & DiClemente 1982 (remade by author)

Changes in health have often involved multiple actions and adaptation over time as some people may not be ready to attempt changing behaviour. In contrast, some others may have begun implementation or be at a readiness level of change. This led to the development of the TTM by Prochaska & DiClemente (1982), as shown in Figure 12. The theory states that changing behaviour or adopting a new behaviour is not a coincidence but instead a process with different individuals at varying stages of readiness. In contrast to models like TPB that could be used to explain ongoing behaviour, TTM focuses more on behaviour change (Noar, Chabot and Zimmerman, 2008). TTM was originally initiated the 1970's when Prochaska and

others intended to identify common factors used in leading theories of behaviour change (Prochaska, Johnson and Lee, 2009). Their empirical work that examined smokers observed that they used different processes of change at every given point on their track to quitting smoking. This led to the formulation of the “stages” aspect of the TTM model, whereby the change is not only viewed as an event but as a series of change process comprising of six different stages. The stages of change in TTM represent a core continuum through which behaviour change movement may take place either backwards or forwards (Prochaska and Velicer, 1997). *Precontemplation* is a situation where people aren’t prepared to enforce any behaviour change in the near future and are unaware of the problematic lifestyle they are leading (usually perceived to be around 6 months); *contemplation* is the stage where people have an intention to change their behaviour and require to be motivated to do so (operationalised as within the next 6 months); *preparation* is the stage where people are ready to take immediate action and require the skills to do so; *action* refers to the stage where people are already making a specific behavioural change with intentions to continue this behaviour; *maintenance* stage means that the individual’s new behaviour has become more habitual and can be argued to have been internalised. The final stage is somewhat theoretical in nature: *relapse*, where a behaviour which has been ingrained is lost, leaving the individual to fall back to their old habits. TTM argues that for an individual to progress through these stages, there needs to be the re-engineering of the environment to facilitate behaviours through cues and removal of those that encourage for unhealthy behaviour. TTM believes that interventions will more likely yield effective results when they are ‘stage-matched’, i.e. applying the stages of change processes appropriate for a given behaviour in relation to the targeted individuals.

3.8 Motivation continuum in relation to behaviour

3.8.1 Self-determination theory

Before proceeding to discuss the self-determination theory (SDT), this section will highlight the relevance of SDT in relation to human needs and the motivations behind the choices people make. The amalgamation of the theories of motivation, development and wellness led to the development of SDT (Deci et al., 1989). It is important not to merely focus on the amount of motivation required to perform a task, but primarily to think about types of motivation. Thus, the core concept of SDT is motivation as a trigger for people to perform a specific action. Deci and others (1989) emphasised that in the field of motivation, one can be intrinsically or extrinsically motivated. The theory hypothesises that motivation exists along a continuum of five distinct motivational types (Ryan and Deci, 2000). Intrinsic motivation refers to performing a task for its own sake because it is interesting and can be self-satisfying. This occurs when an individual consistently carries out a task/activity as a result of the spontaneous satisfaction derived from doing that activity. Autonomous motivation can be said to be intrinsically driven (Deci and Ryan, 1985). On the contrary, extrinsic motivation often indicates that a person does not derive satisfaction from within but from the consequences of the activity. Deci (1971) describes this as an instrumentality between the task and some separable external impulse such as reward or punishment. Thus, the concept of the psychological need in SDT is used to determine whether performing a task is motivated by extrinsic or intrinsic impulses and this includes the three core aspects namely: autonomy, competence and relatedness. SDT centres on the premise that people have an innate psychological need which can support self-motivation (Deci, Connell and Ryan, 1989).

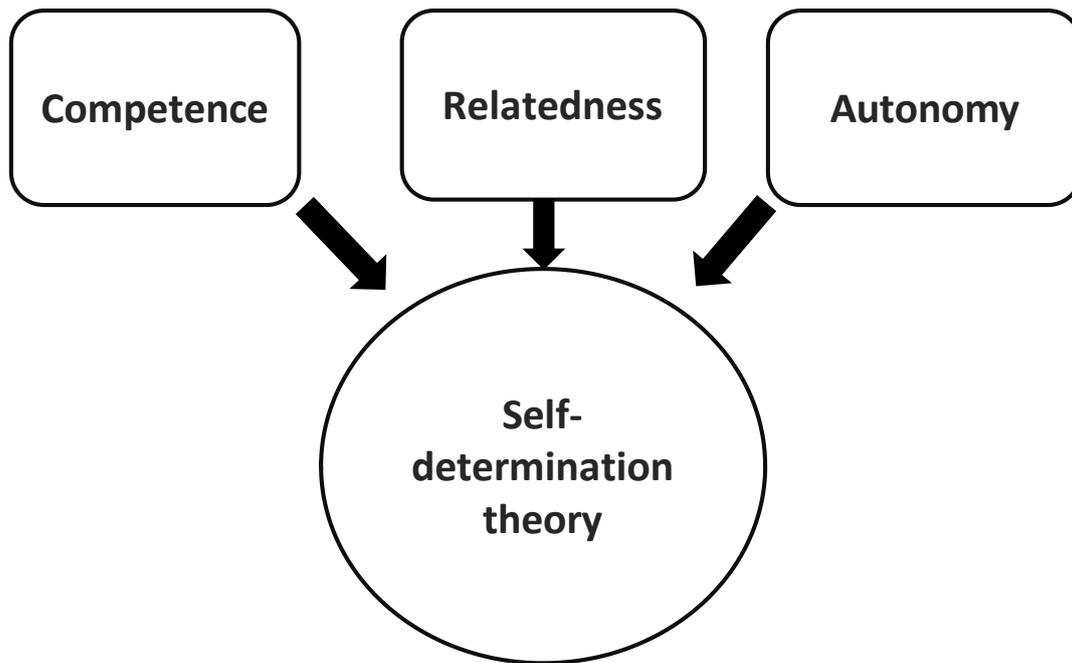


Figure 13 Self-determination theory identified innate human need Deci & Ryan 2008 (remade by author)

Deci & Ryan (2008) claimed that the needs identified in Figure 13 were the three essential elements of the theory. They explained competence as the need to build mastery over task and to be effective in dealing with the environment; relatedness as when people need to have a sense of connectedness or belonging with the people around them; and autonomy as the need for people to feel in control of their choices/behaviour. SDT consists of two sub-theories which provide a more distinct interpretation of the two types of intrinsic and extrinsic motivation. Cognitive Evaluation Theory (CET) and Organismic Integration Theory (OIT) aid in contextualising factors that influence the nuances in the two types of motivation (Ryan and Deci, 2000). CET refers to the element of humans needing to satisfy competence, autonomy and relatedness as explained above. According to Ryan & Deci (2000 p.229) “psychological health requires satisfaction of all three needs; thus one or two are not enough”. They argue that in the bid to develop intrinsic motivation, factors such as interpersonal events, rewards and any form of feedback that increase the feeling of competence when performing a task play a key role in

shifting an individual's mindset. However, for an inherent reward related to a task to yield intrinsic motivation, the activity must result in feelings of self-development and empowerment, which produces an increased sense of competence. If all these factors are present, motivation can, therefore, move towards becoming intrinsic. This also implies that, in a situation where the three basic needs are thwarted or supported, this will determine whether intrinsic motivation will be improved or weakened. OIT as a sub theory on the other hand makes further distinction within different types of motivation, with six different types of regulation which vary depending on the level of autonomy that the individual has and also the amount of internalisation that the individual has obtained. It argues that extrinsic motivation is a behaviour that is instrumental and however seeks to satisfy an external demand. Deci & Ryan (1985) thus described this distinct form of instrumentality as a form of a continuum of internalisation: internalisation being how much the person values the activity.

Behaviour	Nonself-determined				Self-determined	
Motivation	Amotivation	Extrinsic Motivation			Intrinsic Motivation	
Regulatory Styles	Non-Regulation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation
Perceived Locus of Causality	Impersonal	Impersonal	Somewhat External	Somewhat Internal	Internal	Internal

Figure 14 Taxonomy of human motivation (Ryan and Deci, 2000)

From the above figure, OIT proposes that intrinsic regulation represents the highest level of self-determination (Deci and Ryan, 1985; Ryan and Deci, 2000). For instance, a student would attend classes because he or she enjoys learning new things. Conversely, extrinsic regulatory approach means that an individual will go to work because the wages pay the bills; in other words, they perform the activity

because it's a means to an end. In the case of the current study, a participant who continually engages in exercise because they value its impact on their wellbeing will be said to be intrinsically motivated. On the other hand, a participant who only exercises because their parents force them or because they want to gain ST access would be categorised as extrinsically motivated. Figure 14 also shows the continuum of motivation, from the lowest to the highest. The extrinsic regulatory styles are: external, introjected, identified and integrated regulation. These regulatory styles represent any behaviour that is controlled by an external influence, for instance, a child exercising because he is required by law to do so or his parents forces him to. Introjection refers mostly to when the formerly external regulators are partially internalised but not fully accepted by the individual. For example, when the child exercise to avoid the guilt associated with hurting the feeling of his parents (Ricard and Pelletier, 2015). Identified regulation refers to a higher form of extrinsic motivation, where an occurrence of activity has been judged to have a personal value to the individual engaging in it. This type of regulation is often seen to take place when an individual attributes importance to the activity. Conversely, on the closer end of the continuum is the integrated regulation which represents when the behaviour begins to align with the individual's identity. Ryan & Deci (2000) hypothesise that, on the motivation continuum, the lower you are, the more controlled the type of behaviour. Additionally, the last item on the continuum (amotivation) represents neither lack of autonomy nor any sense of control over one's motivation (Ryan and Deci, 2000). However, in the context of increasing PA levels in individuals, a more persistent behaviour is more likely to occur when the individual perceives his behaviour as autonomous as opposed to controlled (Standage and Ryan, 2012). Some cross-sectional studies have shown a clear

indication that autonomous motivation for exercise is positively linked with self-report, and some objectively assessed PA in healthy adults (Ingledeew and Markland, 2008; *Peddle et al.*, 2008; Markland, 2009).

Similarly, Teixeira and others (2012) review reported that developing autonomous self-regulation is the purest form of predicting exercise participation, and this was apparent across the range of samples and settings seen in their investigation. From the above study, it was also clear that when PA behaviour is analysed separately (self-report & accelerometry) introjected regulation shows a more positive cross-sectional association with PA behaviour, whereas external regulation is commonly more negatively associated with PA (Edmunds, Ntoumanis and Duda, 2006; Sebire, Standage and Vansteenkiste, 2009). There are limited studies which have shown evidence on the positive relationships between autonomous motivation and objectively assessed PA; the most available evidence is in the form of self-reports (Barbeau, Sweet and Fortier, 2010; Gunnell *et al.*, 2014). The studies of Gunnell and others (2014) supports previous studies (Brunet & Sabiston 2011) on how changes in relative intrinsic goals positively predict PA behaviour. In other words, the presence of motivation and goals is significant in driving behaviour change as it often meets competence satisfaction. They also observed that controlled motivation had little effect on their sample in fostering autonomous motivation. However, in Teixeira's (2012) review, they suggest that controlled motivation very often shows minimal, negative or no relationship at all when using SDT based evidence within an exercise behaviour context. Despite limited evidence, some other qualitative studies support that the movement through the SDT continuum is more effective when there is autonomous motivation, and this is central to PA adherence and maintenance (Kinnafick, Thøgersen-Ntoumani and Duda, 2014; Brandon-Lai, Funk

and Jordan, 2015). There has been little longitudinal association between the various forms of regulation and sustainable PA behaviour (Gunnell *et al.*, 2014). Additionally, these studies have often relied on self-reported measures of PA behaviour, which are not only prone to bias but are often argued to be subjective (Sallis and Saelens, 2000).

SDT framework in the context of this research was used to explore the motivational processes that underpin PA. For instance, in the context of PA, a person could self-manage their exercise habit for broadly external or autonomous reasons.

SDT's application in health behaviour change interventions is that it resonates with the underlying mechanisms that may be attributed to both behaviour change and maintenance. Its use in the current research recognises the importance of combining motivation or stimulation of psychological energy and its influences in maintaining PA behaviour. Competence, as one of the core psychological human needs, is suggested to be crucial in the SDT model; competence is demonstrated in the other domain as being critical for behaviour change interventions. Other studies that have applied SDT in PA intervention confirm its ability to delineate any circumstances that are likely to promote behaviour change maintenance (Rothman, 2000). In other words, through the process of internalisation, any behaviour changes that occur are adopted by individuals as their own, thereby causing them to integrate them within broader values. Thus, the behaviour becomes a part of the individual and not just a part of the intervention, which increases the likelihood of sustained behaviour change. The theoretical aspects considered herein has been helpful in evaluating how the design methodology adopted for this thesis can be improved to instigate health behaviour change.

3.9 Technology Acceptance Model

The current study explores the feasibility of ‘design’ as instrumentality; therefore, it is crucial to understand how people adopt artefact driven intervention, leading to behavioural change. The technology acceptance model (TAM) was developed in the 1980s on the premise that to increase the use of new technology, its users must first accept the technology, and it functions on questioning the individuals about their future intention to use the technology (Davis, 1989). Its originators reasoned that understanding the dynamics on one’s intentions would allow designers to utilise those factors in order to promote and increase user acceptance, thus, increase the use of the technology. The originators of this TAM were inspired by Fishbein & Ajzen’s (1977) TRA, as mentioned in 3.4. This theory has been proven to be useful in understanding several behaviours, such as exercise and condom use. To date, the TAM has ceaselessly evolved, and the current model has changed from its original form.

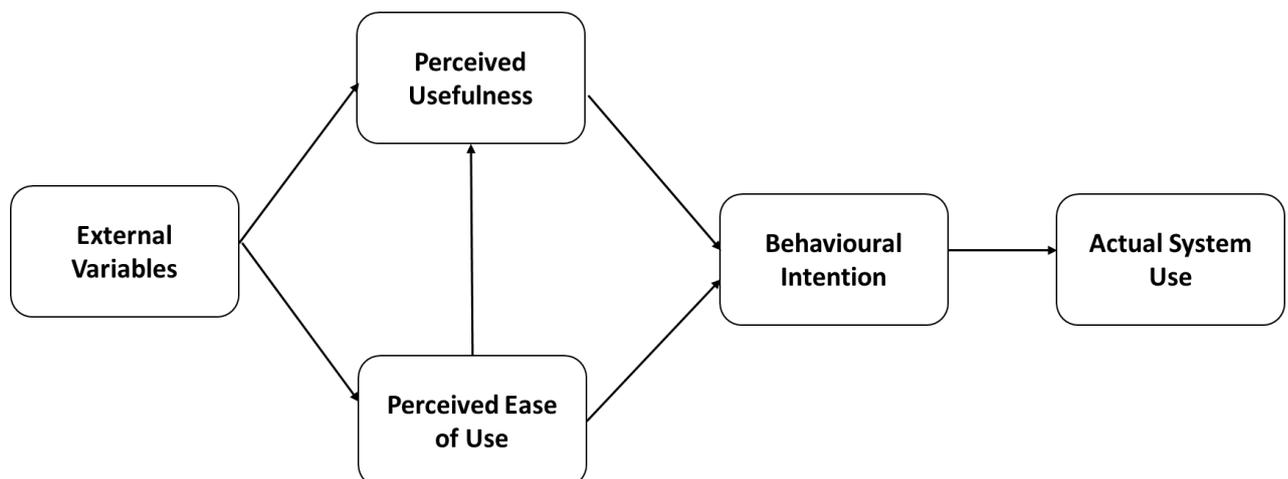


Figure 15 TAM model Davis, 1989 (remade by author)

Figure 15 explains that the originators of TAM highlighted behaviour intention (BI) as the most proximal precursor of acceptance and people’s actual use of any new

technology. One exploratory study examining the technology acceptance of physicians and their decision to accept technology in telemedicine concluded that most physicians could be pragmatic by anchoring their acceptance of technology for its purpose rather than its ease of use (Chau & Hu 2001). Their study only measured BI; Holden & Karsh (2010) suggest that attitude is also an essential element of TAM, and they further indicate that there are two underlying determinants relating to attitude: perceived usefulness (PU) and Perceived ease of use (PEOU). Tyus, from Chau's study above, observed PU be independent of BI, although Holden suggested that PEOU has an effect on PU.

TAM is a highly regarded theory when it comes to testing the acceptance of new technology, and its use has been widely seen in various industries that have recently adopted any form of technology. Thus it was necessary to discuss its application within the confines of the thesis. In some healthcare research, TAM did a great job of predicting and explaining the use of IT in the medical setting (Handy, Hunter and Whiddett, 2001; Van Schaik *et al.*, 2004). Some of the constructs of TAM was adopted in this thesis for the objective of identifying 'salient beliefs' in relation with participants adoption of the proposed intervention and their actual use. This was intended to help in contextualising and understanding the determinants which have influenced the use of the technology or device in this study.

3.10 Feedback and self-monitoring strategies

In behaviour change research, some scholars have identified 4 stages of influencing human behaviour: 'defining the behaviour, identifying the behaviour, change/intervention strategy and evaluation' (Martin *et al.*, 2017). They further suggested that defining the desired behaviour to be changed helps clarify what, by whom, where and when this behaviour is expected to be changed. Schultz & Kaiser

(2012) argue that this limits our understanding of which model will be efficient in evaluating the success of any intervention, as generalising human behaviour can be complicated, and add that explicitly defining behaviour is crucial. Therefore, during this review, most studies that conducted theoretically driven research on SB employed robust and tested behavioural theories such as TPB, “Social Cognitive Theory” and much more, which helped enhance the validity of their results. While these theories may go on to increase people’s awareness of SB (Abrahamse *et al.*, 2005; Schultz & Kaiser 2012; Martin *et al.*, 2017) challenge this notion. They all agree that people’s behaviour may not change without clear messages aimed directly at changing the underpinning beliefs in user behaviour – the function of feedback. Abrahamse and others (2005) suggest that by providing feedback to an individual, it is possible for them to make an association between enacting their behaviour with the outcomes or consequences of the behaviour. Thus, providing feedback shifts the focus of the individual to either continue with the intended behaviour or not, it can make the behaviour more or less attractive to them. Other scholars see feedback as an intervention tool to be implemented in order to generate behavioural action through cognitive reflection (Wilson, Bhamra and Lilley, 2015).

Therefore, the particularities of feedback in facilitating behaviour change are considered to be an important element when designing an intervention. This notion led this thesis to further review the workaround how the discipline of design has evolved around behavioural change studies. One example was the CCC project which was developed to reduce domestic energy use in UK low-income housing estate by implementing user-centred design feedback in changing user behaviour (EPSRC, 2010). The report from this project revealed a 5-15% increase in energy savings resulting from direct feedback and 0-10% from indirect feedback. Further

discussions around how the provision of feedback enhanced behaviour change from the above project were the frequency, duration and accuracy of the feedback. Which design scholars agree to play an important role in how feedback information brings about the desired change (Wilson, Bhamra and Lilley, 2015). Now that there has been an established apparent role of feedback in changing behaviour, the latter part of this thesis will examine how this element induced action more so, a sustainable one.

3.11 Design for sustainable behaviour

Herbert Simon (1969, p.129) in his early discussions around design proposed that design has the capacity to create change “devising courses of action to change existing situations into preferred ones”. Today, there has been a recognised flowering of research in the field of behavioural economics and persuasive technology, contextualising the role they play in influencing behaviour intentionally and unintentionally (O’Reilly & Spruijt-Metz 2013; Niedderer *et al.*, 2014). This area of research helps us understand how design can create desirable and undesirable changes when implemented effectively. Research scholars have, in response, focused their attention on design strategies for behavioural change, with an emphasis on delivering empirically grounded ideas targeting conscious and unconscious behaviours (Cash *et al.*, 2017). Specifically, design for behaviour change (DfBC) has only gained research interest within the last decade, and this still needs an efficient framework for the implementation to gain a strong stance in the research world.

DfBC has helped integrate evidence-based knowledge and theories in implementing sustainable design. This approach has been adopted in practice in re-thinking and applying all levels of knowledge and theoretical landscapes in various sustainable

innovations to promote change (Niedderer *et al.*, 2016). However, DfBC has become a robust way of tackling social, environmental, economic and health challenges (Niedderer *et al.*, 2016; Nidumolu *et al.*, 2009). Thus, the ubiquity of design and its ability to facilitate change has evolved into promoting sustainable change (Jelsma 2006), and as a result, evolved into a new field called DfSB.

This recent field helped design researchers better understand the influence a product has on people and the outcome of their behaviour as a result of an interaction. Individual examples have shown significant impact such as, inducing innovative use of human-powered products (HPP) which encourages energy-saving behaviour that brings a health benefit (Shin & Bhamra 2016). In their study, it also highlights the role of feedback in a design-led intervention which acts as a key driver in sustaining the motivation to carry out the intended behaviour. Beckman and Barry (2007) in their *Innovation Process Framework*, suggest that the core elements of design thinking in relation to the outcome of problem-solving revolve around value creation to improve the artificial environment. Their framework bridges the tangible and intangible worlds of identifying a problem (observation) and problem-solving (solution) with frameworks that explore the problem in order to proffer a solution that connects to the user at a significant level.

Despite the practical examples to illustrate the application of DfSB and the ability for design to influence behaviour, there is a shortage of coherent understanding of frameworks that exist for practical implementation in all contexts.

3.11.1 Design and behavioural decision-making dimensions

Decision science explores how people make optimal decisions in a world of uncertainty. This combines psychology, economics and statistics by considering

factors such as human biases and heuristics in combination with statistical modelling and empirical research, to help people make more rational choices. In order to make informed decisions, designers often assign values to different dimensions to ensure that users are aware of any benefits, incentives and rules attributed to the product. In psychology, concepts such as *expected value and subjective expected utility* are used to understand people's decision-making processes (Fischhoff *et al.*, 1983). However, in the field of design, 'script approach' was one of the suggested design strategies for prompting an intended behaviour (Jelsma and Knot, 2002). Jelsma's idea of the script is to stimulate the user's behaviour in a forceful way, either through value incentive or rules scripted (feedback) in building the service of the product. This approach has been argued to somewhat constrain behaviour, according to Norman's 'affordance' and 'constraints' (Norman, 1999). He described 'affordance' as possible relationships between actors and object; 'constraints and conventions' as arbitrary and artificial, in that they prohibit some activities and facilitate others. He further detailed a clear more nuanced distinction between 'perceived affordance' and 'real affordance'. From his point of view affordance can enhance some behaviours through the use of 'real' physical objects without letting the user think of their actions; however, 'perceived affordance' is more of a scripted design approach that gives the user an opportunity to perceive a certain action with a known outcome in mind. Shin and Bull, (2019) have emphasised that the function of feedback and how it plays a critical role in developing this relationship between actors (users) and object (design-led intervention). Their article reviewed a broad range of literature covering: DfSB, behaviour studies, and environmental psychology, and proposed three dimensions (motivation, information and empowerment) to consider when

designing a design-led intervention - (see Figure 16). They argue that, for a new behaviour to be internalised, there is a need to delegate a strong empowerment to the user rather than forcing a behaviour. In this process, the function of feedback (i.e. help plan future actions) plays a critical role to manage the behavioural consequences and if repetition of behaviour are intrinsically motivated.

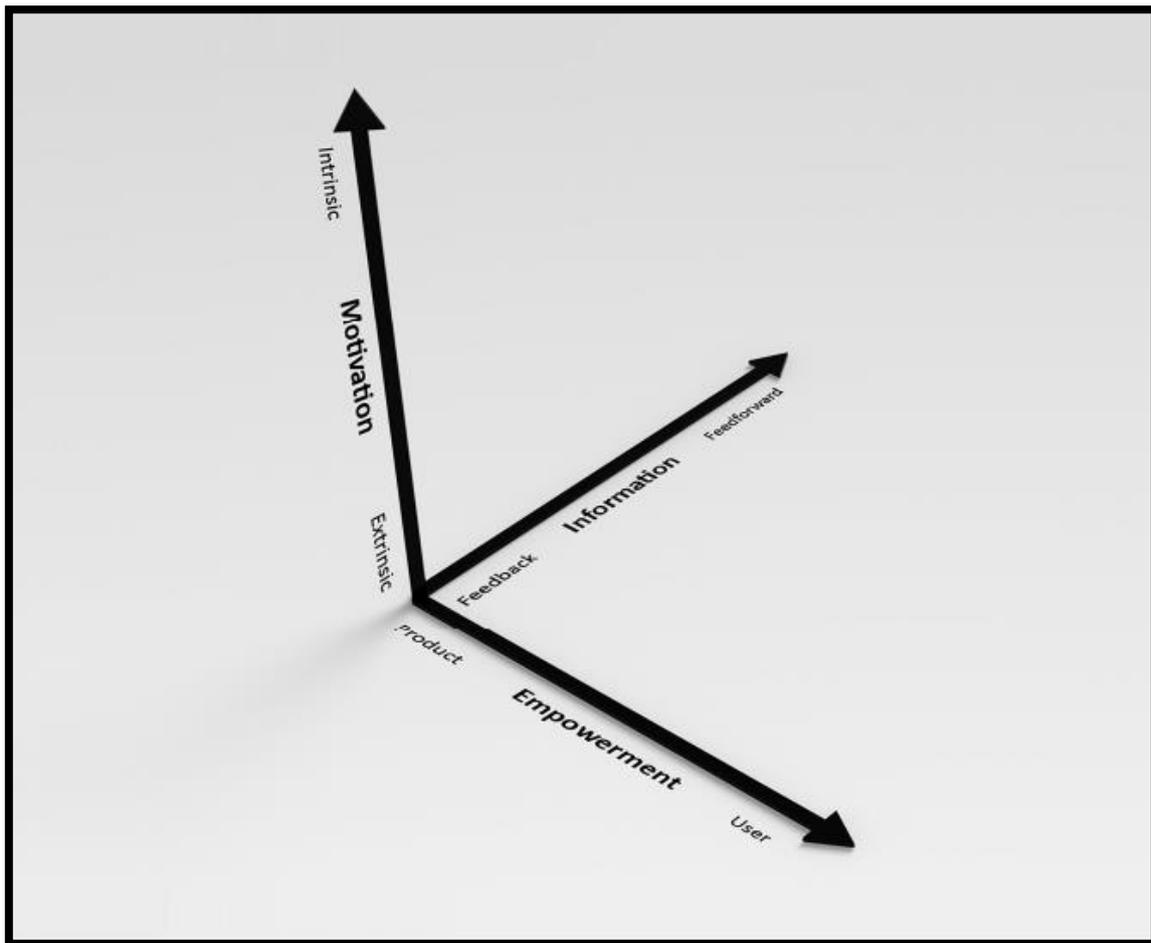


Figure 16 Three dimensions of DfSB Strategies (Shin & Bull 2019)

3.12 Existing home interventions

Exergames have been applied in various studies as an intervention tool in order to ensure that participants are active, and have not necessarily been targeted at influencing SB. However, existing research examined that there is a lifestyle impact that comes with increasing PA via exergaming (Paw *et al.*, 2008; Williams *et al.*, 2010). The above-cited studies did not succeed in determining the feasibility of SB

correlate and its influence on PA. This is because most of the studies measured PA and the potential for environmental influence.



Figure 17 Tacx bike (author's image)

Tacx is a fully interactive indoor bike trainer with a special app that offers its users the opportunity to interact with their friends online. In other words, the element of gamification embedded in this fitness tool allows its users a chance to stay fit in the comfort of their home. Features like unlocking higher levels to gain faster wheels and nice jerseys for the personalised avatar were undoubtedly important in increasing motivation for users. However, Tacx encourages immediate goal setting for its users with the priority of sustaining a behaviour; it is unsure whether social responsibility and the affordances promote sustainable behaviours. This is because their product seems more inclined towards marketing and commercial products rather than intervention, and they seem only to target bike owners. Figure 17 indicates the function of Tacx. It uses the brake force of a stationary bike to

generates energy dependent on the speed of the user from the heat of the brake power. This physical exertion also increases PA levels by creating a fun interface that enables users to stay physically active remotely. As much as these products have increased PA levels, there is no tangible reduction in prolonged sitting in their users, hence the problem of sedentary leisure time remains unsolved (Consolvo *et al.*, 2006).

3.13 Other real-world interventions

Numerous factors influence an individual's participation in PA. Researchers often use social-ecological models (SEM) to classify these factors, some of which include: intrapersonal factors, interpersonal processes, and social and institutional factors (Glanz *et al.*, 2015). Some studies argue that any intervention that targets multiple levels of the SEM is more likely to change behaviour (Luong *et al.*, 2018). For instance, a cross-sectional study that assessed predictors of PA among Nigerian university students using the SEM found that the surveyed group were physically active to a sufficient level and they identified factors associated with their PA participation using the above model (Essiet *et al.*, 2017). These would be useful for the development of interventions focusing on multi-level influences on PA engagement for university students. The key emphasis of SEM within this discussion is that it views PA as a dynamic process that is influenced by other aspects of individual attributes like perceived ability, interest and motivation in combination with social and physical environments. There have been practical applications of SEM in PA promotion, indicating the impact of many variables in influencing PA in different domains (Sallis, Owen and Fisher, 2008).

On the other hand, behavioural economics helps explain people's decision making as it recognises that an individual's decision is based on psychological, emotional,

cognitive and social demands (Zimmerman, 2009). Many factors such as immediate rewards may motivate some individuals to engage in PA. Thus, human behaviour could also be biased, and researchers argue that these “decision biases” could be leveraged to aid decisions related to healthy living (Camerer *et al.*, 2004). For instance, according to behavioural economics, incentivising a healthy behaviour using rewards and benefits may off-set the decision bias, where people tend to engage in the behaviour in order to receive the reward. Some systematic reviews and support the behavioural economics theory that incentives (financial) can increase PA adherence short term, usually for around 3 months (Mitchell *et al.*, 2013, Strohacker *et al.*, 2014). These reviews also highlight that not enough studies have examined the long-term impact of incentives in creating habitual PA behaviour. However, as much as incentives can stimulate health behaviour change, behavioural maintenance may require a more intrinsic motivation to sustain PA, which is one of the goals of the current study. Some of the commercially available technology and devices discussed below do not focus on a particular theory. Still, there is an indication of techniques like goal setting, feedback, self-monitoring and, rewards.

3.13.1 Sweat Coin

This is an example of a commercial product focused on extrinsic motivation. Sweat coin is one of the many incentives based interventions available, with over 20 million downloads globally (Derlyatka *et al.*, 2019). This app works by converting measured PA into virtual currency, with the mindset that if you move, more you gain more coin. The difference with this platform and other fitness incentives is that there are no expectations and users are not pressured to set goals with the perk of continuous incentives. Figure 18 shows how the algorithm uses verified steps using

GPS location, speed and consistency in movement. The incentives link to numerous marketplace subsidised offers for its users. Thus, the incentive of using the accumulated coin to purchase items become an essential element in behaviour, encouraging users to move more in order to earn more coins. Since the launch of the app, an analysis of 6000 users' daily step count has shown a mean increase of over 15% within 6 months (Elliott *et al.*, 2018). Sweat coin takes ideas from behavioural economics to combine psychology and people's decision making by merely nudging them to walk outdoors by offering incentives in the form of sweat currency. This concept can be argued to have fostered sustained behaviour change towards PA. As much as this works reasonably well, embedding incentives into PA programs may lack the potential to increase intrinsic motivation. Furthermore, the use of incentives to increase PA has been widely criticised, with concerns that such approaches might be coercive or seen as a bribe (Giles *et al.*, 2015; Popay, 2008). The main feature of this approach is the step count element which is also a common factor with the fitness trackers, which will be discussed next. The main question is whether incentivising behaviour change interventions facilitate longer-term effect, i.e. habituation of new habit? Therefore, the incentives may not be seen as sustainable stimuli to instigate a sustained behaviour change; instead, increasing motivation and self-efficacy could be a better technique to get people to change their behaviour.

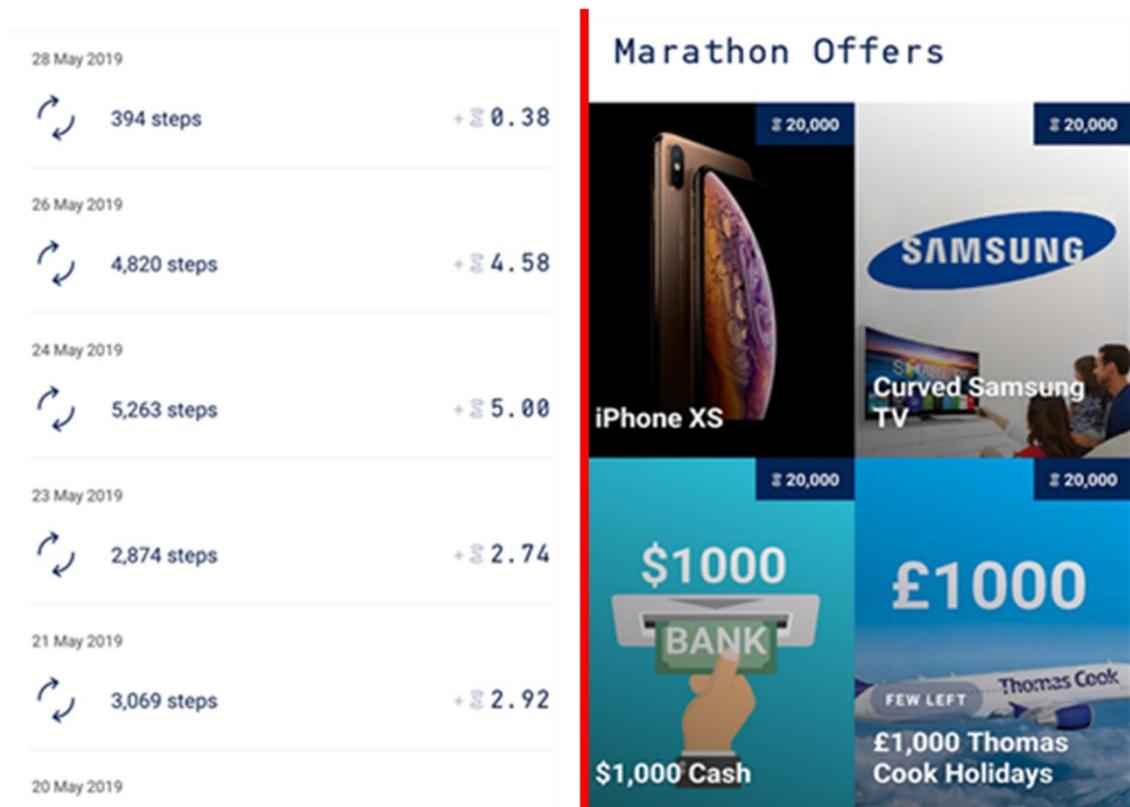


Figure 18 Authors screenshot of the Sweat coin interface

3.13.2 Fitness trackers

This initiated a sudden rush for commercially viable products to get people more active, such as fitness trackers. When it comes to exercise, people believe they should do more hence the rise in sales for these fitness trackers. One study showed that 49.4% of participants discussed their attempt at increasing their PA in the previous year (National Cancer Institute, 2014). The main problem remains initiating and to sustain this behaviour change, which is why the current study is offering an opportunity to help people instigate and self-track their PA behaviour changes. There is a considerable difference between counting steps and changing behaviour (Gualtieri, Rosenbluth and Phillips, 2016). There is limited information about the efficacy of fitness trackers enacting and sustaining behaviour change in any given population. They may use behaviour change techniques such as feedback

and self-monitoring, but it is questionable whether they are able to sustain any changes that may occur.

Nevertheless, increasing PA level is one of the key factors to improve and sustain general health as well as reduce the obesity epidemic. They may have delivered in terms of imitating PA behaviours, but one study questions their ability to motivate individuals to sustain this habit (Gualtieri, Rosenbluth and Phillips, 2016). They also have the capability of encouraging users to set daily goals, create networks of group activities with friends and family, as well as receive visual feedback on the progress of these activities. Arguably, for these devices to effectively stimulate health behaviour change; they need not only to be affordable but also accurate. The mixed results emerging from the studies on the reliability of these fitness trackers as a behaviour change tool, although they are seen to increase overall PA, there is limited evidence in prolonging results.

3.13.3 Gamification

The term “gamification” was introduced in 2008 and was afterwards adopted by technology and health professionals in 2010 (Deterding *et al.*, 2011). Deterding and others (2011) defined gamification as “the use of game design elements in a non-gaming context”. Some contexts in which this has been applied include health and education, and it has been used to improve productivity or enhance user experience. Gamification is mainly focused on user engagement. Engagement could be measured using many various metrics, such as frequency, duration and recency (Zichermann & Cunningham 2011). Thus, it requires a great understanding of user motivations and interest to build a successful gamified design. Seeing that gamification borrows its constructs from the gaming space, interventions that have developed gamification products have had to consider the type of player, for

instance, i) achiever ii) explorer and iii) socialiser in the design process; Zichermann & Cunningham (2011) suggest that this supports user engagement. Also, they argue that balancing between the three factors of difficulty, user ability and variability in the reward system (ratio interval), has the potential to increase engagement.

Source of motivation is a very crucial factor in user engagement and has its variation and can fluctuate between intrinsic and extrinsic. Arguably, most gamification interventions are the traditional mechanism of increasing extrinsic motivation with little evidence of eventually reaching the intrinsic motivation.

As discussed in 3.6, SDT proposed that motivation can be multidimensional, thus in the measurement of gamification outcomes, it is essential to understand where the motivation of a user resides along the continuum. Some may argue that gamification which mainly uses 'fun' as a trigger will only reside around being extrinsic motivation as the activity itself will always be referred as a 'game', and the behaviour may not prolong without the instruments in place. However, gamification as an intervention strategy may target intrinsic motivation, but due to the allocation of points to maintain engagement does not facilitate prolonged behaviour change.

3.13.4 Policy related interventions

Given that existing obesity prevention interventions have failed to stem the tide of the growing trend of childhood obesity, some innovative school-based programmes such as Daily Mile present promising opportunities for policy change within the education sector. Daily Mile is a PA programme which was initiated by a school in Stirling, Scotland and also promoted by the Scottish government (Stirling Council, 2015). The programme aims to get pupils to run or walk outside for 15 minutes at their own pace. Since its inception, there have been many beneficial anecdotally

reported benefits such as reduced SB, improved sleep, increased PA, body composition and the general increase in wellbeing (Chesham *et al.*, 2018). The Daily Mile programme has been suggested to have the potential to impact positively on global public health. Thus, its successful implementation has received interest from the UK Parliament (2016) with over 50% of primary schools across Scotland already enrolled (Chesham *et al.*, 2018). The Daily Mile core principles align with the elements from the Autonomy, Belonging and Competence (A, B, C) model, where it argues that if people have motivation for being active and feel like they are in charge, being active will bring more of personal value to them. Its retrofitting can be attributed to the SDT¹⁰ fundamental principles and has allowed the intervention to stay authentic in motivating pupils across the UK to remain engaged.

However, there is also a need to target a similar amount of time reduction in sedentary time in the domestic setting, as home could be a primary agent for improving children's health. For a design-led approach to increase motivation, it should ensure that the user develops an interest in exercise while achieving a reduction in sedentary ST, with the hope of attaining behaviour maintenance.

3.14 Conceptualising the theoretical underpinning of the current study

The wide range of theories that have been discussed within this chapter has buttressed the fact that individuals in any given situation tend to have many different behavioural options. These behaviours could be intentional or impulsively driven by other behaviours. For each of these behaviours to occur at any given time, factors like motivation and habits, cues and opportunity cost will be present. According to SDT, prior to behaviour change, PIA may be the dominant response

¹⁰ Self-determination theory

when cues for exercise are set in context, however, after behaviour change has been internalised and adopted, the individual exerts an autonomous decision, and newly adopted behaviour becomes the dominant response in that situation. Conversely, TTM hypothesises that since behaviour change is a process, the newly adopted behaviour could become dominant at one stage of the change process and could potentially move towards the prior behaviour becoming dominant again, thereby indicating risks of potential relapse. Thus, from the motivation continuum in SDT, if the individual begins to internalise the exercise behaviour (integrated regulation), this could be maintained over time, thereby becoming the automatic response for the individual. Consequently, the theoretical context of behaviour change maintenance and sustenance will consider various behavioural options and different levels of motivation but also considering how essential elements of competence, relatedness, and autonomy avails to maintain that motivation. However, recent research argues that it is not very clear what conditions are necessary to prevent relapse and sustain the new behaviour (Kwasnicka *et al.*, 2016).

In the context of PA, there has been a paradigm shift in research about understanding the correlates of inactivity, with a particular interest in the psychosocial influences (Sutton, 2008). This has led to behavioural change approaches dominating the literature within the social psychology sphere on PA behaviour. The two distinct approaches are stage-based, and motivation regulation approaches. The current study argues that an individual is more likely to adopt and maintain a new behaviour when they fluctuate within the motivation continuum. The motivation can occur over time because the value increases for the activity, the more the activity is carried out. This also highlights the need for longitudinal study

in order to increase the validity of empirical evidence for advancing the knowledge in the field.

For the current study, the participants were recruited based on the claim that children are investing a considerable proportion of their waking hours on screen devices and this same group of people is highly inactive. Thus, raising awareness on these two behaviours (TV viewing time and PA) was very important. Nevertheless, the main study of this thesis is grounded in three main theories: SDT, TTM and TAM. Based on TTM as explained above, various individuals often move through different stages of motivational readiness and utilise changing cognitive strategies as tools to advance through these stages of change. One study that applied TTM for exercise behaviour in a clinical population focused on the relationship between PA and readiness levels using TTM (Kirk *et al.*, 2010). They found that self-efficacy was more significant in people who were at the maintenance stage and was less with people at the contemplation stage. Fahrenwald and Walker (2003) in their descriptive correlation study examined TTM in relation to exercise behaviour: they found that using the process of change and self-efficacy, women's PA increased with increasing stages. However, in the SB¹¹ domain, there is no current application of its association between the aforementioned behaviour and PA. Therefore, current study investigated the stages of motivational readiness to avoid sedentary screen behaviours, adopt a new exercise behaviour and identify the link between transitions from one stage to another. Although numerous pieces of research have been conducted on the different types of motivation and their effects, no research (as a result of extensive literature review) has conducted a study on the behavioural techniques that impact on the changes in motivation over time. Vansteenkiste and

¹¹ Sedentary Behaviour

others (2010) suggest in their research that intrinsic motivation occurs when people engage in an activity because they find an inherent interest in it. This explains why most researchers have focused on identifying specific factors within the social context that produce variability in the intrinsic drive, the outcomes of this research only succeed in providing ways to intrinsically motivate people without taking into account other factors. This is where CET sits in its arguments that some external factors (free choice and feedback) often contribute in inducing a feeling of autonomy in the performance of any give task and this can improve intrinsic motivation.

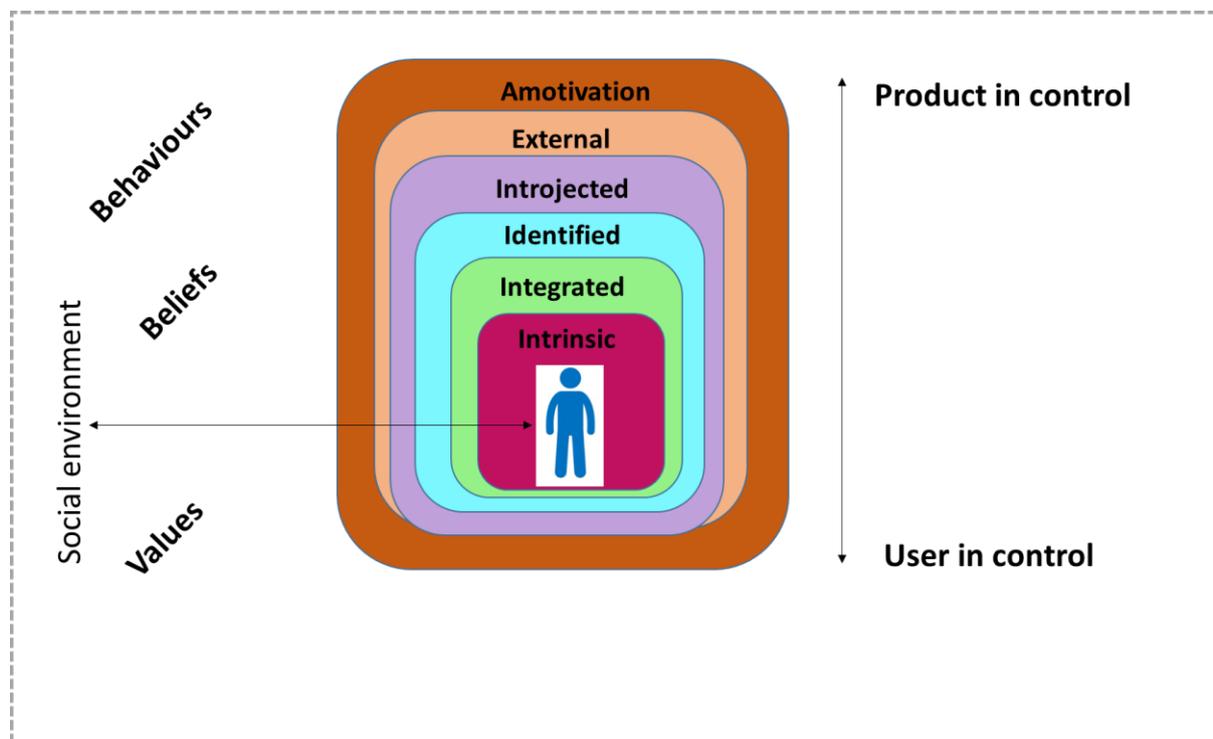


Figure 19 SDT in the context of the current study

Another hypothesis in the study will be that feedback will play a role in enhancing intrinsic motivation for participants. Thus, current research has two hypotheses. (H1): if presented with design-led intervention, people will adopt an autonomous and controlled motivation towards home exercising; ‘people will maintain their new behaviour if they are satisfied with the outcomes and have an inherent enjoyment in

engaging in the behaviour'. (H2): successful behaviour maintenance is associated with people being able to self-regulate and monitor their newly adopted behaviour. Figure 19 shows that intrinsic motivation is attained when the user is in control.

Some theories have received extensive correlational support showing their ability to predict human behaviour with some experimental support (Prager, 2012). Most theories are argued to be weaker than the others and often do not specify how the identified constructs facilitate behaviour change. Thus, piecing theories together and highlighting the constructs that constitute the theory is required when selecting a theory that best suits an intervention.

3.14.1 Key constructs adopted from the above theories

From the discussions of the theories above, this thesis has operationally derived the detailed definitions shown in Table 2 below. These definitions represent how each of these constructs has been applied within this thesis.

Table 2 Operational definition of constructs used in this thesis.

Construct	Definition
Behavioural intention	Perceived likelihood of including PA in their daily routine or not.
Motivation	The role of motives and how they induce action. Belief that engaging in daily PA will yield positive outcomes.
Attitude	Belief that inactivity has a negative outcome on health and vice versa PA has positive attributed outcomes.
Subjective norm	Belief that if the important people around them disapprove or approve this may impact on the motivation to engage in exercise behaviour.
Perceived behavioural control	Similar to self-efficacy, this is the belief that the individual's behaviour is under his/her control.
Self-Efficacy	The belief that one can perform a given behaviour in a given situation.
Relatedness	Belief that the individual feels understood by important others.

Table 3 Theoretical construct conceptualisation

TPB	HBM	SDT	TAM	Current study
Attitude	Perceived susceptibility	Autonomy	Attitude towards use	Interest/Motivation
Subjective Norm	Perceived barriers	Relatedness	External variables	Social norms
Perceived Behavioural Control	Perceived benefit	Competence	Perceived usefulness	Control beliefs/Value
x	Cues to action	NA	NA	Forced functionality
Behavioural Intention	Perceived threat (Self-efficacy)	NA	Perceived ease of use	Perceived Ability

A theoretical framework, therefore, refers to a set of chosen theory a researcher sets out to guide any given research, or a set of drawn concepts obtained from one or more theory to explain a given phenomenon (Imenda, 2014). The constructs identified in Table 3 have been applied in either behaviour or motivation prediction and were essentially integrated to form a theoretical framework for this thesis. For the purpose of clarity ‘, forced functionality’ will be explained in detail in the next section. The reason behind bringing together several related concepts to explain the phenomenon of instigating exercise behaviour and changing screen habits was due to the complexities around the target behaviour. Thus, within this thesis, it was important not to limit the scope of the investigation, therefore refrained from choosing one theory over the other. This then informed the below framework, which will be applied across the thesis. These outlined psychosocial determinants of

behaviour will be measured longitudinally overtime during the intervention. Below is a diagram describing the key constructs adopted from all relevant theories and the discussions of the operationalised meanings as used within the current study.

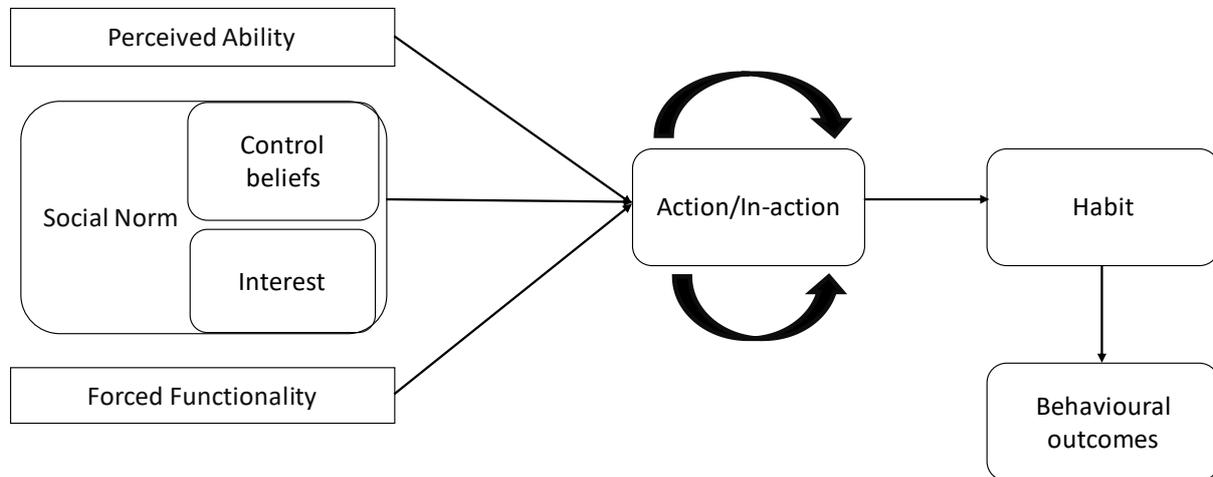


Figure 20 Theoretical framework for the current study

- Perceived ability** This could be perceived as either psychological or physical skills and is significantly linked to Bandura’s self-efficacy which he explained as “how well one can implement the courses of action required to deal with future situations”. This study took into account that ‘ability’ is not simply a matter of being able to exercise, instead, it involves some psychological skills and, according to Bandura, a component of cognitive and behavioural skills for an action to occur. Perceived ability can only be as good as the action itself. The HBM suggests that self-efficacy comes into play when there is an actual perceived threat on dealing with a potentially aversive situation. The cognitive process of dealing with the adverse situation requires increasing self-efficacy, therefore increasing the ability to deal with the situation. Within the context of increasing PA and reducing ST in the home, psychological ability relates to parents being able to model good

exercise and ST behaviour/habits. This could also relate to the children feeling confident to exercise for a given period (physical skills).

- **Social norm** adopted from the subjective norms in this research explains the individual's perception of social pressure from others such as the friends they play video games with and the rest of their family members, and how their thinking towards the intended activity shapes their motivation. TPB argues that actions are controlled by intentions, but not all intentions are carried out without external influences. The subjective norm in TPB was similar to the normative belief component in TRA, and several authors argued that it is the weakest component. For instance, in a meta-analysis study, TRA found that subjective norm was the weakest predictor of intentions (Putte, Hoogstraten and Meertens, 1991). This has led several other authors to deliberately remove subjective norm when analysing TRA/TPB (Zimmermanns, 1995). While the findings of their study reflect the low importance of normative and subjective factors in determining intentions or action, the current study argues that in the context of changing behaviour, this may differ. For instance, when working with children, social norms such as friends and family members play a vital role in determining whether the individual actually takes action in changing their behaviour. In relation to the discussion on social capital in chapter 2.4, if a child's social circle does not consider exercising to gain access to ST an appropriate behaviour, this individual is unlikely to engage in exercise, because it is not deemed permissible by the social group. This was also discussed by Ajzen & Fishbein (1972) when comparing social norms and normative beliefs. The thesis examines the relationship between social norms and behaviour in the analysis. Thus, social

norms are viewed in this thesis as multifaceted phenomena balancing between control beliefs and interest.

- a) **Control beliefs** – these are not directly comparative to PBC¹² which posits that a person's behavioural intention is guided by the fact that they are in control, or rather have the belief that their ability to perform a target gives them control over the behaviour. Thus, control beliefs differ in the sense that they observe the user's ability to influence what might inhibit their capability to perform a target behaviour. Operationally, in the context of this thesis, it was assessed by how the participants believed that, despite the external factors, they still had control over their behaviour. The application of the 'control' construct in the field of design for sustainable behaviour (DfSB) has been implemented in previous studies. For instance, Lilley and Wilson (2013) proposed a dimension of 'power of decision making' and their model, the spectrum of 'control', wavered between the user and the product. Their argument focused on the user either being in control or, on the other hand, the product using exerted force disregarding any conscious decision by the user. Shin and Bull (2019) further argue that user's autonomous decision making is vital in DfSB. Therefore, reinforcing and assessing control beliefs will provide more evidence on how users interact with the proposed intervention and their ability to be more in control of these external influences leading to internalisation of newly adopted behaviour. Arguably, control belief can be either 'internal' or 'external' which is categorised as 'locus of

¹² Perceived Behavioural Control

control' (Wallston, 2015). Wallston argued that these two beliefs are independent of one another. In isolation, this thesis has somewhat viewed the 'internal' belief within the interest and motivation construct which is discussed below.

b) **Interest/Motivation** – Social norm and interest can coincide/intertwine with each other. Sociological explanations of social norms have emphasised how the internalisation of motivation and values induces behaviour compliance. Herein, this thesis assesses and provides evidence on how the individual interests and motivations can influence their actual behaviour. Also, aggregating the patterns of the social norm and control belief could impact on individual action. As Wallston (2015) suggests, control beliefs could either be external or internal depending on the phenomenon; internal beliefs are associated with people's control over their health in the case of this study. Thus, we associate this with interest and how the individuals may perceive the added value they will gain from performing an action.

Some researchers have highlighted the importance of examining interest/motivation (Weber, 2009). It can be argued that one way to ensure high motivation is through ensuring that there is increased interest. This thesis, therefore, acknowledges the need for applying elements suggested from literature such as relatedness, as a key construct in increasing motivation. In other words, relatedness may also be associated with increased interest and high self-determined motivation to change behaviour. Contemporary researchers perceive

interest as a three-dimensional paradigm (Schiefele, 1991):
meaningfulness: how the individuals view the action/task;
competence: personal feelings about the action and their perceived
competency; and impact, which refers to how the action adds value to
the individual or how much value they emit by performing the task.

- **Forced functionality** – A forced function is a design aspect that prevents users from taking action without consciously thinking about the impact (Wever *et al.*, 2008). It is directed at getting people to act forcefully in order to produce results. Lockton and others (2012) argue that a linear human system models a type of user who will only respond to inputs by reacting, in the same manner, each time a stimulus is applied without considering any decisions. Thus, to influence this type of user, designers may be required to implement a forced function. Lewis and Norman (1986) in their study view the deviation from the ‘correct’ behaviours as errors, with the hope that these errors can be corrected to improve usability. In some products and services, this feature is required in order to ensure safety and security for the users. On the other hand, psychologists claim that during a behaviour change process, reactive processes (triggers) can support or inhibit behaviour maintenance directly or indirectly through reflective processes (goal setting, motivation). Thus, at the later stages of the behaviour change process, engaging in the target behaviour requires less deliberate effort. In this thesis, this forced function is not merely viewed as a construct, but a feature that is embedded to understand how users choose to make a decision for themselves; it is intended to facilitate them to take action or not.

- **Action/Inaction** – As discussed in chapter 3.4, TRA¹³ behavioural intentions are self-instruction to perform or behave in a certain way, mostly directed towards attaining the behavioural outcomes. In other words, it predicts how individuals will behave/act based on their behavioural intentions. Intention captures both the level of objectives, such as steps the individual is willing to take to perform the action and the individual's level of commitment but does not necessarily encompass the actual behaviour. In the current study 'action' was used to cross-examine if the user's intention was proportionate to their intention to act. Action = Inaction is the outcome of the individuals being exposed to these constructs.
- **Habit** – Habits can take a long time to form. One study has suggested that setting goals are capable of activating habitual actions (Aarts & Dijksterhuis, 2000). Within this thesis, habitualisation is characterised by the consistency in repeating the intended behaviour and their ability to resist going back to the old habits. Lally and others (2010) argue that displaying a particular behaviour unintentionally and repeatedly shows that automaticity has been achieved. The results from the empirical study showed whether the participants formed a habit or not. Within chapter 9.2,¹⁴ there were discussions around the habitualisation process of the participants, with a more detailed analysis of the maintenance of any new behaviour formed.

Each of these constructs was the key criteria used to gain the empirical understanding of collected data. To ensure the uniformity, these same constructs

¹³ Theory of Reasoned action

¹⁴ Can be found in page 277

were utilised to both assess and evaluate the process of habituation instigated in the main study of the thesis.

3.15 Summary of Chapter

The aim of this literature review phase 2 chapter was to present the multidisciplinary background of research that informed the processes of this PhD project. It signposted possible strategies for a design-led approach to be adopted in creating interventions for improving general health and wellbeing. The reviewed behaviour change models helped understand the current application of behaviour change theories in creating interventions. This current study refrained from picking and choosing one behaviour change theory to inform the current research; however, reviewed the relevant theories related to the current research and emerged with key constructs pertinent to this thesis.

Research and knowledge gaps were identified from the current review of literature done within this chapter. Previous studies indicate that there is a need for research in the following aspects:

- The rising problem of childhood obesity indicates that more research is needed on behavioural approaches to combat this global epidemic.
- There are existing interventions on ‘move more, sit less’ including Daily Mile, sweat coin, fitness trackers, gamification and other incentive-based interventions. Nevertheless, no study was identified on changing ST behaviour with by instating PA within the home setting.
- Excessive screen use presents an interesting area for research, given the high potential for replacing children’s ST with more active behaviours, especially within the domestic environment.

- There are limited studies measuring any changes in behaviour when adopting technology, for instance, active gaming.
- Most interventions do not explore past behaviours and the psychosocial determinants when creating behaviour change programmes.
- Most behaviour change studies evaluate the effectiveness of new interventions without measuring the potential impact on the health of users.
- Habit internalisation and automaticity in behaviour change studies in relation to PA and ST reduction lacked in the literature.
- Numerous studies focused on extrinsic motivators indicating the need for further research on intrinsic motivators in enhancing PA behaviours.
- There was little or no research in displacing children's ST with active behaviours within the home context.

This phase of the literature review demonstrated examples of behaviour change application and how design-led approaches can contribute to creating sustainable interventions. This thesis intends to fill some of the research gaps which are notable from reviewing the studies presented above. One of the outcomes of the studies identified above highlighted a 3-dimensional model proposed to help design researchers to develop more effective interventions, whilst gaining a full understanding of how cultural, social and material environments play a role in how people behave. This thesis adopted this model in framing the questions for the analysis of findings.

Chapter 4 Methodology

4.1 Introduction

This chapter outlines the research paradigms, approaches and strategies used within the current study in order to achieve the aim and objectives presented in Chapter 1. With the research purpose and plan set out for this thesis, this chapter goes on to answer the research question seen below.

RQ3: How can longitudinal investigation identify key behavioural determinants that influenced change?

Chapter 2 and Chapter 3 reviewed the relevant literature and discussed the theoretical frameworks that inform decisions in this thesis. In this chapter, more emphasis is placed on the methodological approach that oriented this research, ranging from research design to the justification of using both qualitative and quantitative methods.

This thesis herein demonstrates their understanding of research types/approaches to ensure that there is a critical justification of the methodological position of the current research. During the literature review for methodology, it was apparent that there was an identification of conflicting taxonomies within the field of research methodology. For instance, Saunders (2009) categorise inductive, abductive and deductive reasoning as research approaches, while Blaikie, (2004) refers to these as research strategies. These inconsistencies led the researcher to rely on the “research onion” by Saunders and others (2009) to decontextualize the various approaches considered for this thesis. Here the reader will also find explanations about the research methodologies presented in this research and how they were selected, taking into consideration their suitability to answer the research questions set out in

chapter 1. At the end of this chapter, the design sequence underpinning current research was briefly visualised and described. Ethical considerations are also discussed at the end of this chapter.

4.2 Overview of research paradigms

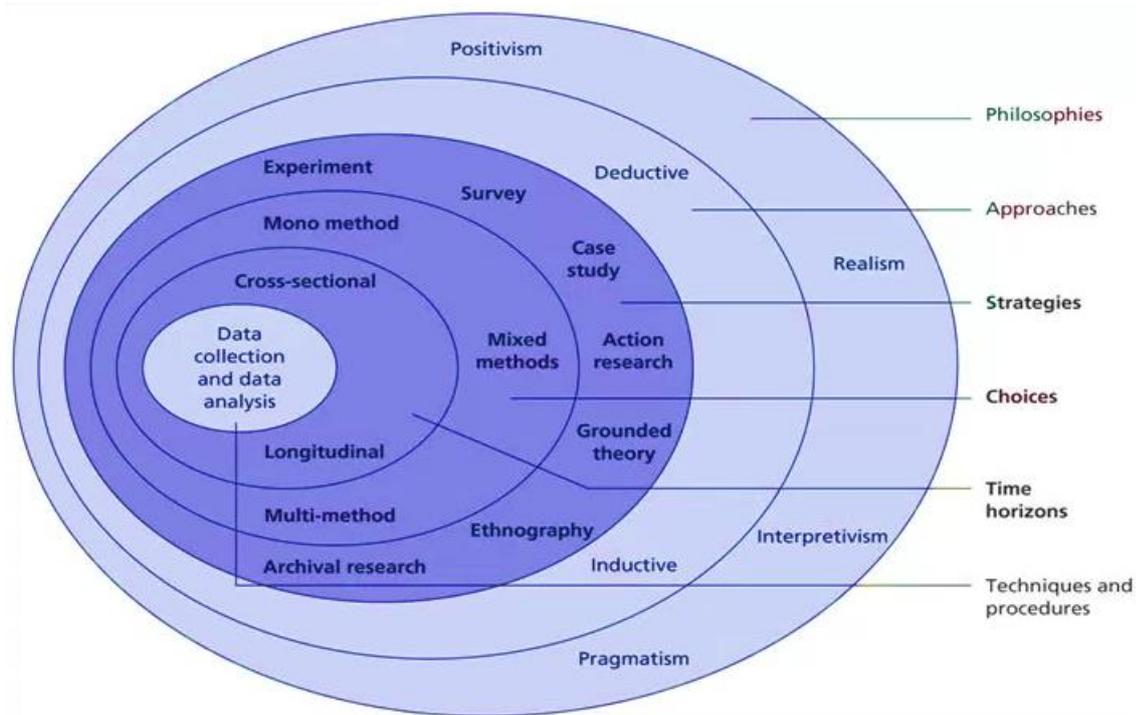


Figure 21 Research process 'Onion' (Saunders, Lewis and Thornhill, 2009)

Research frameworks are often characterised from a wide range of specific theoretical approaches. Thus, researchers are urged to understand and situate their study in a selected paradigm. Guba and Lincoln, (1994) describe a paradigm as a worldview that gives a description of the social world linked to connected sources of information and suitable methods of these sources. They suggest that three questions need to be addressed when defining paradigms: what is the nature of reality? (Ontology); what is knowledge? (Epistemology) and how best do we obtain the desired knowledge of reality? (Methodology). On the other hand, Morgan, (2007) views paradigms as 'sets of beliefs and practices that guide a field'; thus, researchers use paradigms for summarising their beliefs. They can be strong tools,

which guide the decisions that arise when answering any research questions in any given research. In the field of social science, the two main paradigms most often used are the positivist view (quantitative assumptions) and the interpretivist (qualitative assumptions). Figure 21 above shows the research onion that was developed by Saunders (2009) and its illustration of developing a research strategy when viewed from the outer layer. This onion, according to the authors, was to guide a researcher through formulating an effective methodology.

Research methodology has been approached and defined in various ways by several authors. This thesis chose to go by the explicit definitions and approaches showed by Saunders, by peeling the onion to explain the choices of every method used in the current study. Therefore, this study has adopted the research onion as a tool to discuss the underpinning choice of the approach used for the current study. The next section begins by peeling the onion from the outer layer to the inner layer.

4.3 Research philosophies

4.3.1 The positivist views

The positivist approach is directed at explaining relationships; it attempts to identify causes which influence outcomes (Creswell, John, 2009. p. 7). Positivism has been in existence for many years, and one of its main tenets is that objective knowledge (facts) can be obtained from direct observation (Robson and McCartan, 2015). In their book, Robson & McCartan explain that positivism has been a standard philosophical view for researchers in the field of natural science and has also been adopted by social science researchers. They often draw ideas from numbers, controlled environments, measurements, and sometimes randomised control trials. It explores facts, causes and drivers of human behaviour through direct observation, objective, quantifiable data, or measurement of any phenomena (Ulin, Robinson and

Tolley, 2005). This term, according to epistemologists, refers to quantitative research (Carter & Little, 2007). In quantitative research, the researcher is perceived as an objective scientist who utilises standardised tools to observe the effects on subjects (Etscheidt, Stainback and Stainback, 1984). As a result, control is essential from a positivist view, in order to sequence irrelevant variables and focus on links that are relevant to the emphasis of the research question. Since positivism is perceived as an objective approach, it mostly directs to studies relating to social phenomena, as positivists often consider it to be value-free and mostly subject to scientific explanation (Denscombe, 2014). Generally, positivism as a paradigm is related to varied schools of thought such as naturalism, behaviourism, determinism, and empiricism. Behaviourism is not merely the science of human behaviour; rather, it is the philosophy of the science that studies human behaviour (Skinner, 1974). It seeks to investigate instincts, reflexes and automatisms and denies any independent significance of the mind.

Over the years, quantitative researchers have gone through various challenges in order to answer difficult questions in public health research. Although their results yielded a significant amount of knowledge, there are still questions which remain unanswered, such as understanding and internalising behaviour change. The answers to the above questions are important as they contribute to why some people make healthy changes and others fail.

Consequently, researchers have developed other ways to study human behaviour, especially from different paradigms, such as in qualitative research (Tashakkori and Teddlie, 2010). There has been much attention on the objective monitoring of PA; however, the same did not occur with regard to inactivity or SB interventions (Bryant *et al.*, 2007). Studies around TV viewing measurements of children and

young people found that most interventions used were self-administered surveys using a single item as part of a multi-component survey (Hidding *et al.*, 2017). Few studies measured TV viewing through direct observation, however, the concept of the current study is to use a design-led approach to directly capture¹⁵ how the users interact with the device and measure any behaviour change that results from the testing. The current study is not fully situated in the positivist paradigm because it is not simply obtaining knowledge through a quantitative method. Although the researcher and the researched are independent entities, meaning does not solely rely on objects (research instrument in this case), but also relies on the researcher's interpretation of the qualitative aspects of the data gathered. Positivists believe that there is only one reality and that the reality is not influenced by external factors such as human actions (Orlikowski & Baroudi 1991). Interpretivists argue otherwise and theorise that social systems are not independent of the influence of some of external factors as discussed below. The next section will elaborate their school of thought.

4.3.2 The interpretivist views

The interpretivist paradigm positions itself in the ontological position of a relativism. Relativism views reality as subjective, with interpretation varying from person to person (Guba and Lincoln, 1994 p.110). For most qualitative researchers, their theoretical paradigm stems from an interpretivist view, generally also known as social constructionism (Robson & McCartan, 2016). They look at the world from a view that social properties are constructed from people's interactions and their experiences. This thesis believes that reality is constructed and in the context of the current study, the participants created their own meaning (subjective) as they

¹⁵ Design-led intervention included data logging function which captured the behaviour around exercise and TV usage.

interacted with the intervention exposed to them. This thesis is situated more around the interpretivist view because the researcher had sought to understand the reality that emerged when participants engaged with the object (research instrument) assigned to them. This view seeks for a relativistic understanding of a given phenomenon and is often seen in qualitative studies.

Consequently, from an interpretivist methodology, the researcher was directed at understanding the intervention outcome from the participants' perception without questioning each participant's ideologies but accepting and interpreting them as individual cases. This is also because interpretive methodology provides insight and in-depth understanding of behaviour with plausible explanations of actions from participants' viewpoints through qualitative interviews. This is driven by most qualitative researchers believing that meaning does not exist on its own (Eisner, 2017). In order to make sense of an individual's world, they focus holistically on social, cultural and physical environments of the participants (Green and Thorogood, 2018). Qualitative researchers generate findings from methods such as interviews and observations as meaning, and participants' perceptions allow them to acquire multiple perspectives (Robson and McCartan, 2016). For example, a qualitative researcher is not necessarily interested in delivering interventions for improvement of PA, but rather, how these interventions create meaningful health and wellbeing outcomes. Since this research is exploring the diversity of people's behaviours and their determinants with regards to habitual PA and ST using the design-led intervention, an interpretivist approach was embraced. The results generated from this thesis provide a rich account and credible justification (internal validity) and replicable research process (reliability) and "*research is deemed good*

if it provides rich evidence with credible account of replicable findings” (Ritchie et al., 2014 p. 263-286).

4.3.3 Design science research as a paradigm?

This thesis is situated in the field of ‘Design studies’. Design researchers attempt to create and design and develop artefacts that serve human purposes (March & Smith, 1995) and in contrast, natural and social scientists seek to understand the reality of things without often focusing on the usability and human applicability of their findings (Weber, 2010). Thus, design researchers suggest that design studies can be seen as another research paradigm that ultimately seeks to solve practical human problems (Au, 2001; Weber, 2010). This is mostly because the above two paradigms do not completely illustrate and fit the perspective of designers. A research paradigm is defined by a “*set of interrelated assumptions about the social world which provide a philosophical and conceptual; framework for the organised study*” (Filstead, 1970 p. 329). Design science research (DSR) comprises of developing valid and reliable knowledge and utilising these to solve problems with the intention of constructing a new reality (Simon, 1996). He suggests that DSR is essentially a problem-solving paradigm. Au (2001) argues that building and evaluating products are the designer’s intents, whereas theorising and justifying the application of the device in a real-world context are more natural and social science intent. Gregg and others (2001) further argue that, from a technologist point, positivist and interpretivist paradigms provide a reasonable basis for the majority of researchers in the information technology research stream, but do not adequately address unique requirements when designing a product. Thus, they recommended a new paradigm that will harmonise the two paradigms to offer a unique contribution to DSR. This new paradigm is the socio-technologist/developments paradigm,

where they describe reality as “technologically created” with knowledge coded both explicitly and implicitly as interaction takes place within the created system. Weber (2010) affirms that this new paradigm can be sorted into the DSR and further argues that DSR is not capable of representing a standalone developmentalist paradigm. However, he suggests that the socio-technologist paradigm is one possible approach to shift between being pragmatic and critical without being limited to fitting into one paradigm. He concludes by saying that “DSR is a research approach rather than a paradigm”. An important aspect of this thesis is to evaluate an artefact which was built with the intent of solving a real-world problem. This thesis has refrained from boxing itself within a paradigm and has considered the DSR approach, but as the primary study focuses on people, this thesis has taken into account that people’s behaviour can differ from their expressed attitudes. Also, DSR often looks to gaining user insights before designing a solution based on the findings; however, this thesis has designed an intervention based on findings from the literature review, tested this at a pilot stage and enhanced the instrument before conducting a thorough empirical study.

4.4 Research approaches

4.4.1 Deductive approach

Method of reasoning as an approach is one of the important features in research design. In the field of social science, theorising reasoning approach is anchored by three main types of reasoning: deductive, inductive, and abductive (Timmermans & Tavory, 2012). Arguably, deductive and inductive reasoning is the most dominant approaches in various research disciplines (Hyde, 2000).

Deductive reasoning dates back to ancient philosophy, whereby Plato argued that the only valid method of developing a theory is by logical deduction (Evans *et al.*, 1993). Miller and Brewer (2003, p.67) defined deduction as:

“An approach to data analysis, explanation and theory that sees empirical social research as conducted on the basis of hypothesis derived from a social theory which is then tested against empirical observations and then subsequently used to confirm or refute the original theoretical propositions”.

Deductive reasoning generally begins from generalisation towards reaching a particular conclusion (Miller & Brewer, 2003). While deductive reasoning can be used to expand implications as well as make observations, Müller *et al.*, (2017) argue that a deductive approach is unable to provide new insights that go beyond its original premise. In DSR and information systems (IS), there are limitations of specific theories pertinent to this field; thus, researchers in these disciplines that have adopted a deductive approach have embraced theories from neighbouring disciplines. For instance, TAM (Davis, 1989) is based on the TPB (Ajzen, 1991) and the TRA (Fishbein, M & Ajzen, 1975) and these two originated from social psychology. Due to its limitations of not being able to prove a theory right fully, researchers in DSR refrain from using a deductive approach because this could restrain their data to only pre-existing concepts and assumptions (Müller *et al.*, 2017).

During the analysis process, it was endeavoured to capture the qualitative richness of the data gathered by using both inductive and deductive approaches. Based on preliminary scanning of the textual data, this thesis used a prior developed codebook, also known as the template approach (Fereday and Muir-Cochrane,

2006). These prior developed themes emerged from the literature review highlighting some key determinants/constructs relevant in behaviour change studies, see chapter 3.14.1.

4.4.2 Inductive approach

Aristotle recognised induction as a valid approach for knowledge generation (Pries-Heje, Baskerville and Venable, 2008), and this involves working towards conclusions from observation. Inductive reasoning evaluates knowledge or arguments based on observation (Gregory & Muntermann, 2011).

Induction in a real sense corresponds to the reasoning that people apply in their everyday life (Hayes, Heit and Swendsen, 2010). Examples could be: predicting whether it is likely to rain tomorrow, or how your partner will react to the box of chocolates you purchased as a present; both of these involve some form of induction.

A useful formulation of inductive reasoning has been provided by Glaser & Pellegrino (1982 p.200):

“All inductive reasoning tasks have the same basic form of generic property requiring that the individual induce a rule governing a set of elements.”

Miller & Brewer (2003) further strengthen the inductive reasoning conversation by suggesting that empirical generalisation should be derived from data. Induction is very much associated with qualitative research, and Miller argues that this is because the data derived from induction and qualitative “research speaks for themselves”. In contrast to deductive reasoning, induction begins with specific observations (raw data) and further examines the collected data to find any emerging themes/patterns/relationships between them (Gregory and Muntermann,

2011). However, based upon the observations and interpretations derived from the data, it may be possible to generate inferences and theories (Gray, 2009). Therefore, with an inductive approach, when raw data are collected, theory or concept may be generated as a result of data analysis. Timmermans & Tavory (2012 pp.171) suggest that the researcher often starts with a collection of given cases and instances to ensure a degree of reliability. Thus, to progress to the development of examining their implied results in order to develop an inference that can be operated on a universal level, he proposes that:

“All observed A are C.

Thus, all A are C.”

Inductive reasoning is usually exploratory in nature as it reveals not only the regularities but also any irregularities in the data. It could be argued that this type of approach is appropriate when new knowledge needs to be examined, whereas deductive reasoning may be applied when there is a need to test existing knowledge (Lee *et al.*, 2011).

Having established that the inductive approach allows researchers to construct a new theory, this thesis can be described as more inductive. Within the premise of inductive reasoning, the thesis provided the opportunity to get close to social phenomena during the data collection, and this allows for the generation of a theory which could be posed to represent reality. One of the limitations of inductive reasoning is the challenge of reaching generalisation only based on observation of cases or events (Timmermans & Tavory 2012).

4.4.3 Abductive approaches

As mentioned above, deduction and induction are both dominant ways of generating hypotheses or theories in any given research (Miller and Brewer, 2003). Charles Sanders Peirce proposed abduction, which became the third method of reasoning (Krupnik & Turek 2014). Pierce defined abduction as “the process of forming an explanatory hypothesis” (Pierce, 1903, pp.171). Abduction has been described by other researchers as a step of an initial hypothesis from an inference. Having discussed the duality of the forms of logic/reasoning that have been more widely embraced in the research above, abduction has been described by design researchers as the “logic of what might be” (Kolko, 2009). Although similar to inductive reasoning, the conclusion derived from an abductive argument could turn out to be false, even when the premise is true (Kolko,2009). In deductive reasoning, the different limitations of a given problem begin to act as logical premises, and abduction in this sense can be driven by design or cultural patterns; this may act as an argument for ‘best explanation’. Legrenzi (2005) argue on the contrary that in the context of creative problem solving, insights are perceived to be developed not occurring in a “flash”. He suggests that some steps/processes often lead to insights. Therefore, this thesis refrains from positioning itself as abductive.

4.5 Research strategies

The next internal layer of the research ‘onion’ is the research strategy. The research strategy determines what type of knowledge needs to be discovered through the research and its activity. The researcher begins to develop and design the project according to what kind of research is needed. Robson and McCartan (2016) classified some of the strategies as:

- Exploratory – to clarify a phenomenon when there is very little to be understood.
- Descriptive – to portray a profile of event or person in detail.
- Explanatory – explain patterns between different phenomena.

From the research ‘onion’ experiments, surveys, action, and archival research are all the variations in which the purpose of the research inquiry can be classified, and these are commonly adopted. For the purpose of the current study, this thesis has only highlighted three strategies which are discussed below, with emphasis on the strategy implemented in this thesis.

4.5.1 **Ethnography**

Ethnography is a study that investigates social interactions, behaviours, and perceptions that exist within groups, organisations or communities (Reeves *et al.*, 2008). It often aims at providing rich and holistic insights into people’s perceptions and behaviours within the location which they inhabit, usually via the collection of detailed qualitative observations and or interviews. Although this type of study is often viewed as a qualitative inquiry, it could sometimes involve the use of quantitative data and analysis (Hammersley, 2006). This approach is mostly used by social scientists to explore the nature of a particular social phenomenon in great detail, rather than setting out to test an already established hypothesis. In contrast, designers are mostly concerned with developing a product that modifies the behaviour of the studying group/organisation/community.

DSR methodology centres on building and evaluating products with a knowledge base and real-world application (Baskerville & Myers 2014). Their study discusses various ways in which ethnography is related to DSR. The first highlighted that

there is ethnography for design, which focuses on ‘the broad patterns of everyday life’ these are important for the conception and development of new products. Ethnography to study design encompasses the behavioural characteristics shared when planning and navigating a particular design process and can be viewed as an ethnographic technique. The third way is design ethnography, which is mostly associated with designers being actively involved in a design process where products are introduced into social or cultural contexts. Gunn and others (2013) argue that this is similar to anthropology. Due to the nature of the current study, using an ethnographic technique is not suitable, even though the research aimed at understanding patterns in the behaviour of the participants. A central feature of ethnography is the researcher getting out into the field and staying there (Robson & McCartan 2016), and this was highly unrealistic in the case of the current study. Also, the presence of the researcher observing the changes in the behaviour of the participants could affect people’s intentional activities, create bias, and generally reduce the validity of the data collected.

4.5.2 Grounded theory

Grounded theory was originally founded by Glaser & Strauss, (1967) who explained how theory could be generated from a dataset inductively. Grounded theory closely represents both a method of inquiry and a resultant of the inquiry. Glaser & Holton (2004) define grounded theory as “*a set of integrated conceptual hypotheses systematically generated to produce an inductive theory about a substantive area*” (p.43). Using grounded theory provides a specific procedure for both theory generation and analysis of qualitative data. Its hallmark is the generation of a new theory ‘abstracted from or grounded in the generated data gathered by the researcher’. Researchers who use grounded theory are often experts and have

enormous research skills and tend to have a procedural precision in their use of the method (Birks & Mills 2015). Some of the reasons why the current study did not adopt grounded theory are: in grounded theory, data obtained cannot merely be inspected. Also, as more analysis of data was suggested by Glaser (1967) to go through a prescribed mechanism of coding; it is also challenging to decide when the categories in the data analysis are saturated or when the theory is adequately developed. Robson & McCartan (2016) highlighted that grounded theory has three distinct data analyses: axial and open, and selective coding; thus, this coding approach was perceived as too restrictive.

4.5.3 Case study

Hamel and others (1993) traced the history of case studies within social science research. The essence of case studies is central to illuminating *a decision or set of decisions* and how and why they were taken to achieve a certain type of result (Schwandt, 2007). Yin (2014) criticised their view on case studies as being sufficient to establish a complete basis for case study inquiry, mostly because they only focused on “*decisions*”. He further defined a case study as “*an empirical inquiry that investigates a contemporary phenomenon (the “case”) in depth and within its real-world context especially when the boundaries between phenomenon and context may not be clearly evident*” (p.16). Thus, it can be said that case study research enables exploration and understanding of complex situations and can be considered a robust and holistic method of inquiry. The current study has adopted a case study approach for various reasons. This type of research allows the use of both quantitative and qualitative evidence with the need to define a “case”; it was suggested by Yin (2014) that case studies go beyond being a type of qualitative research. This thesis examined behavioural changes, and this goes beyond obtaining

mere quantitative information on the constructs within which these behaviour changes occurred. Therefore, including both the quantitative and qualitative data helped explain both the process and outcome of the explored phenomenon through both observation and analysis of the all the cases under investigation. Another advantage of the case study, as suggested by Yin (1984) is that it allows the researcher to examine the data obtained from the cases within the context of their use. In the current study, it was essential to understand the process by which the participants comprehend and interact with the research instrument; this meant that the researcher observed them within their environment with all variables present. Some longitudinal studies investigating individual subjects adopt a case study approach, and the current study is a longitudinal investigation which is relying on the information recorded on the device which shows a descriptive account of the user behaviour. Also, the research questions guiding the current study provided a clue to the type of research strategy to adopt. Yin (2014) suggested that case studies are most appropriate for “how” and “why” questions and research questions 2 and 3 in the current study align with this. For longitudinal or ethnography case studies, one of the frequently discussed criticisms is that, due to the nature of the data collected over a period of time, managing and organising this data systematically could be quite problematic (Bryman, 2016). Case studies have also been criticised for lack of rigour and the tendency for researchers to have biases on data interpretation; this was not the case in the current study, especially with the information received from the device. The data was straightforward on the PA time and time spent on screens, and this was cross examined with the qualitative interviews, thus strengthening grounds for establishing reliability and generalisability. Case research enrich and expand understanding of phenomena

beyond individual conceptualisation and this is like action research which focus on production of solution through practical problems.

4.5.4 Action Research

Action research, also known as participatory research, collaborative inquiry, or emancipatory research, embraces a variety of viewpoints and research design. Put simple ‘action research’ can be described as “learning by doing”- whereby one identifies a problem, create solutions to solve it and observe to understand how successful their proposed solution was in making an impact (Hendry, 1996). Action research can be traced back to work done by Lewin in 1946, where he was mainly concerned with the shortcomings of the natural science methods when applied within social sciences (Larsson, 2001). He conceived ‘action research’ to bridge the gap between practice and theory. There was no formal definition of action research by Lewin. He, however, emphasised on change and investigation of change (Hendry, 1996). Gilmore and others (1986) defined action research as “*the aim to contribute to both practical concerns of people in an immediate problematic situation and to further the goals of social science simultaneously*”. This suggests that the purpose of action research is to study a system and concurrently collaborate with the other actors of this system to create solutions that move the system in a desirable direction.

When compared to other forms of research investigation, action research appears to have similar orientation like case studies. They both deal with context-bound knowledge and offer greater opportunity for researchers to focus on issues and concerns and how their solutions/action fulfil practical needs at the end of the research. Other similarities between case study and action research, include, that they are both concerned with researchers gaining an in-depth understanding of any

given phenomena when trying to solve real-world problems. They both adopt a style of collaboration by involving participants within the action of research and embraces both *postmodern* and *realist* perspectives (Dobson, 2001).

Scholarly literature argue that action researchers rely on some case study methods, considering they already adopt specific guidelines when conducting research, some of which contain case-study proponents (Cunningham, 1993). This has been predominant in situations where action researchers reflect on requirements of a research process. Action researchers do not often declare their intellectual framework in advance, and this has often led to this type of research becoming blurry from mere action and unable to be positioned as a viable research practice. (Checkland & Holwell, 1998). Yin (1984) also discusses the importance of an intellectual framework of ideas and how this facilitates analytical generalisation, which is often a difficulty faced by action researchers. The current study had an established theoretical framework which has been argued to enable analytical generalisation. Thus, elements of the current research have some case study proponents such as an established theoretical framework. Also, the theoretical explanations of the phenomenon helped the researcher view the individual household as cases which was also considered in a broad sense during the evaluation of the result stage. It also positions itself within the action research continuum whereby, the adopted strategies considered active and deliberate self-involvement of both researchers in the context of the investigation and the participants' involvement.

4.6 Research choices

Saunders and others (2009) suggest that research choices are mostly associated with data collection methods. Thus, if more than one method is required for a study, how

could the researcher combine these methods? He further outlined three different research choices in the research onion, as seen in 4.3:

- **Mono method:** this method adopts only one type of method and perhaps various data analysis procedures when being applied in a given study.
- **Multiple methods:** this method exclusively adopts qualitative or quantitative approaches for data collection and possibly different procedures for data analysis.
- **Mixed method:** this research has been suggested when mixing qualitative and quantitative methods in a study.

This thesis assumes a multiple method choice whereby the qualitative information was obtained from the participants before and after the study, and the use of numerical data (quantitative) was used to facilitate patterns and make meaning from the qualitative data obtained. Detailed explanations of both qualitative and quantitative methods will be discussed below.

4.6.1 Qualitative

The qualitative methodology provides a rich and detailed account of an event. Qualitative researchers often acknowledge their humanity, and this helps shape how any obtained data is interpreted. Denzin and Lincoln (2011) suggest that the word qualitative “*implies an emphasis on the qualities of entities and on processes and meanings that are not experimentally examined in terms of quantity or frequency*” (p.8). Flick (2018) in his book gave a historical account of the development of qualitative research and concluded that this research choice had been widely applied and accepted as a continuous process, sensitising concepts, and constructing meaning. However, qualitative research has been broadly defined as “*any kind of*

research that produces findings not arrived at by means of statistical procedure or other means of quantification” (Corbin & Strauss 1990, p.17).

Qualitative research offers compelling and thorough insights into people’s perspectives and lived experiences in ways utterly different from the knowledge we can obtain using quantitative methods. It enables the researcher to become the ‘instrument’ of data collection and transform the participants’ unique experiences from just numerical ID’s to interpreted peculiarities of the narrative. Qualitative approaches aim to seek an understanding of a phenomenon from the view of participants or those experiencing it. In the field of health and wellbeing, there is an existing tradition of qualitative research (Braun & Clarke, 2014). Nevertheless, grounded theory has been widely used within the field. From a positivist stance, the origins of this theory were first applied in Strauss & Glaser’s (1965) study of deaths in the hospital and through a constructivist lens Charmaz’s (1983) study on loss of self in chronic illness.

There are many different approaches to qualitative analysis which have been widely debated, particularly in the field of social sciences (Bryman & Burgess, 1994; Coffery & Atkinson, 1996; Mason, 1996, Silverman 2015, Braun & Clarke 2006). For instance, one of the authors outlines three possible approaches: “literal”, “interpretive” and “reflexive” (Mason, 1996, p.54). The literal approach was described as an analysis protocol focusing on the participant’s exact use of words or grammatical structure. On the other hand, interpretive is more focused on drawing meaning from the participant’s account of the narrative. Lastly, reflexive focus on the researchers and their contribution to the analysis process. Therefore, in any given research, the researcher needs to be articulate regarding which research approach /method best answers the research question (Fereday & Muir-Cochrane,

2006). During the data collection, qualitative interviews were conducted to understand the factors of behaviour, and the participants' attitudes towards the intervention (before and after).

4.6.2 Quantitative

This involves applying logical positivism and employing experimental measures to test a hypothesis (Hoepfl, 1997) and measuring and analysing causal relationships between variables (Denzin & Lincoln 1998). In a quantitative study, the researcher is allowed to familiarise him/herself with the concept to be studied and conceivably generate hypotheses to be tested. Generally, a quantitative research choice is supported by scientific or positivist paradigm and often leads us to regard the world as measurable. Glesne, C., & Peshkin (1992, p.7) state that through this assumption, *“social facts have objective reality and variables can be identified and measured”*.

Quantitative researchers often suggest that methodological tools imbue objectivity which is not the case in qualitative studies. It is therefore vital to embed reflexivity in research practises to see more gain; numerical data is necessary, but qualitative information shapes it into insight. The use of both qualitative and quantitative was useful in this thesis to gain facilitate the interpretation of the entire data set gathered for this study. It was also valuable in answering the research questions posed for this study. Therefore, for validity, the qualitative interviews were used to gain understanding into the user behaviour, the quantitative data helped to widen the scope of the study through statistical analysis. The various points in which these data were collected are discussed in detail in the following sections of this chapter.

4.7 Time Horizon

Time horizon usually stipulates how the research will be carried out in terms of duration and periodicity. Below discussions will detail the characteristics of the two primary time horizons as specified by Saunders in the research onion. Bryman and others (2018) describe this research design as either longitudinal/successive independent samples or cross-sectional. The next section discusses what constitutes both longitudinal and cross-sectional below and justification for the time horizon chosen for this thesis.

4.7.1 Longitudinal study

Longitudinal research has been suggested to follow a particular set of individuals over time: often years or decades with continuous or repeated measures (Caruana *et al.*, 2015). A longitudinal study has been defined as “*a research design that involves repeated measurement over time of one or more groups of subjects*” (Deschenes 1990 p. 153). One of the characteristics of this research design is that it is observational in nature, and the data collected could either be quantitative or qualitative. In health research, a longitudinal study is used to evaluate the development and risk factors of diseases and treatment outcomes over a given period of time (Van Belle *et al.*, 2004). Longitudinal studies often take different forms, such as:

- Repeated cross-sectional: this usually involves study participants being widely different on every sampling occasion (Caruana *et al.*, 2015).
- Prospective studies: this means that the same participants are followed over a period of time and may often be segmented into control **panel**;- where individuals with similar exposure are considered, or **representative panels**

wherein data is collected from random individuals over time (Newman, 2010).

- Retrospective studies: in this type of design, some of the participants may have been exposed to similar events of relevance to the study and the data which is collected is examined retrospectively (Menard, 2002).

A longitudinal study is good at establishing sequences of events. One study that objectively measured 7-year-old children's PA changes over a 2 year period reported that low and declining levels of activity occur well before adolescence (Basterfield *et al.*, 2011). One of the advantages of this research design is that when the same individuals within a cohort are followed over time, it is easier to observe the changes. The current study adopted a longitudinal design because it simultaneously provides a repeated rich account of data and increases the statistical power for predicting changes over time. Also, one study that explored how habits are formed in the real world examined 92 individuals for a 12 week period and concluded that the time in which it took for participants to reach automaticity of behaviour was between 66 days (Lally *et al.*, 2010). They further highlighted that although the average modelled time for individuals to reach 95% asymptote was 66 days, if the study was to be replicated, 'plateau of automaticity' would vary between 18 - 254 days There is a lack of literature supporting how long it takes to form a habit, with Lally and others, being one of the scholars to validate Ronis, Yates and Kirscht's, (1988) study. The latter authors argue that, for a behaviour to become habitual, it must have been performed as often as twice a month and extensively up to 10 times (p.213). Therefore, the current study opted to examine the user's habitualisation through a longitudinal investigation for a minimum of 90 days. The research tool used for data collection logged participants' behaviour consistently

and repeatedly to show the behaviour curve that emerged. Obtaining data through repeated measures for specific variables can provide a comprehensive evaluation of changes in people's attitudes across a time period (Guo *et al.*, 2013). One of the characteristics of longitudinal investigation is the collection of data at more than one-time point (van Weel, 2005), which was also implemented during the main study (DUS¹⁶) for this thesis. One study that recently reviewed how longitudinal studies can contribute to advancing health behaviour maintenance through intervention suggested that most interventions focus on addressing automatic or reflective decision-making processes but rarely focus on both (Dunton *et al.*, 2019). They argue that timing and circumstance in which an individual may progress between the two systems are challenging to assess in cross-sectional and laboratory-based research methods. They contend that longitudinal studies which collect real-time data, such as the current study, strategically capture when individuals shift or fluctuate between automatic and reflective systems of decision making, underlying their behaviour change process. Therefore, this thesis also contributes to the methodology gap, as it is the first study to the best of the researcher's knowledge to observe changes in PA and ST behaviour of participants using the design-led intervention to capture both automatic and reflective systems of change longitudinally. In contrast, the cross-sectional design also analyses many variables but usually collects data at a one-time point.

4.7.2 Cross-sectional study

This thesis was not a cross-sectional investigation, because researchers have used cross-sectional studies to estimate the prevalence of any given outcome of interest within a population, usually at a one-time point (Levin, 2006). Unlike longitudinal

¹⁶ Domestic User Study, See Chapter 4.10

studies, this type of study does not often indicate the sequence of events, thus very little chance of inferring causality. Some researchers argue that cross-sectional studies are useful for determining prevalence (Mann, 2012). Cross-sectional studies are relatively quick therefore have been used in a lot of studies relating to PA and SB investigations (Ryan S. Falck *et al.*, 2017; Howitt *et al.*, 2016; van Sluijs *et al.*, 2007). In contrast to longitudinal studies, cross-sectional studies provide no information on the influence of time on the variables measured. They are, however, generally considered useful pilot evaluations of possible associations before exploring a longitudinal-type investigation because they require less time to set up.

4.7.3 Time focus of the current study

The time horizon chosen for the current study is a longitudinal study, and this was mostly to quantify trends in people's PA behaviour and identify patterns of any significant behaviour change. There is also a shortage of research on studies that have longitudinally used designed intervention to change behaviour, more so in PA behaviour studies. To the best of the researcher's knowledge, this will be the first study to examine the relationship between children's PA behaviour and ST using the design-led intervention and determine if those engaged in exercise behaviours have the potential to reduce screen-related behaviours. Longitudinal research is often relevant in determining direct causation and in the case of this thesis, it was useful to determine *how* the intervention led to the effect.

4.8 Technique and procedure

And finally, the middle of the 'onion' which is most central is the selection of techniques and procedures for data collection and analysis of data. These are mostly seen as the tools researchers use to effectively gather the information/data and knowledge required about the phenomenon under inquiry and measure the aspects

of reality that are peculiar to the study. For instance, when examining the way people behave, it is important to watch what they do (observation), cross-examine their views about the subject of inquiry (interviews, questionnaires, tests etc.) and determine their abilities using any standardised tests. Details of the methods and techniques used for the research will be described briefly below.

4.8.1 Literature review

Firstly, an extensive and detailed literature review was conducted prior to all the subsequent stages of this study, using databases such as Scopus, Library OneSearch, Google Scholar and many more. The literature review stage helped address the first and third research questions. 1* *“What is the current background of research related to PA behaviour, and how does it indicate possible interventions to tackle the obesity crisis?”* 2* *“How can behaviour change theories create pathways for developing physical activity interventions?”*. Books, peer-reviewed articles, published reports and conference proceedings were compared and critically reviewed to produce a wide picture of the background for this study and then further narrowed down to identify the gaps in the research.

4.8.1.1 The first phase – Understand parental views of screen time

This phase of the study explored parental attitudes and understanding of their children’s ST behaviours. Data were collected using questionnaires and semi-structured interviews. The qualitative information was coded using thematic analysis to produce themes highlighted by the parents, and this was included as a guide to frame the primary study.

The quantitative data was further analysed statistically using the correlation coefficient (Spearman's Rho), which was useful in measuring the strength of association between the studied variables. This phase of the research also intended

to understand how concerned parents were about their children; it was apparent that children's use of technological devices was a huge concern to parents and they emphasised a need for interventions to induce more active behaviours for their children. The outcome of this phase reinforced the need to propose interventions such as the current study.

4.8.1.2 The second Phase - Pilot testing

A pilot study is relevant to understand any complications that may be faced by a wider study. It has been defined as a 'small scale part of the research where ideas are tested for feasibility'. In the case of the current study, the pilot test enabled the researcher to frame the intervention to fit the context in which the main study was proposed to be conducted. The 4 participants were selected randomly, and details of the outcome of the pilot study phase will be discussed in chapter 6. This phase also addressed the research question: *How can behaviour change theories create pathways for developing physical activity interventions?*

4.8.1.3 Third Phase – Domestic User Study (DUS)

The third phase was the central and most crucial aspect of this thesis, whereby the research instrument was tested in 20 households for a period of 90 days or over. The knowledge gathered from the literature review and pilot testing facilitated the deployment strategy. The responsibility depended on the researcher to make and justify some decisions based on research evidence and recommendations from previous studies. Further to the above, idea generation meetings frequently took place between the researcher and the supervisory teams to discuss how participants could be recruited and encouraged to participate.

4.9 Overall study design

The overall aim of this study is to evaluate the design-led intervention that is intended to reduce sedentary behaviour in the domestic environment. The DUS focused on instigating habitual physical activity whilst reducing ST with an emphasis on sustaining this new habit.

To accomplish the objectives, both qualitative and quantitative methods were adopted. A comprehensive literature review was undertaken to identify the research gap and centralise existing knowledge in different disciplines in relation to design for behaviour change. According to Robson and McCartan, (2016), any research aimed at investigating an imperative issue or casual relationships with the aim of establishing the direction and the magnitude of the problem can be classed as longitudinal research. Therefore, the main study of this thesis has attempted to gather participant's behavioural data through a longitudinal study. The nature of this research, to investigate the 'what, where and when' and change with the aim of producing measurable and tangible evidence, can be described as longitudinal research. The main study of this thesis used an intervention technique to investigate the behavioural modification outcome. In this study, a qualitative and quantitative method was used to understand the perceived influences around sedentary ST and an in-depth understanding of participants' PA levels at baseline. The demographics will cut across ages 11-15 years old, following the Public Health England data on the highest number of overweight and inactive people in 2015 (Public Health England, 2015). The framework for selecting study time will also examine habit formation to see how long new habits take to be internalised. The complexities may vary as individuals show changing patterns in their behaviour over a life course.

4.10 Domestic User Study (DUS)

DUS is similar to already existing approaches such as Home-Usage Test/Home User Test (HUT/IHUT) which have been applied in market research by making provision for consumers to test products in their own homes as they would ordinarily do. It is beneficial for commercial products to be tested by their potential users, to enable manufacturers to gain real-life feedback before the product is launched in the market. Thus, DUS has taken a similar approach, as it reflects an investigation of children's behaviour towards the use of the research device and any significant changes in behaviour during its use in the domestic setting.

As discussed in chapter 3, there are a few behaviour change interventions that have targeted children, although they are limited to domains other than the domestic environment. As established in the literature, prolonged sitting is related to cardiometabolic risk profiles. Sigman (2012) argued that ST was not merely SB but agreed that increasing TV viewing had been suggested to be associated with increased weight gain in children, primarily. Hence the need was not only to increase parental awareness but to find simple measures by which to displace ST with active behaviours. One systematic review reported that 29 studies successfully achieved a significant reduction in TV viewing and general screen media use (Schmidt *et al.*, 2012). Replicating this in the domestic environment is very crucial, and therein lies the novelty of the current study.

Also, in order to investigate any behaviour changes that could occur as a result of the screen limiting device, it was apparent that no design intervention currently exists. Thus, the current study has not only tested the effectiveness of the research instrument longitudinally but has also validated its use from the user perspective. The first stage of the DUS provided a view of the user's level of interaction with the

research instrument - a pilot stage to elicit feedback from users and understand its application in the real world. Due to limited study prototype, and participant availability, DUS was carried out in batches over a period of 11 months. This entailed deployment to one household while another participant is put on standby in other to participate. Other challenges included difficulty in finding participants which led to the taking on board different participants from different locations outside the midlands, such as Swindon, Cardiff, Bristol, Reading.

4.10.1 Data analysis

Due to the nature of the research, both quantitative and qualitative information was gathered for this study. At pre-intervention, participants' TV consumption was assessed using an energy monitor. This information was to assist the researchers in understanding the baseline ST level and was analysed with the final ST post-intervention. Accordingly, during the analysis, it was important to keep an open mind when reviewing all the gathered data, searching for patterns and insights that emerged as themes. Some of the pre-analysis was done to help understand the patterns involved in creating flowcharts and going through the field notes obtained during the home visits. From the observations made during the pilot study, the researchers applied a simple approach attributed to grounded theory 'memo writing' (Corbin & Strauss 2008). These memos contained hints and conceptualisations on the preliminary interpretation of the data gathered, which helped to form the generally analytic path for the DUS stage 2. Although the current study used a qualitative approach, there were deliberations on combination with quantitative research. After a deep understanding and research, it was established that most quantitative research specifies its hypothesis in advance (Maxwell, 2010) and this was not the case in the current study as there was no prior hypothesis made.

However, during the quantitative consideration a structural equation modelling was deliberated, but based on the sample size of 20 participants it was not appropriate, and this was informed by literature (Hair *et al.*, 2010; Bryman 2012). These studies suggest that a structural equation modelling analysis requires a 200-400 sample size. Thus, the current study utilised a mixed linear regression was used in the statistical analysis. This type of analysis is used to analyse data that are summarised in groups by charting changes that occur over time (Singer and Willett, 2009). It is used to determine the relationship between a response variable and an independent variable with coefficients that vary between groups. As the data was repeatedly measured at consecutive points (longitudinal), a simple regression was carried out initially but did not show any significance. This led to the conclusion of applying a linear mixed model (LMM) regression approach, which is commonly used for longitudinal data. Puspongoro (2017) suggests that the use of LMM provides the researcher with the flexibility to model the covariance structures and model relationships between the independence of observations. In the context of the current study, the participants were seen as independent of each other, as there were daily observations of their behaviour outcomes across the intervention period. There was also an attempt to use a linear model, but it became apparent that it is not applicable in covering the characteristics of longitudinal data. In contrast, LMM is and offers the flexibility to think more clearly about the random effects within subjects. Thus, the design of the current study is longitudinal, hence the use of LMM as a statistical analysis procedure. The term “mixed” in LMM represents the fixed and random effect which is used simultaneously across the analysis within the model. In the current study, the fixed effect was classified as the constant variable across the participants and the random effects were the experimental units that varied across the participants.

4.10.2 Thematic analysis

Gerald Holton, in his work “themata”, has been credited as the first philosopher to invent thematic analysis (TA) in the 1970s (Holton, 1988). But some musicologists in the 1930s are suggested to have used the TA term to describe the analysis of musical scores (Kinsky & Strunk 1933). Also, the terms “TA” and “content analysis” have been used interchangeably and most often as the popular mixture of “thematic content analysis” (Brewster *et al.*, 2014). Regardless of the origins of TA, Braun (2018) points out that it has shared history with content analysis.

“Thematic moves beyond counting explicit words and phrases and focuses on identifying and describing both implicit and explicit ideas. Codes developed for ideas or themes are then applied or linked to raw data as summary markers for later analysis, which may include comparing the relative frequencies of theme or topics within a data set, looking for code occurrence, or graphically displaying code relationships.” (Namey et al. 2008 p. 138)

The current study followed recommendations from Ando and others (2014) to develop and refine the codebook for the interviews conducted. All interview transcripts (pre- and post-study) were transcribed and listened to a couple of times to ensure accuracy. During the listening phase, the researcher jotted comments down and combined this with observations made during the interview. In order to avoid missing nuances and themes, the transcription was also included as part of the analysis process of the semi-structured interviews. Braun & Clarke (2006) suggest that reviewing extracts from a transcript will entail outlining and evaluating the themes within each individual interview before evaluating the entire data set; this was applied at the code level rather than theme level to ensure that a codebook was generated and no meaningful information lost. The coding analysis was done with a

combination of NVivo pro and Microsoft word. An inductive approach was used to create a codebook which ensured that all the potential themes were captured before the secondary phase of the coding.

4.10.3 Study population

The population for the current study comprised of children aged between 11-15 years from different parts of the UK. The literature review already established that children are the most inactive demographic and there are limited interventions available encouraging them to be more active. This study concentrated on children without involving parents for a few reasons; to focus on instigating PA in children specifically, to fill the gap on existing interventions focused on increasing children's PA and decrease their ST and to avoid complications in the data analysis.

As discussed in chapters 1 and 2, the group most often suggested to record high amount of ST is 'children'. With an Ofcom, (2017) report revealing that 90% of the said group aged 12-15 watch TV for around 13.5 hours a week, with 71% of them owning their mobile phones/tablets. From the findings of the first phase of the current study, parents reported that their children spent an average of 6 hours a day watching TV. Secondly, chapter 2 discusses studies that have shown strong links between ST and obesity and a BHF (2015) report suggested that only 20% of girls and 23% of boys aged 5-15 meet the recommended PA guidelines of 1 hour of MVPA daily. Another reason for choosing the study population is that a further report (NHS, 2016) suggested that meeting PA guidelines declines with age and the above age group were observed to have shown a considerable decline. Thirdly, numerous studies highlighted that substitution of TV or ST with MVPA is not likely to fully occur (Maddison *et al.*, 2014), thus giving children an opportunity to earn their ST through PA might increase the chances of achieving the above substitution.

Since it has been established that inactivity behaviour increases with age, this might be an important time to introduce good practices, as these habits are not yet well-formed in this study population. Table 4 below details the inclusion and exclusion criteria for participant recruitment.

Table 4 Inclusion and exclusion criteria for main study (DUS)

Inclusion	Exclusion
Children aged 11- 15 years	Medical condition
No pre-existing medical condition	Children outside the age range
Have at least one TV in the home	Refusal to give informed consent

4.10.4 Justification of sample size

Experts in qualitative research have often argued that there is no basic answer to the question of how big or small the sample size should be. The main assertion, according to these scholars, is that the sample should be dependent on factors relating to the practicality and methodology approach the researcher is taking (Sandelowski, 1995). Their study recommends that sample size should be considered on the basis that they are large enough to unfold ‘new and rich understanding’ of the phenomenon under review. Morse (2000) suggests that as long as there is a reasonable amount of usable data collected from each person, then few participants will be required. His suggestions invite researchers to take into consideration parameters such as the scope and nature of the study, the study design and the quality of the data. Therefore, taking into account the scope of the current study being longitudinal and using a limited number of study prototype, the sample size was set to 20 households, which was assessed as sufficient to evaluate the effectiveness of the intervention. With regards, the quality of the data, longitudinal investigation yielded interesting and rich findings, including the various types of data collected. Also considering that the participant had similar characteristics, the

behaviour pattern was uniquely related after 15 households. Notwithstanding the sample size used for this thesis, future investigations can include a larger sample size while using this preliminary finding as a benchmark.

4.11 Using material as a tool in design research

In the field of research, there has been a growing interest in research through design (RtD) (Bardzell & Bardzell 2011; Forlizzi *et al.* 2008; Gaver, 2012; Zimmerman, *et al.*, 2008; Frayling, 1993). The above researchers typically discuss the nature of RtD and how it needs to improve and formalise. The conversations around formalising and ensuring rigour of RtD have also pointed researchers in the direction of the role of the actual RtD artefact, the making of it and the role it plays in informing knowledge (Kroes, 2002). Hengeveld and others (2016) argue that artefacts carry design knowledge which extends beyond mere design and can be translated into research knowledge. They suggest that a prototype or artefact should not just be viewed as a physicalisation of the artefact but should be seen as a physicalisation of the rationale behind the design of the artefact, as it embodies the knowledge and choices made by the designer through informed theories. On the other hand, using design artefacts in research has also been widely seen in validation studies and doctoral studies in the school of design. Pedgley (2007) discuss in detail the use of artefacts in design in PhD. He contextualises his views by saying that it's different to satisfy one's personal curiosity, but a PhD aims at combining and increasing the body of knowledge in association with discipline beyond any institutional borders or one's quest to know. He made reference to Archer's (1981) definition of DR:

“Design research is systematic enquiry whose goal is knowledge of, or in, the embodiment of configuration, composition, structure, purpose, value and meaning in man-made things and system” (definition obtained from Pedgley & Wormald 2007). Pedgley & Wormald's view was

relevant on the premise that Archer's definition showed that research has several conditions attached to it which are not relevant to just design, rather had more emphasis on knowledge and this should be the focus of both PhD and other researchers. Thus, in the current study, the researcher has hinged upon knowledge generation in an evidence-based manner ensuring the methodological approach taken is not only effective but also focused on making a societal contribution and consolidating existing knowledge in this field.

Since it has been established how much of a role material plays in DR, the current study is built around the position of design-led research (DLR). The term design-led was defined by Bucolo & Matthews (2011) as 'tools and approaches that enable design thinking as cultural transformation within a business'. Another author defined design-led as a tool required by any company to map out all aspects of their vision with deep insights on customer requirements with thorough customer and stakeholder engagement (Wrigley, 2017). The term design-led is not the same as design-thinking, which describes the way designers think and solve world problems, mostly from an iterative and multiple perspective approach. With adaptation from design-led definition and design thinking, design-led intervention in the context of this thesis is described as using a design thinking approach in synthesis with user needs, to create design solutions that inform radical transformation with regards social problems.

4.12 Ethical consideration

The study gained ethical clearance from the Joint Inter-College Ethics Committee (JICEC), which is the university's Ethics Committee on the 23rd of August 2017. During the field work, it was ensured that the researcher establish a relationship with the participants to maintain right of privacy, honesty in corporation and interaction with the intervention. They were also given the opportunity to reach out should they wish to withdraw at any point or contact the researcher at the occurrence of any issues during the intervention. The researcher also minimised the

issue of intrusion into the autonomy of the participants considering they are children; they were encouraged to act within their own rights.

4.13 Summary of Chapter

Table 5 Research methodology summary

Research Paradigm	Component of Research Onion	Justification of choice
Research Philosophy	Interpretivist View	This thesis is situated more around the interpretivist view because the researcher has sought to understand the reality that emerged when participants engaged with the object (research instrument) assigned to them.
Approach	Inductive/Deductive approach	The thesis demonstrates rigour using both inductive and deductive approaches. Inductive gave the author the opportunity to get close to social phenomena during the data collection and this allows for generation of theory which could be posed to represent reality. Deductive helped in logical consistency using the prior template that emerged from literature review.
Strategy	Case Study	Case studies enable exploration and understanding of complex situations. The current study has adopted a case study approach because this type of strategy allows the use of both quantitative and qualitative evidence in combination with the need to define this on a case by case basis.
Research Choice	Multiple method	This method allows you use both qualitative and quantitative information. The thesis used the qualitative method to validate the quantitative data obtained.
Time Horizons	Longitudinal study	Factors that dynamically influence people's behaviour may vary over time. Therefore, longitudinal design helps capture these changes across micro timescales. Longitudinal study helps show when these factors fluctuate and simultaneously provides a repeated rich account of data and increases the statistical power for predicting changes over time.
Techniques and Procedure	Primary and secondary data tools	Primary data- questionnaires, interviews, device deployment. Secondary data- literature review

This chapter outlined the methodological approaches that support the current study and has provided a detailed summary in Table 5. The general discussions were

guided by Saunders' research onion, where the philosophical positioning of this thesis was highlighted. It also proceeded to explain how design science research has been viewed as a paradigm and seeing that the current study is situated in the field of design it was relevant to highlight this. Within this chapter were also the various research approaches with emphasis on the inductive approach being the key reasoning applied for this thesis. The next layer of the onion was the strategies with the variations that exist; with justifications on how using case studies was suitable in achieving the purpose of the research inquiry. The research choices were then discussed, which involved the data collection method such as interviews, surveys, participant observation, objective measurement of PA, which enabled the research to obtain rich data to support the purpose of this study. Following this, the time horizon used in the data collection was discussed, and the characteristics of longitudinal study aligned with the research design for the current study. There were discussions explaining the technique and procedure for the current study, including reasons behind the analytical approaches applied and the underlying choice for the study population. The chapter also highlighted the implications of using an artefact as a material for a PhD, with consideration of both "completeness" and "esteem" as recommended by Pedgley (2007). His view was that the combination of these two tools facilitates adequacy of the artefact, principle and technology used together with the method employed in the designing of the artefact. The ethical considerations and approval were also discussed herein. Having concluded on the methodological underpinning of this thesis, the next chapter will focus on the development of study prototype – the Knudgbox. It includes a detailed process of making an iteration of the main research instrument and describes key scripted concepts behind the prototype.

Chapter 5 Design development of the Knudgbox

5.1 Introduction

This chapter discusses the design process and the positioning of design-led intervention strategies, moving on to explore how the key theories examined influenced this process. The main purpose of this chapter was to answer the research question posed below directly.

RQ2 – How can behaviour change theories create pathways for developing physical activity interventions?

This chapter outlines the choice of the research instrument and the iteration process of the prototype used for data collection in the current study - called the Knudgbox. It highlights the role of the researcher in applying the findings of the literature review, results from the pilot study and current design principles to inform the design of the prototype¹⁷ used in the current study. The research instrument used for this thesis is designed as non-invasive and helps in improving children's home exercise habits, and as well as reducing ST. It also discusses the quality of materials used in the prototype development and how the device was used for logging all the data required for the DUS.

To explain the broad adoption of the materials used in the prototype, findings from the literature review were helpful to pursue the goal of delivering solutions to influence users' ST behaviours. Thus, validating the instrument is critical to support any evidence obtained from findings (Boudreau *et al.*, 2001). There are limited behavioural change devices available targeted at changing ST behaviour. A wide

¹⁷ Discussed in detail within 5.3

range of these active ingredients have been identified in psychological research; Michie and others (2011) suggest that Behaviour Change Taxonomy (BCTs) are strategies that support individuals to change behaviour. In their study, they point out examples of BCTs as self-monitoring, feedback, goal setting and action planning. Since BCTs can be used in various format, the current study identified and utilised them to induce and internalise human - power product use leading to the design of the Knudgbox prototype development. Figure 25 shows the schematic concept of the prototype. The theoretical framework, which was developed in Chapter 3 characterised the concept of design-led intervention development. This chapter further addresses the research question shown at the beginning of this section.

5.2 Instrument development process

The process of designing a prototype for this research links back to a concept called 'white box' (WB), which was initiated by Shin (2014) see Figure 22. The WB was designed to enable its users to have control over their energy use; its interface displayed real-time units generated from user's cycling on the bike in the form of a 4-digit display.



Figure 22 The 'White Box' (Shin, 2014)

Shin further explained that the name 'white box' was influenced by the 'Black Box Script' which refers 'to design approaches adopting the delegation of every control to a machine' with the aim of eliminating any external forces of behaviour change (Jelsma 1999; Shin, 2014). The WB consisted of a battery storage unit in conjunction with pedal power acting as an energy generator, and it was designed to encourage users to have autonomous control in practising an energy-saving behaviour. For example, as the user exerts human power into the bike, the corresponding amount of energy is credited to the feedback (count up), and as the TV is connected to the WB and the power current of TV flows, the display will show corresponding energy storage loss (count down). The TV shuts off when reaching the unit at 'zero'. The unique strategy was being an intervention that uses both force and feedback function as stimuli to instigate a behavioural change.

The recommendation from Shin's study suggested that the model should be further developed and be tested in a broader context, such as encouraging home exercising. After reviewing the results from the pilot study and the questionnaire with parents, a

newly designed intervention called the Knudgbox was developed. It incorporated findings from the literature review, which highlight the active ingredients that motivate and encourage behaviour change. Figure 23 shows a system diagram of all functions the prototype.

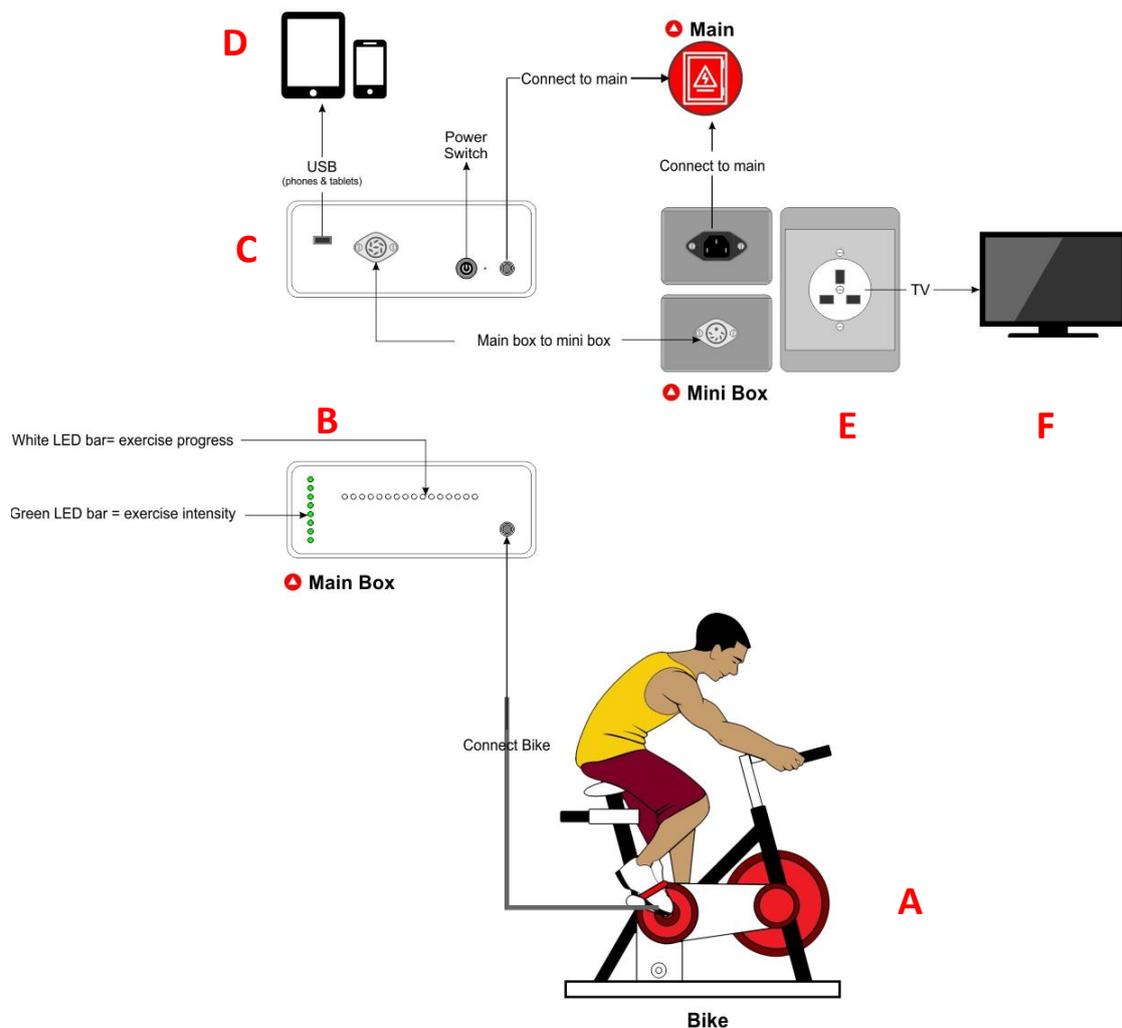


Figure 23 Label of the device components

Considering there is limited research in displacing children's ST with active behaviours within the home context, this prototype was designed to instigate PA behaviours within the home. The overall aim of designing the prototype was to utilise a novel approach to help users reach habituation in their exercise behaviours and to reduce ST at home.

- A – Each participant was provided with an exercise bike during DUS. The bike then connects to the Knudgbox (study prototype).
- B – This represents the Knudgbox which has two feedback indicators (white-showing user's exercise performance), green (exercise intensity). It also has a connection outlet for the exercise bike as seen in Figure 23.
- C – This is the back view of the Knudgbox indicating from the left, a USB and TV outlet, the power switch and the main connection outlet.
- D – Indicate to the user that they can plug in either a phone or a tablet.
- E – For health and safety reasons, the Knudgbox was made developed in two separate parts, the main and the mini box. Label E represents the mini box which facilitated the TV connection. It also shows the outlet where the main box is connected with the main box.
- F – Indicates to the user where the TV is plugged (into the mini-box).

The theoretical background supporting the function of the Knudgbox is discussed in detail in Chapter 5.3.1. However, as mentioned in the introductory part of this chapter, the development of the Knudgbox was based on the foundation on some behaviour change agents, which are reliable interventions such as this. Some of which were mentioned by participants from the pilot study. Here are some of the active behaviour change agents incorporated within this design-led intervention.

- Goal setting – The white LED bar was included to help the user set goals after the behaviour initiation stage, considering they feel confident to engage in the behaviour. This also includes frequency and duration of behaviour

- Feedback – The white LED also served the purpose of increasing participation by providing performance indication. It was intended to provide informative feedback to users.
- Repetition – The intended aim of the design-led intervention was to change users ST habits and instigate exercise behaviours. Thus, this BCT was incorporated by ensuring that the user repeats the behaviour. In some cases, the user might substitute the unwanted behaviour with a different behaviour which could be positive or negative.
- Prompts and cues – The Knudgbox as the design-led intervention was developed to be the environmental cue to prompt new behaviour.
- Self-regulation – This assumption was that when the user engages, set goals and repeats the behaviour, they will begin to regulate their new behaviour without the presence of external cues.

Elucidation of how these BCTs interacted to change participant's behaviour and whether they had any impact on the behavioural outcomes was discussed further in Chapter 9. The next sections provide an outline of the design and development process of the Knudgbox.

5.3 The Knudgbox

The design process was broken down into 6 key stages adopting design thinking approach. Details of each step has been explained in the Figure 24 below.

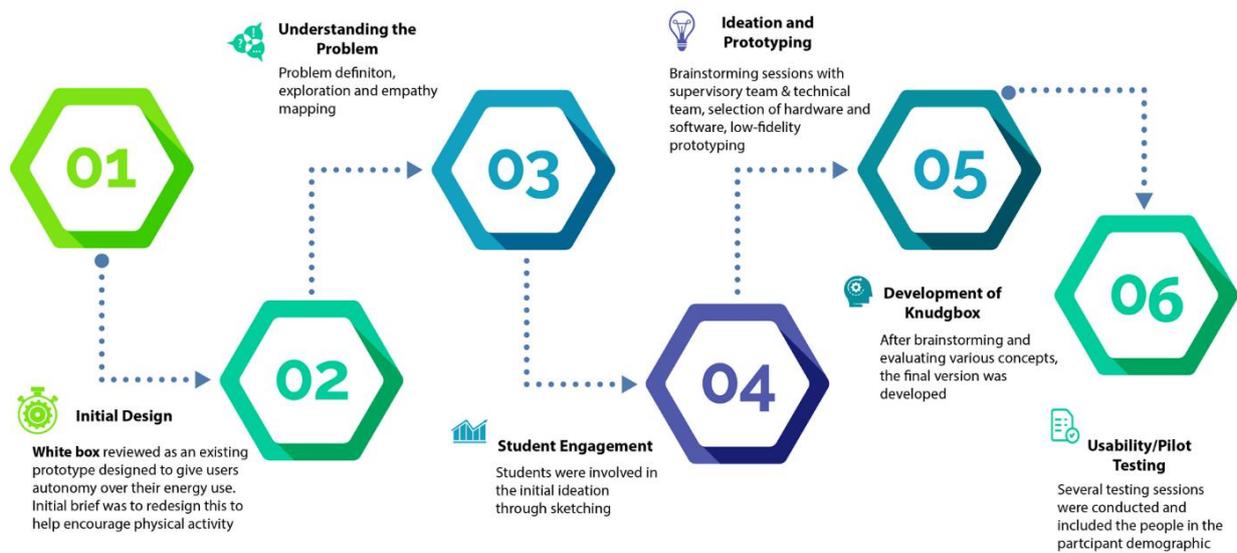


Figure 24 Design process of the Knudgbox

The Knudgbox development undertook numerous brainstorming, problem exploration exercise and several ideation sessions. See Figure 24 for overall design process.

The focus of concept generation is around designing a function that provides appropriate behavioural information to the user such as the amount of exercise and TV usage. See Figure 25 for initial schematic design.

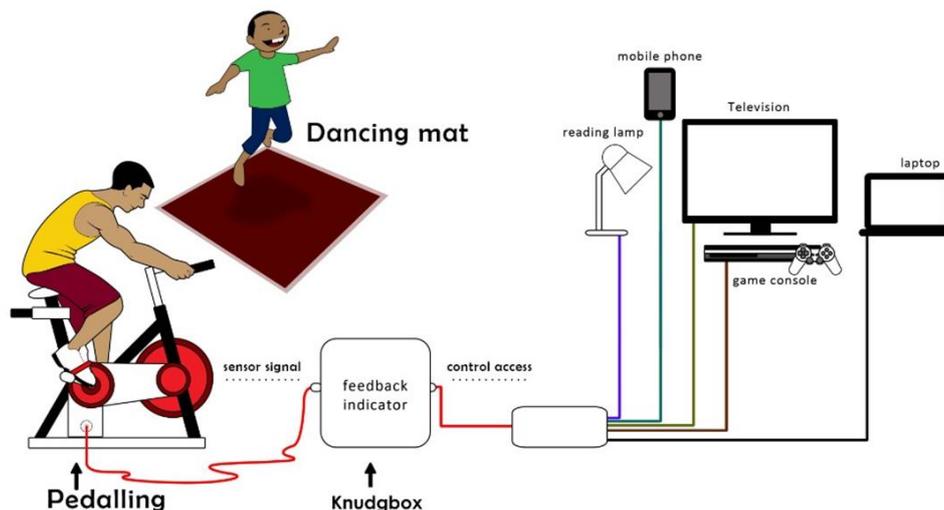


Figure 25 Initial schematic design of the intervention

The purpose of the feedback display was to provide real-time performance information to users which allows them to manage their exercise routine while enabling them to control their screen usage. Another key function of the prototype was the data logging which was regularly consulted with the University technicians. Series of sketch development were carried along with utilising Undergraduate students through a small-scale project some of their designs can be seen in Figure 26. More initial sketches can be seen in appendix 11. The chosen concept was refined and recreated into an advance sketch, and a 3D model sample was created to know if it was fit for purpose before the prototype was built, see Figure 27 for the final prototype.

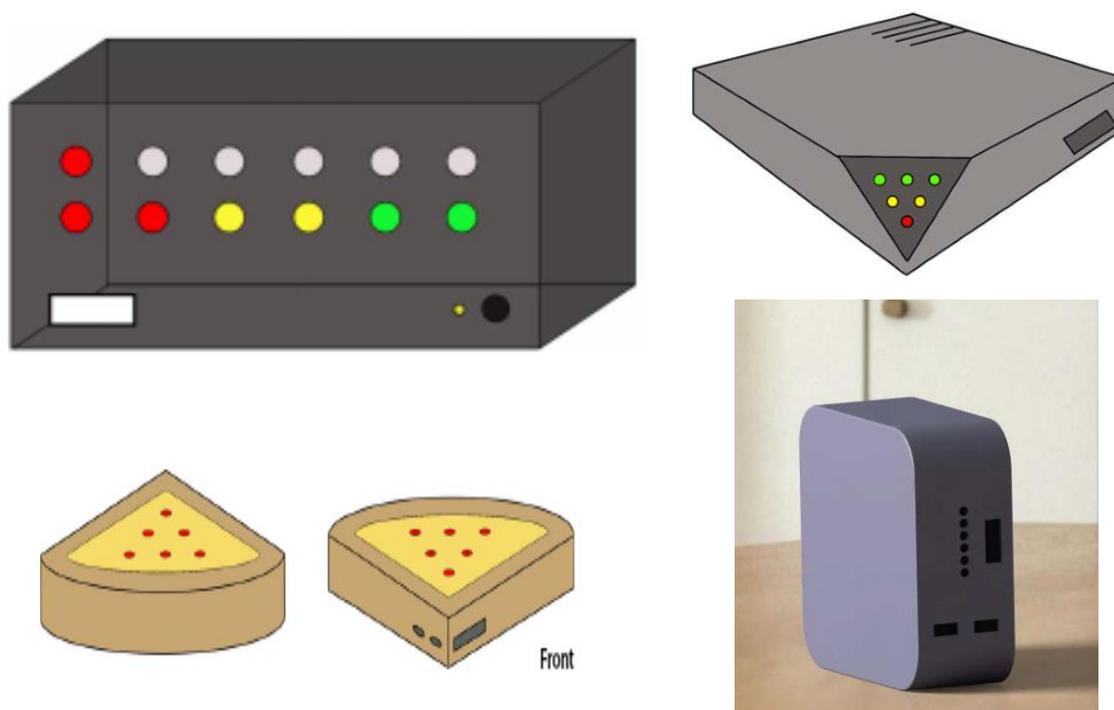


Figure 26 Initial design ideas



Figure 27 Knudgbox as the research tool

The image seen in Figure 27 is the final representation of the prototype, The Knudgbox concept, was derived from the word ‘nudge’ which simply put means “to prod lightly: urge into action” (Merriam-Webster, 2019); in other words, nudge aims to influence the choices people make. There is a large body of evidence on what influences people’s behaviour, and these distinctions are most complex. However, the nudge theory postulates that little prompts can alter our behaviour while giving an individual the freedom to maintain a feeling of being in control of the decisions they make (Thaler and Sunstein, 2008). Thaler and Sunstein (2008.p6) define nudge as:

“Any aspect of the choice architecture that alters people’s behaviour in a predictable way without forbidding any options or significantly changing their economic incentives. To count as a mere nudge, the intervention must be easy and

cheap to avoid. Nudges are not mandates. Putting the fruit at eye level counts as a nudge. Banning junk food does not”.

The psychology behind the Knudgbox is to work with a human tendency for inaction, as this has been shown to enable people to stick with a choice for many years (Gill, 2018). Nudges are usually beneficial in helping people make decisions unconsciously and instinctively rather than logically. Nudge is an interesting concept in game design, and it infers normative thinking. The aim of the Knudgbox is to tap into that automatic way of thinking in people’s decision approach. The nudge concept has been in existence and has been applied in various sectors such as the government and financial institutions. The workplace pension scheme, Nest, is one of the organisations that has implemented the nudge concept and recorded a huge success. Setting up a pension scheme usually requires people to opt-in, and this often requires time and effort. Nest changed the pension scheme to something that you opt-out of (meaning that you are now automatically enrolled) to take away the trouble of thinking about setting it up. The auto-enrolment scheme, since its inception in 2012, has recorded a significant increase of active membership from 2.7 million to 7.7 million in 2016 (Chu, 2017). Another study that attempted to tackle problematic smartphone usage by nudging users with information on their usage behaviours concluded that nudges help lower most indicators of smartphone use (Palokangas, 2016). However, they found that it might increase recurrent glancing at the phones. According to Thaler and Sunstein (2009), people are nudge-able and creating nudges requires observing people’s behaviour and identifying what needs to be changed. A BBC (2019) report states that children should take a break from screen-based SB after two hours of use and Knudgbox provides that

autonomous element to help children set their TV time goal by exercising for 40 minutes to gain 2 hours of TV time.

5.3.1 **Knudging technique**

Thaler & Sunstein (2008), with their concept of the nudge, explain why people behave in some ways that deviate from ‘rationality’ drawing from behavioural economics and social psychology. They further explain that in traditional economics, humans make choices to ‘maximise their welfare’. In contrast, in behavioural economics, the underlying assumption is that humans have “bounded rationality” thereby making biased decisions that most times counter their interests (Stewart, 2003).

In the field of design, it has been argued that *all* designs have an intention to influence/change human behaviour (Buchanan, 1985), this suggests that all artefacts around us have been socially scripted for users during the design process (Akrich, 1992). For instance, if a bin is positioned on the street, we are influencing a user to ‘follow the script’ and put their rubbish in the bin. Yet, some systems are also designed in such a way that the user does not often have a strong idea of what to do: Lockton and others (2010) describe this as design with intent. The user’s ability to engage with the product, in this case, will relate to their intention and appropriation (Salovaara, 2008) which suggests that often the designer’s intention does not always translate to the user behaviour.

The targeted behaviour as established from Chapter 1 is ST and PA; thus the design of the Knudgbox itemised in the design process how these user engagements and behaviours will be displayed to the user. The tools for nudging include default options of filling up the LEDs as shown in Figure 27. When the LED is incomplete

mode and the TV unit is plugged in, the LED drop reminds users that after a few hours (depends on the TV wattage) that the LEDs will reach zero and that they have the option of using it up at once or using some of the LEDs and storing some for future use. This idea draws from using framing to change people's behaviour (Mont & Power, 2013). There is a consensus that human behaviour is influenced by a range of factors, such as social norms, desires and values.

The concept of the prototype was to indicate performance indication in the form of feedback through an LED display. The LED bar was designed to be incremental when a user is exercising and decremental when connected to any screen device. For instance, a user gets on the bike ready for exercise; as they continue to exercise, the white LED bar seen as seen in Figure 28. continues to increase until they finish their exercise. The green LED only indicates intensity. Was the user plugs their TV or begin to charge their tablets/phones, the white LED starts to decrease until it reaches zero, this will switch off their TV or seize charging their phone in any case.

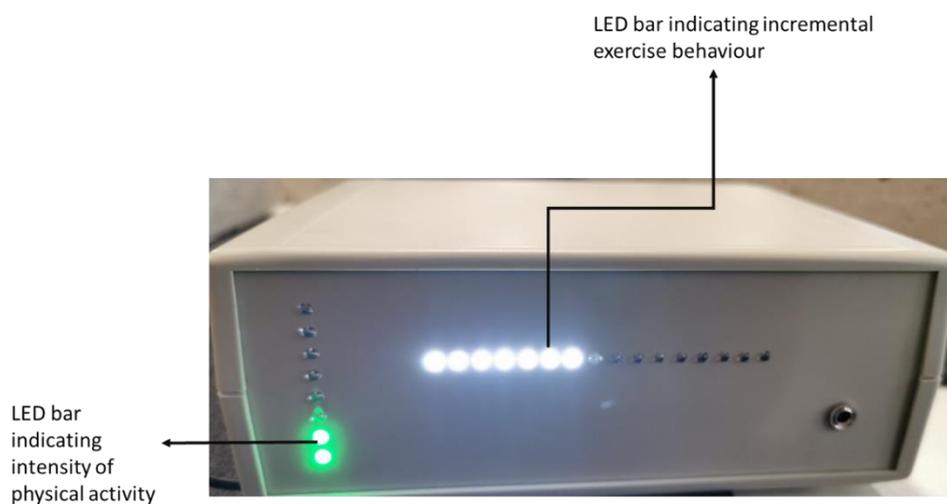


Figure 28 LED indication

This LED incremental and decremental system was viewed as screen credits by participants; thus, screen credits will be used interchangeably in subsequent

discussions. The concept was intended to get users to reach habitualisation in their exercise behaviour.

5.3.2 Hardware selection

The hardware was selected based on flexibility, affordability, modularity and ease of use. The prototyping process often requires the development of boards and modules that are simple and could be used for scaling depending on the application used. There were no considerations of designing any new hardware for the purpose of the prototype due to time constraints. Thus, after exploring different kinds of prototyping kits, the choice was between Raspberry Pi and Arduino Uno as the affordable off the shelf modules. Raspberry Pi would require an additional analogue to the digital module, and Arduino offered this option out of the box without the additional components. In terms of modularity, both modules are similar. The programming tools provided to run both modules are similar in terms of ease of use, although Arduino was better suited as its interface supports sensors and other devices. In the case of the current project, it was essential to pick a module that allowed something to respond to different outputs or sensor readings in real-time.

Most importantly, to decrease development time, the technician was more conversant with Arduino, and this essentially saved more development time which ensured affordability and ease of use. Due to Arduino's low power requirement and low maintenance, it was also ideal for this project as the device, after it had been built, was required to run with little or no interaction. As a result, Arduino's versatility made the module and its features easy to get started on, and it's usually helpful in addressing real-world problems.

5.4 Improved design optimisation and metrics conversion

The research team managed to secure some funding to purchase better bikes to work with the prototype. This was tested with the prototype on 7 different occasions to ensure the countermeasure was effective. A gizmo was also developed for faster testing (see Figure 29). As discussed in 3.13.1¹⁸ sweat coin was able to counter this pitfall in their app: they managed to cross-step count data with GPS location, thus making it very difficult to cheat on step count.



Figure 29 Gizmo for prototype testing

¹⁸Can be seen in page 82

5.4.1 Security of data

The data obtained from the study did not contain any sensitive information relating to the participants. However, in line with the new Data Protection Act, all information collected from the current study was used solely for the purpose of this research and was accurately stored in the university's protected PCs. During each site visit, the SD card was obtained, and all data copied and saved in an encrypted form. The availability of this secure system for data storage provided by the university meant that there was no requirement to build a security system into the prototype. The technical diagram of Knudgbox programming can be seen in appendix 12.

5.4.2 Reliability

Reliability measures determine the extent to which the obtained results can be replicated (Fay, 2005). For instance, if we use a scale to measure a person's body weight six times, ideally all six measurements should be the same in order for the weight measurement instrument to be reliable. Therefore, reliability is concerned with data precision. Justifiably, this thesis used the triangulation technique to corroborate evidence obtained from both observations and interviews. Triangulation reduces the systematic bias, therefore providing a fuller understanding of the explored phenomena, and this increases the reliability of the data generated from this thesis.

5.5 Building the prototype

The design meetings involved numerous meetings with the technician, who is also a programmer. These meetings allowed the progress of the storyboard to improve from just a schematic to a full working prototype. Nudge theory, which is discussed

in detail in the evaluation chapter, guided the discussions around building a prototype that could facilitate the desired change.

5.5.1 Performance testing

During the prototyping stage, there were numerous limitations encountered, and this delayed the DUS¹⁹ deployment. Working closely with the technician to build the prototype meant working around their work schedule considering they had other project commitments. The recommended PA for children aged 5-18 is 60 minutes of MVPA, as has been referenced in chapter 2.4. Therefore, the decision to calibrate the prototype factoring in this guideline was essential. During the pilot study, there was a huge margin between the PA and TV output, and the participants suggested that this was too easy and impacted on their engagement. Thus, there was a development of the ratio of 1:3 (40 minutes of pedalling = 120 minutes (2 hours) of TV). This TV output was also chosen to support the children meeting their ST recommended guideline of 2 hours (see chapter 2.4.2.1). The feedback mechanism was inbuilt to enhance user's goal-setting behaviour using the LED bar. This was considered as an element that can facilitate the user to set daily/weekly exercise and PA/ST goals. Although 40 minutes of exercise is lower than 60 minutes suggested by WHO as the recommended PA time, the intensity of exercise may vary among participants. Therefore, the 40 minutes exercise duration was the best close ratio to meet with average performance, also considering that the participants from the pilot study suggested that 20 minutes was too easy. Also considering that the participants may have engaged in other formal or informal PA during school hours (walking to school, PE classes), 40 minutes was a good benchmark. Another justification for this ratio was the Arduino board used for the prototype configuration, which only

¹⁹ Domestic User Study

had 16 digital output/input pins (see Figure 30). During one of the technical meetings, we decided to incorporate this by having a 16 LED feedback display. This was programmed to have the first LED light come up within seconds of exercise activation, leaving 15 LEDs which will require 2.66 minutes to light each one and 40 minutes to full charge.

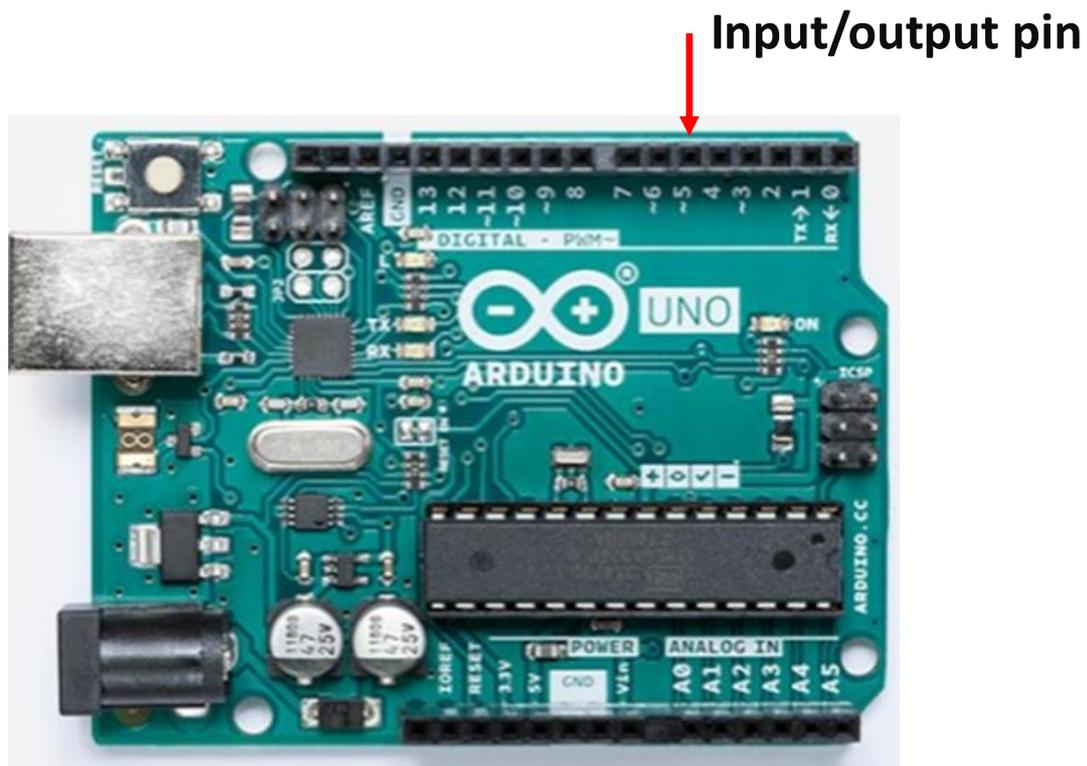


Figure 30 Arduino digital pin

Table 6 PA input and TV output value allocation

<p>Physical activity</p>	<p>10 pedals = 1 LED display 150 pedals = 2 LED display 4800 pedals = 16 LED display</p>
<p>TV output</p>	<p>Full 16 LEDs = approx. 2 hours of TV time (TV watt dependent)</p>

Table 6 shows the output and input value allocations. One of the limitations in the TV output value was that it was difficult to allocate time to TV due to the wattage difference in most TVs. During the calibration process, there was a struggle to program the device to decrease the LED value when a device is plugged. This is mostly due to the realisation that the LEDs was programmed to decrease the LED unit even when the TV is on standby (i.e. device recognising the TV as power on). In another case, an LCD TV took longer for the LEDs to run down when plugged; therefore, it was difficult to calibrate the prototype to serve every device universally. So, despite these challenges, the decision was made to set a benchmark for the TV output at a minimum of 45 watts, and a maximum of 100 watts in the programme, i.e., every TVs between 45 and 100 watts had a somewhat similar LED decremental rate.

5.6 Summary of Chapter

This chapter describes the design and development process of the design-led intervention that was used to explore instigating habitual exercise in children in their homes. The development process was achieved in four different stages: concept generation, hardware selection, performance testing and reliability testing.

The concept generation involved the consideration of the variation of interface suitable for the target demographic with consideration of how to set the right prompts and cues. Also, the literature on behaviour change intervention helped identify the BCTs that would be incorporated during this stage, such as visual feedback. The outcome of this stage led to the hardware selection stage, where the selection of the material was decided. Some key considerations were around the avoidance of technical issues which could impact on the data and could inherently

result in the data being unreliable. This was not totally unavoidable but was minimised as most technical issues were identified at the testing phase.

The performance testing was divided into pre-test and pilot testing. The essence of the pre-test was to identify any technical issues or data logging issues which could then be improved before the pilot phase. The pilot test was useful in confirming the reliability of the data. The findings from the pilot study demonstrated an acceptable level of data reliability with areas for improvement, which were addressed before deploying for the main empirical testing.

The final deployment phase of the main prototype consisted of 20 households, which investigated their behavioural attitudes for a minimum of 90 days and data from this phase had high levels of reliability. The full details will be discussed in Chapter 7 and Chapter 8.

Chapter 6 Preliminary research

6.1 Introduction

As discussed in Chapter 2, parents play an essential role in shaping children's behaviour; therefore, it was important to carry out a qualitative and quantitative study on parents' perceptions and attitudes towards children's ST and PA behaviours. This chapter discusses the findings from the preliminary study, which involved piloting the developed prototype and to understand how parents think around PA and ST via a questionnaire with 16-point questionnaire (See Appendix 4). The questionnaire preceded the pilot testing. The results obtained at this phase provided great insights into the need for interventions that support parents in controlling the screen use of their children.

From the literature review, it was apparent that children spent a ubiquitous amount of time on-screen devices, it was, therefore, important to survey parents to get their own understanding of this problem. Furthermore, the observations and knowledge gathered from the pilot stage were used to feed the DUS systematically. The pilot testing involved the deployment of the research instrument and a combination of interviews, to understand the influences of user behaviour. The qualitative interviews were chosen to avoid relying on the recorded information on the research instrument and to corroborate the behaviour determinants relating to any behaviour changes. This is essential to prevent discrepancies between reported and real behaviours (Robson, 2011). This chapter also discusses the limitations and lessons learnt from this phase of the study and how it was implemented in the subsequent phase of the current study.

6.1.1 Questionnaire findings and discussion

As explained in the introductory part of this chapter, the questionnaire with parents aimed to understand their concerns with regards their children's ST, to tailor solutions towards managing this behaviour. The first phase of the study used a questionnaire comprising of 16 questions. Parents were asked about their knowledge of the benefits of PA and what they thought deterred their children from being physically active, especially in the domestic environment. The survey was distributed across the university communication systems and some social media platforms. A total of 140 respondents completed the survey. The questions asked were mainly around parents' views on the following: 'access to screen devices' of their children, 'social influence', 'general screen behaviours', and 'duration of screen use' for both recreational and non-recreational activities.

The second part of the questionnaire was semi-structured interviews with 10 parents to extract some qualitative information on parental perceptions about significant barriers to PA and their actual use of ST.

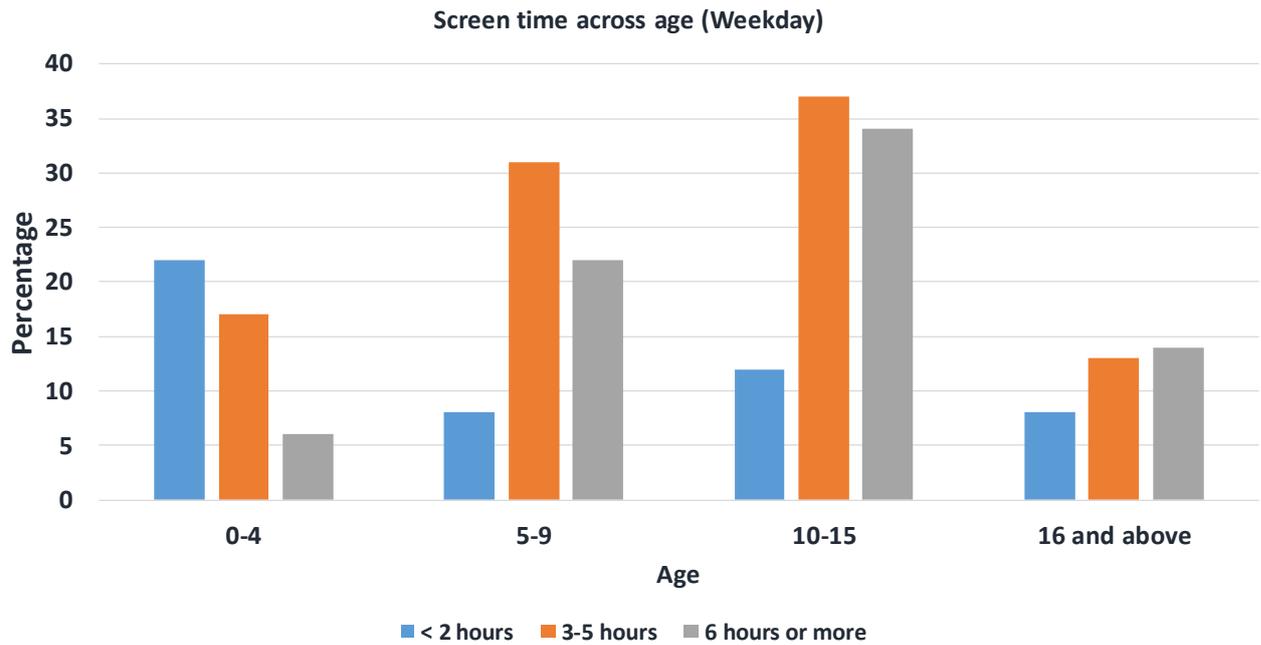


Figure 31 Children’s screen time by age

Figure 31 shows the percentage of children and their ST across as reported by parents. It is apparent that children aged between 10 - 15 spend the most time on screen devices. One limitation was identified: it was unreported whether this amount of time was attributed to just recreational ST or also for educational purposes. One study that assessed young children using TV diaries for 10 days duration indicated that measuring TV viewing using single questions for parents is moderately correlated ($r = 0.60$) (Anderson *et al.*, 1985). This validates that parents’ reporting on their children’s ST in the context of this study reflects a positive association of the actual behaviour. Children aged 12-15 spent the most time per week online (close to 21 hours), followed by using a mobile phone (around 18 hours) and watching TV on a TV set (more than 14 hours). On the other hand, children aged 8-11 spent comparable amounts of time watching TV on a TV set and using the internet (around 13 hours 30 minutes per week), with fewer hours spent gaming or using a mobile phone (10 hours) (Ofcom, 2017). From this response, 14% of the respondents belong to this age group of 10-15 years of age.

Parents concern about children's screen time

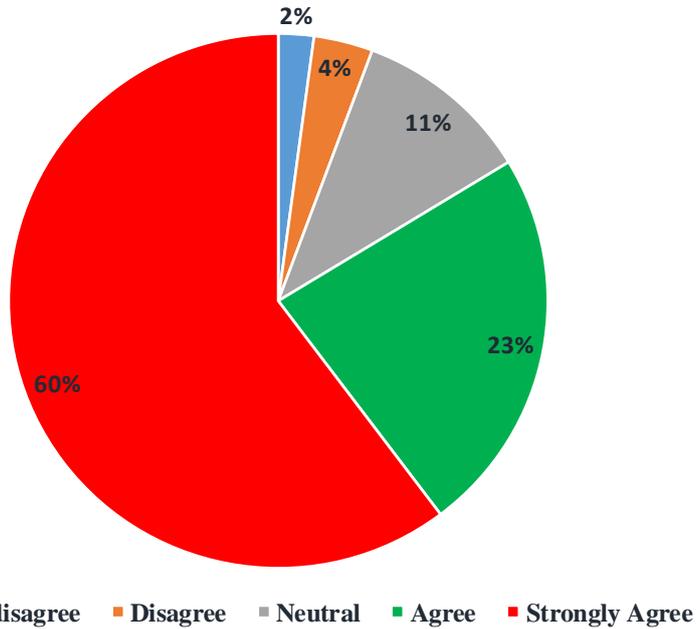


Figure 32 Parents' concern about children's general screen time

Parents reported finding ways to negotiate appropriate ST in the home was a major issue. Figure 32 shows that 83% of parents are very concerned about this. In the additional comments sections, some parents highlighted that, although technological devices can provide some educational opportunities for the children, they were still generally concerned about their children not getting a good balance of ST, thus the need for boundaries to limit this habit.

Which of these screen devices do they spend the most time on?

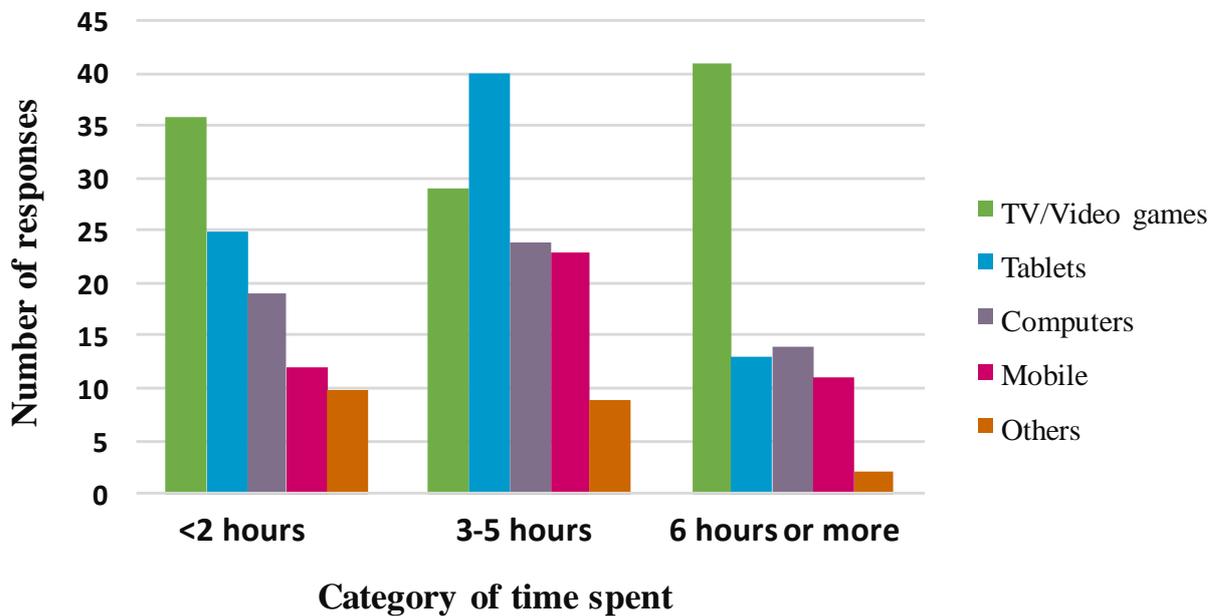


Figure 33 Most used device and amount of time

Figure 33 shows the devices respondents quoted as the most frequently used by their children. It shows that the majority of the respondents acknowledged TV as the device widely used. This is followed by the use of tablets, with mobile phones being the least used device. 23% of the surveyed parents reported that the major driver of the use of the above devices was an addiction. This is definitely supported by Livingstone and others (2015) who argue that parents who often use digital devices themselves have an opportunity to foster children’s uncontrollable use. One of the interviewed participants said *“Whenever I signal him to get off the iPad, there is a usual expected hysterical reaction such as crying and throwing tantrums and this continues when we insist on him getting off, as a parent, this is so difficult to deal with and in the end, we often give in. In our minds, we know that is this not good as we can see he now has increased anxiety and even sometimes panic” ... (P4).*

6.1.2 Snack consumption and screen time

From the findings, it was apparent that children who spent much time on TV almost always snacked (see Figure 34). One quantitative study that examined 14,880 school students in Iran found that students who spent more than 4 hours on ST per day snacked on sweets, salty snacks and canned fruit juice when compared to those with lower ST (Kelishadi *et al.*, 2017). Most interviewed parents in the current study were asked how influential they are for some of the habits their children exhibit, and one of them reported that the children learn the eating habits from them (parents). *“We as parents are supposed to be the gatekeepers for our children in everything they do, so I think they emulate our habits in the sense that we eat while watching TV as parents and I guess that’s why this has become a habit for them too”* (P7). Although the central aspect of this study did not target unhealthy dietary behaviours in children, obtaining this information identifies clusters of unhealthy behaviours, their influences and how they should be taken into consideration when building an intervention. The focus of the current study was on encouraging active behaviours considering that the home is the place where sedentary activities are abundant.

Snacking and watching TV

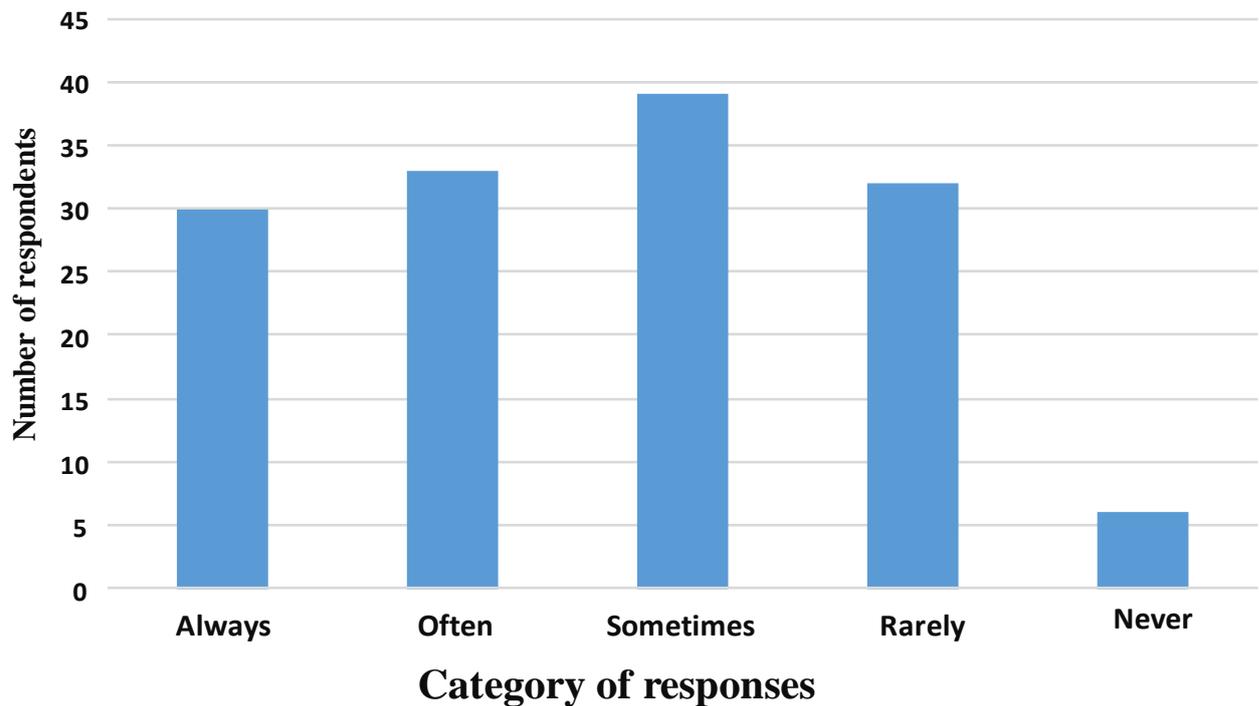


Figure 34 Eating habits while watching TV

The outcome of this phase contributed to the thesis by making clear the apparent concerns parents regarding their children's behaviour. It validates the notion that there is a need to target the home environment and this also corresponded with other studies that identified negative associations between ST and PA (Aggio *et al.*, 2012; Sandercock, Ogunleye and Voss, 2012). This led to the next phase of the piloting of the home intervention, which is discussed below.

6.2 Pilot of DUS

The first study of this research was initially designed with the objective of understanding the study feasibility. This was aimed at getting a clear understanding of parents' perceptions of children's ST & PA behaviours and the various behavioural determinants. The information assisted in answering the second research question and provided a measurable guide towards the design of the wider study. This approach of pilot testing was taken from Baker (1994) and his concept

of ‘trying out’ a particular research instrument prior to the main study, and this was also supported by De Vaus & De Vaus (2013) “pilot testing first, do not take risks”. Van & Hundley (2001) also suggest that an advantage of conducting a pilot study is that it might highlight an advance warning of the possibility of the main study failing or that a proposed method or instrument could be inappropriate for the study. Table 7 shows a short description of the approach taken during the pilot testing.

Table 7 Synopsis of pilot study approach

Study phase	Research investigation	Method
Start of Knudgbox testing	What factors mediate the association between excess screen time and physical activity?	Semi structured interviews and questionnaires were used to obtain information on this according to research questions.
Mid-test analysis	How reliable is this TV limiting device at increasing physical activity and reducing screen time?	Participants were asked 5 standard open-ended questions to review their perception of the device.
End of testing	Is the change in behaviour significant to encourage meaningful healthy lifestyles?	Semi-structured questionnaire was employed to discuss the general perception of the device and how this had affected lifestyles.

The initial pilot study began on the 26th of February 2018 and was aimed at understanding the initial perceptions of participants with regards to the design-led intervention, but after 5 days, the testing failed due to technical issues. The devices were retrieved, and some of the problems identified were hysteresis²⁰ and a low

²⁰ Hysteresis happens with magnetic materials with respect to delaying/lagging the applied signal in magnetism.

ratio of pedalling to credits. In the context of the bike, the participants experienced that leaving the pedal of the bike at a particular position sent some form of signal to the device, which increased the gained credits concurrently. Hysteresis is a widely occurring phenomenon that happens in either natural or constructed systems (Manoonpong *et al.*, 2010). The hysteresis effect was a difference in error in measurement, where signal passed as air rather than frequency. To correct this error, a bandpass filter was used to set the upper cut off frequency, i.e. the upper limit that allows the frequency to pass through which completely cancels any signals beyond this point. A frequency multiplier assisted the modification of the ratio issue.

The second attempt at the pilot study began on the 27th of March 2018; see Figure 35 for the set up in the participants' living spaces. Participants $n=4$ ²¹ were interviewed and updated on the functionality of the device and its intended use for the pilot study. The pre-interview guide explored their baseline activity levels, their expectations and intended goals towards the use of the device.

²¹ n value = number of participants



Figure 35 Pilot study set-up

6.2.1 Participants' characteristics

Four children (2 boys and 2 girls) aged 10-15 in the same household, were recruited through their parents via flyers posted within the university. Table 8 show the inclusion and exclusion criteria for the pilot study participant selection.

Table 8 Inclusion and exclusion criteria for the pilot study

Inclusion	Exclusion
Children aged 10- 15 years	Medical condition
No pre-existing medical condition	Children outside the age range
Have at least one TV in the home	Refusal to give informed consent

6.2.2 Procedures

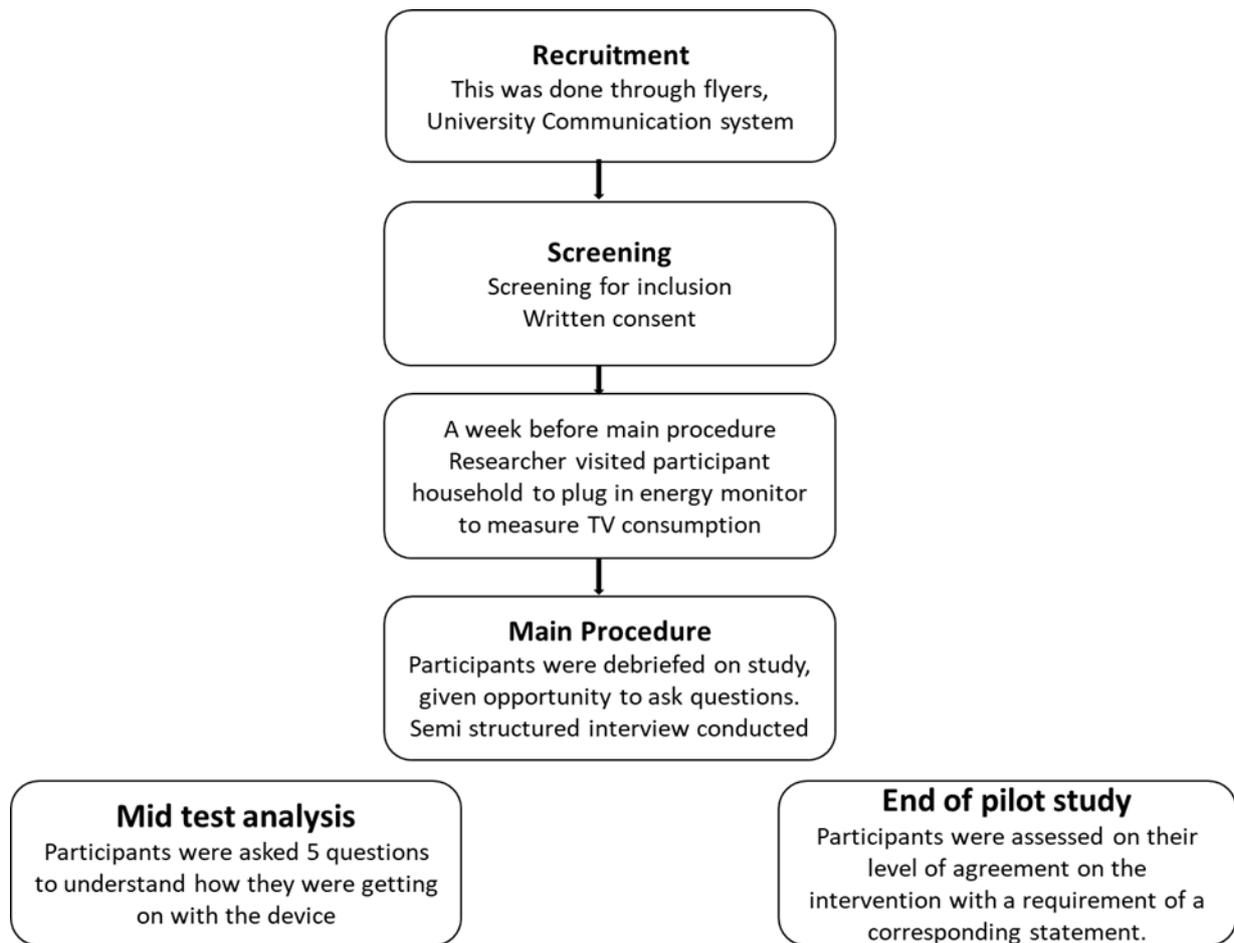


Figure 36 Flow chart of recruitment and participant involvement

This pilot study was initiated to determine the feasibility of the main study (Figure 36 shows a flow-chart of participants during the study). The condition for the study was using a device to monitor TV time, measuring the total input and output of LED units, as explained in Figure 23²². Figure 35 shows the participant home setup.

6.2.3 Measurement of screen time and physical activity before and after the intervention

7 days prior to deployment, and energy monitor was used to record the ST (TV watching) data of the participants. On the day of deployment, they then reported

²² Can be found in page 139

their PA levels which were coded as either “active” or “inactive” and classed as subjective measurements. As discussed in chapter 2.4.1²³, IPAQ²⁴ is one of the only reliable and valid tools for subjective measurements. Since the current intervention targeted improving home-based PA, it was considered unsuitable to measure their baseline PA precisely. Figure 37 shows baseline TV watching before intervention exposure and their TV watching and PA after the intervention. One quantitative study that has explored the association between ST and PA in Spanish adolescents found that no single screen-related behaviour justified a reduction in MVPA in the participants (Serrano-Sanchez *et al.*, 2011). Their study suggested that the negative association could be due to increasing engagement in ST and lower availability of time to engage in PA. The current study proves that when children and adolescents are allowed to displace ST with exercise, any increase in PA will be associated with reduced levels of ST.

²³ Can be found in page 28

²⁴ International physical activity questionnaire

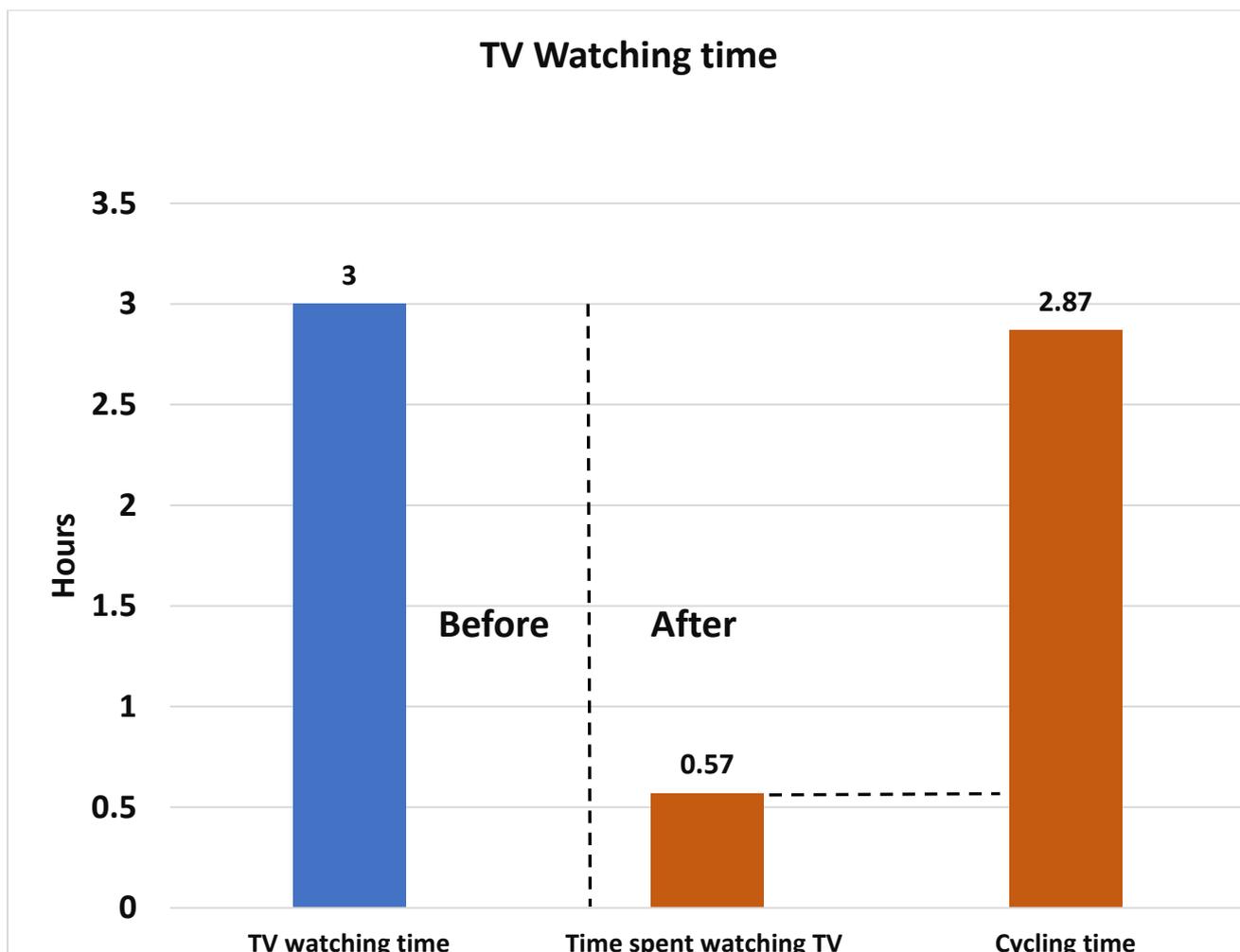


Figure 37 Average TV watching time in hours before and after the pilot study

6.3 Semi-structured interview and analysis

Pre and post-intervention interviews were carried out during this phase, and the findings from both will be reported below, respectively. The transcripts from both sets of interviews were transcribed verbatim and imported into NVivo 12 in order to facilitate thematic analysis (Braun and Clarke, 2006). The discussion below was facilitated by the themes and codes that were generated through the thematic analysis process.

All participants reported spending time using at least one type of screen device prior to the intervention commencement for more than three hours daily. They reported spending much more time engaging in these screen activities on weekends as

opposed to weekdays; the boys spent more time overall using TVs for games compared to the girls who spent more time watching TV and using their tablets. Also, they admitted to being involved in at least one form of PA sparingly during and after school hours but admitted it was not to a sufficient level.

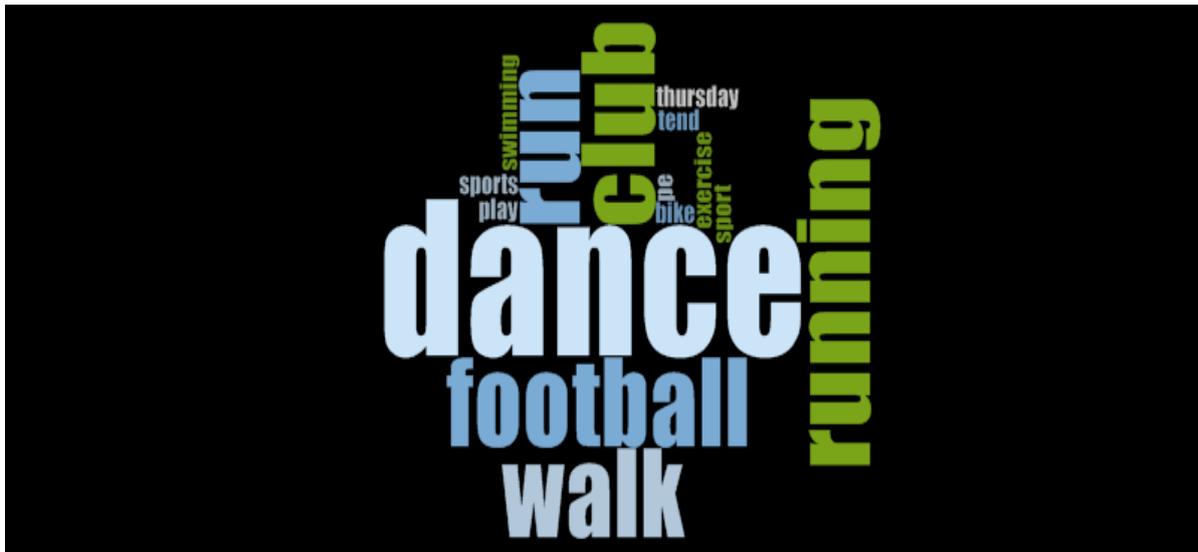


Figure 38 The word cloud shows the types of activities that respondents admitted being involved in.

- **Thoughts on physical activity**

Some of the respondents felt that PA should be incorporated into their daily home activities. It is something that requires movement and causes an increase in heart rate which is a good thing, “...*physical activity requires movement, so you get tired and have a heart rate so anything that requires movement at all is good*”.

- **Current level of physical activity and habits**

The level of PA varied between respondents with half of them claiming to be not so active and only involved in sports for instance because it was a requirement in school, “*I still would not consider myself physically active because I only do them because we are asked to do them especially at school*”. While others admitted to getting involved in activities which are self-initiated like participating in sports for

four days a week during school days and every day during the holidays. Some were more conscious of the importance of PA and were gaining interest in physical education at school. Other activities included walking to and from the school bus stop, *“Most times too I get off at my friend’s bus stop and will walk for about half an hour to get to school, cos we’ve realised it’s healthy, and it wakes us up for the day.”*

When asked about how much time they spent doing PA, all respondents agreed that they were active at least half an hour daily and the activities involved PE, dance, walking home from school, football, swimming and afterschool clubs that encouraged physical activity, for instance, the ‘steps feel-good club’. *“...’steps feel-good club’, the club that I went for in the summer was good, but the challenge was that most people have a Fitbit now and with the Fitbit, you can get instant an feedback of your steps and if you want to reach a goal. Say like I want to reach 10,000, and I’m only on 7000 and then say oh that close enough, and you would want to do extra more to reach your goal. And that’s made me want to do more in the ‘feel-good club’.”*

- **Attitude towards increasing physical activity**

All participants expressed their strong desire to increase the PA at home. This showed willingness and positive attitudes towards getting involved in PA. They admitted to being willing to work for ST and believed that watching TV as a reward after hard work could help in maintaining good PA habits, *“...I will see watching my show as a reward which I have to earn/work for. Since I’m preparing for my GSCE, this will also help me reward every hour I do during my leisure time instead*

of laying around doing nothing". They also admitted to being excited because the device would help them be more physically active.

- **Feelings towards weight**

Regarding their feelings towards weight, respondents' answers varied from not being too concerned at all to be very concerned. They admitted not liking the idea of being fat and being willing to do more to maintain a certain weight. Some of the participants also admitted that their weight made them uncomfortable and that they had tried losing weight through diets and walking, which wasn't yielding any results. For those who had no concern at all, they explicitly expressed their beliefs that "hope" will keep them away from being fat, *"I don't have any concern about my weight, but I don't like the idea of ever being fat, so fingers crossed I don't get fat."*

Concerned



Not too
concerned



Not concerned
at all



Figure 39 Participants' weight concerns.

- **Motivators of physical activity**

There are some factors that emerged from the interviews that were motivators to being more physically active. Some participant emphasises that competing with others to generate more LED units was one of their main motivators. Just one of them thought that competing with siblings' high scores rarely motivated them to get higher scores.

- **Presence of visual feedback**

Another motivator is when one can see an indicator of their performance. The feedback indicator allowed participants to set daily goals and plan ahead, for instance, if one planned on watching a TV show which would last an hour, after

school. They would either choose to cycle when they wake up and store the screen credits for when they got back, or cycle when they got back from school. Due to the limited time for the feasibility study, it was difficult to explore further how feedback display facilitated behaviour. However, the participants of the pilot highlighted how feedback enabled and increased their performance.

- **Hindrances to physical activity**

Most respondents agreed that sedentary habits such as excess ST were a hindrance to PA at home, “Watching TV is my biggest problem when it comes to not being active because from school I am already thinking about getting home to go and watch my TV...” They consider home as a place to sit, relax, eat and watch TV. Other habits include too much use of mobile phones and playing on the computer while laying down and playing video games. However, commitments like studying for exams can also prevent them from being as active as they would like. The amount of time spent on these activities is a great contributor to the lack of PA. Some admitted to spending more than an hour per day term time and up to five hours during the holidays pursuing these habits. Parents often intervened by preventing the children from spending too much time on screens by hiding remote controls to the TV, for instance. The results showed that home is considered a hindrance for PA. However, the respondents still valued the concept of incorporating PA in their home routine to get them more active: not only because it was safe, but also perceived as a way to build healthier habits.

- **Experience in using the device and willingness to continue**

All participants had a good experience using the device, and some of them were willing to continue using the device since it had improved their lifestyle. They even said they wouldn't

mind if it was made a bit harder. The respondents also felt that the device had allowed them to concentrate on other activities aside from watching TV and spending time on their phones. The remainder disagreed about continuing to use the device because they thought it was a good experience at first that soon wore off. *“...it is a good experience at first but that soon wears off. I really enjoyed using this device, but I would not like to use it long term because it will probably stop me from watching TV entirely as a result of me being lazy to go on the bike”*.



Figure 40 Participants’ feelings towards continuous use of the device.

6.3.1 Recommendations for device improvement

Based on the findings and the emerging themes identified, the following points has been found as being of particular interest in improving the study prototype. These points were noted from the end of the pilot study interview during which the researcher sought to determine if the design-led intervention has fulfilled its requirements. Some of these recommendations were not applied considering the time frame and cost implications of improving the prototype. However, any further testing should take this into account.

a) Portable and wireless distance tracker

The respondents felt that the size of the device was too big and not portable *“...I would take away the size as it is too big and not very portable.”* They preferred if the size of the device was changed and made wireless hence easing movement, especially when the adults wanted to watch television.

b) Viewable distance tracker

The respondents also recommended the use of a viewable distance tracker, one that enabled the user to see distance travelled every time they used the device.

c) Replace bike other exercise equipment

A respondent recommended the replacement of the bike with a treadmill since they thought the bike was not helping. This was explored by incorporating a home boxing set, a dance mat, however, they did not seem feasible due to numerous errors in data logging, location installation (dance mat was not feasible for participants who lived in a flat).

d) Ability to reset the device

The respondents also preferred if they were able to reset the device after every session, so as to motivate them to be active every time they want to watch TV. This would discourage the storage of too much ST. Again, this was not implemented as it would have tampered with the data logging system and will negatively impact on the quality of the data. Further testing can explore ways to implement this either through a remote data logging system; that way, the data is backed up even when the user resets this device.

6.4 Lessons and limitations from the pilot study

There were promising results in terms of changing two key behaviours that contribute to childhood obesity and overweight epidemic. The study aimed to investigate the efficacy of a design-led intervention to reduce sedentary ST and increase PA across domestic environments. One participant met the recommended PA guidelines of >60 minutes/day before the start of the study (self-reported). In relation to the first research question, which focused on examining the effectiveness of a design-led intervention in increasing PA and reducing TV viewing, there was a significant reduction in ST and increase in PA among participants over the course of 4 weeks. The second research question aimed at exploring the influence of feedback

on the device in encouraging PA: a short survey carried out at the end of the pilot study showed a tremendous increase in motivation.

The sample size was considered to be small, although the pilot study objectives were achieved. The result, however, indicates that a bigger sample size would provide much in-depth analysis, and identifying a more explicit correlation of findings between participants. Also, the inability to correctly log real-time activity in order to determine the sequence in which the participants generated their ST was a significant limitation, although this has been identified and reflected in the newer version of the prototype.

6.5 Summary of Chapter

PIA²⁵ remains a significant health-related issue that needs attention, especially in combating childhood obesity. Other researchers suggest that solving this will require a multifaceted approach and structured interventions combined with intrinsic motivational strategies. AVGs²⁶ and fitness trackers are amongst the emerging technologies that have recently entered the healthcare arena, with promises to address the obesity crisis. Preliminary evidence, as seen in the pilot phase, suggest that design-led intervention could potentially encourage a reduction in ST and instigate self-directed PA of light to moderate intensity. Some technical improvements were made to improve the feedback display, and the data logging feature before conducting the DUS. From some of the emerging themes, the feedback was essential as it motivated the initiation of the behaviour. Therefore, it was important to enhance the way feedback is displayed for the user. Also, from a methodological point of view, the feasibility study lasted only for a month, and it

²⁵ Physical inactivity

²⁶ Active video games

was apparent that a longer intervention exposure will yield better results. Thus, this strengthened the need to conduct a longitudinal study for the main empirical study. The initial technical failure at the start of the pilot was due to hysteresis, and this was also taken into consideration when reiterating the prototype for the DUS in order to avoid any technical error in the data collection. It was not possible to observe if the users newly adopted behaviour is maintained due to the time frame, although there was evidence of behaviour changes in both exercise and ST. The case of habituating these new behaviours were explored further in the DUS and discussions around the determinants of the behaviour maintenance was also discussed in detail in Chapter 7 and Chapter 8.

Chapter 7 The main study – Domestic User Study (DUS)

7.1 Introduction

DUS entailed deploying the design-led intervention to 20 households as a simple measure to instigate exercise behaviours while reducing ST in the home environment. This was done by installing the research instrument (Knudgbox) to these households for a minimum of 90 days. This chapter focuses on reporting the types of data gathered, with one representative data set, setting the scene for the comprehensive results (obtained from all participants), which will be discussed in the next chapter. The representative data discussed herein will be useful in understanding the next chapter. The empirical aspect of the thesis was designed with the objective of understanding any changes that may occur in users' PA and ST and any determinants of these behaviours. DUS helped answer the second and third research question and provided a detailed account of the participants' behaviour throughout the intervention. This chapter, however, will discuss a detailed account of one household as a case study indicating user's behaviour from the start to finish of the intervention. It creates context on what to expect in chapter 8. The approach taken was a longitudinal study in the sense that it obtained measurements of data at more than one time point during the intervention period.

The literature indicated that parents usually struggle to mediate their children's ST practices (*Jordan et al., 2006; Lindsay et al., 2019*). Jordan (2006) gathered household inventory data on media use from 180 parents and children aged 6-13 years; the average home had 4 television sets with two thirds reporting a TV in the children's room. Most parents in their study expressed an interest in adopting any steps that would help to reduce their children's television time as they were uncertain how to go about this. Our previous study investigated parental mediators

and supports the above findings that parents are seeking an appropriate intervention that would help them regain control over children’s screen behaviours (Nwankwo *et al.*, 2019). Since there is no known intervention that supports children in-home exercising or better child-parent negotiations for screen use, this study attempts to generate new knowledge grounded in the design-led intervention. As discussed in chapter 4, the approach taken for the thesis is a case study. The first case study discussion of the findings will set the scene for further presentation of other home cases investigated during this project which will be reported in chapter 8. Baseline PA across all participants was self-reported; an energy monitor was used to obtain baseline TV watching time across 7 days pre-intervention. This chapter begins by with reporting a typical responsive household, whom during the minimum 90 days of intervention recorded 65 days of regular exercise. It details the progression of the PA and TV watching habit throughout the intervention, with indications of how their habit developed throughout the intervention. Participant no or household no will be used interchangeably to refer to every participant throughout the result chapters.

7.2 The data collection process for the DUS

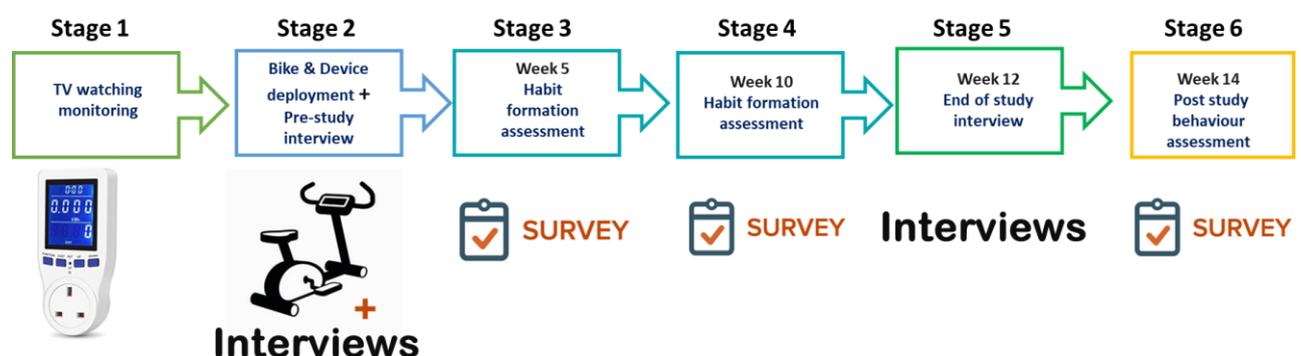


Figure 41 Data collection process

7.2.1 TV watching monitoring

Figure 41 details the stages that were employed for the data collection stage. Prior to the intervention, an energy monitor was used to measure each user's TV watching habits for a period of 7 days. This helped the researcher get a broad understanding of whether children generally have their TV in their bedrooms or an allocated TV room different from the main home TV. In the case of participant 17, they had two TVs in the home: the participant had her TV in her bedroom, which was measured for the first 7 days. Table 9 show the pre-intervention information and other details about this participant. Equation 1 highlights the formula that was used to obtain the TV watching hours.

Equation 1 TV watching hours-formula

$$\frac{kWh \times 100}{TV \text{ watts}} = \frac{h}{\text{number of days}}$$

7.2.2 Bike and device deployment and semi-structured interview

The second stage of the empirical study involved the researcher visiting the house to obtain the information on kWh and to install the Knudgbox system into the user's home. Upon arrival, the researcher obtained the kWh value and did the calculations to obtain the pre-intervention TV watching hours, see Equation 1. This was further used in the semi-structured interviews to ascertain if the user was aware of how much time they spent on the TV per day. The semi-structured interview was conducted using the interview guide, which contained 11 open-ended questions: see appendix 6. The interviews were recorded, transcribed and further analysed using NVivo. In order to avoid misinterpretation of context, content and loss of meaning, the transcription process was done verbatim (Slembrouck, 2007). The field notes

taken during the interview were revisited during the transcribing process, to ensure that it provided an accurate reflection of the participant's voice. Figure 42 shows the participant's home setting with the device set-up.

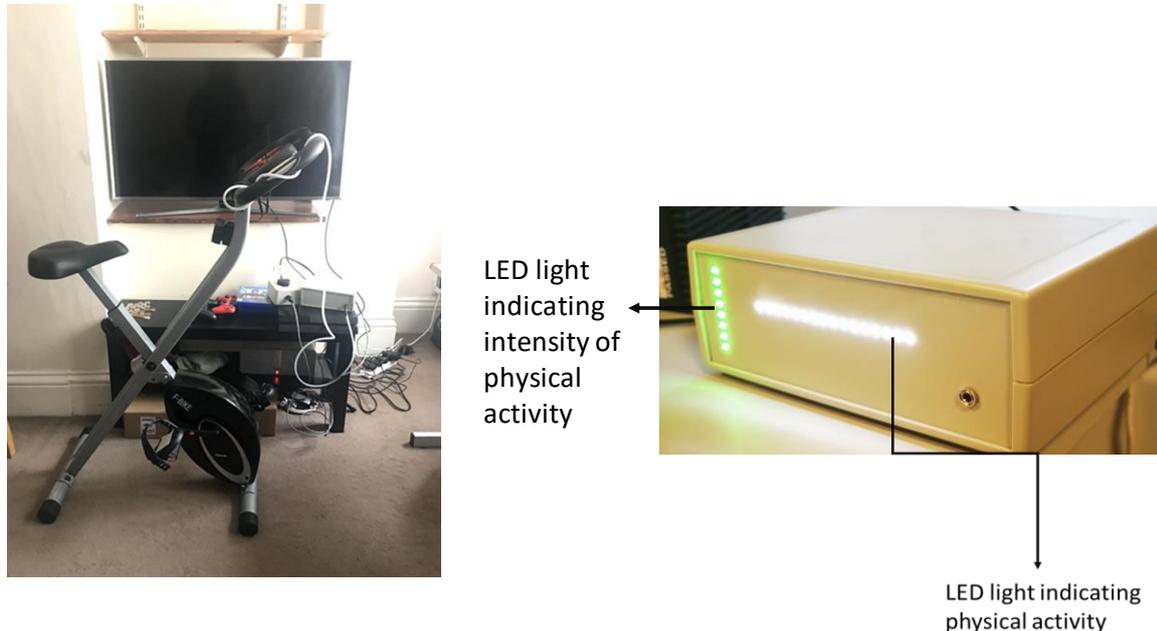


Figure 42 Device home set-up and LED indication

As mentioned in chapter 4.9, the research instrument was sampled across 20 households for a duration of 3 months. The Knudgbox deployment essentially started examining each user's PA and TV behaviour throughout the study duration. The device which was fitted in the participant's house collected and displayed exercise progress in the form of an LED light bar and recorded data in real-time; the data was logged every five minutes. The cleaning up process of the data enabled the researcher to ascertain how much exercise and TV/USB charging the participant did or used during the intervention use. From the obtained samples, some houses engaged more with the device than others, and this variation of user behaviour was useful in understanding the numerous behavioural personas that emerged. The detailed analysis of this variation is discussed in Chapter 8.

7.2.3 Mid study assessment at weeks 5 & 10

The development of the mid-study assessment measured the constructs within this theoretical framework to assess participants' motivational influences at week 5 and 10 of the DUS. The sections were separated to reflect the four primary constructs of the framework, as shown in Figure 43. The instruments assessed within the questionnaire used a validated scale Intrinsic motivation inventory (IMI), see appendix 9.1.

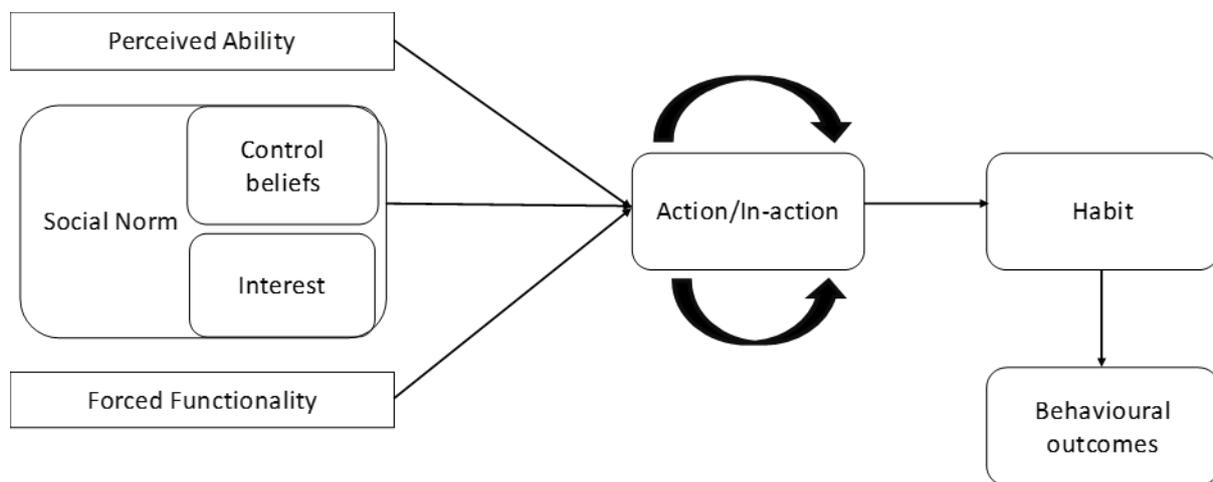


Figure 43 Theoretical framework for current study

▪ Perceived ability

As discussed in chapter 3.14.1 perceived ability influences the way in which the participants interpret their immediate environment and how this shapes their behaviour and motivation towards an intended activity. To measure perceived ability, questions were used to score participants' perceived ability towards exercise habits.

When dealing with exercise behaviours, it is suggested to focus on the premise that people's behaviour is strongly influenced by their inherent ability to achieve or engage in a certain task. This is similar to perceived competence, whereby failure to engage in a task or behaviour represents the individual's lack of capability. The

stronger the perceived ability, the more likely it is that an individual will have the intention to perform a certain behaviour.

- **Social norm**

The second part of the direct measurement of user behaviour includes the combination of control beliefs and interests. People's behaviour has a direct influence on their social environment. From a social psychology point of view, social influences encompass external and social factors which impact on an individual's behaviour, and this has been argued to either be normative or informational (Deutsch & Gerard, 1955). According to TPB, subjective norm suggests that people's engagement in a specific behaviour depends on them being under pressure to meet the requirement of normative conformity (social influence). Normative conformity relates to shared values and understandings of the intended action; this can either be permitted or obligatory. In other words, the concept of norms, either subjective or social, refers to behaviour supported by groups and how the behaviour of these groups affects the others. Ajzen & Fishbein, (1972 p.2) elucidate that "social norm is usually referred to a broad range of permissible but not necessarily required behaviour". Other researchers examined the inter-relationships between individual behaviours and social norms, such as Lapinski & Rimal, (2005). In their study, they concluded that social norms (descriptive, subjective and injunctive norms) have effects on behaviour and confirmed that norms are "dynamic phenomena"; therefore, self-interest plays a key role in altering people's normative contours.

- **Forced functionality**

TAM²⁷ has been widely applied in measuring participant ‘ease of use’ and value of ‘usefulness’, as this relative advantage could impede on users’ actual use of the technology. The questions asked to measure this construct was in relation to ease of use and any new habits formed as a result of the device introduction.

7.2.4 End of study interview

The end of study interview was conducted after the 12 weeks intervention. This was important in understanding the determinants of participants’ general behaviour throughout the intervention. The interview lasted between 40 – 60 minutes, depending on the participant’s engagement with the device. The interview guide has been attached in appendix 8. The researcher took some observational notes during the home visits, which were also useful in ensuring that the participants’ words and actions accurately reflected the data collected. Thus, accounting for participants’ actual perspectives to support their spoken words ultimately and independently reduced the bias that may influence the findings from the study.

7.2.5 Post-study survey

The final phase of the data collection process comprised of a four-item questionnaire, scored via a similar scale to the one used for the surveys at weeks 5 & 10 (see appendix 9). This scale was adopted based on a validated scale (see appendix 9.1). This was carried out 2 weeks after the intervention was withdrawn. The four-item questionnaire examined if their PA and ST habits had been maintained since the end of the intervention and enquired about current estimated PA time and ST. Their current PA time was obtained on a scale ranging from 1

²⁷ Technology acceptance model

(Decreased) to 7 (Increased). These items were important to understand any sustained behaviour change that may have occurred even after the research instrument was taken away.

7.2.6 User demographics

The population for this study comprised of children aged between 11-15 living in the UK. The sample for this study had 20 participants, 10 boys and 10 girls. The study attempted to obtain heterogeneous demographics to ensure there was wide cultural sampling. Thus, participants were from different ethnic backgrounds, including Asian or Asian British, Black or Black British, White or White British. These participants were sourced through snowballing sampling²⁸, university communication channels, flyers and word of mouth.

7.3 Pre-intervention data (TV usage monitoring)

This chapter, as mentioned during the introduction, highlights the various types of data collected, using household 17 as a point of discussion throughout the entire chapter.

²⁸ Snowballing sampling involves sourcing for new participants through already recruited participants.

Table 9 Sample of User Pre-intervention information and study duration

House 17	Data
Gender	Girl
Age	14
Ethnicity	White British/White Other
Pre-intervention TV watching assessment	1 Week
Average TV watching pre-intervention	10.4 Hours/day
Intervention exposure	12 Weeks
Post Intervention assessment	2 Weeks
Total study duration	15 Weeks

7.2.1 discusses the TV watching data collected before intervention for each participant. Table 9 demonstrates that participant 17 watched 10.4 hours of TV/day; see Figure 44 for the energy monitor obtained from their TV record prior to the intervention. An Ofcom report showed that children aged 8-11 watched an average of 2 hours 36 minutes of TV per day; children aged 12-15 years viewed for an average of 2 hours 42 minutes (Ofcom, 2016). When compared to the participants of the current study, the Ofcom report is a self-report while the TV watching habit in this study was an actual measurement. The only limitation in the accuracy of the measurement could be the issue that TV being 'on' does not mean it was being watched. However, from the qualitative findings of the current study, children and parents were mostly under-reporting their actual screen habits as a result of unawareness.



Figure 44 Energy monitor showing Kwh value for house 17

7.4 Pre-intervention analysis

The following section discusses the behaviour information of participant 17. The initial analysis was about familiarisation with the data, the audio transcripts, field notes and reflective journals, which all formed part of the interpretation of the data. Braun and Clarke (2006) recommend that after the familiarisation stage, the researcher can then proceed to generate codes based on having an in-depth idea of what is in the data. There was a continuous re-visitation and interaction with the data until a specific characterisation of the data set was reached. The next phase required a thematic classification of the coded text into different themes. “A theme is an abstract entity that brings meaning and identity to a recurrent experience and its variant manifestations” (DeSantis and Ugarriza, 2000 p. 362). For participant 17, the below themes were significant to a substantial proportion of their data.

Prior to the study for each household, the semi-structured interview sort to understand participants’ baseline activity level and general home activities related to SB. The participants were asked about their PA daily routine if they had any, how

much PA they did at home, activities done around the home that required sitting, and general ST rules around the home. Through the thematic analysis, some broad themes emerged. For participant 17, the following themes were pertinent to their responses:

7.4.1 Lack of exercise

The participant reported walking to school on occasional days and engaging in dance classes once a week. The participant reported a lack of confidence in their weight as the reason they did not participate in open exercise classes such as school Physical Education (PE). As illustrated by the participant, *“I do dance once a week, and that’s about the only exercise I do, I have a private dance lesson because I can’t join other kids at the dance club. I am not confident about my weight”* (Participant 17).

7.4.2 Sedentary behaviour

Participants reported whether they engaged in PA at home, or if they spent most of their time inactive. This directly affected the typical home behaviours and their willingness to adopt new behaviours. *“I have a skipping rope in my room, so I skip at home”* (Participant 17). Skipping at home in the case of this participant was related to their lack of confidence and unwillingness to participate in outdoor activities with peers. Although in another instance, she expressed her interest in doing more active things: *“I have told my mum to get me a trampoline, but she thinks we don’t have enough space in our back garden to put this”*. This statement signifies that she understood her level of inactivity and was prepared to do something about it.

The prominent thing across most participants was that the lack of active things to do resulted in prolonged sitting behaviours such as watching TV and playing video games. From the review of literature, specifically in Chapter 3, it has been seen that technological abundance leads to inactivity. In the context of the current study, most participants expressed that they watch a lot of TV because there is no alternative thing to do: *“I watch a lot of TV and it’s mostly YouTube”, “I guess I can use my skipping rope more often and maybe hope that one day we could get a trampoline for me to use at the back garden”* (Participant 17). These above sub discussions highlight the types of data that emerged from the interview for this case study.

The next chapter discusses the various types of behavioural data pertinent to participant 17 from the thematic coding process.

7.5 Behavioural Data

7.5.1 Physical activity behaviour

The discussion in Chapter 3.7.1 about TTM²⁹ highlights how the model has described the concept of behaviour change by drawing arbitrary lines differentiating these stages of changes. TTM model considers conscious decision-making and the planning processes which an individual might consider when deciding to change. One of its flaws is its inability to draw attention to some important underpinning of human motivation which SDT³⁰ highlights, and this was useful in the context of this study. The model also supports the researcher’s reasoning behind not identifying one behaviour change model/theory as the benchmark for the study. Thus, one of the benefits of the TTM is to remind us that people’s behaviour change occurs gradually; in the case of the current study, this meant moving from participants

²⁹ Transtheoretical Model of behaviour change

³⁰ Self-determination theory

being uninterested and unaware through making slow changes. The results from the study suggest that all participants took determined actions to change during the intervention. Prochaska and Velicer (1997) described the action stage as crucial and as a point where people need to be supported in order to fully transition into the maintenance stage, as it demonstrates a desire for a lifestyle change. The next subsection details the action stage, using the sample data from Participant 17.

Initial stage (first 5 weeks of the intervention)

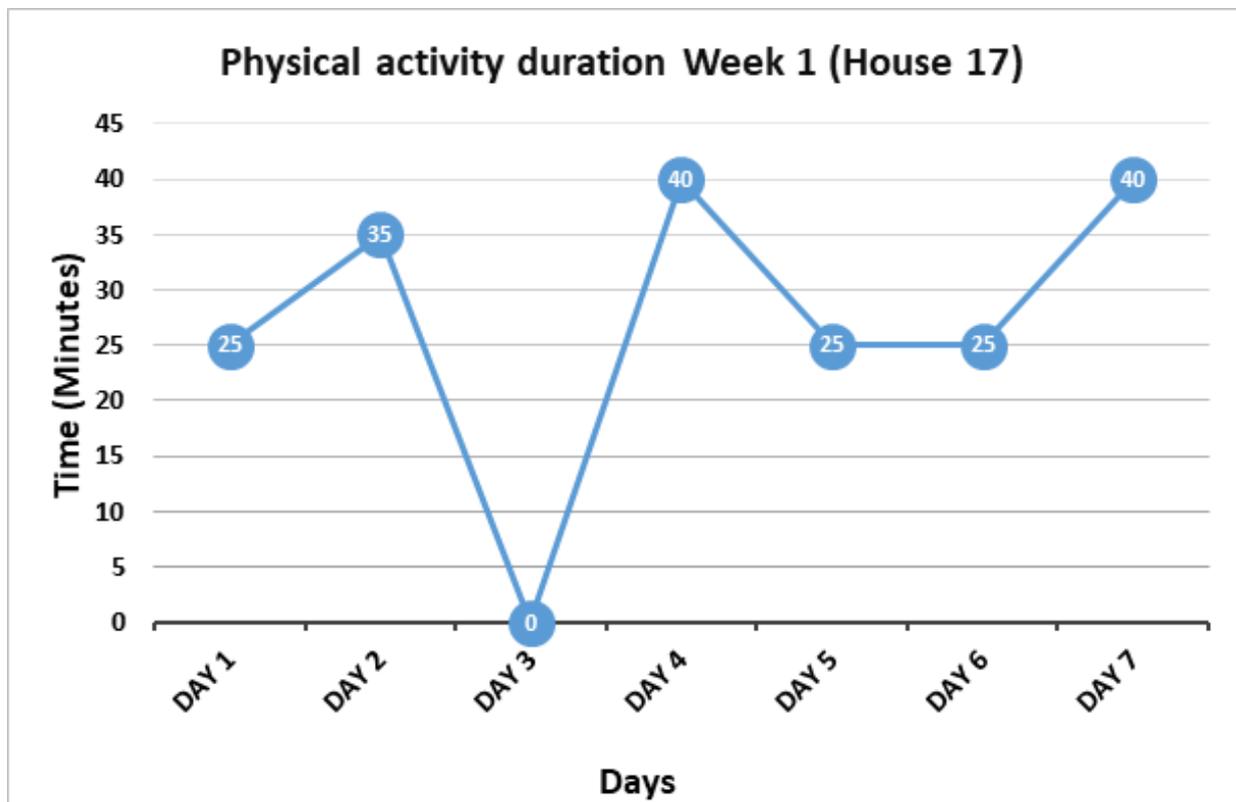


Figure 45 PA Week 1

The originators of TTM argue that when people are ready to change their behaviour, they should be provided with structural cues to support this change (Prochaska, Johnson and Lee, 2009). Figure 45 shows that there were 25 minutes of exercise activity on the first day using the intervention tool, which could be seen as a cue to exercise. From a psychological perspective, this could be attributed to the

participant potentially familiarising herself with the device. It is not enough to say that people make decisions based on conscious awareness of their intention to change: it is necessary to consider motivational forces that reinforce habitual behaviours. Hence, the survey conducted in week 5 explored the psychosocial determinants or the external factors that underpinned the fluctuations in exercise habit. Additional factors will be discussed in detail in the next chapter, as this was common amongst the other participants. Although from the mid-survey (week 5 & 10), it was evident that the participant had already worked out the ratio of PA: ST which explains the PA fluctuation between 40 and 25 mins done on day 4-7.

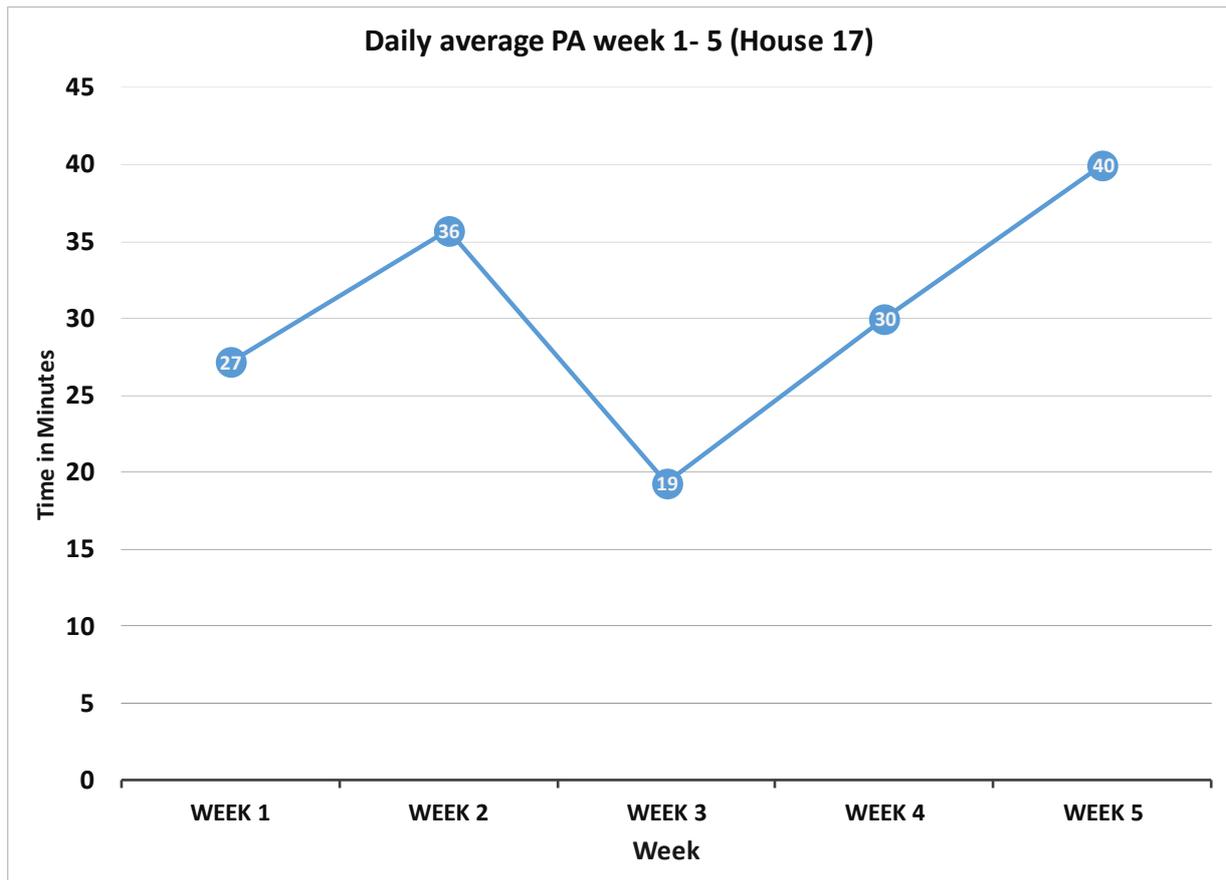


Figure 46 First 5 weeks of intervention exercise data

Figure 46 presents a weekly view of exercise for the first 5 weeks of intervention exposure. Participant 17’s baseline self-reported PA was less than 30 minutes daily,

and she expressed a lack of confidence in engaging in PA with peers at school and outdoors. The LED³¹ provided feedback to the participants to induce sustainable habits and behaviour change; several studies in the literature indicate that individuals change their behaviour when provided with feedback in a subtle manner (Kappel & Grechenig, 2009; Kim, Hong & Magerko, 2010). From the observation, the participant exercised for an average of 27 minutes a day in week 1, and this increased to 36 minutes in week 2.

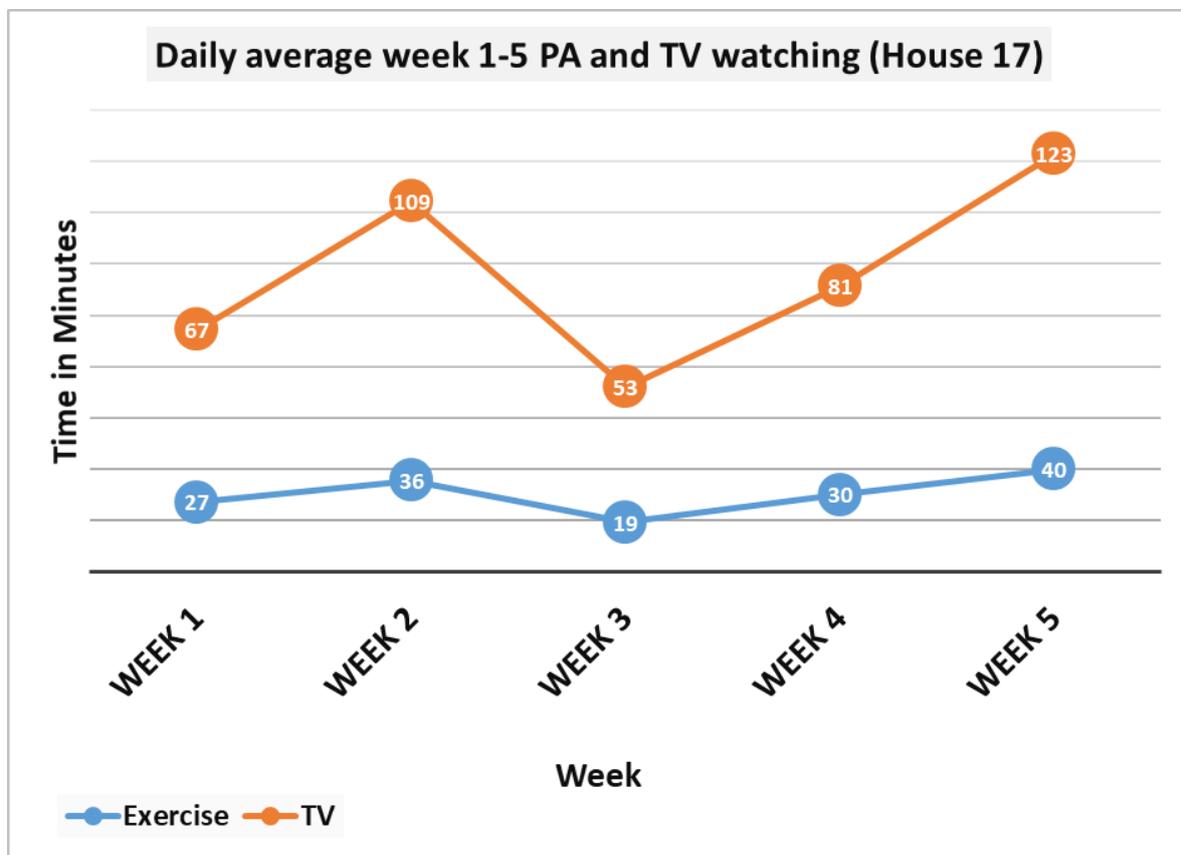


Figure 47 First 5 weeks of PA and TV watching data

At pre-intervention, the daily TV average for this participant was 10 hours, and Figure 47 shows both PA and TV watching activity results for this case study during the first 5 weeks. The apparent interpretation from this observation is that the

³¹ See Figure 28 with image indicating LED meaning.

participant's TV watching drastically reduced. The participant was relatively engaged in exercising for the first two weeks until week 3 when there is a sudden decline, and there is a direct correlation showing that they watched TV based on the amount of PA they had done. During the pre-intervention interview, the participant emphasised that she was quite keen to lose some bodyweight as this was affecting her confidence. The first 5 weeks shows her habit changing behaviour.

7.5.2 Attitudinal changes

The mid-study assessment was about evaluating the attitudinal drivers of the participants' change in behaviour. The questions were coined to address if the behavioural data in Figure 43 were accountable for the participants' change in behaviour. Each instrument assessed participants with varying numbers of items. Various types of analysis were carried out to ensure that the results represented the participants' attitudes. The chosen analysis was to manually review each question and see the difference between participants' responses at week 5 and week 10. For instance: "*I am good at setting goals for my daily exercise now*". If a participant's response for this question at week 5 scored 3 and at week 10 scored 6, this was an indication that there had been a positive shift. The results after the manual analysis were inputted into MATLAB for scale normalisation to ensure reliability.

The original scale used for this survey³² was adopted from the IMI as a validated and reliable scale for measuring motivation and respondent attitudes (Center For Self-Determination Theory). This scale was chosen due to its reliability and validity, and its use can be applied in different domains and varied sample

³² See appendix 9.1

populations; research has also shown that it has robust historical reliability (Tsigilis and Theodosiou, 2003).

Questions 1-4 measured for perceived ability and this participant reported high attitudes with regards to this construct, which was focused on measuring if the individual's self-belief was a driver for their actions. Responses to questions 1-5, 9,15,19 and 23 indicated that their motivation and attitude positively shifted during the different time measurements. The most influential construct seems to be perceived ability, with neutral attitudes expressed regarding the other constructs. Questionnaires are subjective and can often be misunderstood, and this can be a limitation. During the participant's end of study interview, she stated that parental and friends' influences were some of the determinants of her actions during the early days of the intervention. The next chapter will discuss if there were in-depth differences between other participants by questions and overall.

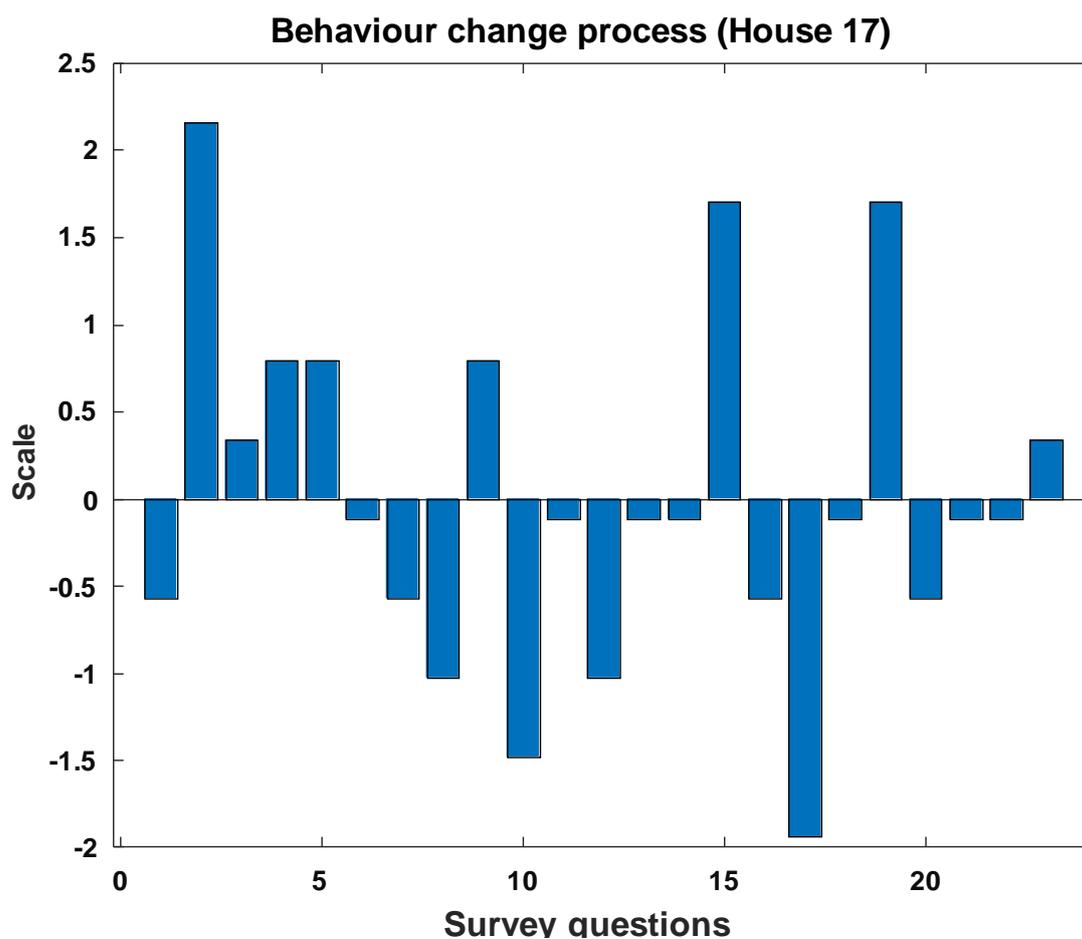


Figure 48 Responses on constructs measuring motivational changes

7.5.3 Maintenance

From the literature review conducted in Chapter 3, there was considerable evidence that behaviour change interventions can effectively modify behaviours. However, evidence for sustainability and maintenance of the new behaviours is limited, and it has also been suggested that intervention effects diminish over time (Dombrowski, Avenell and Sniehot, 2010). Maintenance in this thesis, therefore, provides evidence of behavioural implementation with evidence of the behaviour’s initiation and maintenance over time. In the case of most participants, they had no prior PA behaviour; thus, this intervention attempted to establish new behaviours, and it was unclear what conditions were required to maintain their new behaviours to prevent relapse. Figure 48 provides evidence of data that allowed this study to examine some of the motives behind the participants’ actions.

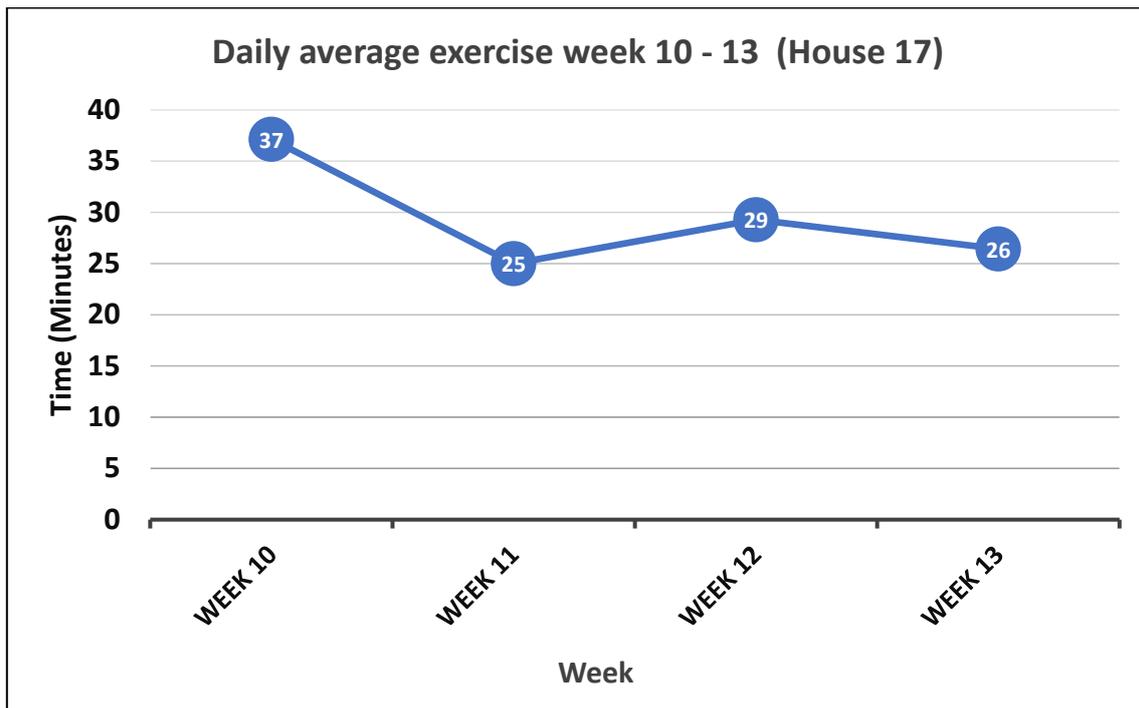


Figure 49 PA for week 10 - 13

The 4th stage of the data collection was collecting measurements of the key determinants influencing their habits. The essence of the data collection points at week 5 and week 10 was primarily to understand the changes in attitudes that precede the behaviour. From the literature review, some scholars argue that behavioural intention translates to actual behaviour. In comparison to weeks 1-5, where the PA behaviour was fluctuating, the participant began to find balance after 10 weeks, as shown in Figure 49. Their responses on the questionnaire signified that at this stage, they had formed a routine for their new habit.

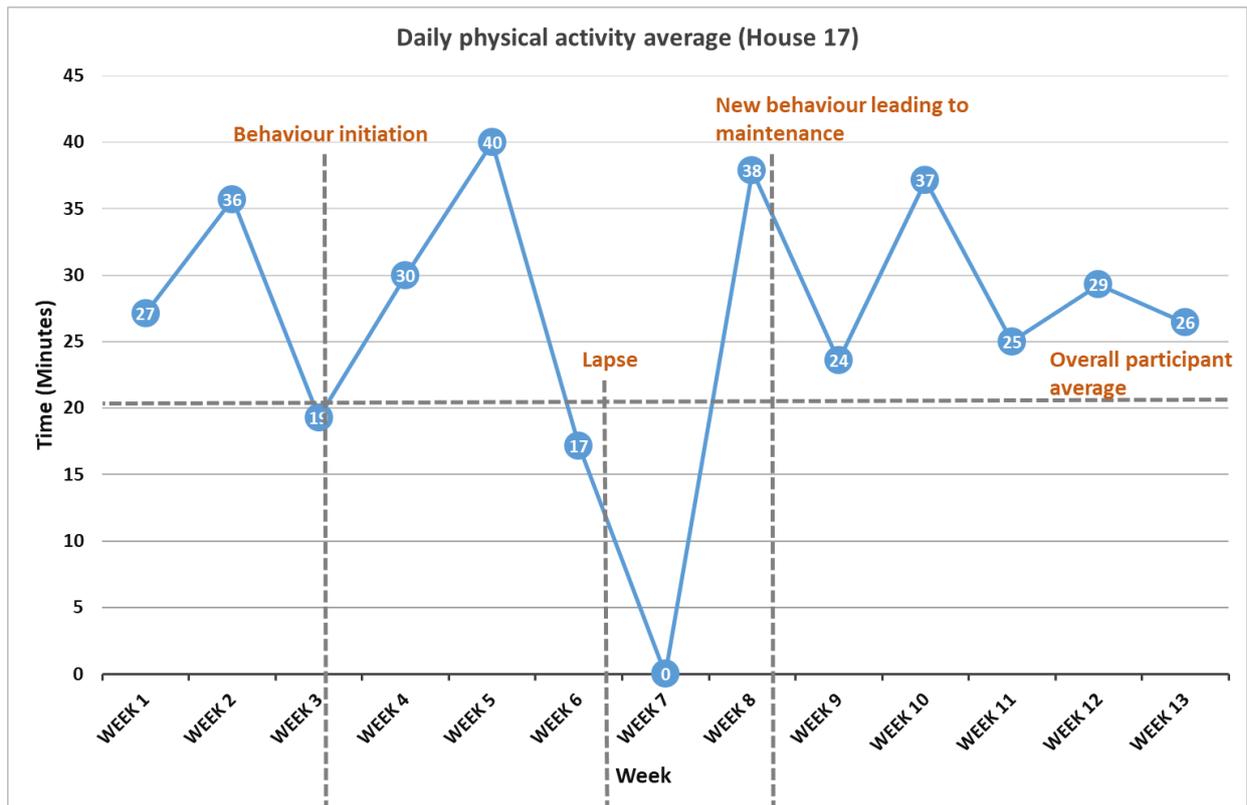


Figure 50 Physical activity overview across weeks

Figure 50 presents the log of exercise for all the weeks, showing the daily exercise average for household 17. It is apparent that the first 3 weeks comprised the new behaviour initiation stage, where the participant was getting used to the new action. Week 5 recorded a significantly higher amount of PA, with a sudden lapse in week 6. According to the end of the study interview, the participant mentioned that they had intentions of exercising more for two weeks before they went away on their summer holiday. The holiday mood must have kicked in at week 6 hence their lapse. Although not quite steady, the participant seemed to have found some consistency in their exercise habit from week 8 until the end of the intervention period, with an average PA duration of 41 minutes.

This stage could be categorised as the new behaviour leading to the maintenance stage. In the science of habit formation, there are no typical time frames to form a

new habit, it's usually a matter of motivation. Thus, the fluctuation in the PA chart is typical in the habit formation process as habits are formed by a repetition of the behaviour. Psychologists suggest that allowing at least two months could show if a habit is either broken or maintained; in the case of this participant, her long term and consistent engagement is a determining factor in her motivation. The data from week 3 detailed that the participant exercised every day of the week for an average of 19 minutes. As this was still early days of the intervention, it was clear that they thought it was best to form this habit gradually as opposed to during week one.

The intervention duration was expected to last for 12 weeks, but as with this participant and most of the others, their availability to end the study at a precise time made the study run over by a few weeks. This was positive, too, as most of the participants carried on using the device.

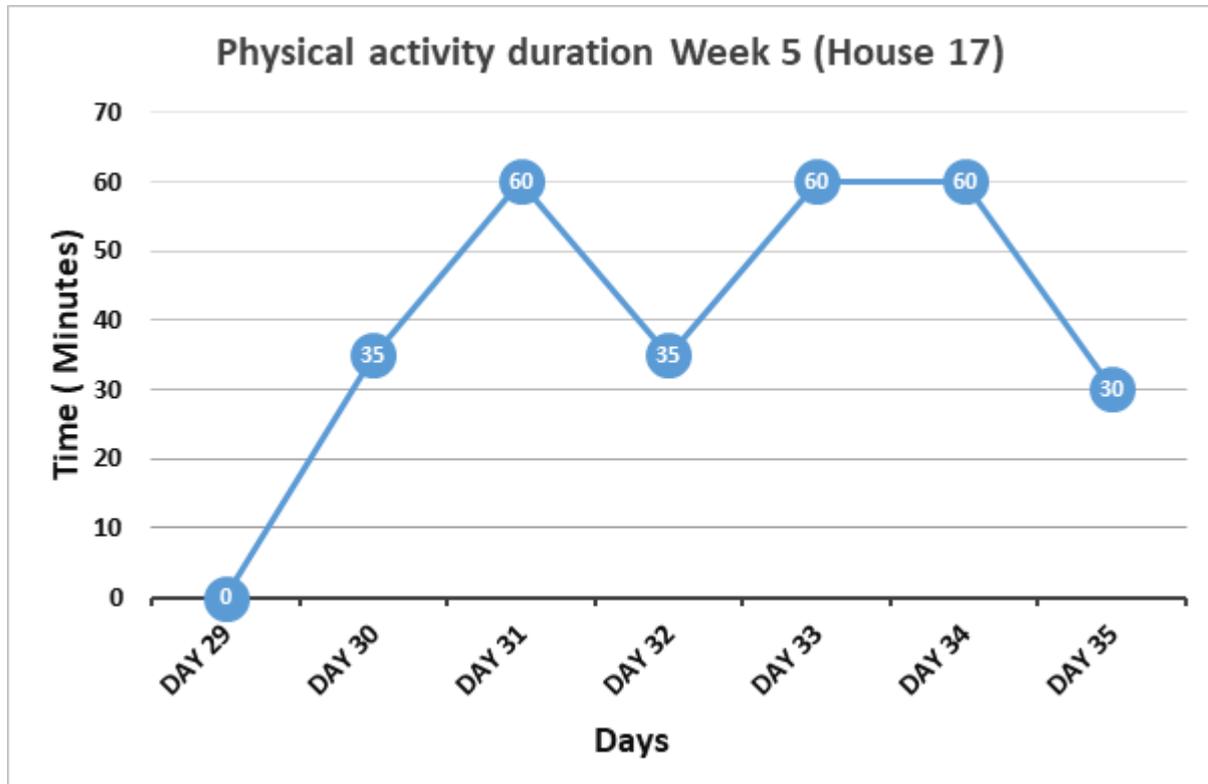


Figure 51 Physical activity week 5

- **The week with the highest physical activity**

The diversity of PA behaviour across the intervention was illustrated in Figure 50; however, Figure 51 shows a week with an outstanding PA performance for this participant. The participant reported not exercising most weekends, which explains why there is no record of PA on day 29. However, there were some occasions when the participant reported having exercised on weekends in order to meet their set goals for the week. In terms of habit formation, initiation requires participants to be generally motivated to engage in the said behaviour. In this case, however, the participant, after familiarising themselves with the device in week 1, started the process of repeating the action consistently. Previous research on habit formation has demonstrated that repetition of behaviour or action consistently within a given context helps in maintaining motivation and this is supported by autonomy and sustained interest (Gardner, Lally & Wardle, 2012).

Figure 53 below shows the week with the least PA performance for this household (week 7). The participant reported having gone away for 13 days, hence the low activity reported herein. Since the average was calculated by the number of days within a given week.

- **The week with the lowest activity due to holiday**

When adopting new behaviours through conscious effort, there is often a period whereby the old behaviour or the urge not to respond to the new behaviour may be dominant. Also, when using devices that record data in micro timescale, it is easy to see when participants record no activity due to unavoidable life events such as holidays and sickness. These events could impact on the habit formation process; the collection and representation of these data in the 'no activity period' help in

painting a clear picture of the contextual features that support re-engagement when the participant resumes the activity. Figure 52 illustrates times when the participant had no activity record, and this was explained as the period when they went on a family summer holiday. In the instance where this was a genuine lapse in behaviour, opportunity cost could also be a reason behind low motivation, and this may increase momentary lapses. Opportunity cost is an economic term often used in decision-making frameworks for analysing the consequences of different choices. The participant's ability to re-engage with the new behaviour after these periods shows the function of the reflective process such as self-monitoring to avoid relapse of behaviour is vital.

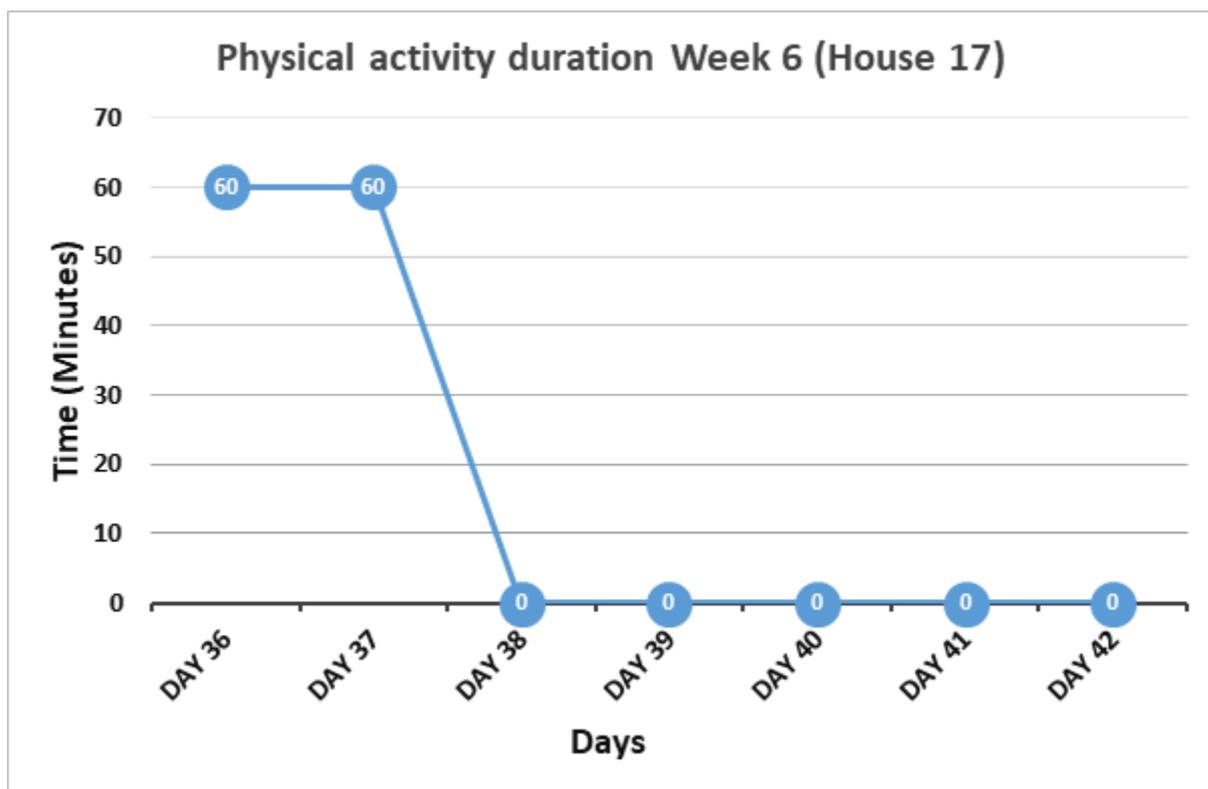


Figure 52 Low physical activity log

For any participant who experienced lapse periods and failed to re-engage, it could mean that their decision not to participate was promoted by them measuring potential gain and loss that will result from their engagement in the intervention.

Dunton (2019) argued that new theories are needed to define these stagnation and regression points along the behaviour change scale, especially in longitudinal studies. Hence, re-engaging is considered as a possible phenomenon in any intervention process. This study highlights the notion that design-led intervention considers how these opportunities could be maximised when instigating a behaviour change.

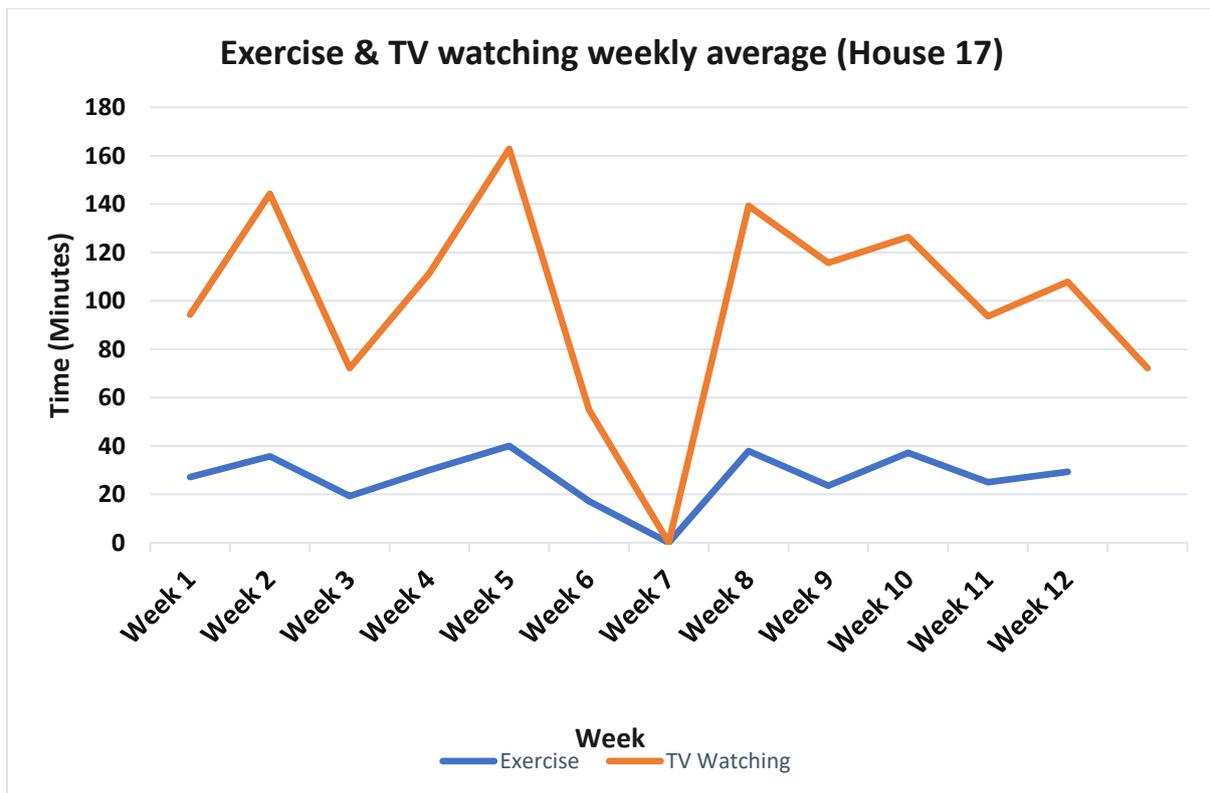


Figure 53 Physical activity and TV watching weekly

Figure 54 and Figure 55 indicate a clearer defined behaviour pattern: the monthly data shows a more systemic process in behaviour change over time for both PA and TV watching. The cumulative total for month 2 does not necessarily signify low activity, because from the previous graphs with weekly view the participant went away at week 7 hence the decline in month 2. Thus, with the attitude shown across the months, the participant engaged with the intervention with a positive attitude

based on the qualitative evidence which will be discussed in the following sections of this chapter. For participant 17, Figure 53 shows average daily PA and TV watching by week throughout the intervention. The main fluctuations show that the participant started getting into the habit of watching as much TV as they exercised across the weeks. The variations indicate that her attitude changed after week 7. The graph shows an illustrative example of the participant's attitude and behaviour towards PA and TV watching. From the observation, the two activities going down towards the end of the intervention could mean that the novelty is wearing off or they are finding a better balance than they did in weeks 1 to 5.

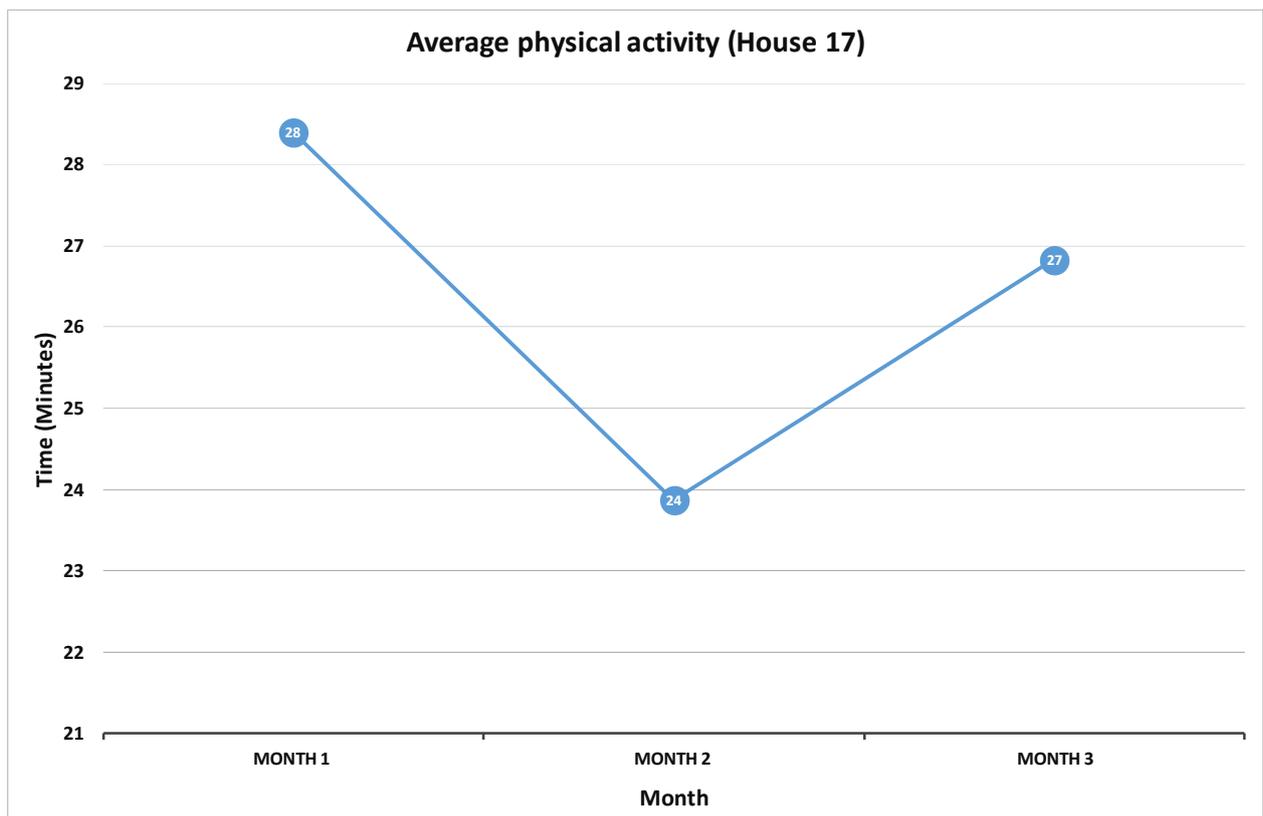


Figure 54 Daily average monthly PA

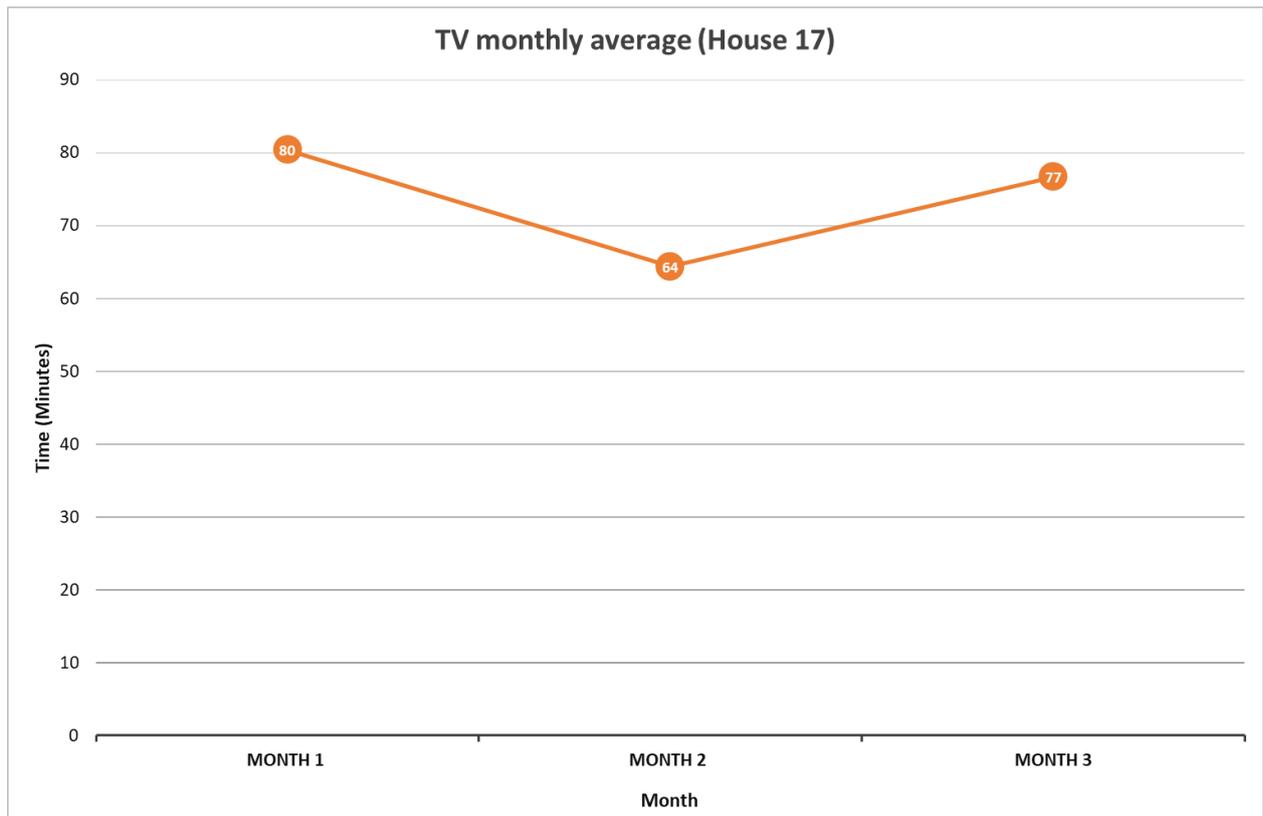


Figure 55 Average daily TV watching monthly

The TV-watching information for the participant as shown in Figure 56 highlights the significant changes in viewing times, and there was a dramatic decrease from the average TV watching time of 10.4 hours/day as shown in Table 9. The graph shows an improving trend with TV habit. The change does not appear to be linear, and the decline was very slow: changes like this can occur in actual behaviour change. Week 1 is the week with the lowest TV watching time, although Figure 50 shows that the participant did 27 minutes of exercise on average that week. The participant probably did not use up the accumulated TV time for that week. On the other hand, week 5 as expected records the highest amount of TV time and this corroborates the PA data for that week, as she also recorded the highest PA time that week.

The end of study interview concluded that the participant engaged voluntarily with the device in order to meet their PA goals. Thus, their high engagement can be attributed to personal interest and reported parental support.

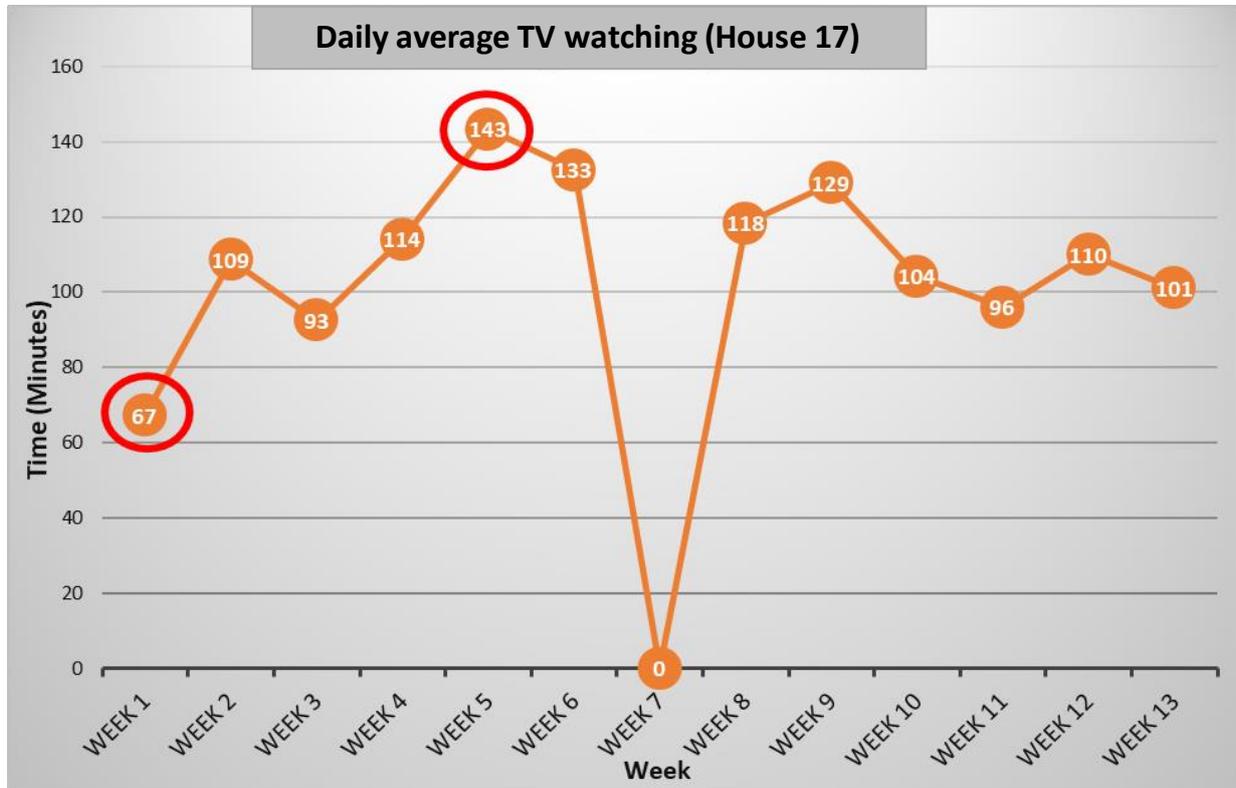


Figure 56 TV watching the lowest and highest recorded weekly averages

Habit Retention

The intervention period was for a minimum of 90 days, although participants were expected to have completed the intervention at the 12-week marker. There was a challenge in arranging the collection of the device considering the availability of the participant. From the results of Participant 17 it is evident that this study provides sufficient behavioural data to understand how participants behaviour changed over time. Also, from week 5 and 10, the data obtained was useful in understanding the motivational influences of participants, thus, linking this with the behavioural data.

7.6 End of study interview analysis

At the end of the intervention, another semi-structured interview was conducted (see appendix 8 for interview guide). As mentioned in the pre-intervention interview discussion in chapter 7.4.1, the main themes will be elaborated upon in the next chapter. Some of the exemplar themes specifically retrieved from participant 17 are briefly discussed in the following subsections. It is important to note that its purpose is to show a sample of data interpretation to demonstrate the qualitative analysis undertaken.

7.6.1 Self-regulation

This participant suggested the need for active self-regulation as an integral factor in successfully maintaining a new behaviour pattern, *“I had to make up my mind that I will do a little bit every day or all the time when I can at least”* (Participant 17). People often initiate new behaviours when they feel the moment is right. From the general participant engagement in the intervention, self-regulation is needed to ensure the behaviour becomes automatic. Although some habit theorists hypothesise that as individuals continuously repeat and develop new behaviours, self-regulation needs decrease (Verplanken and Aarts, 1999). This also reflects in the increase in the participant’s perceived ability, as shown in Figure 48. The increase in perceived ability at week 10 explains the participant’s ability to self-regulate their behaviour after several conscious repetitions.

7.6.2 Interest and enjoyment

Children are active beings and love to engage only when they are interested. SDT³³ discusses the contrast between intrinsic and extrinsic motivation, where the intrinsic

³³ Self-determination theory

involves interest and the feeling of the behaviour being rewarding on its own, and the latter represents engagement in activity with the anticipation of an external reward. Participant 17's engagement in the activity was high because their interest level was high, as seen in Figure 48. Similar to the social and environmental influences, their interest was increased because they tended to have overcome the distraction that comes from the social norm which the participants in the study mostly classed as fear of missing out (FOMO). *"My friends who came home a few times thought the whole concept was cool and it kinda made it easier to be the one doing the cool thing"* (Participant 17).

7.6.3 Environmental influence

The participant responded to behavioural options which had been facilitated by environmental choice architecture cues. The presence of the device and the bike was a key driver in habit change, *"I really had to go on the bike because it was here, and my mum wouldn't let me watch TV until I went on"* (Participant 17). Contextual factors observed from the DUS³⁴ were the influence of social and environmental factors, affecting the effort needed for an individual to perform a new behaviour. Social support increased participant and individual behaviour capacity; *"I went on the bike a few times to encourage her to, some days when she wasn't feeling up to it at the beginning, I went on the bike, and it was also a form of workout for me"* (Participant 17, Mum). This social modelling must have facilitated the participant to replicate this action performed by their subjective norm. Therefore, deploying the device in the participant's usual environment opened a window of opportunity for them to adopt a new habit, and they were also willing to

³⁴ Domestic User Study

maintain it. *“My mum already bought me a treadmill and maybe if you could let us have the bike too, maybe I can go on one or the other” (Participant 17).*

7.7 Post-intervention data

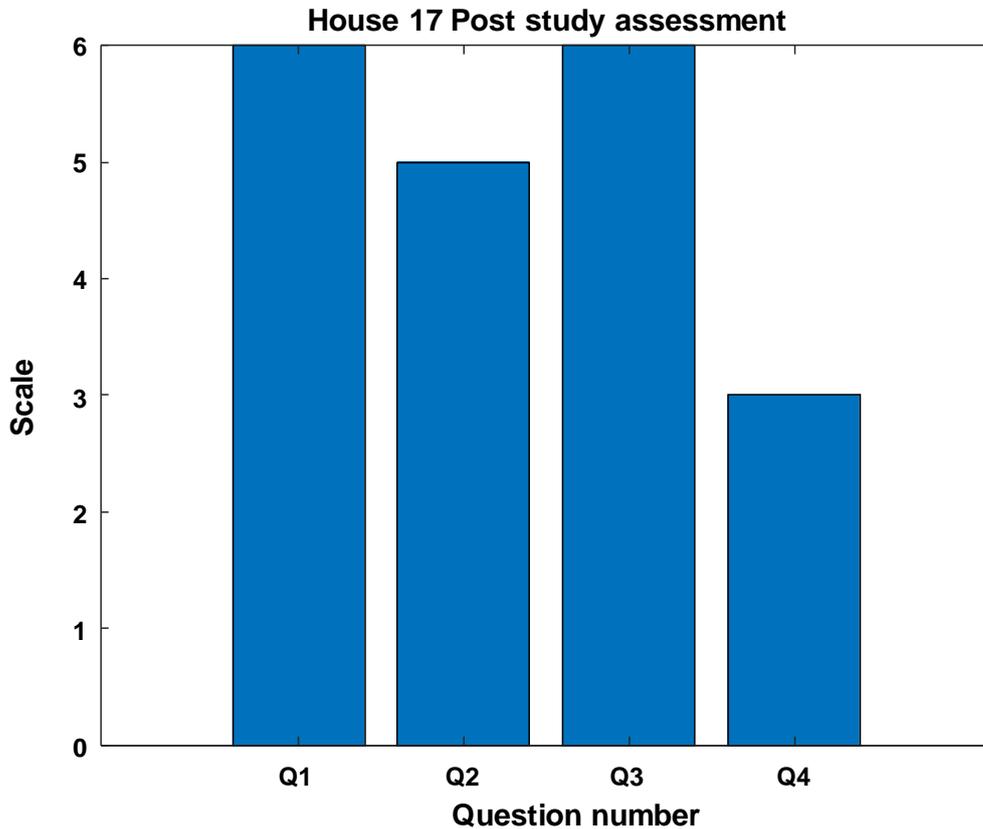


Figure 57 Post-intervention feedback (Participant 17)

At the end of the intervention, the device was taken away with the bike. A post-study survey (see appendix 9) was conducted to measure their attitude and understand if their behaviour change had been sustained. In corroboration with other existing models, the proposed framework for the current study suggests that maintenance of behaviour is a function of repeated performance, and this could invariably lead to a re-evaluation of the action. The essence of the post-study was to assess whether the participant continued this habit or if they found it less desirable to continue with the adopted behaviour.

As shown in Figure 57, participant 17 is observed to have maintained their new habit. From the end of the study interview, the parents reported having purchased a home exercise kit for the participant, indicating their interest to maintain and regulate the new habit. The outcome of this study tells us that, in facilitating any habit development, reshaping the environment and providing social support are essential in behaviour change maintenance. The participant's attitude highlights their ability to utilise enjoyment and interest motivators to enhance their behaviour outcomes. The significance of the change and how it improves their overall wellbeing and habit will be discussed in the next chapter.

7.8 Summary of Chapter

This chapter highlights the data collection process, how the design-led intervention was deployed and used and shows a range of collected data. The chapter presents evidence from one household in the form of a case study to provide context for the series of data that emerged from the study. The results shown in this chapter provide an understanding of the participant's behaviour data for both PA and TV time throughout the intervention. In the case of household 17, this chapter highlighted all results related to their behaviour changes over the course of the intervention exposure. The result presented within this chapter demonstrates the various types of data collected throughout the DUS using one participant as an illustration. The next chapter presents the compiled data from all participants with a more comprehensive analysis highlighting the behavioural changes while evaluating the effectiveness of the design-led intervention.

Chapter 8 All Results and Discussion

8.1 Introduction

The detailed analysis and the DUS results from the 20 households are presented in this chapter. The primary purpose of this chapter was to present the findings that directly answer the below mentioned 3 research questions.

RQ4 – What behavioural changes are evident as a result of the intervention?

RQ5 – What are the changes in the measured psychosocial determinants over time?

RQ6 – What are the key effects of the design-led intervention on habit formation and behavioural intention?

Design for behaviour change to solve multifaceted societal problems has been studied and applied in various disciplines over many years (Fishbein and Ajzen, 2011). Several researchers have implemented the use of designed products and services to influence people to behave in a more sustainable way (Shin and Bhamra, 2016; Shin, Al-Habaibeh and Casamayor, 2017). Designers can indicate how they intend users to behave using different methods and strategies. The framework presented in Shin & Bull's (2019) paper suggests that design for sustainable behaviour should not only focus on changing attitudes using external factors but should also focus on improving and sustaining practices. They present an interconnected and interdependent dimension which represent empowerment, information and motivation as spectrums in which designing for sustainable behaviour could be adopted for future interventions targeted at the internalisation of new behaviour. The pilot study of this thesis was designed to precisely understand the intended user's home behaviours, getting a clearer picture of their screen sedentary related activities and the various determinants, to regulate those

behaviours with PA. This led to an inductive longitudinal study examining the associations between PA and ST behaviours and their determinants.

Using a combination of methods, the empirical study of this thesis provides an extensive amount of data regarding participants' PA and ST behaviour and the determinants of these behaviours in both qualitative and quantitative forms. Observational methods, including logging the user PA and ST behaviour repeatedly, were applied. The information obtained from these recordings was combined with a semi-structured interview and questionnaire to corroborate the data obtained on the determinants. The combination of methods was chosen to avoid inconsistencies between reported data and actual behaviours, thus avoiding relying on just one approach. Additionally, using only one method, for instance, the observation, underutilizes the ability to first-hand understand the participants' reasons and motivations for changing their behaviours. The study demographics were reported in the previous chapter.

The study generated some remarkable findings which will be reported in this chapter. It details the full participant results from the empirical study (the DUS) conducted for this thesis. Some of the data presented included the themes that emerged from the thematic analysis conducted from the qualitative data and highlights the participant characterisation based on the behaviour archetype. The comprehensive statistical analysis from all data sets is also presented in this chapter.

8.2 Intervention setup

Figure 58 shows the set up in the participants' houses (additional images can be found in appendix 15). The pre-intervention interview was conducted on the same day during the bike set up, with safety guidance given. The participants were given

an opportunity to familiarise themselves with the device and ask any questions they might have. The set-up session was also crucial to ensure that the device had been installed with minimal risk; for instance, it was important to ensure there was no risk of tripping wires or obstruction. Some participants requested the device be installed in the child's bedroom, which mostly implied minimal space to work with.

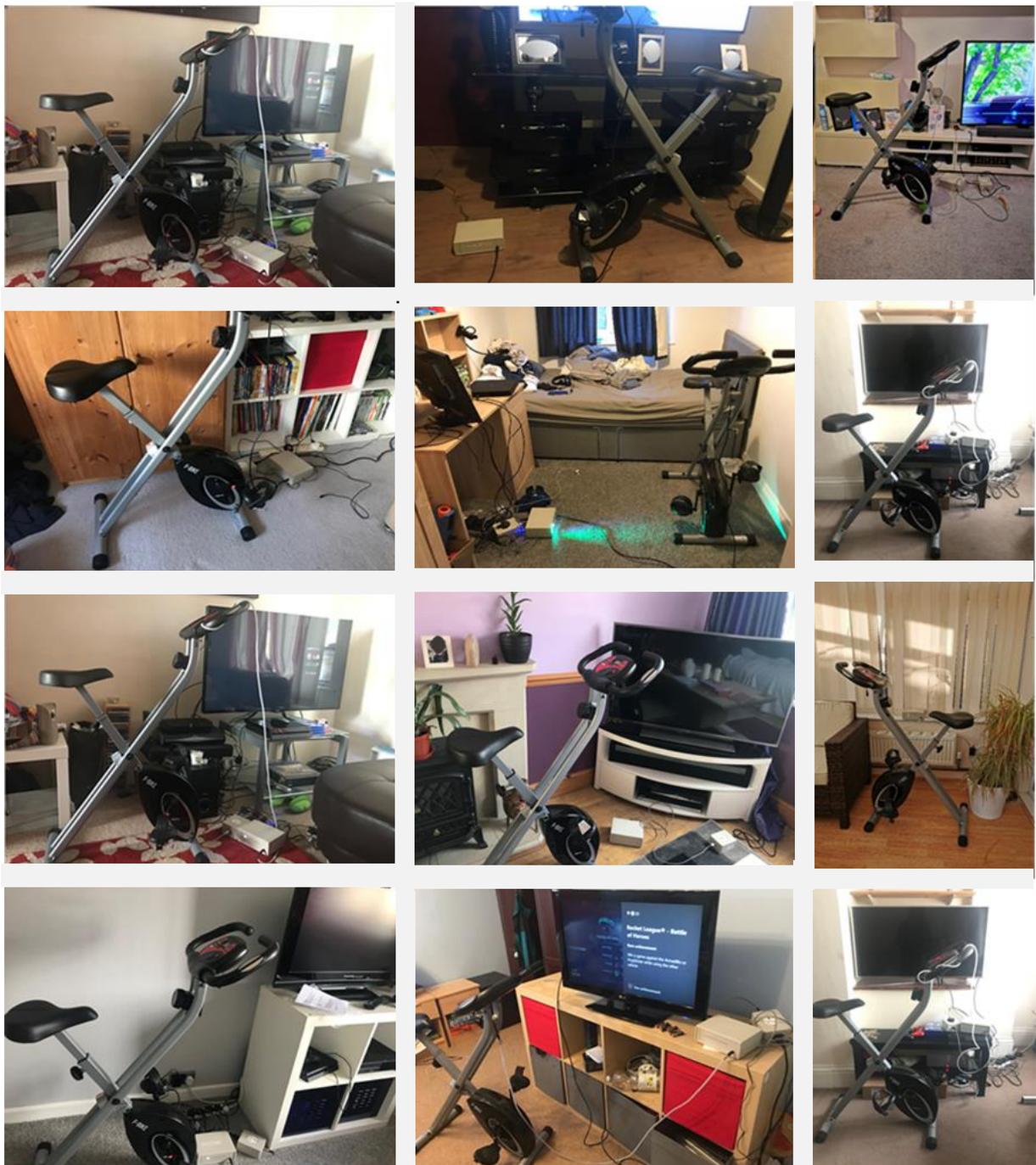


Figure 58 Study setup – Participants' homes

8.3 Participant Profile

Table 10 User demographics

House Number	Participant Age	Gender	Ethnicity
1	13	Girl	White British/White other
2	11	Boy	White British/White other
3	15	Girl	Arab
4	15	Boy	Arab
5	14	Boy	Arab
6	13	Boy	White British/White other
7	11	Boy	White British/White other
8	14	Girl	White British/White other
9	14	Girl	Asian/ Chinese
10	14	Girl	Black African/ British
11	15	Boy	Black African/Black British
12	12	Girl	White British/White other
13	14	Boy	White British/White other
14	14	Boy	Black African/Black British
15	12	Girl	Black African/Black British
16	13	Girl	Mixed/ African/White
17	14	Girl	White British/White Other
18	14	Boy	Black African/Black British
19	15	Boy	Asian/ Chinese
20	14	Girl	Black African/Black British

The sample for this study comprised of 20 participants, 10 boys and 10 girls between 11-15 years of age. Table 10 shows the participant background for each household. All participants were recruited from various parts of the UK.

8.4 Pre-intervention Analysis

8.4.1 Screen time habit before the intervention

Figure 59 shows the data for TV watching before and after the intervention. The average pre-intervention TV watching time was 9.3 hours per day across participants. By the end of the intervention, all participants' TV watching time had significantly reduced, with an average of under 2 hours a day. Figure 59 below shows the mean durations throughout the intervention for both TV watching and PA. On average most participants exercised for more than 10 minutes per session. Most participants recorded a weekly average of 3 times a week for PA and over 4 times a week for TV watching, even though this cannot be seen on the single time graph.

There was a 78% TV viewing reduction rate across all participants at the end of the intervention. For each participant, TV time was recorded using the energy monitor for one week before the intervention (see appendix 13 for screen capture for all houses). This information was useful in comparing the participants' TV watching behaviour during the intervention. The results shown in Figure 59 illustrate how the intervention was effective in reducing TV time dramatically.

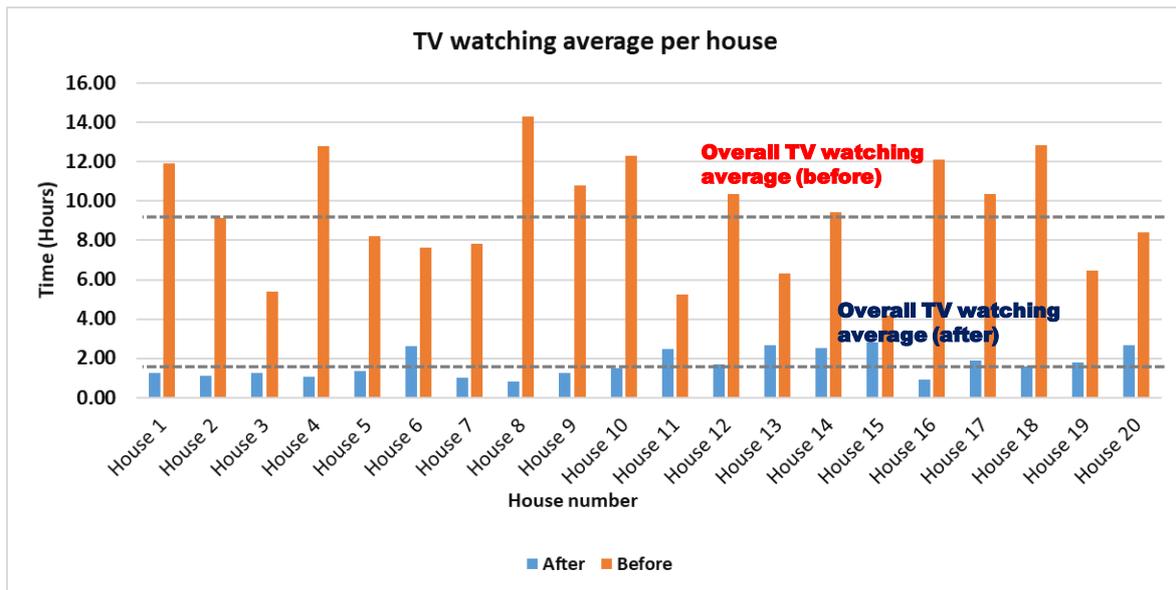


Figure 59 TV watching before and after the intervention for all participants

Post-intervention, the highest average daily TV time, as seen in Table 11 below, was 132 minutes (2 hours 12 minutes) from household 20. This fits within the ST recommendation discussed in Chapter 2. The dotted lines at the top indicate the overall average TV watching before the intervention (9 hours) and the bottom dotted line showing the average at the end of the intervention of just under 2 hours across the participants. Therefore, design-led intervention proved effective in reducing the TV watching habit of this sample population. On the other hand, low PA = low ST, for instance, the participants with the lowest engagement were houses 7 and 8, with the lowest record of TV time (13 and 10 minutes respectively). The conceivable reasons behind their low engagement and low TV time will be discussed in a subsequent section within this chapter.

Table 11 Basic statistics for daily TV time

House number	Mean TV (minutes)	Std. Deviation	Min	Max
House 1	71	61	0	235
House 2	15	31	0	165
House 3	44	91	0	278
House 4	38	50	0	195
House 5	28	48	0	180
House 6	110	212	0	1790
House 7	13	40	0	210
House 8	10	37	0	209
House 9	20	43	0	150
House 10	76	76	0	210
House 11	88	77	0	275
House 12	100	74	0	195
House 13	81	76	0	195
House 14	83	73	0	280
House 15	48	72	0	210
House 16	25	50	0	210
House 17	95	59	0	215
House 18	87	49	0	185
House 19	100	35	0	135
House 20	132	91	0	410

8.5 Behavioural archetype

The data above shows a variety of user engagement and behaviour, and the diversity of these behaviours will be grouped using several data points that emerged from this study. The main goal of grouping the participant behaviours was to establish several patterns and similarities between participants. This section focuses on uncovering these patterns that emerged from this study. The qualitative interviews conducted at the end of the intervention were helpful in enriching the data set gathered, and this information has also been factored into the behavioural classifications of the participants for the study. The most robust and consistent factors associated with the

change in behaviour were support from peers and other subjective norms like friends and siblings. The traditional approach in classifying user behaviour within an intervention will usually involve grouping them mainly based on demographic attributes, but in this thesis, the participants were grouped by their actual behaviour, drawing insights from their PA and TV watching patterns. The variables that were used to determine behavioural patterns have been listed and explained in Table 12 below. The two different behavioural archetypes discussed in the following section were derived based on the dichotomisation of these characteristics.

Table 12 Behavioural variables explanation

Behaviour variables	Description
Exercise duration	The length of time for which a participant exercises in each session
Exercise count	The number of exercise sessions the participant undertakes in a day
TV reduction	The percentage of TV watching in comparison to the TV watching data before the intervention

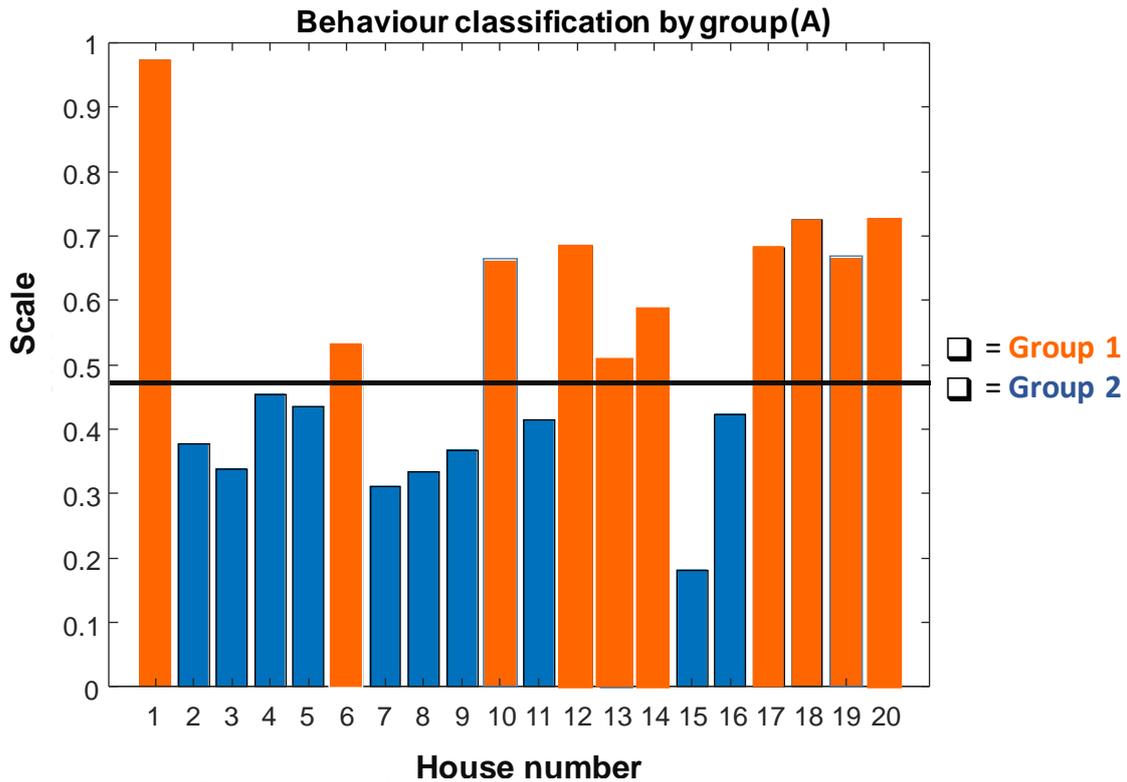


Figure 60 Participant classification using three main variables

Figure 60 represents user profiles based on three behavioural variables:

- ❖ Average exercise duration
- ❖ Average exercise count
- ❖ TV reduction percentage

The data from participants after the initial analysis had different ranges, and it was essential to employ the normalisation technique to change these values without distorting differences within the ranges. This correlation was useful in identifying the association between behavioural patterns amongst participants in order to develop behavioural archetypes. A numerical computing software MATLAB was used to compute the data obtained and normalise the data by scaling the variable to have values between 0 and 1. MATLAB was also used to rescale and normalise each participant's performance. The overall mean calculated was 0.48 signified in the threshold for the first categorisation in Figure 60. See appendix 14 for the editor

window from MATLAB justifying group thresholds. From Figure 60, participants whose score were ≥ 0.48 , were classified into group 1 and <0.48 were classed in group 2. The participants in group 1 had a median score of 24.5 minutes of exercise on average, while the group 2 participants were below this exercise threshold.

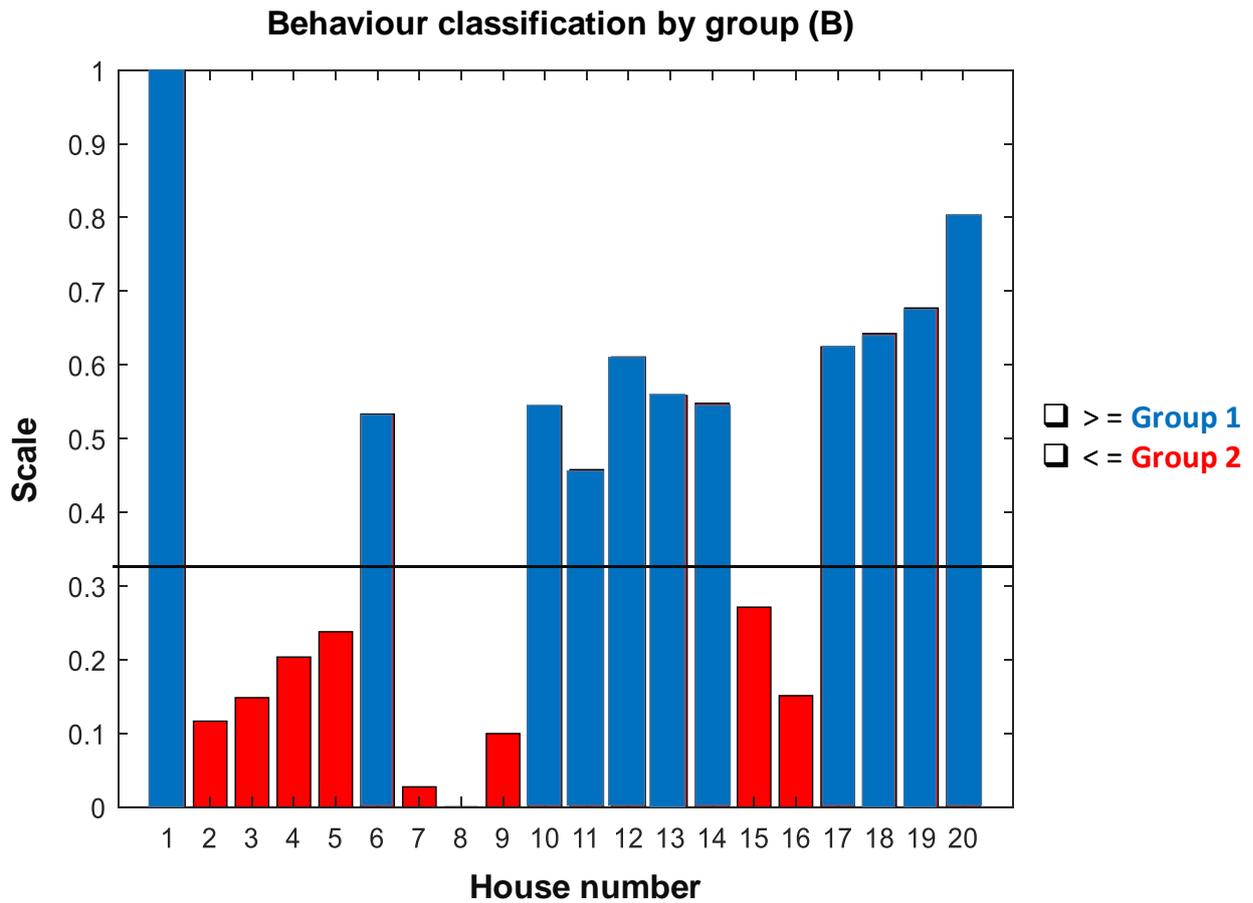


Figure 61 Participant classification using two variables

Figure 61 represents user profiles based on two behavioural variables:

- ❖ Average exercise duration
- ❖ Average exercise count

Following the same procedure used above, the rescaled values obtained from the exercise average and exercise count were averaged to categorise participants, and the groups remained unchanged in terms of classification. Only one participant shifted from group 2 to group 1 (participant 11), which connotes that their exercise

behaviour was above the average performance. However, there is a peculiar difference seen amongst the individual behaviours. For instance, participants 2, 3, 4 and 5 showed a significant drop on the scale, and this connotes low engagement with exercise. This factor of low engagement also became apparent, particularly for house number 8 whom from basic descriptive analysis averaged around 8 minutes of exercise per day during the intervention. In general, all participants experienced significant reductions in TV time.

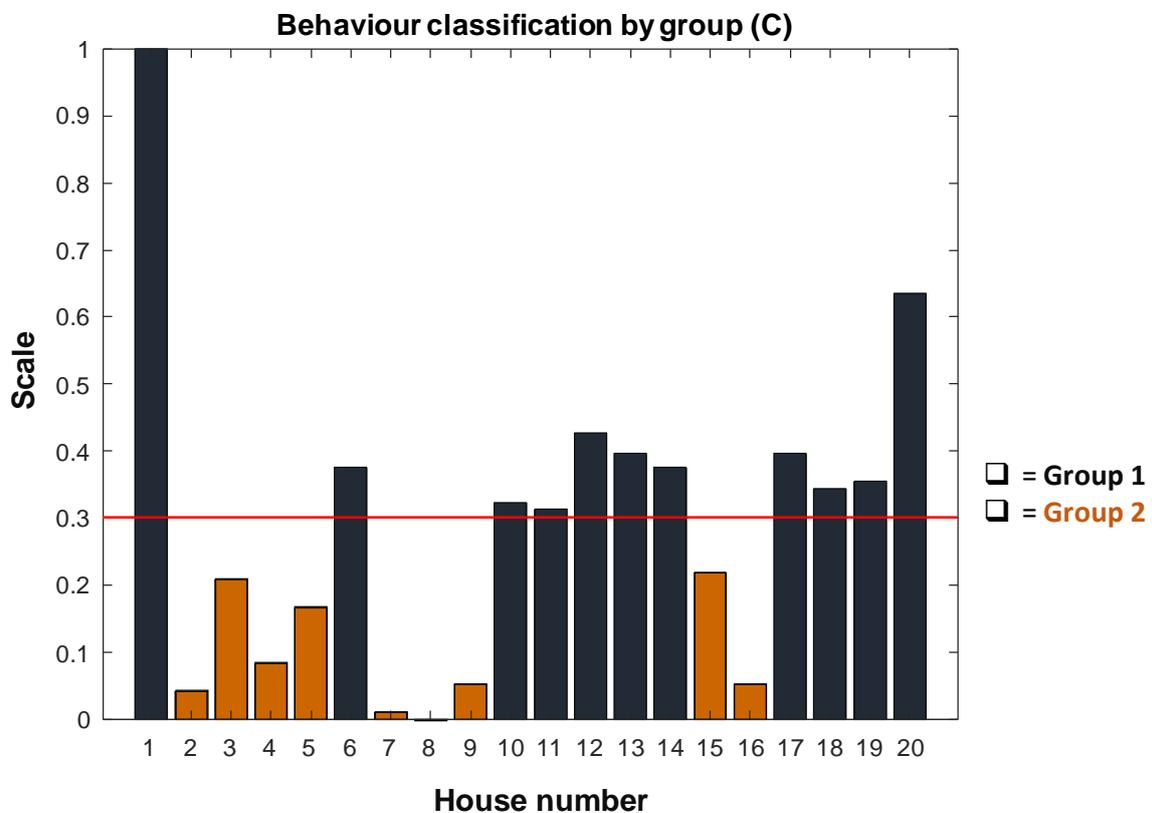


Figure 62 Participant classification using one variable

Figure 62 represents user profiles based on one behavioural variable:

❖ Average exercise duration

The exercise average was rescaled and plotted to see if there was any difference in participant behaviour since exercise behaviour was the dependent variable for this study. The only participant who shifted from group 2 to group 1 was participant 11.

This participant's case will be discussed later in this chapter with more detail on their behaviour.

After the 3-categorisation process shown in the 3 figures above, with no significant individual moves across groups 1 and 2, it was concluded that the first classification using the three key variables was enough justification for discussing the participants using these two archetypes. The next section will group the participants based on the conceptual theorisation discussed in Figure 20 (theoretical framework). Going forward, the participants will be discussed within either group 1 (*Responsive*) or group 2 (*Inert*), and this will be used interchangeably.

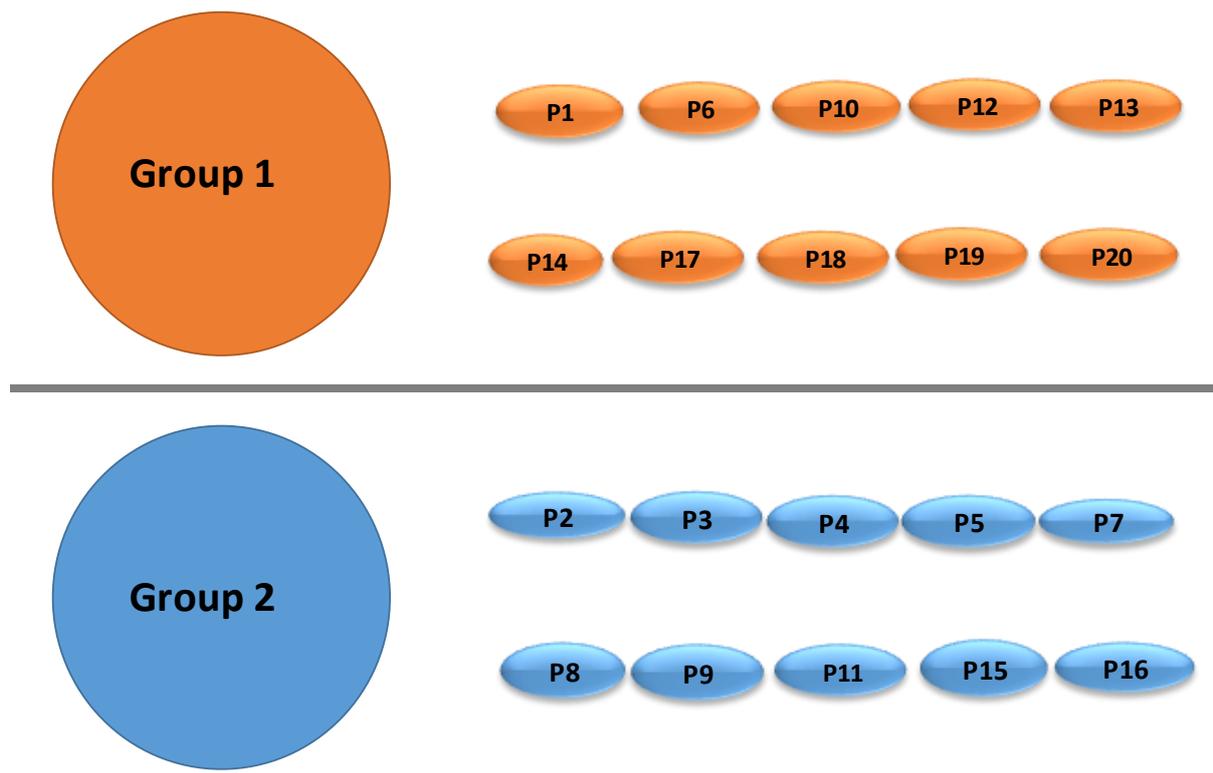


Figure 63 Participants' behaviour archetypes

The behaviour patterns, attitudes and engagement with the Knudgbox, as uncovered in this chapter, are intended to add more depth to how design-led interventions may contribute towards changing behaviours, especially SB.

The diversity of behaviours of the participants is illustrated in Figure 63 above, where there is an equal distribution of participant across the groups. As explained in the previous section, these behavioural archetypes were inferred from the in-depth analysis using 3 different patterns. The qualitative study also confirms that these archetypes constitute a meaningful way of classifying the participants and can be used to generate new interventions targeting the same demographic. Subsequent sections within this chapter will highlight which psychosocial determinants were salient in shaping the behaviours seen across these groups.

The next section of this chapter will report participants' behaviour based on the above archetypes.

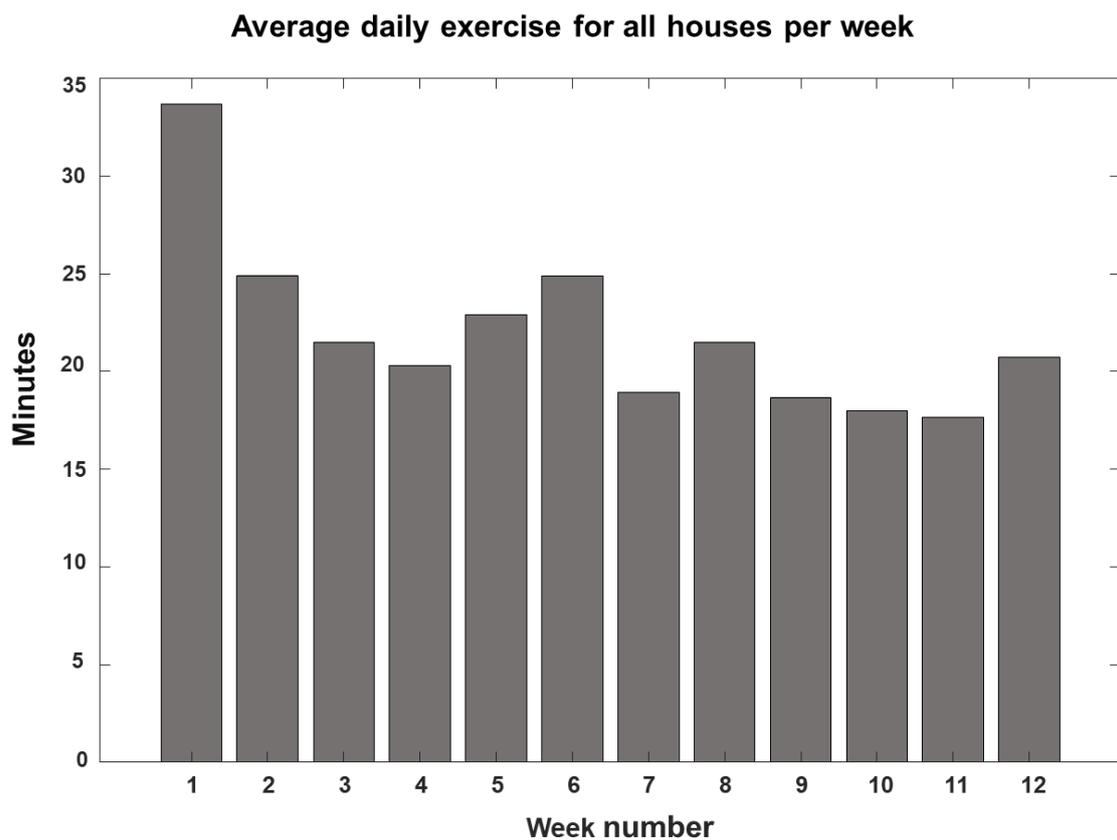


Figure 64 Physical activity daily average

Figure 64 represents a general overview of participants' weekly average PA and week 1 epitomises how participants were receptive to the new behaviour in the first

week. This figure shows that there is a consistent sigmoid pattern of how the participants behaved during the intervention. This describes the nature of the change of the new behaviour and entails that each participant has distinctively begun to adopt the PA at their own pace. Before the intervention, qualitative interviews allowed the assessment of the participants' intentions to change their habits. From observation, there is PA fluctuation from week 2 to week 12 showed a considerably good variation of habituation throughout the course of the intervention.

The fluctuations during the initial first 6 weeks of intervention exposure could be a case of trialability, whereby the participants were trying out the new behaviour before deciding whether to commit to it. One abstract concept to explain the adaptation of this new behaviour would be the 'diffusion of innovation concept' which is often used to measure rates of adoption of people's voluntary choice for any given intervention. The classical diffusion paradigm suggests that innovation is communicated consistently among the members of a social system over time through different channels until the decisions are adopted voluntarily (Rogers, 2003). In the current study, each participant seems to have a distinct adopting structure, as some are earlier than others in adopting and engaging with this intervention, and this is also similar between groups. Motivation differed amongst participants during the intervention, especially in the early stages. The details of these motivational factors will be discussed in the motivational changes section of this chapter.

8.5.1 Exercise Initialisation

Drawing from physics Newton's first law of motion describes 'inertia' in which, "an object in motion has the tendency to remain in motion or at rest unless acted upon by an external force". Inertia is a term has been applied in various disciplines,

for instance: in sociology, “social inertia” represents people’s resistance to change, especially within social groups (Bourdieu, 1985); in psychology, “inertia effect” is more about the ability of one to reduce their confidence in making a decision as a result of disconfirmation of information (Pitz and Reinhold, 1968). In the current study, the phenomenon of ‘inertia’ is related to people’s resistance or ability to change their behaviour. From the obtained results, the Knudgbox as a tool was acting as a trigger in influencing people’s decision making in general.

8.5.1.1 Responsive (Group 1)

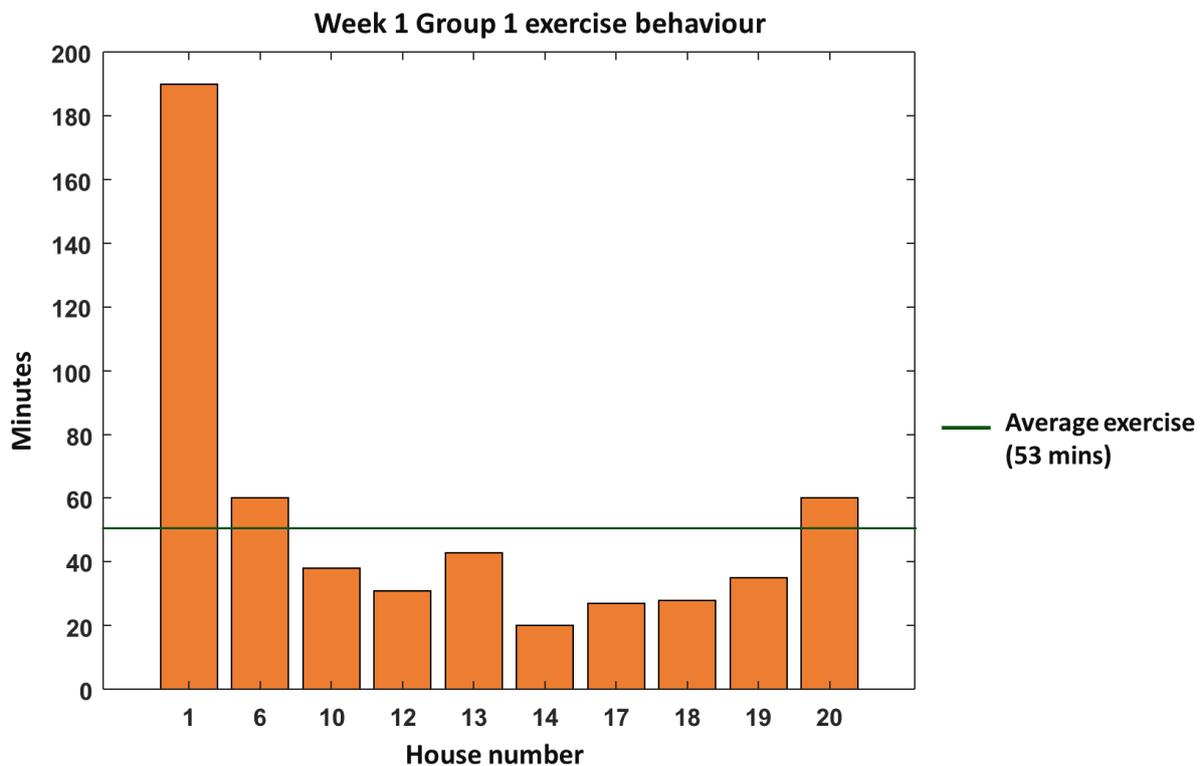


Figure 65 *Responsive* group daily average exercise behaviour (week 1)

The overall goal of this study was to design and evaluate an intervention to encourage children to be physically active. In the context of the data gathered during the empirical study, the thesis aim can somewhat be classified in the form of ‘behaviour adoption’ and ‘habitualisation of the new behaviour’. For instance, behaviour adoption is very independent of habitualisation. Psychologists have

described human beings as people who perceive their behaviour to be goal directed but are not often successful at doing so. Further to that, behavioural economics insights recognise that people are often guided by the “bounded rationality” concept (Conlisk, 1996). Bounded rationality denotes the rational choices which are constrained by cognitive limitations and the decision maker’s ability to comprehend the determining consequences of their action fully, and will most likely engage in satisfying behaviour (Simon, 1990). This is to say that for most participants exercising satisfies their need to watch TV without processing the rational cost-benefit relating to the value of exercise. John (2009) argued that decision making is conditioned by cognitive boundaries, therefore, when people are faced with a choice to make, the option they choose will be based on which one optimises their utility. In the context of the study, the two archetypes’ initial behaviour shows that they both exhibited a great deal of inertia, as seen in Figure 65 and Figure 67. However, the *Responsive* group was found to be the group which engaged most with the intervention. From Figure 65, house 1 is shown to have the highest amount of PA with considerably higher amounts than the rest of the participants within the group. Participants 6 and 20 exceeded the group average for week 1, as shown in the figure above. Although Fogg suggests that a “trigger” is a key factor for the target behaviour to occur repeatedly, if this is redundant, behaviour change is unlikely to take place irrespective of how high the motivation and ability are. He describes triggers as something that reminds the individual that it’s time to act. The Knudgbox was designed with the “trigger” feature in mind, whereby a user is notified by the decremental LED lights or LEDs reaching zero that it is time to get back on the exercise bike. The first week was more about the activation of behaviour and

familiarisation, which explains the spike in exercise engagement, as seen in Figure 65. This is a visible indication of a positive reaction to stimuli.

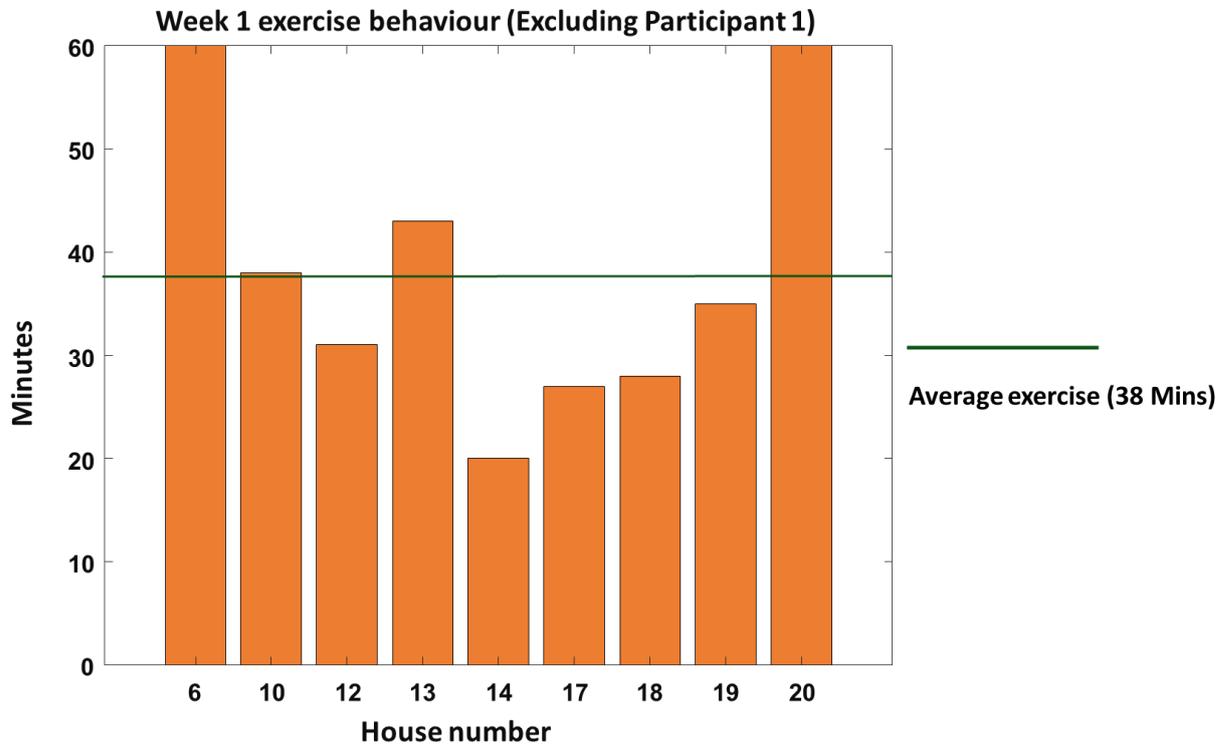


Figure 66 Responsive week 1's daily average (exercise excluding house 1)

It was important to highlight that the standard deviation of the exercise engagement for this group was high, as house 1's engagement was remarkably higher than the rest of the group. When participant 1's data were excluded, the overall average shows a difference of 15 minutes (53 mins with participant 1, and 38 mins without) when comparing the data with participant 1 in Figure 65 and without participant 1 as shown in Figure 66. The reason behind showing this graph without participant 1 was to clearly highlight the amount of variability without this household's data.

8.5.1.2 Inert (Group 2)

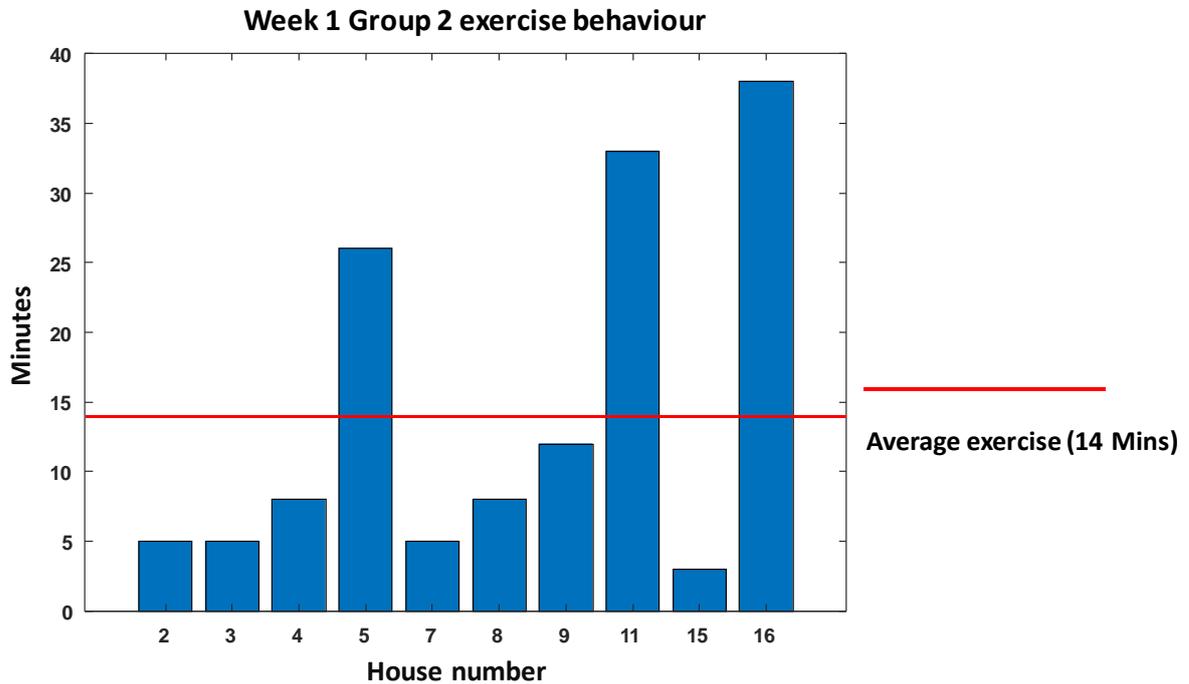


Figure 67 *Inert* group daily average exercise behaviour (week 1)

Figure 67, on the other hand, shows the second group averaged 14 minutes daily in the first week, with participant 16 being the most engaged. Similar to the *Responsive* group, only 3 participants exceeded the average threshold of exercise in this group, participants 5, 11 and 16, respectively. This differs with *Responsive* group exercise average by 24 minutes. The qualitative interviews were useful in explaining why there was a significant difference in exercise for the groups in the first week. For instance, some of the participants knew they should engage in daily exercise but did not attribute many benefits to it. One of the participants' views before the intervention was, "To be honest, I know I should do more exercise, but I don't think anything will change if I don't exercise as often" (P2, before intervention). This participant had low exercise engagement from the figures shown above on the exercise engagement average per house in the first week. At the end of the intervention, the participant reported, "I think I have mostly played outside

nowadays and haven't used the bike as much. But I think I am more conscious of the fact that exercising is good for me and will hope to start exercising more, maybe by attending PE lessons" (P2, after intervention). The intervention had not impacted on the participant's home exercising habit but had been helpful in instigating a new behaviour, of playing outside. From the thematic analysis antecedent behaviours (spending long hours playing video games) contributed to the lack of engagement in the first week. Therefore, the current intervention was a trigger for behaviour activation, and most of them managed to overcome this challenge across the intervention weeks. Another participant also supported this new habit being beneficial to them: *"For someone who doesn't really exercise at all, I quite enjoyed this experiment and all the good vibes going on the bike brought" (P16, after intervention).* Interestingly Participant 16 engaged more with the intervention in the first week, hence and revealed in the interviews that visual feedback increased their self-confidence as they began to find the exercise routine meaningful. A participant can have the required amount of motivation but may not have the ability. Ability can be contextualised into different forms, such as simplicity. Fogg (2009) suggested that, in order to increase ability, designers should strive to make intervention simple; this was evident from the results that simplicity changes behaviour. *"It wasn't that easy to start with, I must say" (P7, before intervention).*

Responsive (Group 1)

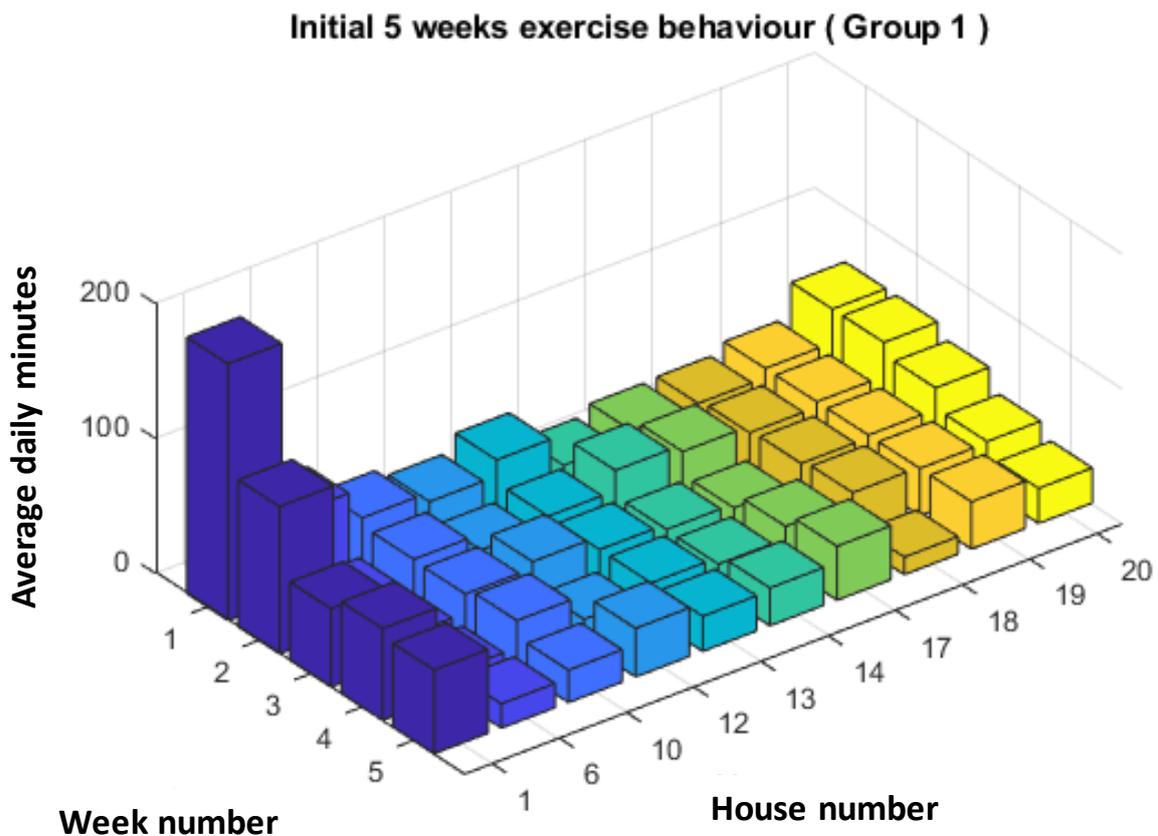


Figure 68 First 5 weeks of intervention exercise data (*Responsive* group)

Their overall average from week 1 to 5 was 38 minutes. The three-dimensional bar chart, as seen in Figure 68, explains the exercise behaviour of the *Responsive* group indicating a subtle decline in their exercise habit over the first 5 weeks. This type of infographic was used as it shows the habituation process in an interesting pattern (see appendix 19 for weekly figures). This 3D stacked bar chart shows that most of the participant got rather excited with this intervention at first, and after the first week, participant 1, for instance, continued with this new habit in high energy. Although their average dropped by half, it can still be considered a positive change in comparison to the other participants. The rest of the participants from the stack indicate that there was a reasonable amount of motivation to continue with this new

habit at a more moderate pace. From the interview and survey data, the steady decline was more attributed to the impact of the feedback. The visual feedback indicated the user's behaviour in real-time through the incremental value of the LED's, most participants saw this as a challenge, and most saw it as a way to compete with themselves to fill up all LED's. Some other participant also indicated that they were not comfortable losing their ST, therefore had to exercise a lot in order to gain access to ST.

Inert (Group 2)

Initial 5 weeks exercise behaviour (Group 2)

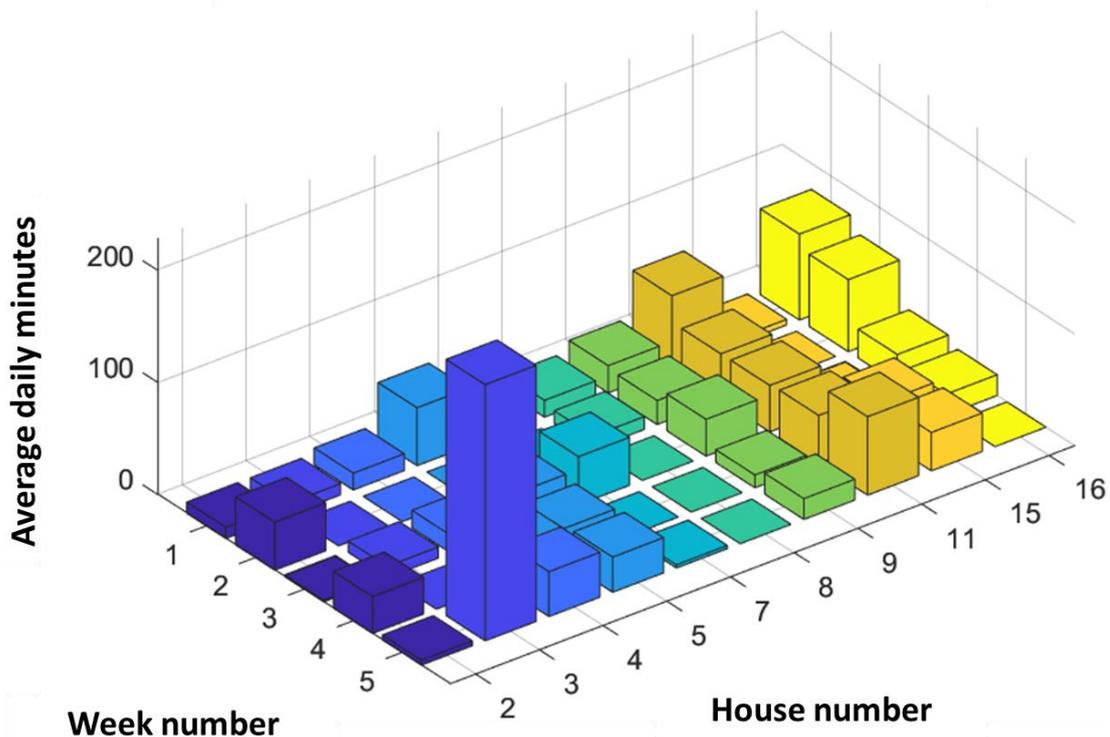


Figure 69 First 5 weeks of intervention exercise data (*Inert* group)

In comparison to the *Responsive* group, this group had an overall average of 13 minutes between week 1 to 5. Figure 69 clearly shows a lower stack which indicates low engagement from the majority of the participants in the first 5 weeks. Most of

the participants in this group had a challenge of being resilient to the intervention and struggled to give up old habits. Habit formation studies from the literature review suggest that it takes between 66 – 254 days to form a habit. The reason for the range is because this can vary by individual, and this is prominent in the case of the participants investigated in this study. In the current study, the participants were exposed to the intervention for a minimum of 90 days, which gives an opportunity to start slowly or at their own pace. The participants in group 1 got into the habit quickly and repeated it consistently in the first 35 days. The stacks shown for group 2 above confirm that even their slow engagement could indicate they were starting to build this habit, but needed to try until they found a balance of what works in the long haul. Participant 3 recorded extraordinarily high exercise engagement in week 5, considering they had averaged 5 minutes in the previous weeks. The participant and the family admitted having spent considerable amounts of time as a family taking turns to exercise. *“My husband and I thought, we are letting her off too much and haven’t pushed her much and we thought it was time to do it as a family”* (Mum, P, 3). In this case, the parents acted as a ‘spark’ in triggering the participant, and this was recognised as a cue to take action. In addition, the intervention also fostered family interaction, *“We once had a game on our family night where everyone was expected to fill at least 3 lights so we could all use it to watch the movie we had set out to watch that night”* (P, 3, after intervention). The Knudgbox captured multiple behavioural data/information; thus, the ability to show these different types of behaviour increases its validity.

Participant 8, on the other hand, was engaged only in the first two weeks and showed very little engagement in weeks 3, 4 and 5. The reason for their low engagement was predominantly due to continually being distracted, which may

indicate the novelty wearing off. In other cases, they suggest having struggled to keep up with their usual screen engagement with friends. Participant 11 was habitual in their exercise routine as shown in the figure above, and this stands out in comparison to the rest of the group. Most of the participants reported having gone on holiday during the intervention, which affected their engagement.

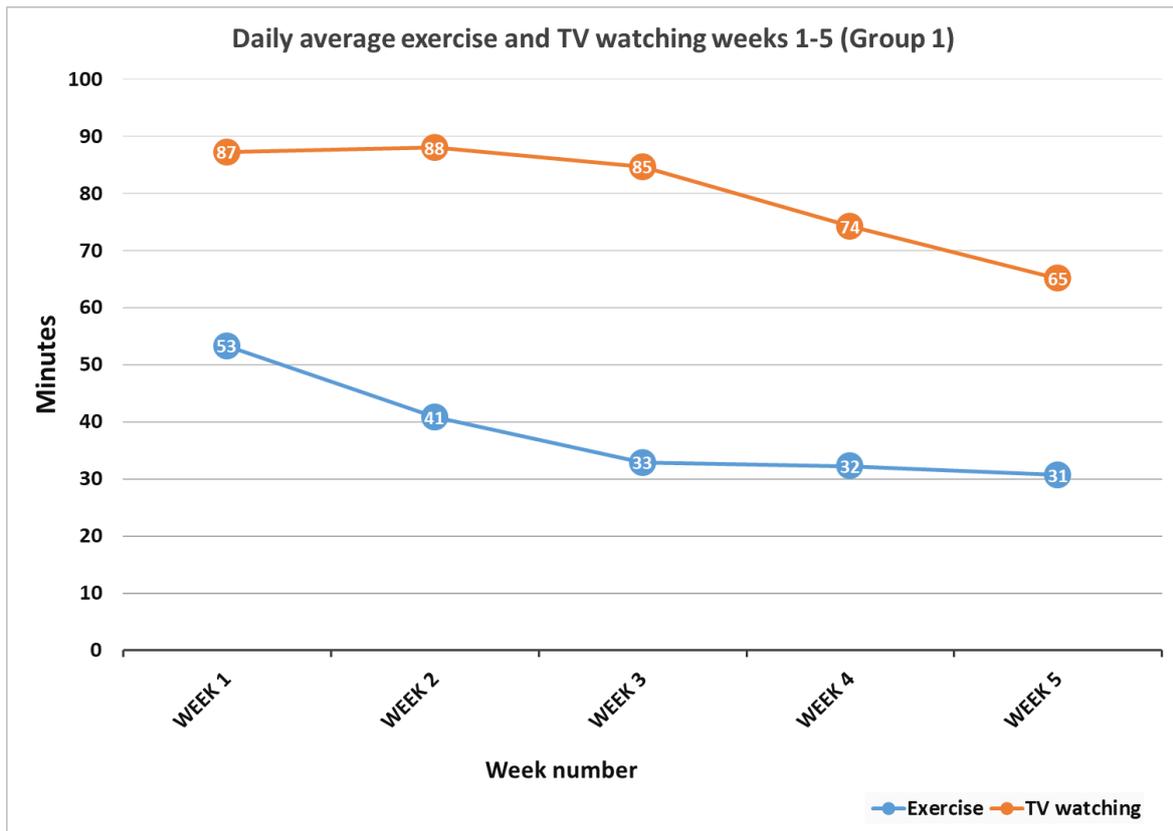


Figure 70 Weeks 1-5 daily average exercise and TV watching (Group 1)

Prior to the intervention, TV watching habits of all participants were measured to understand their screen behaviours with the ultimate goal of reducing this amount and instigating new exercise behaviours. Figure 59 illustrates the results for TV watching before and after the intervention for each participant and shows a 78% reduction in average of TV watching time. Figure 70 shows the *Responsive* group, which indicates that the more exercise the participant did over the weeks, the more

TV they watched. From the general data, most participants went on holiday in week 5, hence the decline in that week.

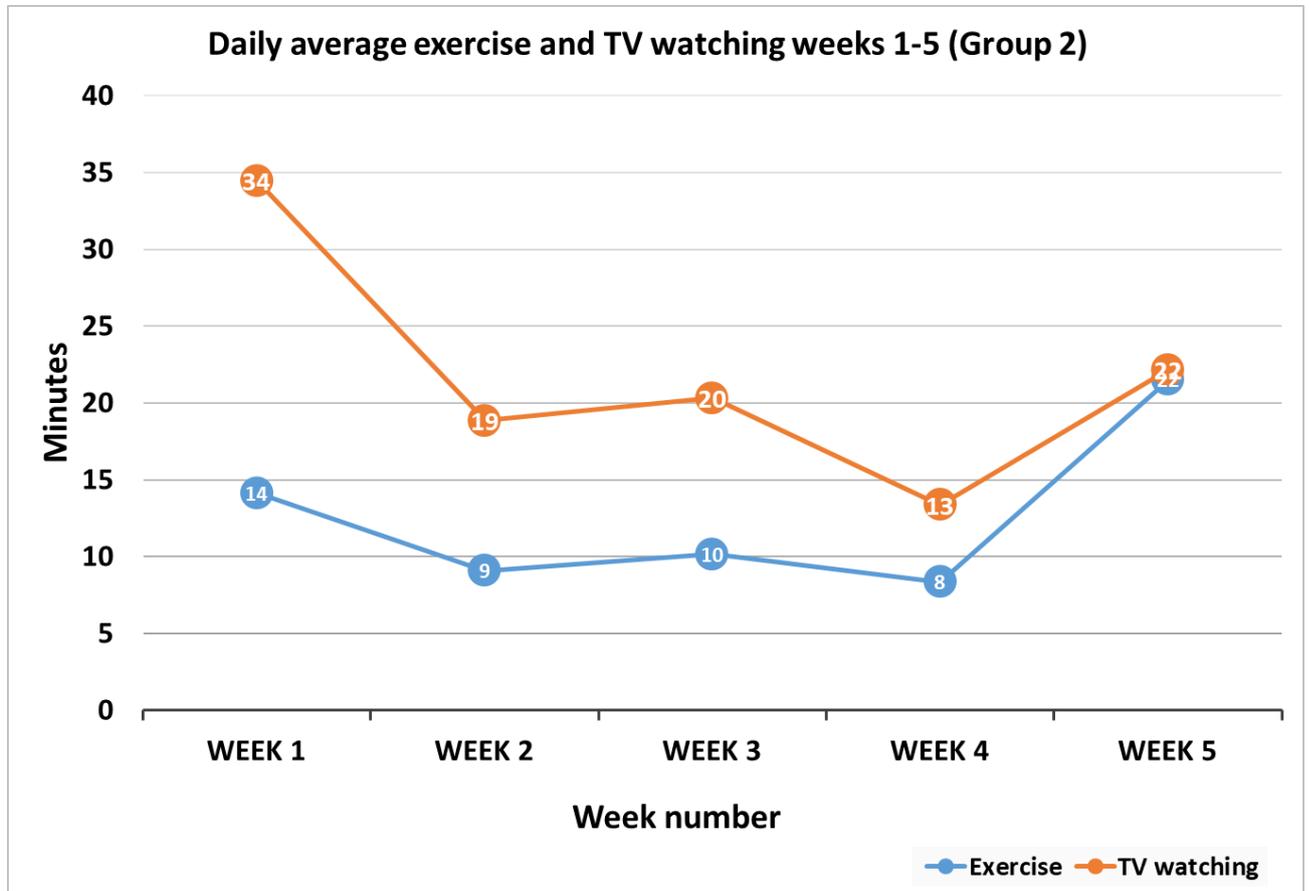


Figure 71 Weeks 1-5 daily average exercise and TV watching (Group 2)

The RCPCH³⁵ UK contends that the evidence is too weak to warrant an ST guideline, but for the purpose of recommended ST, the Knudgbox was programmed to give the user around 2 hours of TV time for 40 minutes of exercise. One of the limitations of the study was that the programming was unable to allocate this timing universally for all participants, so this was done as per the wattage of the TV. Figure 70 shows that exercise behaviour was proportionate to the TV time across the weeks with a fluctuation between week 3 and 4, then a decline at week 5 for *Responsive* group. The decrease was because of decreased PA and also an indication of

³⁵ Royal College of Paediatrics and Child Health

inactivity from the participants who reported to have been away. Figure 71 indicates a downward decline right after week 1 for *Inert* group. Despite this difference across groups, it is evident that *Inert* group increased their activity more in week 5 (22 minutes of exercise), but this was still lower than *Responsive* group's average (31 minutes of exercise) in the same period. Some of the participants mentioned at the end of the study interview that they started keeping track of how much time they spent watching TV due to the introduction of this intervention. Limiting the TV watching habit in children is vital for optimising child obesity prevention and general psychosocial health (Tremblay *et al.*, 2011). This study certainly shows a significant decrease in the participants' TV time since the deployment of the Knudgbox. Amongst the targeted behaviour, some participants highlighted that they learned to switch off their electronic devices such as the TV when not being used, which indicates a sustainability mindset.

8.5.2 Exercise Frequency (habit building)

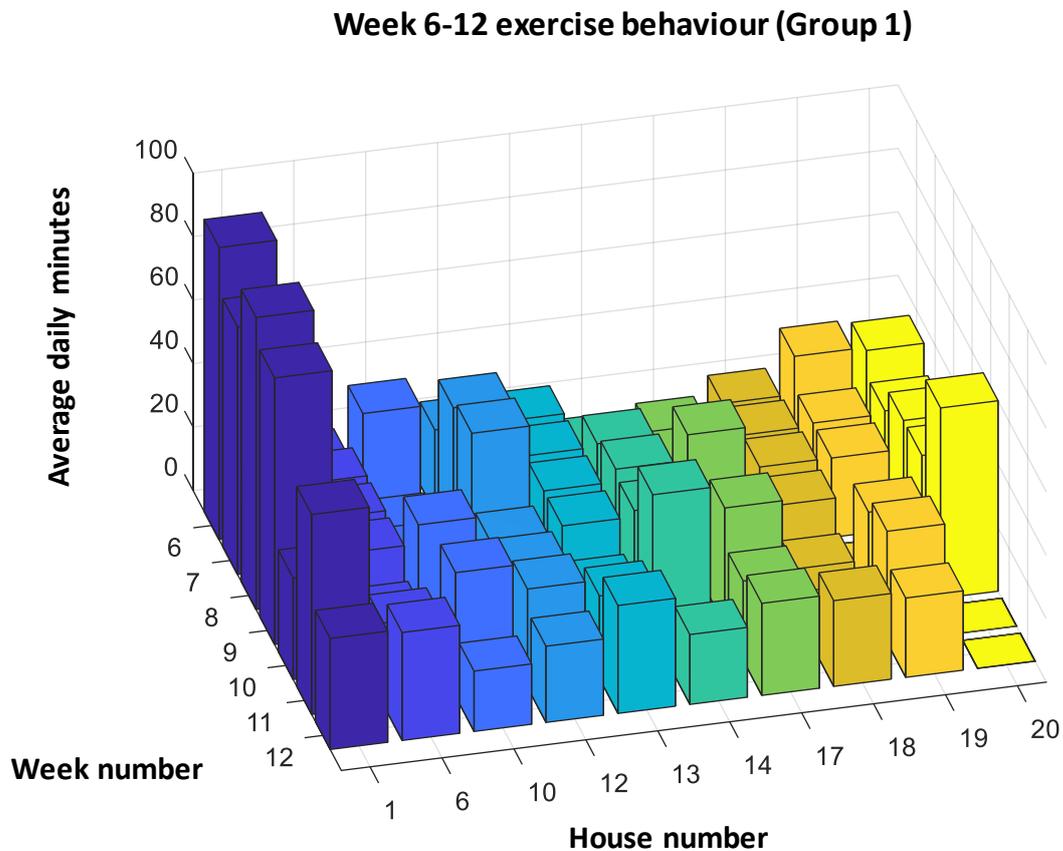


Figure 72 Daily average weeks 6-12 exercise behaviour (Group 1)

Behaviour maintenance is one part of a behaviour change process that most researchers do not explicitly address, and one of the strong points of this thesis is the vast focus on discussing maintenance and sustenance of any adopted behaviour. The theoretical framework generated from this thesis hypothesises that various constructs have the ability to facilitate action or inaction. At this stage, people behaved as a result of a distinctive desire and ability to control the said behaviour. Although these constructs might affect intention, as the developers of this model propose, the current study insinuates that repeated performance driven by different determinants may lead to a re-evaluation of their ability to behave by merely desiring the target behaviour. The participants shown in Figure 72 seem to have maintained a similar equilibrium from initiation to this maintenance stage. Although

the exercise amount fluctuates every week, but all managed to perform at least above 20 minutes of exercise daily. New behaviour is usually more likely to be sustained if the individuals receive immediate gratification from engaging in the said behaviour. Before the intervention, most of the participants set goals, for instance, 8 out of the 20 participants were concerned about their weight: P1, P5, P9, P10, P14, P16, P17, and P18. Thus, it can be argued that participants behaved as a result of observed immediate outcomes. One of the participants' parents within this group said, *“And she lost 2Kg within the first-month cos she was very concerned about her weight, and I guess she feels a lot more confident now”* (P, 1 parent). This indicates that the immediate changes (first 5 weeks) the participant observed were extrinsically motivated by the desire to lose weight; however, it can be argued that intrinsic motivation had a strong influence on their continuation and willingness to maintain the behaviour.

After 10 weeks of intervention exposure, there is an expectation that the behaviour becomes influenced by subconscious cues. Figure 72 shows the diversity of behaviours for all participants in group 1. Participant 1 had a positive attitude throughout the intervention, as even in the final weeks, they averaged 49 minutes of PA, which ranks the highest across all participants. The stack shown in the figure above reveals the differences in behaviour observed within the group in the few weeks of the intervention. Missing data for participant 20 at weeks 11 and 12 was as a result of them travelling during the last few weeks.

Further discussion around the qualitative analysis will be discussed later in this chapter and will explain the interrelated themes explaining the changing motives and contextual factors on how each of the groups-maintained behaviour changes

over time. In the case of group 1, the stack shown in the 3D bar depicts the successful maintenance of building exercise habits.

Week 6-12 exercise behaviour (Group 2)

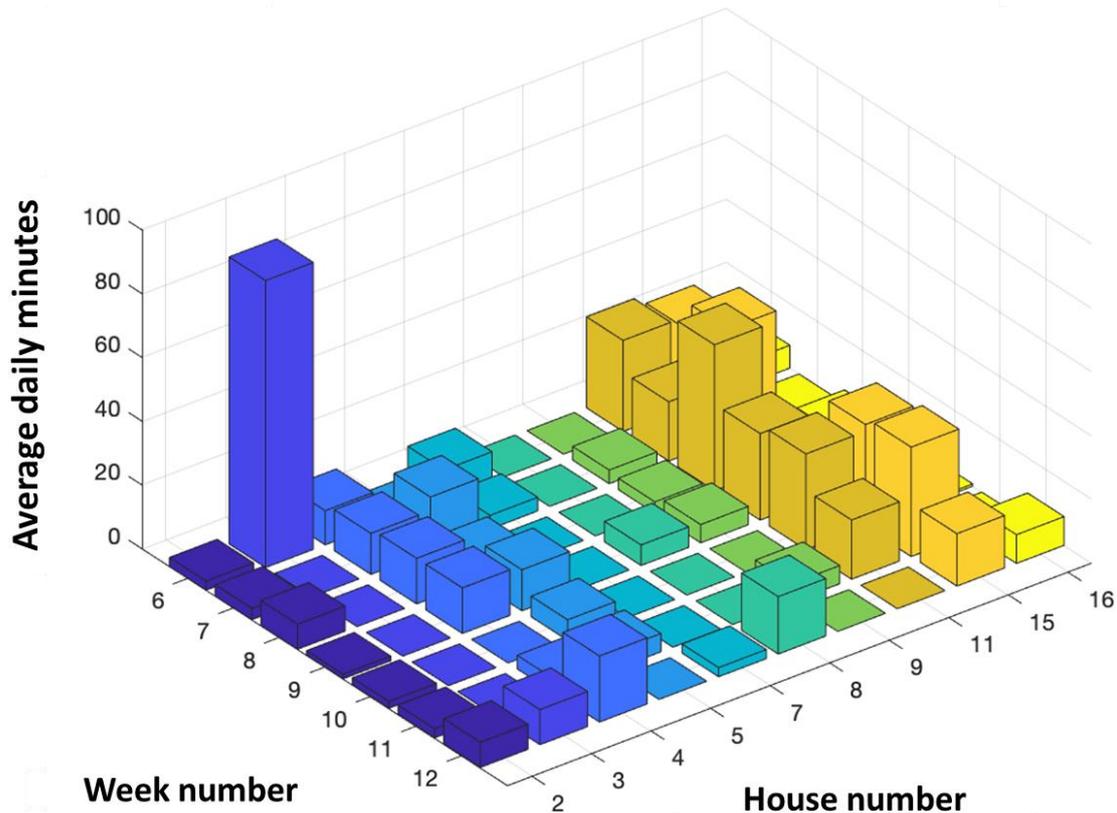


Figure 73 Daily average weeks 6-12 exercise behaviour (Group 2)

In comparison to the *Responsive* group, Figure 73 shows the behaviour maintenance of group 2 after 5 weeks of intervention exposure. Most of the participants in this group did not respond more than they did in the first 5 weeks since the behaviour has not become habitual. Participant 11 is the outstanding participant within this group with an average of 30 minutes of daily exercise. Their engagement surpassed all other participants within this group but did not meet the grouping criteria to fit into group 1 (please see Figure 60)³⁶. Although during this period participant 4 and

³⁶ Can be found in page 220

15 also maintained good exercise momentum but much less than participant 11. Usually, after the initial adoption of new behaviour, it is theorised that if the actual result does not reflect value, this is the point where the individuals' relapse, which is evident in Figure 73, and if vice versa, the motivation is reinforced as seen in Figure 72. The referenced figures above Figure 72) indicate that majority of the participants exercised mostly daily. At the same time (Figure 73), on the other hand, shows that the participants who exercised did not do it every day.

Participant 4 is shown to have averaged 10 minutes per day from weeks 6-10, which indicates that, despite not accumulating a huge amount of exercise time, their daily engagement still contributes to health improvement. This mostly aligns with the latest UK PA³⁷ guidelines discussed in chapter 1. This guideline suggests that there is no minimum amount of PA needed to attain any health benefits, but still, recommend that children aged 5-18 should aim for at least 60 minutes a day. Thus, for people pursuing a behavioural PA goal, targeting to do at least 10 minutes can also yield good benefits, as well as small bouts of less than 10 minutes repeatedly accumulated over the day/week. This thesis did not only aim to improve the health and wellbeing of the followed participants but also at breaking up sitting time by instigating exercise behaviour change in the participants, with the hope of habitualising this behaviour. So, although the participants in group 2 engaged less in comparison to group 1, it can be argued that the intervention was productive in helping them break up prolonged sitting habits with small bouts of exercise (see appendix 19 for figures showing more data).

³⁷ Physical activity

The engagement for group 2, as seen in Figure 73, implies that they did not entirely stop exercising. They averaged around 7 minutes per day with participant 15 showing the highest peaks. It is impossible to design a ‘one-size-fits-all’ solution to change the behaviour of such a heterogeneous population. However, the detailed evaluation of the design-led intervention discussed in chapter 9 elaborates what worked and why group 1 engaged more. The synthesis of this discussion provides a path for increasing performance in participants such as those in group 2 in any future intervention.

The thesis sought to make the teenagers break up their sitting time by staying active, without missing out on watching TV or playing videogames as they would normally do. Most participants during the intervention instead of engaging intensively spread out their exercise in small bouts, for instance, participants 4 and 5, as observed across the weeks. The Knudgbox was designed to integrate with the participants’ daily life seamlessly, and this requires a lot of repetition to be performed automatically. Having discussed the observed behaviour patterns seen in the participants exercise actual engagement, the next section will address the attitudinal changes associated with the habits during the intervention.

8.5.3 Introducing attitudinal Changes

This section of the thesis seeks to answer the 5th research question:

RQ5 – What are the changes in the measured psychosocial determinants over time?

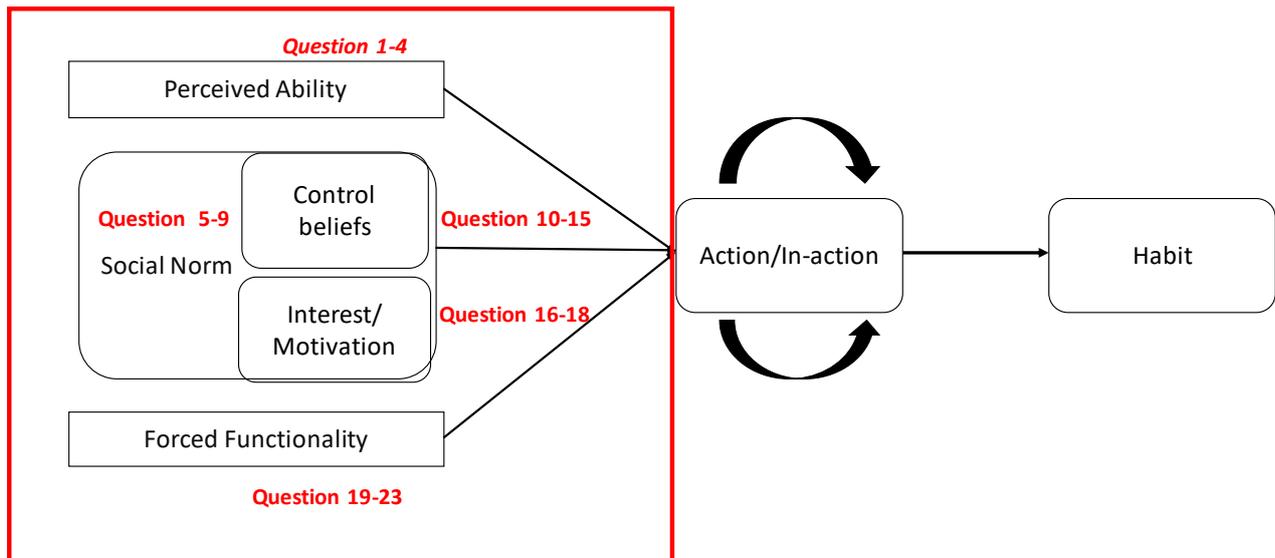


Figure 74 Survey questions addressing each psychosocial determinant measured

The survey questions discussed below addressed these determinants in the order highlighted in Figure 74. As explained in chapter 7.2 the above template themes were measured at two different time points in line with the longitudinal study design. Thus, it was essential to measure the same variables at each time point.

In survey analysis researchers often recommend focusing on the insights, not just the data: therefore, it is also useful to interrogate the data obtained thoroughly. During the analysis, there was an initial review of the most common responses to the questions, understanding which determinants were impacted the most on user behaviours and how each respondent's attitude differed. Furthermore, the survey responses and any observed motivational changes were used to complement the actual ST and exercise data obtained from the research tool.

Using the theoretical framework developed for this study as shown in Figure 74, the mid-study questionnaire was conducted at week 5 and week 10 to understand not just motivational intentions but also the drivers of the new behaviour, see appendix 7. The original responses from the survey ranged on a scale of 1-7: 1 (not at all) to 7 (very true). During the analysis, there was a review of all the questions individually

to review which statements were positive and negative. It was possible to aggregate all measurements for both weeks 5 and week 10 into one single variable.

There was an attempt of different forms of survey analysis, such as cross-tabulation which was done by showing the collective data in subgroups; this was not useful in comparing the individual behaviours across the two-time points measured. Further to that was the use of another popular method in survey analysis, modelling data by looking at how every participant answered each question. In the longitudinal analysis, benchmarking is often used to establish baseline values to ensure that there is an accurate comparative analysis of what was and what has happened (Fitzmaurice, Laird and Ware, 2012). This thesis employed a longitudinal approach, thus in addition to the data modelling, the analytical approach taken was to subtract week 10 responses from week 5 and vice versa by reviewing each question to see how the participants' motivation changed during the intervention exposure. After several analysis attempts, the data set was imported into MATLAB for further analysis and visualisation for precision and reliability: the results can be seen in Figure 75, Figure 76 and Figure 77. The *y*-axis in Figure 75 represents the evaluation of the five measurement constructs (perceived ability, social norm, control beliefs, interest/motivation and forced functionality), and the *x*-axis represents different participants.

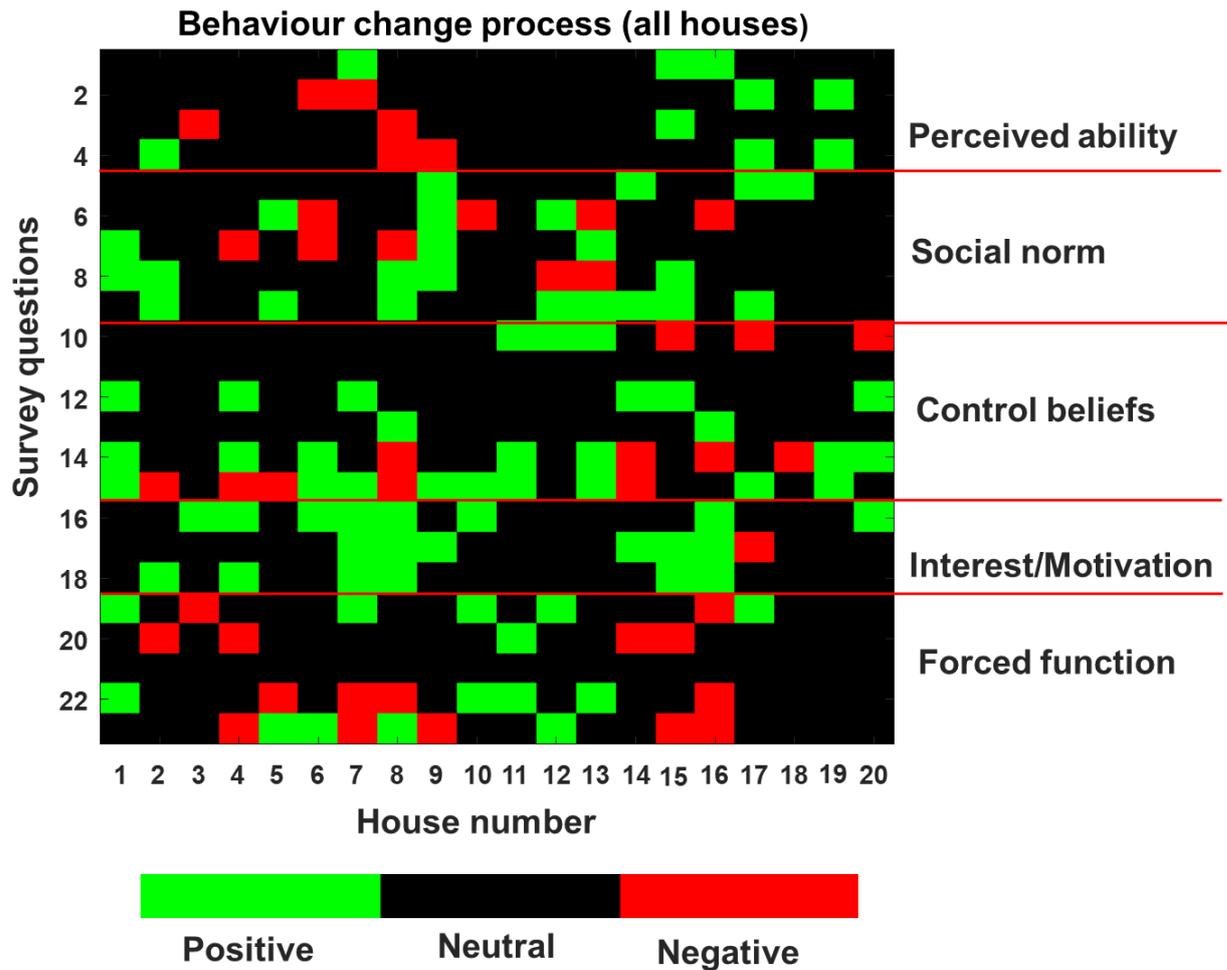


Figure 75 Behaviour change process for all participants

The 3 coloured chart shown in Figure 75 above expresses a pattern of different types of attitudes: green pattern indicates ‘positive’, black ‘neutral’ and red ‘negative’. There appears to be a mixed view in some areas and more positive views in some others. For instance, the responses to questions 3 and 4, within the perceived ability construct, representing neutral attitudes than for the other questions. 3, *‘I believe the device is easy and clear to use’*, 4, *‘I am good at setting goals for my daily exercise now’*. Chapter 3.9 highlights the relevance of TAM³⁸ in determining intention and how expected user satisfaction is an indicator of successful acceptance of new technology. Therefore, the negative implications are

³⁸ Technology Acceptance Model

seen from the question 3 and 4 contradict the notion that participants did not engage in the target behaviour due to technological complexity, thus did not think the device would be easy to use. This thesis argues that either the participants did not understand the question or technology complexity positively affects perceived ease of use, thereby increasing ability. Conversely, questions 16-18 indicate that most participants had more positive attitudes towards the construct of interest and motivation. *Q.16, 'After a few weeks of using this device, I find this exercise method interesting'*, *Q.18, 'I am motivated to continue with this new habit because it's very valuable to me'*. This evidence is completely unsurprising, given that most participants indicated interest, which is seen to relate to motivation directly, and this contributed to increasing their ability. Consequently, while some participants displayed positive attitudes, others had neutral attitudes on questions 19-23 which represent the forced functionality construct. *Q.19, 'I tried hard not to let my TV shut off by itself'* *Q.22, 'I was frustrated when my TV went off all the time'*. Only participant 1, 10,11 and 13 had positive attitudes on *Q.22*; this frustration could be linked to their fervent exercise engagement and reduced ST. In product-led interventions, designers make a clear distinction between *behaviour steering* and *functionality matching* (Jelsma and Knot, 2002). While functionality matching helps match desired functionalities and ensure that redundant functions are removed so as not to steer unwanted behaviour, behaviour steering is where the product is designed in a way that triggers sustainable behaviour (Lilley *et al.*, 2005). This design-led intervention was adapted from what designers proposed; thus the function whereby when the LED reaches zero the TV switches off is a behaviour steering function, which can be perceived as forceful but was intended to induce exercise behaviour. The negative attitude indicates that most participants felt forced

to change their behaviour, although Wever, van Kuijk and Boks, (2008) argue that this function is meant to induce not force a change. However, this function induced another positive behaviour whereby participants switched off their TV when not in use which potentially further reduces the ST.

Overall, the relationship between the variables is more dynamic and unidirectional and more research is required to clarify these reciprocal relationships.

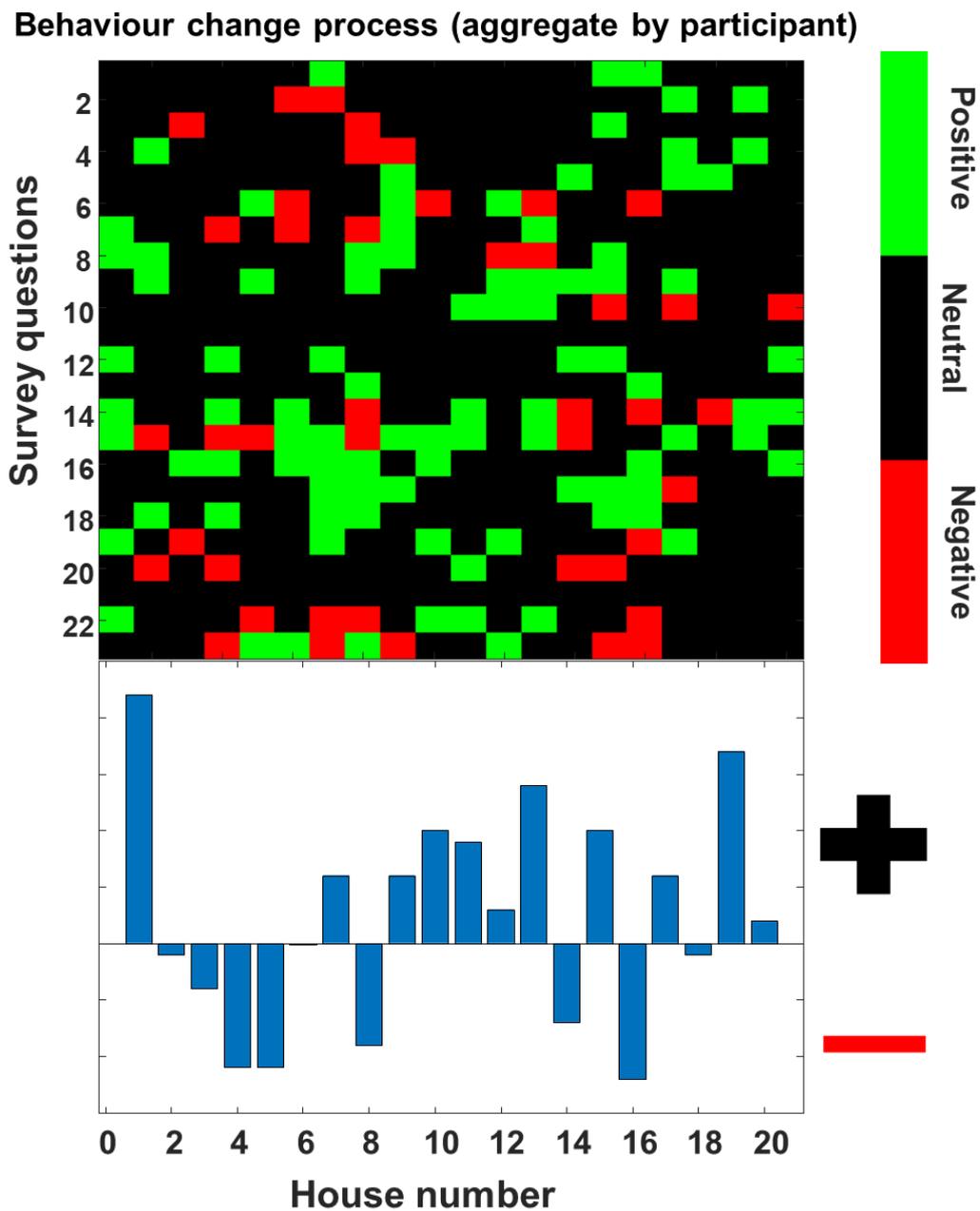


Figure 76 Motivational changes aggregate by participants'

Participants 1, 13 and 19 are seen to have the most positive attitude and, from the behaviour archetypes discussed in chapter 8.5, fall under the *Responsive* group, i.e. the group with high engagement. 7 out of 9 participants with negative attitudes, as shown in the figure above, belong to the *Inert* group, i.e. the group with low engagement.

Thus, to ensure that the data analysis was reliable, it was essential to integrate the data obtained from the surveys and qualitative insights from the semi-structured interviews in the form of triangulation, to gain a more in-depth understanding of the motivational phenomena being explored. This will be discussed in the section below in detail.

Figure 77 below shows the attitudinal changes based on the archetype developed in 8.5. There are observed differences: *Q.14-16* for *Responsive* group indicate a more positive attitude. One of the questions asked is “*I believe exercising daily could be very valuable to me*”. Value attainment has been suggested to influence people’s adoption of and continuous engagement in new behaviour, and this case increases the willingness of action (motivation). Because interest and motivation are highly related and are interchangeable, participants in the *Responsive* group attributed their exercise behaviour to have been elicited by interest.

Similarly, positive attitudes from *Inert* group were mostly observed between *Q.16-18* which relates to interest/motivation. For instance, *Q.18* “*I am motivated to continue with this new habit because it's very valuable to me*”. From this correlation of both groups, it is apparent that interest increases motivational processes and improves chances to maintain engagement or re-engage in the future. The thematic analysis from the qualitative interviews indicates that *Responsive* group, had higher

interest and were optimally motivated. Whereas the *Inert* group had a feeling of being controlled towards engaging in exercise, and were therefore unable to create a compliance-oriented habit of exercising; see a negative indication in *Q.19-23* in Group 2.

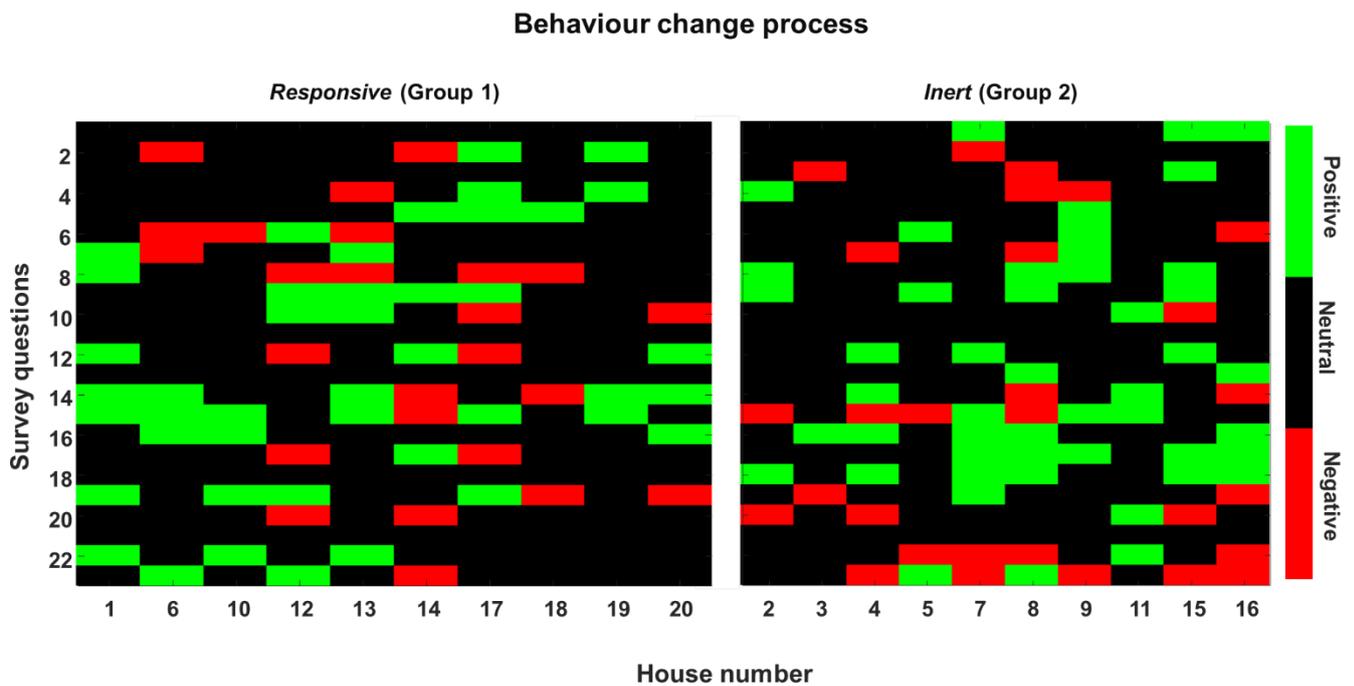


Figure 77 Change in motivation (both groups)

8.6 Attitudinal analysis

The data collected from the current study was a combination of in-depth semi-structured interviews before the intervention and at the end, the intervention, as shown in the stages of data collection in chapter 7.2. Examining the quantitative and qualitative paradigm helped to identify how the divergent approaches implemented in this thesis complement each other. This thesis refrained from relying exclusively upon “objective” views but instead recognises that both qualitative and quantitative approaches have positive attributes which can be useful in decontextualizing participants’ behaviour.

During the pre-intervention interviews, the participants were asked to describe their past behaviours, their expectations, and goals; the end of study interviews were mostly about their experiences or identified behaviour changes as a result of the intervention. Thematic analysis was further carried out, not just to interpret the themes or to retrieve the content of the verbal aspects, but also to transcribe the nonverbal cues of the unspoken words. The transcribing of the interviews was viewed as part of the analysis process, thus used a manual transcription process in order to ensure there was no loss of meaning. All transcripts were entered into NVivo (QSR) for the coding process, and this was continuously refined to allow for any inductive emergence of supplementary themes. As the coding was done numerous times, pyramids of categories were created initially and later summarised by the themes shown in the theoretical framework of the study. This section will discuss the several themes that emerged from the initial data and further discuss the themes pertaining to the constructs within the framework.

8.6.1 Perceived ability

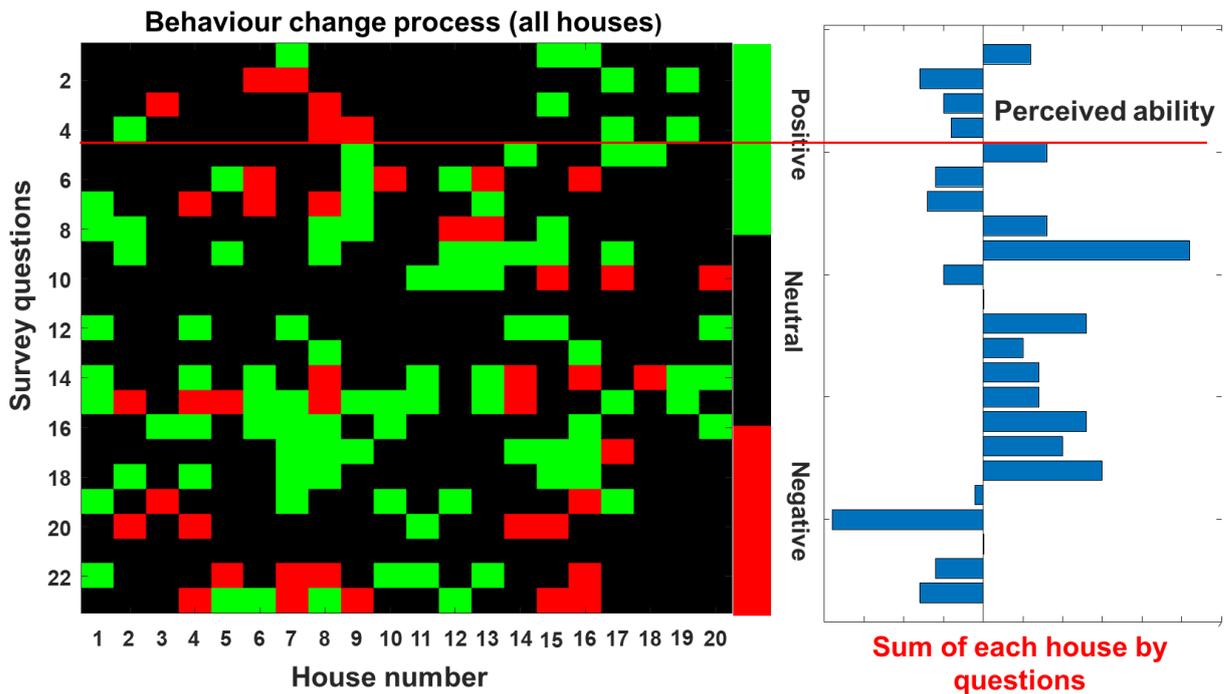


Figure 78 Attitudes relating to perceived ability

To assess the perceived ability, four questions were implemented, see appendix 7. In the literature review, there were discussions on what determines human behaviour. Most of the theories include the concept relating to one’s ability to perform the target behaviour. From the theoretical framework of this study, perceived ability is a representation of not just self-confidence but also the ability to perform the task or target behaviour. This thesis further argues that human behaviour is based mostly on their perception of the environment and personal realities. This, therefore, indicates that an individual will assess their ability over time and from the attitudinal changes, this construct is regarded as a major one in shaping their behaviour. From the mid-intervention survey results shown in Figure 78, cumulative perceived ability appears low across the board, although the qualitative interview results indicate otherwise.

“I am really looking forward to getting on the bike cos we have been talking about doing this type of thing for a while now” (P1)

“I target 27 minutes of daily exercise but some days, I walked to school instead of going on the bus. I came up with that 27 minutes because I timed it and it takes me exactly 27 minutes to get to school if walked. So, I walk 2 days a week and go on the bike for the other days. Although there was a time, I was down with cold for a few days, so I didn't go on the bike” (P13)

“Hmmm, I got into it really quickly cos before you brought this machine, I wasn't very active. I did tennis every now and again but that was it and I was really beginning to notice that I was getting bigger and I needed to do something about it” (P20).

In this thesis, understanding how the participants' capabilities influenced their ability to partake in exercise behaviour was crucial. The quotes shown above came from the participants who had a medium-high engagement. In contrast, some other participants believed they did not have what it takes to form a new habit, thus expressed a lack of perceived ability. Some of these individuals expressed self-confidence and self-efficacy after the initial periods of the intervention. However, from the actual behaviour, it is evident that these psychological assets and abilities depleted quickly in the later stage of the intervention, which reflected in their low engagement. The absence of sufficient psychological resources such as perceived ability (self-efficacy) justifies their inability to maintain the behaviour. In contrast, those who expressed positive perceived ability showed an increased chance of engaging over time, and this led to their behaviour maintenance.

“Initially when the device was brought here, it was kind of difficult to get into the routine but after the first two weeks, it wasn’t so bad” (P4).

“It wasn’t always physically easy for me to get on the bike the first week” (P7).

The evidence of the quote above explains that people will be resistant to new things if they must learn or be trained on how to do them, especially because this requires effort. People are inherently lazy, and increased ability requires making the new behaviour easy, and then people will follow. Perceived ability is relative to incorporating simplicity into a design. A typical example is the 1-click shopping on Amazon: people shop more because it’s easier than ever to buy things.

From the level of engagement shown in both groups, if the perceived ability is well accepted, this will stimulate further to build motivation and may trigger them to begin setting a goal.

8.6.2 Social norm

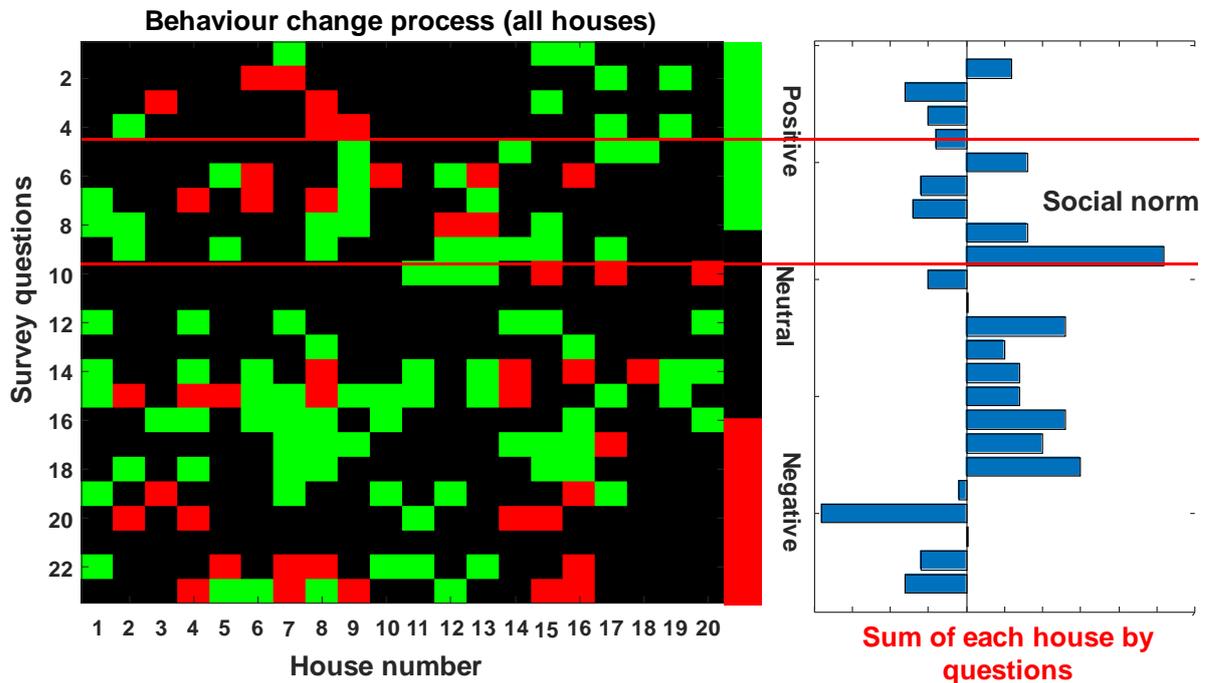


Figure 79 Attitudes relating to social norms

One may ask, how do social norms affect behaviour change? The way individuals behave can be strongly influenced by their social environment. Researchers in other fields have identified relevant behaviour change effects based on social norms in various domains such as health-related (Dempsey, McAlaney and Bewick, 2018), violence and harassment (Gidycz, Orchowski and Berkowitz, 2011) and gambling behaviours (Neighbors *et al.*, 2015). Therefore, it is important to underline the necessity of social norms as predictors of actual behaviour. In the case of this study, questions around social norms explored whether external influences impacted on behaviour changes. Figure 79 demonstrates that social norms were relatively perceived as motivational drivers. The results further illustrate that social norms determine behaviours that individuals perceive to be the right thing to do.

Social norms can be perceived as socially acceptable ways of acting or behaving, and these external influences become a part of a person's own beliefs. With specific

reference to some of the questions asked about social norms, this thesis examined whether participants behaved because their friends, parents and siblings approved of them exercising to watch TV. The interpretation of the results in Figure 79 evidenced that, at some point during the intervention, these norms influenced the participants' behaviour.

TPB, in general, is grounded on the supposition that intention drives the performance of the behaviour itself. Therefore, the intention is overseen by the connection between people's self-confidence and the external influences and the certainty that action will yield outcomes. Thus, social norms can have either a positive or negative effect on behaviour, although this consensus is deficient when it comes to explaining the process through which they change behaviour. Some of the participants perceived the intervention as something that required them going against the social norm, which Fogg described as "social deviance". During the intervention, it was important to have support from both family and friends, with the anticipation that these interactions could make the norm of exercising more salient and create a more powerful social norm perception. Thus, the focus of this thesis was to not only rely on normative effects (merely telling participants that increasing their exercise is good for them); the researcher provided a cue in the form of the Knudgbox and the bike to support the target behaviour (increasing exercise). The insights from the thematic analysis revealed rather conflicting findings, with some mixed feedback on social norm influences.

"Playing video games with my friend is an important part of maintaining our friendship and if I now need to cut down how much time I spend doing that it could make my friends think of me as avoiding gaming with them" (P11 before intervention).

This same participant, after the intervention, managed to get through this barrier:

“I was actually quite cool going on the bike cos I told my friends about the experiment, and they all thought it was cool, so this means I was the one doing the cool thing, hahaha” (P11 after intervention).

“My mum didn’t really bother whether I went on the bike or not, so I didn’t really feel like I had to do it” (P8).

“My dad always told me you had to go on the bike, and sometimes he did go on it himself” (P10).

One of the parents during the pre-intervention interview made a passive statement of *‘the digital world being limitless and how these technologies have invaded our home’*. The outcome of the first part of this thesis highlights that parents are overwhelmed at how the digital platforms are limiting their parenting and are in desperate need of any novel approach to help them regain control. They even fear not to upset the children: *“I also feel that her brother gets anxious when I scold off the TV” (P16, before intervention)*. Most of the participants had no ST rule: *“Not at all, we do not have any rule for screens, my parents are pretty chilled, and they allow me to do whatever I like to do and do not stop me from playing video games or using my tablets” (P11, before intervention)*. Some do have technology rules at home, like this participant’s report before the intervention: *“My dad set up screen times from the settings of our phones and set specific downtime when the app should go off and set limits for some social media use.” Parent – “I give them time depending on the holiday and term time; term time, I have set all apps to go off at 9, 9:30pm and holiday period I let them cut off their screen limits from 12:30pm because they are not overly expected to be up early. I give them less time during*

term time” (P3). The current study enquired about what they did when the timer went off, and they said they sometimes hide and use these devices quietly, and therein lies the problem still for parents, as the mobility of these devices means children could potentially bypass their ruling when they are out of sight.

The outcome of the intervention resulted in 6 out of 20 participants taking control of their own screen use, and this was observed for P1, P10, P17, P18, P19, and P20 respectively which all belongs to the *Responsive* group. For instance, one participant said, *“I am a creature of habit and like to and form a pattern in whatever I am doing. Like I generally eat breakfast at the same time all the time, and I like to eat the same thing every day, I go to bed the same time every night”* (P13). This implies that the participant managed their own ability to exercise and used their accumulated screen credits as appropriate. Looking at Figure 59, it was apparent that this participant averaged a little over 2 hours of TV time post-intervention in comparison to their 6.5 hours before. Also, Table 14 shows that they had a mean average PA of 28.50 minutes during the intervention. Children’s worlds feel foreign to adults; thus one of the lessons from the design-led intervention, which aligns with interpretivist views is that instead of forcefully trying to change people, may be better to expose them to the change environment. This offers them the opportunity to construct their meaning, as seen in P13’s behaviour.

During the pre-intervention interview, there was a consistent mention of FOMO³⁹ by most of the participants, and it became evident that any intervention intended to reduce children’s screen use would need to consider this factor. The parents of the participants reported that spending hours perusing and checking their own mobile

³⁹ Fear of missing out

phones limited their ability to be good role models for their children. *“I think I had to control my own TV time too in the process of supporting her, one Saturday afternoon, she said, mum, you do realise you have been on your phone since morning? And this actually made me think that I too have a fear of missing out”* (P17 before the intervention). Admittedly, the children consistently expressed that playing video games was as much about FOMO as it was about keeping up to date with virtual interactions with their peers.

8.6.3 Control beliefs

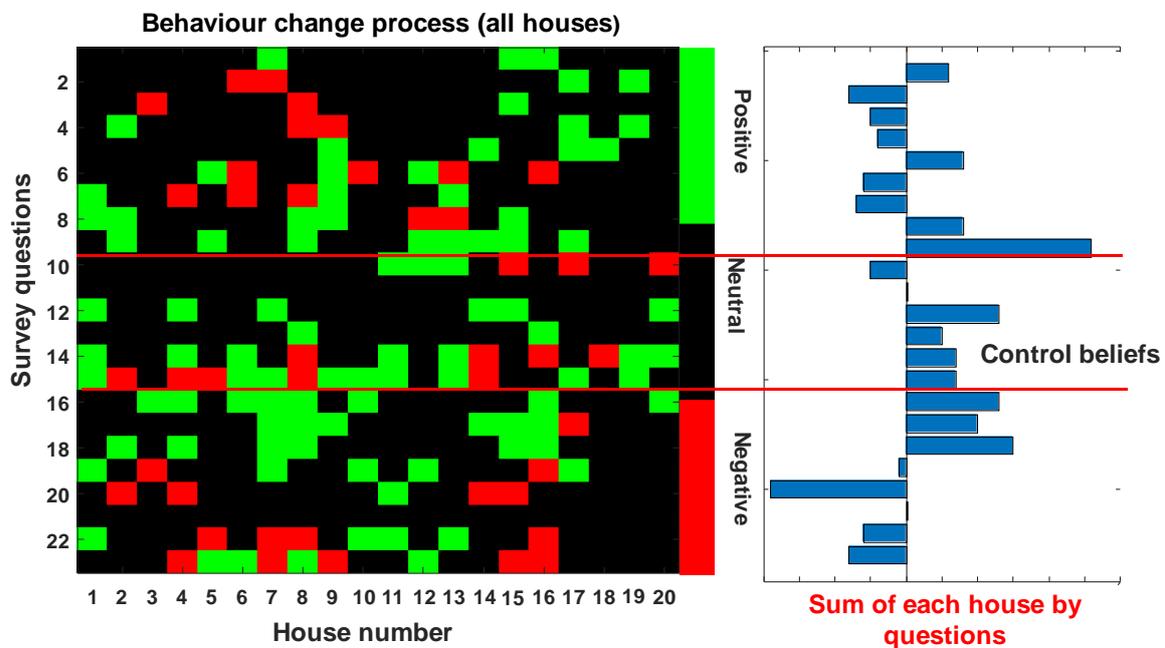


Figure 80 Attitudes relating to control beliefs

Control belief is a universal concept widely discussed in the psychology literature. When people set out to change their behaviour, they often encounter opportunities and challenges that stop them from changing their behaviour. Thus, the application of the control construct to the framework of this thesis emphasises how the individual handles the external factors that may positively or negatively impact on their ability to engage in the target behaviour. Control beliefs are strongly related to social norms as they describe the participants’ ability to overcome the social

deviances encountered during the adoption and maintenance of this new behaviour. Although this might seem similar to perceived ability, the clear distinction between them is that control belief manages the presence of the factors that may impact behaviour. In contrast, perceived ability relates to individual assessment of their own behaviour.

As mentioned in the early part of this thesis, the operational definition for control belief is validating the distinction of a user's capability to exert influence over what might inhibit their ability to perform a target behaviour, in other words overcoming the social norms. This can be relative to perceived ability, for instance, for participants who lack the ability to exercise, this paradigm might put their behaviour under voluntary control and by implication does not encourage them to perform this behaviour. The logic is quite similar to the 'rational' perspective of TRA⁴⁰ which assumes that people consider various control beliefs and often the ability of these factors to impede or facilitate their behaviour, in order to determine whether the action required is within their control to act. In other words, people can forge control beliefs by association with other external influences. Conversely, "when people lack control or feel incapable of performing the behaviour, it is unlikely that they will perform the behaviour" (Fishbein and Ajzen, 2011). In an attempt to assess the influence of control beliefs regarding the participants' actions, a range of questions were introduced to both the survey and interviews to measure this construct, see appendix 7.

The results shown in Figure 80 show that the participants had a great sense of control although the qualitative data explains the inter-individual differences across

⁴⁰ Theory of Reasoned Action

participants. *Q.10 I often encounter events that stops me from exercising*, seem to indicate mostly neutral feeling and *Q.11* was an open question where participants indicated some encounter that impeded their exercise activity, *“Playing outside with friends or riding on my bike on the street”* *Q.15* had the most positive response indicating that control was a moderating factor for high exercise engagement. This is promising as it suggests that the sense of control is a modifiable factor which can help those who lack a sense of control in future interventions. One important distinction to note from this result is that a high sense of control is seen to be beneficial for resilience and habit maintenance over time, as indicated by this longitudinal study. Within the theoretical framework of this thesis, control belief and interest are the highest predictors of habitualisation of new behaviour. This teaches us an important lesson: that a sense of control is of utmost importance in behaviour change interventions. Some quotes shown below reveal some optimal conditions that require promotion of resilience when it comes to control beliefs.

“I think this device was hard to use for him and because he spends some days at his dad’s and some days here. It was difficult to keep up with the exercise routine” (P2 parent).

“There was Ramadan which kind of got in the way of me using it. So, if the timing was different, we would have used it more. It’s just bad timing really” (P3).

“Even though my friends saw me as a loser when my Play station went off cos, I had finished my screen credit at the beginning stage, it didn’t really stop me from going on the bike, but they came around to the idea in the end”... (P18).

The last quote explains that stimuli which could impact on the participants' behaviour were also the visual feedback. This was programmed to indicate how much exercise or ST the participant had done or had left. Put simply; there is no ceiling on the number of control beliefs that could pertain to each participant, and every participant may have their own unique obstacles and generate ways to overcome them. The reliability of results obtained for this thesis lies in the distinction that control beliefs have a remarkable deal of heuristic value in predicting participants' actions.

General media use inhibits family and social interactions, as people are consistently glued to their technological devices. *"It's ridiculous how they reach for their tablets and devices first thing when they wake up in the morning, I have caught them sneaking around to take their seized game console, and all I want is for us to spend time as a family without the interruption of a ping!"* (P16 parent before intervention). 13 out of the 20 participants noted that having participated in the intervention study had not only made them aware and alert of ST management but had also improved their family interactions: *"I played a lot more with my brother and we had family time too playing on in turns which was really good"* (P1). More so, most of the families perceived this intervention as a wakeup call to spend some more time as a family. For instance, *"Yea I think it was a wakeup call for us as a family considering that we didn't know how these technologies are taking over our life"* (P10 after the intervention); *"I didn't do this every day, the most time I was on the bike, I and my dad did it together, and my dad did it for 30 minutes, and I did it for about 28 minutes at most"* (P5).

8.6.4 Interest/Motivation

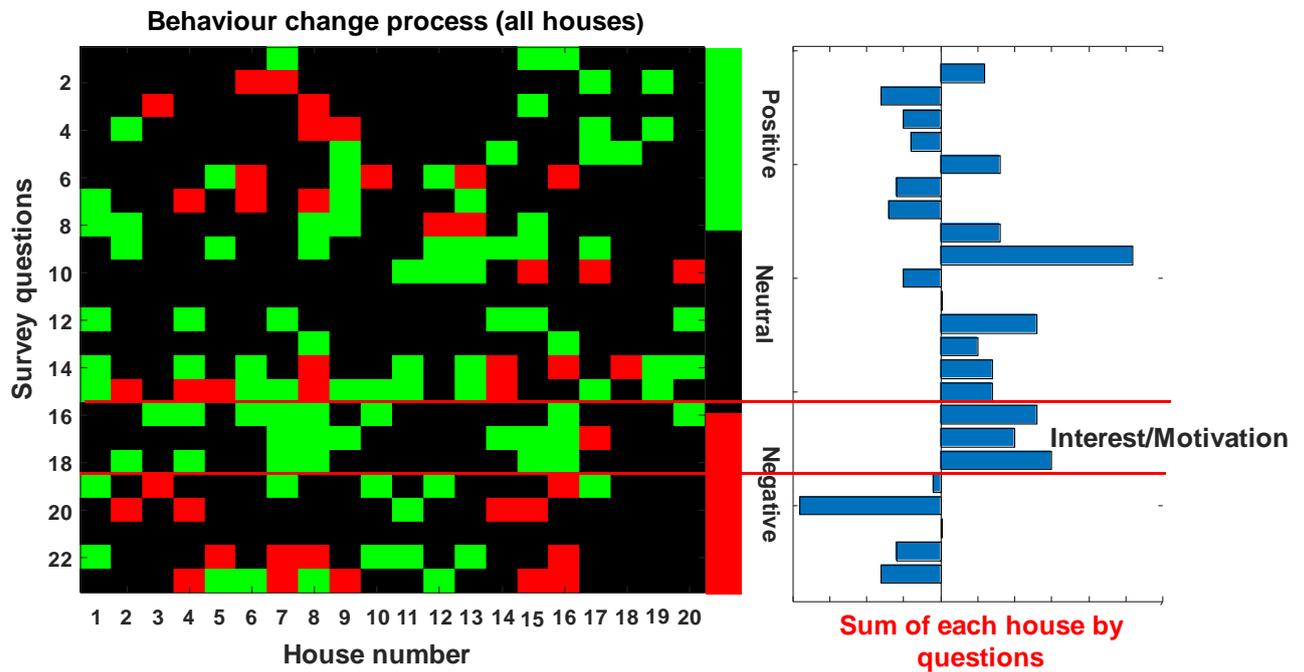


Figure 81 Attitudes relating to interest/motivation

This thesis considers interest to be a massive motivational variable in any behaviour change intervention. The fundamental state in which this occurs is during interactions between persons or objects, and it is often characterised by increased attention and affects. Singularly, ‘interest’ is a relative predisposition to continuously engage with objects, people or things in a given task. One of the purposes of the current study was to increase motivation by observing participants’ thus interest and motivation was part of the measurement construct within the theoretical framework. Behaviour repetition was achieved by repeated action, which was driven by interest. Bandura's (1997) self-efficacy postulates that individuals’ ability to produce successful outcomes and reach their set goals are critical in increasing their motivation. As seen in Figure 81, most participants had a high interest, and this reinforced their motivation over time.

Consequently, interest and motivation have a direct link with perceived ability. However, the observations seen in the exercise activities for both groups suggest that, as interest develops, motivation also dynamically fluctuates until the individual identifies stability in their behaviour. The evidence from the qualitative interviews supports the fact that interest/motivation developed over time, and this was relative to lapse periods and their ability to reengage with the intervention. Given the apparent benefits of high interest/motivation, as seen in Figure 81, it is worthwhile to highlight that participant interest was seen as an opportunity at the initiation stage of the intervention. Some of the indicators of interest for some participants were centred around enjoyment and fun. Interest increased overtime following the impact of visual feedback and the user's feeling empowered.

Individuals are thought to continue any newly adopted behaviour if they find it intrinsically motivating. Participants with low engagement saw the visual feedback as a deterrent, therefore struggled to find motivation. In contrast, those with high engagement had the strongest self-regulation, inhibition of impulses, goal setting and planning to increase their motivation.

“The light was a motivation, and when you see one light on it makes you want to get more. I would also like to see a motivational message for the user. Different colours for how well you are doing maybe this will make me not get bored quick. It was fun to use, and I enjoyed using it and really hoped I used it more. All my siblings enjoyed it” (P3).

“I wasn't really motivated, to be honest. It felt boring, and there was no enjoyment, so it was hard to keep up” (P8).

“I quite enjoyed it and I played on it a lot of the time at the beginning and I couldn’t stop going on cos I thought the idea was fun” (P1).

Interest/motivation in the context of this thesis allowed for an investigation of specific processes, including ‘affect’ through which interest may influence behaviour initiation and behaviour maintenance. For instance, high perceived ability is one of the drivers of how interest unfolds, and how it increases and enhances motivation maintenance. If interest is observed closely, each phase would be characterised by the amount of affect and value as perceived by the participant:

“I liked that it made me feel good in myself whenever I got off the bike” (P1).

Motivation was seen a driving construct in both initiation and action stages. From observation, motivation is not required when the user attain habitualisation.

8.6.5 Forced functionality

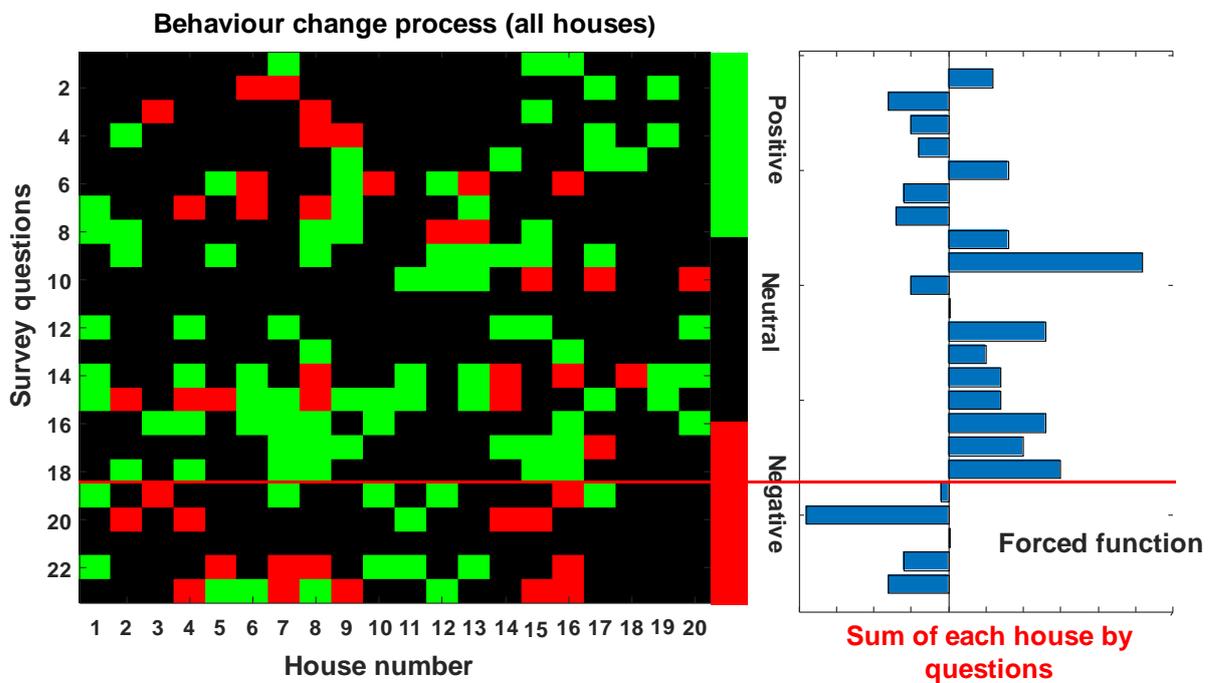


Figure 82 Attitudes relating to forced functionality

The intended outcome of the study prototype was to design a usable device that will instigate new behaviour and become applicable in addressing the lack of PA problem. Therefore, it was important to influence user behaviour without using any form of force. Forced functionality as a construct indicates influencing people's decisions through 'force', which may have a negative impact on people's behaviour. From the results seen in Figure 82, participants of this study mostly had negative attachment relating to feeling forced to engage with the intervention. Loss aversion was driven by visual feedback whereby users were more concerned about losing their ST than actually exercising. An example of how this was reflected in the findings was *Q.19 I tried hard not to let my TV shut off by itself*, had the most positive response. In some cases, this indicated a feeling of feeling forced to engage otherwise denied of ST. the intention of this intervention was to shift the user's mindset from 'feeling forced' to 'feeling in control'.

One DfSB framework referred to as the "axis of influence" provided a spectrum which shows the distribution of control when it comes to users and products (Lilley *et al.*, 2017). One end of the spectrum indicates the user in control, and the other indicates the product applying force to instigate user behaviour change. Shin and Bull (2019) argue that the exertion of force makes users unaware of any values or incentives that may result as a result of their action. Lilley (2009) originally came up with the concept of forced functionality, which mostly only referred to intelligent products which adapt automatically to change situations with the aim of preventing unsustainable behaviours. Changing and maintaining exercise behaviour was paramount in this thesis; thus, it was important to understand if the intervention was intrusive. The way the intervention was set up, the participant was expected to exercise in order to gain access to ST and unplugging their TV from the device

could indicate that they felt forced to exercise even when they did not want to. Lilley (2009) argued that evaluating forced function is necessary to understand if the intervention yielded the intended change. The semi-structured interviews revealed that most participants felt forced at the start of the intervention and this helped prompt them into action. The participants' action or inaction was observed to either require less or more deliberative effort. It was not intended to force participants to change their behaviour; most of the participants at the initial stages felt they had to make a deliberate effort, making it difficult for them to regulate their behaviour. The evidence from the data shown in chapter 8.5.1.1 explains that self-efficacy played a larger role in the early stages of the behaviour adoption, thus most participants made a deliberate effort which was necessary to inhibit their prior patterns of not exercising or watching too much TV. As observed in their behaviour over the course of the intervention (Figure 72), both reflective (contextual) and reactive (goal setting, motivation) triggers were perceived in promoting maintenance of positive exercise behaviours, which indicates behaviour change independent of feeling forced. Some perceived this behaviour as a punishment, and this may explain the lack of engagement. Some participants said,

“The trouble is I was trying to do half an hour and it doesn't give me enough time on the screen, so I needed to do more. 30 minutes gave me roughly an hour and that was kind of annoying, so I stuck to doing 30 minutes all the time or just slightly over just to make sure I exercised and that was better than doing it because of the screen time I can get” (P4).

“I think it felt like punishment sometimes, but all in all, I enjoyed it only in the first week and felt like I was forced to do it after that” (P2).

“At the start, I was doing it to get my TV time but after some time I started to actually enjoy it and wanted to do it to get my bit of exercise in when I got home from school. I also got fit and lost some weight for hotgirl summer” (P10).

Also, as discussed in chapter 2.5, children’s digital footprint is their social currency, which relates to the FOMO culture. Therefore, this intervention targeting a limit on their screen use could well be perceived as a punishment. Before the intervention, most of the participants were concerned:

“Seeing that I spend some good amount of time on my video gaming with my friends, I’m a little concerned that this will get in the way of the time I spend with my friends. I also don’t want my TV to shut off when I’m playing video games; this could be seen as weakness” (P19 before intervention).

Overall, the pattern seen in the exercise data demonstrates that participants can easily become disproportionately biased towards old behaviours by either unplugging the device and not exercising or exercising a little and then unplugging. Also, the nature of the intervention meant that the participants had an option to choose between changing their behaviour or not; thus, non-adoption was also a behaviour. After the intervention, some of them reported having engaged in at least 30 minutes of PA outdoors, thus the intervention may not have facilitated their home exercising habit but have instigated exercising outdoors: *“I played in the garden most times, and I never used to do this” (P8). “I walked to school instead of getting dropped off by my mum” (P7).*

At the end of the intervention, participants stated some new behaviours they had acquired from the intervention, and this explains some missing days of engagement

in most cases. A very common habit was unplugging the device when their parents were not in sight: *“I used to unplug the device when I’m struggling or when I haven’t done enough to give me enough TV time. So, I unplugged it quite a lot of times (P2).* Some of them unplugged with consent from parents: *“When my mum feels like I have been a good girl, she would normally allow me to unplug the machine and plug my TV to the mains” (P15).* In other cases, the LEDs going off meant that the participants would find another activity to do around the house, or move on to another technological device as was the case for this participant: *“I don’t think this was ever the case. I would generally go on the bike, then take a shower then start playing on PS till the lights finish, I either unplug it or I go on social media” (P19).*

In summary, these findings reflect how these constructs from the theoretical framework identified the changes in the participant behaviour. These key themes mentioned were used during the thematic analysis to identify further opportunities and challenges. There was also evidence that these themes are interdependently linked and further discussion to buttress; this will be presented in chapter 9.

8.7 Habit Retention

Habits take time to change, and this warrants a long-term evaluation of any habit formation intervention targeting new habits. Lally and others (2010) in their study of a once every day repeated behaviour, showed that for a new habit to plateau to automaticity a median time of 66 days is required, with significant variation at the individual level; for their study it took between 18-254 days. Another study that examined gym goers exercise habituation found that new gym-goers needed to exercise at least 3-4 times a week for at least 6 weeks (Kaushal & Rhodes, 2015). However, few interventions targeted at habitual behaviour lend themselves to

establishing whether any given intervention has resulted in habit maintenance or permanent change in behaviour (Fogg & Hreha, 2010); therefore Fogg and others recommend that post-intervention monitoring is vital to establish whether the new behaviour changes have been maintained. The research tool used for this study was instrumental in eliminating self-report measures of actual habit, as the Knudgbox recorded the timestamp of every PA session by each user. The post-intervention, although self-report, highlighted each user's PA progress following the removal of the Knudgbox, and this will be discussed in detail in the next section. Two weeks after the end of the study, when the bike and device had been taken away, post-study questionnaires were disseminated to assess whether the new behaviour had been adopted.

8.7.1 Post study results

8.7.1.1 Responsive (Group 1)

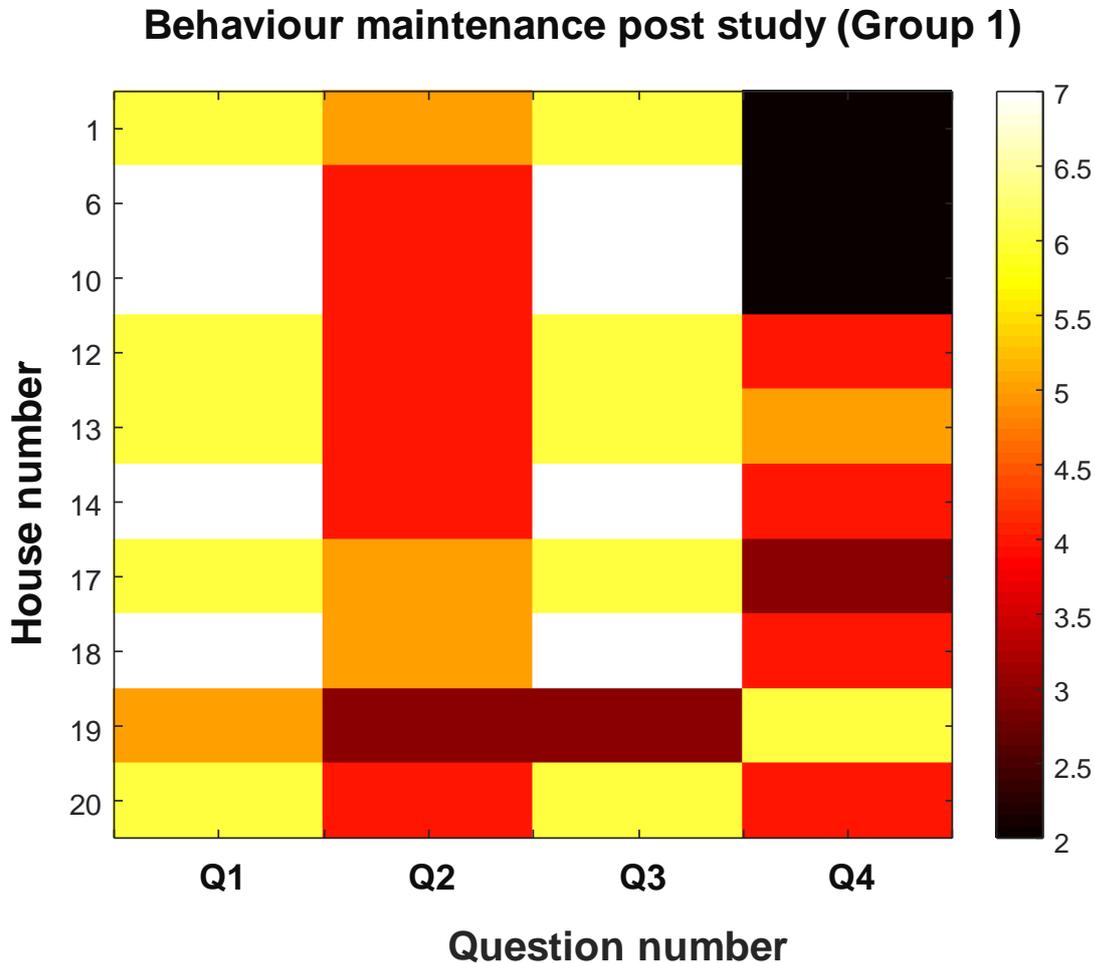


Figure 83 Post-intervention feedback (*Responsive group*)

The final phase of the data collection comprised of asking participants 4 key questions to obtain information on their newly adopted behaviour (see appendix 9). The same scale used for week 5 and 10 questionnaires were used, however, there was no need to rescale the responses as the questions were straight to the point. The data shown in Figure 83 includes only group 1 participant. Scale 1 (not at all) to 7 (very true), or 1 (decreased) to 7 (increased). *Q.1: 'My exercise habit has been maintained since after the experiment'.* Participants 6, 10, 14 and 18 expressed a strong point on having maintained their exercise habit since the end of the primary

study. Although not as strong as the above participants', participant, 1, 12, 13, 17, 20 also indicated a sustained exercise behaviour post-intervention. *Q.2: 'Tell us about your current exercise time since the end of the experiment (average 1 hour)'*. 7 out of 10 participants in this group revealed that they are indifferent about their exercise behaviour maintenance, although they stated to average an hour or less. According to Item.1, it can be assumed that only participants 6, 10, 14 and 18 exceeded one hour of exercise per day post-intervention. *Q.3: 'My screen time habit has been maintained since after the experiment''*. Almost all of the participants reported their screen habits, which had dramatically reduced during the intervention, had remained the same since the end of the intervention. Only one participant (P19) reporting that their screen habit had returned to what it was before the intervention (over 6 hours). Research shows that individuals tend to disengage from a new behaviour when they do not receive feedback indicating any progress. The absence of the Knudgbox in people's homes could counter the impact on the participants' newly adopted behaviour. *Q.4: 'Tell us about your screen time use since the end of the experiment (TV, Video gaming, tablet use) average 2 hours'*. The dark block shows that only 3 participants were very confident about their ST reduction being maintained, whilst the other participants sat on the fence. Again, participant 19 stated to have watched over 2 hours of TV.

8.7.1.2 Inert (Group 2)

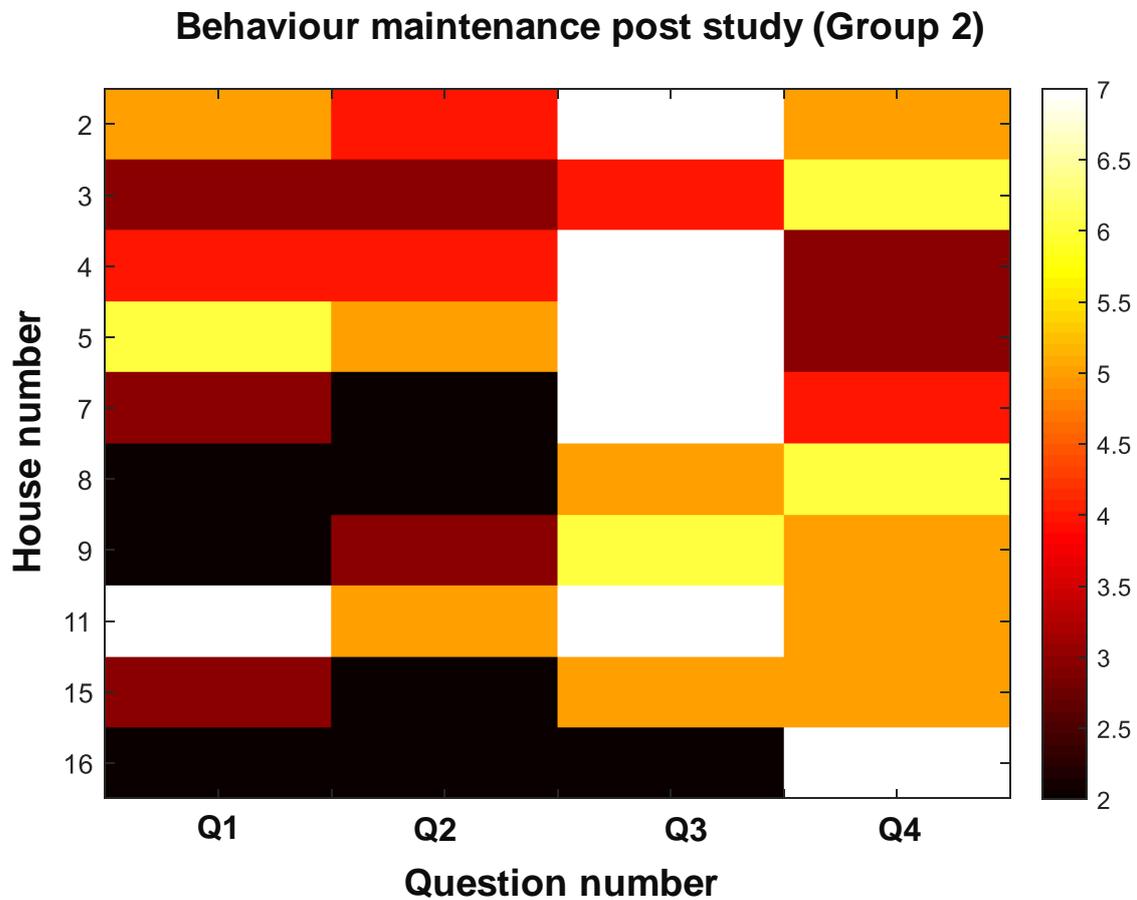


Figure 84 Post-intervention feedback (Inert group)

There is an obvious difference in the maintenance habit of group 2 in comparison to group 1, as shown in Figure 83. *Q.1: 'My exercise habit has been maintained since after the experiment'*'. Participants 8, 9 and 16 did not continue this new behaviour when the bike was taken away, even though participants 8 and 16 had indicated in the mid-intervention survey (see Figure 77) that they were happy to continue their exercise habit as they considered exercise a valuable behaviour. Thus, there is a discrepancy between what they say they value and what they do, and this could be as a result of lack of concrete feedback showing that they are achieving their goal. That said, P2 and P5 who did not seem to have had as much engagement in comparison to some of the participants in group 1 who continued with this new

behaviour, Participant 11 seemed to be the one with the most positive attitude in the group, based on their response to item 1. *Q.2: 'Tell us about your current exercise time since the end of the experiment (average 1 hour)'*. The responses showed that half of the participants did not maintain their exercise habit, and this supports the responses seen in item 1. Although there seem to be no apparent changes in their exercise habit, the earlier section of this chapter reported that there was an overall TV watching reduction across participants, which is positive and is seen in the bright shades representing the scales. *Q.3: 'My screen time habit has been maintained since after the experiment'*. 9 out of 10 participants scored above 4, indicating that their reduced screen habit had been maintained. Maintenance for these participants was very subjective, as in *Q.4: 'Tell us about your screen time use since the end of the experiment (TV, Video gaming, tablet use) average 2 hours'*. The participants mostly reported their ST to have increased, excluding 2 participants (P4 and P5) who maintained that their TV watching habits were still within the confines of two hours a day or less. The findings from this thesis indicate that there is a distinct difference in behaviour at the post-intervention stage. Therefore, one can argue that the participants who engaged have managed to maintain this new habit post-intervention and the next section provides a detailed statistical analysis done to validate these findings.

8.8 Statistical analysis of all results

The current study examined the impact of the design-led intervention in improving children's exercise habits, specifically focusing on regulating their ST in the home setting. Following an exploration of the literature on what is already known in the subject area, six key research questions were developed, see chapter 1.5.2.

Statistical analysis was also used to answer the research questions this study set to investigate.

Linear mixed model regression

As discussed in chapter 4.10.1, LLM⁴¹ was the selected statistical analysis for the collected data in this thesis, although other types of analysis were attempted (see appendix 20). When applied to longitudinal data, LLM is integrated either as within-group or within-subject model, between-group or between-subjects model. The study took the between-subject approach where each participant's behaviour parameters (β_1) were considered as random dependent variables. There was an initial linear regression conducted to define the behaviour patterns and further model them as a single set of parameters. This took into consideration that the participants were observed for a minimum of 90 days, and the measures were based on PA and TV time, respectively. The participants were selected using the criteria shown in Table 4⁴², from across the UK; hence, the inference is targeted at the general population and not just the participants in the study.

Table 13 Fixed effect parameters

Parameters	Model 1	Model 2	Model 3
β_1 (Intercept)	53.0	10.4	5.8
Standard error	7.11	5.7	2.4
95% CI	(38.7 – 67.3)	(-0.9 – 21.7)	(0.9 – 10.8)
β_2 (slope)		1.9	2.3
Standard error		0.1	0.18
95% CI		(1.8 – 2.0)	(1.9 – 2.7)

⁴¹ Linear mixed model

⁴² Table 4 can be found in page 135

Model 1 is the minimal model that could be fitted to the data set; this has been represented mathematically as:

$$screen\ time_{ij} = \beta_1 + b_i + e_{ij} \quad \text{Model 1}$$

Where $screen_{ij}$ is the j-th ST⁴³ measurement recorded for i-th participant, β_1 is the population mean ST across all participants, b_i is the zero-mean random intercept (average) for the i-th participant and e_{ij} are the uncorrelated random/unexplained fluctuations among participants.

With a value of 53 (95% CI: 38.7, 67.3) this shows that, on the average, participants' PA time was 60 minutes.

Model 1 explains the average ST across the participants without their PA time being considered. To investigate the effect of exercise on ST, another model was fitted to the dataset with PA time inclusive as a variable; this is model 2 Table 13 and represented symbolically as:

$$screen\ time_{ij} = \beta_1 + \beta_2 exercise_{ij} + b_i + e_{ij} \quad 2$$

In model 2 the significance of the PA variable was assessed using a parametric bootstrap approach, and with a p-value < 0.0001 it was retained in the model. The coefficient for PA is 1.9 (95% CI: 1.8 – 2.0, SE: 0.1).

Model 3 is an extension of model 2 with b_{2i} inclusive to capture the variation in the slopes of the different participants, as shown in Figure 85. The variance component, b_{2i} is 0.62 indicating the amount of variation of the participants' individual slopes from the general slope (β_2). Although the value is low, it still had a significant p-

⁴³ Screen time

value ($p < 0.001$) which confirms the understated variations in the slopes of the participants as shown by Figure 85.

A scatter plot of TV time against PA for each participant is shown in Figure 85. There seems to be a clear variation of the initial (intercept) TV time amongst all 20 participants, and an obvious difference in their TV time as they progress differently in their involvement in exercise. For instance, participants 3, 6, 13, 16, 17 and 20 show a steeper slope indicating a steady increase in TV time as PA increases. Participants 2, 7, 8 and 9 show a flatter regression line (slope) indicating a very slow increase in TV time as PA increases. A plausible explanation for the variations in TV output is the fact that the participants had different sizes of TV, and this was a limitation considered in the prototyping process.

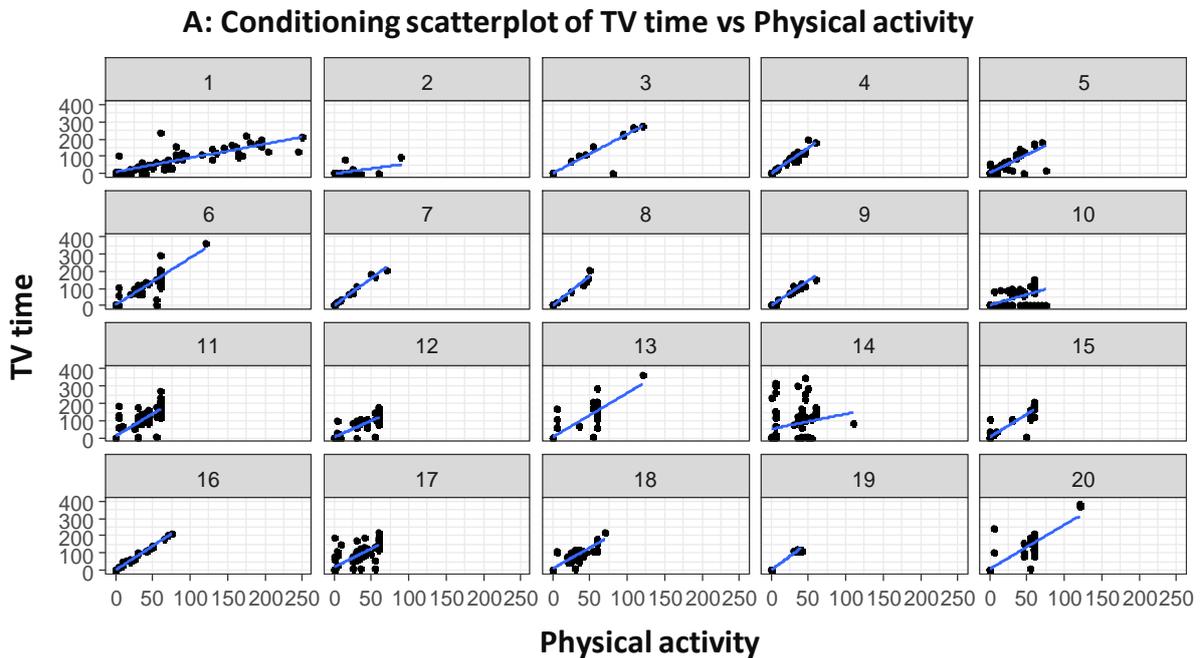


Figure 85 A scatter plot conditioned by participants' TV time against physical activity

Figure 86 represents an initial (intercept) TV time for both boys and girls, as there appears to be a significant difference. Their TV times as they increase PA (slope) look similar: a plausible explanation would be that they equally enjoyed using the

device regardless of their gender. The model used in this statistical analysis will also capture this understated difference to be able to fit the data set adequately.

B: Scatter plot conditioned by gender

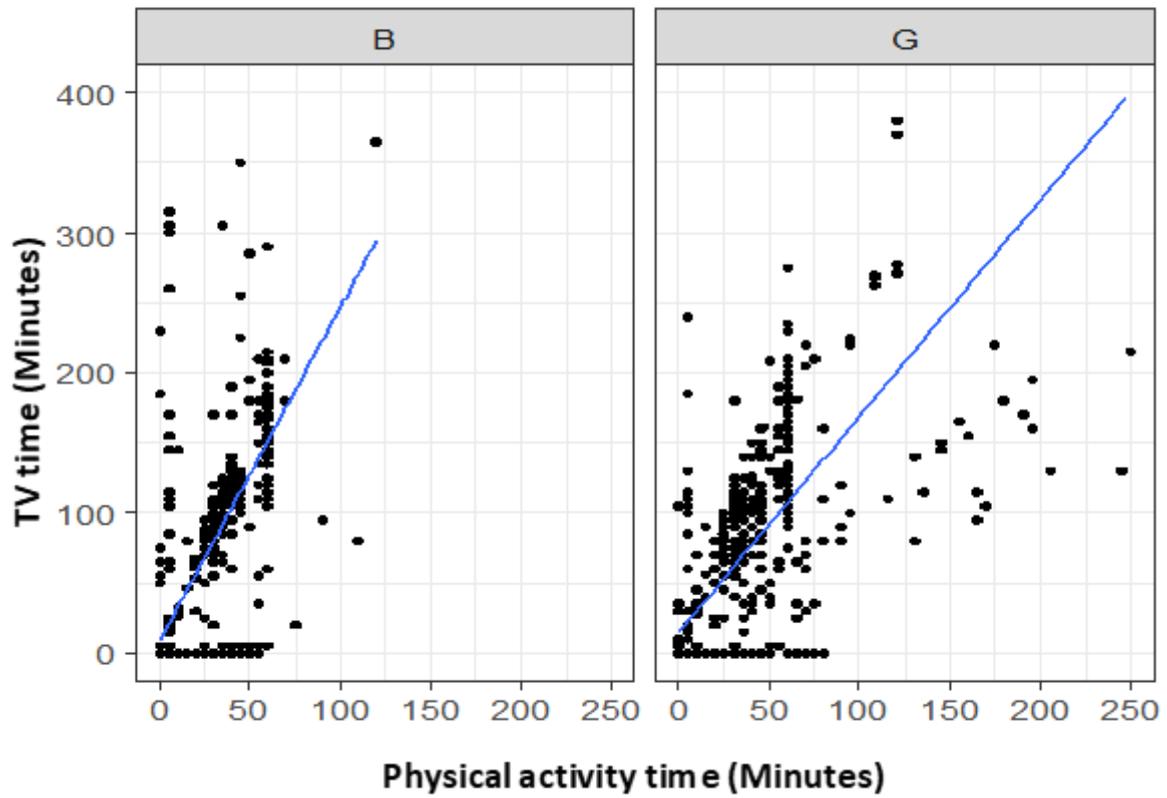


Figure 86 A scatter plot conditioned by gender for TV time against physical activity

8.9 Statistical analysis from all households

Table 14 Basic statistics for daily exercise

One-Sample Statistics					
House number	Mean PA (minutes)	Std. Deviation	Std. Error Mean	Min	Max
House 1	74.67	64.637	7.464	0	250
House 2	6.53	14.565	1.682	0	90
House 3	19.28	39.003	4.504	0	121
House 4	12.47	16.712	1.930	0	60
House 5	11.64	19.315	2.230	0	75
House 6	30.93	27.847	3.216	0	120
House 7	4.07	12.700	1.466	0	70
House 8	3.03	10.731	1.239	0	50
House 9	6.87	14.514	1.676	0	60
House 10	28.53	25.611	2.957	0	75
House 11	27.80	24.025	2.774	0	60
House 12	35.33	24.333	2.810	0	60
House 13	28.20	28.542	3.296	0	60
House 14	29.27	22.552	2.604	0	65
House 15	16.27	25.470	2.941	0	60
House 16	8.80	17.703	2.044	0	75
House 17	33.60	20.950	2.419	0	60
House 18	28.53	16.415	1.895	0	60
House 19	31.20	10.931	1.262	0	40
House 20	45.80	30.023	3.467	0	120

Table 14 shows the mean and standard deviation values for PA time. The intervention exposure was for a minimum of 90 days, although not all participants engaged with the device all the time during exposure. Participant 1 from the table appears to have exercised the most, averaging approximately 75 minutes a day. The high standard deviation indicates variability in her daily PA during the intervention. In contrast, participant 8 recorded the lowest PA levels with a low standard deviation similar to participant 19. The total mean average for PA across the

participants was 24.14 minutes per day, which indicates that the majority of participants engaged with the intervention.

8.10 Summary of Chapter

This chapter presented the methods and results from DUS⁴⁴, designed to understand how the Knudgbox has been effective in changing participants' exercise behaviours, and what are the determinants of these behaviours. Before this study, an extensive literature review uncovered that most people in the world today are highly sedentary with increasing obesity rates, more so children of the age group observed in this thesis. Therefore, it was evident that any intervention aimed at tackling the negative outcomes associated with sedentary habits would need to focus on the environment in which these behaviours are widely observed (home). The results, as presented in this chapter, demonstrate how the participants behaved in diverse ways during the intervention; as a result, the exercise and TV watching times varied considerably, with slight similarities across groups. It was also noted that participants had various psychosocial constructs that influenced their attitudes and motivations, most notably high perceived ability, and interest. Evidence of Hawthorne effect⁴⁵ is scant and does not influence why participants improved their behaviour. The current study was longitudinal and participants fluctuation in behaviour suggest that their engagement was intentional. Perhaps the lesson learned here is that prolonged intervention exposure mitigate the effect of observer effects.

The TV watching data taken prior to the intervention demonstrated that most participants and their parents underestimated how much time they spent watching

⁴⁴ Domestic User Study

⁴⁵ Hawthorne effect – is the tendency, particularly in social experiments, for people to modify their behaviour because they know they are being observed, and so distort (usually unwittingly) the research findings (Henry, A. 1920).

TV. Thus, a few new behaviours were developed, like playing outside, walking to school, not spending a lot of time playing video games and interacting with the rest of the family members. The new behaviours raised a screen awareness consciousness in most of the participants, and they also reported to have influenced some of their peers. Social norms were also found to change participants' behaviour in both positive and negative ways and consequently resulted in a lack of engagement in some participants. These issues gravitate around FOMO, lack of parental influences, and desire for interpersonal attachments.

As participants in the Inert group discussed their lack of motivation in relation to external influences, they also expressed a lack of social support which contributed to their amotivation. Benefits to health were seldom mentioned within this group, meaning that any discourse attempting to motivate the said group will need to go beyond the long-term health benefits associated with exercising. For any behaviour change intervention to successfully achieve its aim, behaviour change taxonomy such as goal setting, feedback and monitoring must be incorporated into the intervention design (Abrahamse *et al.*, 2007). The intervention evaluated in this thesis incorporated these elements into the behaviour change taxonomy and considered the determinants of the participants' behaviour. The semi-structured interviews and the mid-intervention surveys provided a detailed correlation of the exercise behaviours, and this highlighted the evidence for the actual behaviours. Overall, the psychosocial determinants were relevant in providing a myriad of motivational influences and showing how they affected the participants' behaviour in different ways. With a better understanding of the participant behaviour, it was possible to create behaviour archetype descriptions with characteristics for each

construct. These could be adopted by future interventions for people in this demographic and particularly for participants such as the *Inert* group (group 2).

Chapter 9 Domestic User Study Evaluation – The Behaviour habitualisation model

9.1 Introduction

As established in the literature review, increasing ST has resulted in depriving children of both social and cognitive learning, with limited time to engage in PA as well as unstructured play. For most parents, the advancements in technology represent both promising benefits in terms of learning and potential harm to their children. This chapter discusses the drivers of the habitualisation process and how design-led intervention was effective in instigating new behaviours. It also uncovers how the intervention provided parents, who felt ill-equipped, with a tool to manage children's ST. The content of this chapter also focuses on the distinction between different dimensions and how these classifications instigated and contributed to maintaining new behaviour changes. Such classification is essential when creating a toolkit for future designers, incorporating key functions to ensure behaviour is instigated and regulated, rather than forced.

The evidence presented in Chapter 8 demonstrated that design could play an important role in improving home exercise behaviours by indicating some key determinants of these behaviour changes. This chapter presents two and three-dimensional models and how people gained control over their decisions at different stages. The intervention presented in this thesis is discussed in relation to effectiveness and functionality in a broader setting. This chapter also discusses the processes of habit formation through design-led intervention in the context in which the study was conducted.

9.2 Intervention evaluation in two dimensions

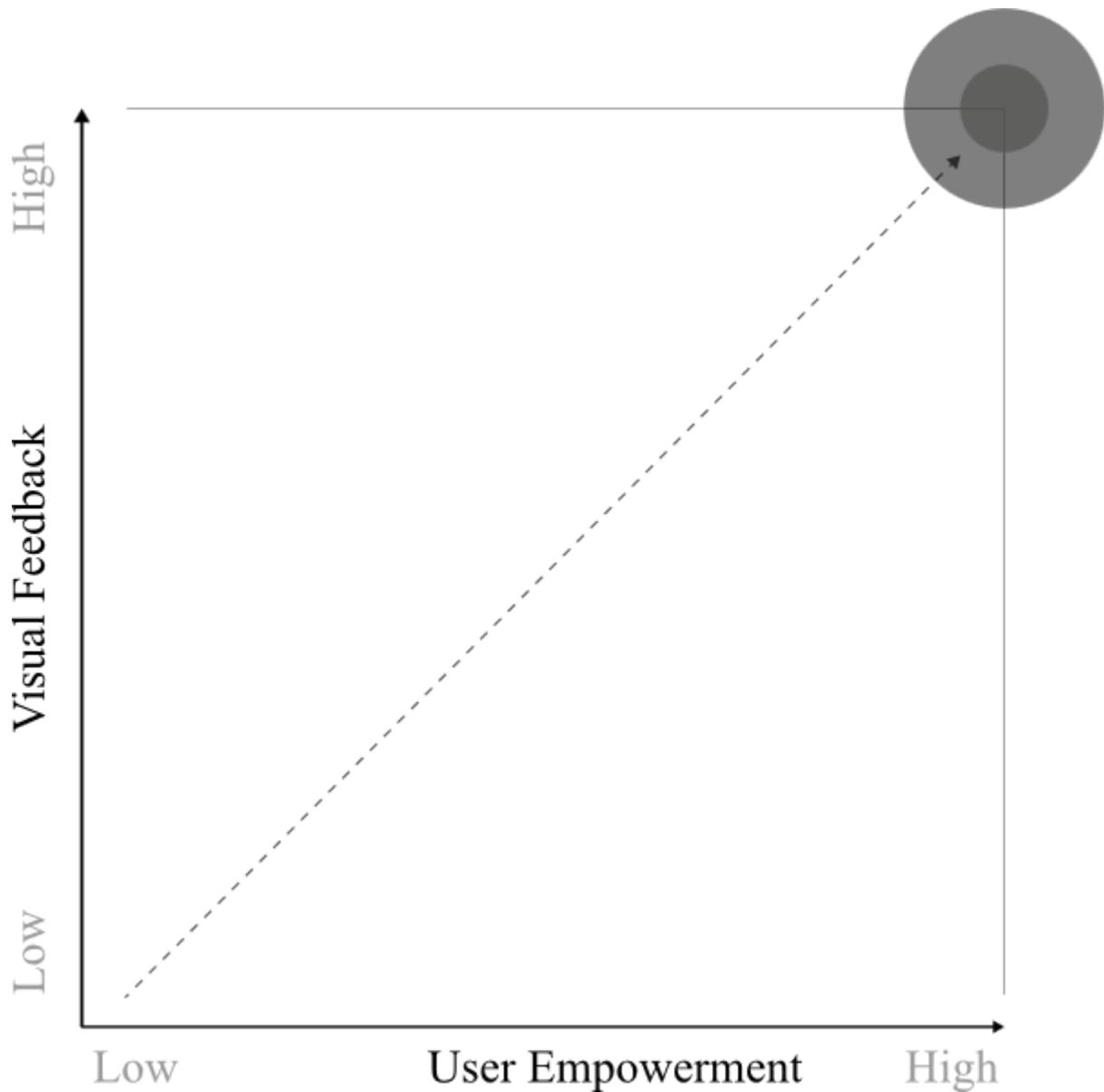


Figure 87 Behaviour habituation determinants

A blueprint theoretical framework was formulated following the literature review of this thesis, as shown in chapter 3.14.1, to explain the relationship between the explored phenomena. Behaviour change is often seen as a complex system that includes a set of interrelated concepts. Within this chapter, these are viewed in various dimensions. In most cases, these dimensions facilitate change or mitigate factors that prevent behaviour change. The dimensions shown in

Figure 87 were selected on the basis of how users interacted with the intervention. The ellipse at the upper right represents the ‘intended behaviour’ in this case, ‘exercise’. The first dimension was ‘Visual feedback’ which included the information provided on the user’s performance, identified as a motivator (encourage them to set goals on how much activity they want to do each time) or deter (e.g. difficulty accumulating more LEDs can hinder engagement) action. In this thesis, the visual feedback was in the form of white LEDs in the front of the Knudgbox, as shown in Figure 42⁴⁶. The second dimension involves ‘User empowerment’, which describes the individual’s abilities, capabilities, autonomy, and adequate support to carry out a behaviour. Empowerment is a broad term that has been at the core of the WHO’s vision of health promotion and has been well recognised in the Ottawa Charter for Health Promotion (1986). They suggest that people should be empowered to be active in promoting their health. Designers’ views on empowerment include reinforcement, enabling and helping people realise their abilities and strengths in order to attain self-sufficiency (Ladner, 2015). We often implicitly assume that behaviour results from a rational thinking process, when, in fact, evidenced by this thesis, the behaviour is strongly determined by non-rational cognition. Visual feedback delivered clear performance information to guide users’ logical decision-making by modelling empowerment (through increasing users’ autonomy and capabilities). Thus, this thesis conceptualises that the interaction between visual feedback and users’ levels of empowerment represents their decision-making. For instance, a user who lands in the lower right part of the model has high ‘user empowerment’ and still perceives the visual feedback as a reward, rather than an indication of performance. Another user, on the

⁴⁶Can be found in page 182.

other hand, might not attribute the visual feedback to a form of 'reward', but rather see the intrinsic value of exercise, thereby enhancing their feeling of self-efficacy, and placing them in the upper right-hand corner of the model. Invariably, users' attitude tends to fluctuate throughout the course of an intervention. This model supports the argument that empowering users alone is not sufficient to get people to change their behaviour if the performance indicator impact does not improve behaviour execution. These two dimensions, shown in the diagram, act as a useful path to users' behaviour change, and the next section will discuss their conceptualisation.

9.2.1 User Empowerment

From the analysis, the factors that indicate users' empowerment vary and fluctuate throughout the stages of change. The user empowerment dimension describes a mechanism of action suggesting that empowerment could either be intrapersonal or interactional. The intrapersonal components relate to one's perceived ability and the feeling of confidence about engaging in the behaviour. This is comparable to Michie and others (2011) COM-B⁴⁷ model, where they defined capability as the individual having the psychological and physical capacity to engage in the behaviour. User empowerment in this thesis is a broader concept and goes beyond increasing the individual capacity but also encompasses users' motivation and interest, as these could impact on perceived ability. This was informed by people's views towards empowerment in the DUS study, which were dynamic and varied across stages, as seen in Figure 90 Intervention evaluation by phases Figure 90. The interactional components relate to the feeling of control. Zimmerman's (1995) psychological framework suggests that, beyond having the necessary skills, an

⁴⁷ Capability, Opportunity, Motivation, Behaviour

individual requires an ability to control their actions. Thus, user empowerment, as proposed in this study expanded on the view of empowerment to be more inclusive of persistence, autonomy and control. In the same light, user empowerment relates to motivation in different ways, e.g. increasing the chances of personal initiation and persistence to repeat the behaviour by setting goals continuously.

Empowerment has been utilised by a variety of ‘theorists’ including Deci and Ryan (1985) in their cognitive model SDT⁴⁸. They argue that choice is an autonomous, self-determined action and is salient in people’s decision-making processes. Therefore, the ability for one to have a sense of personal agency was found to be associated with an increase in motivation and interest. This was mainly observed when the participant initiated their own goals: they presumably felt more self-determined to change their behaviour. *“I went on the bike most days straight after I came home because I knew I needed to get that out of the way before watching TV”* (P,17). In the same way that user empowerment is highly associated with motivation, lack of personal agency may be subsumed as being directly associated with self-control leading to lack of engagement.

The lesson learnt from the DUS is that sometimes behaviour change can be authoritarian and very often neglect the individual’s perception of what they deem to be necessary. The use of a design-led approach could be argued to have been limited by its failure to offer more choice-making opportunities. Although as seen in the behaviour archetypes presented in Figure 63⁴⁹, individual experiences of empowerment may differ, and the stage at which they feel empowered will determine their attitude towards the behaviour. Therefore, from a health promotion

⁴⁸ Self Determination Theory

⁴⁹ Can be found in page 228.

stance, this thesis adds value to the interconnection between user empowerment and motivation, providing reasons why giving individuals greater control can increase their chances of achieving sustainable behaviour. The next section discusses how visual feedback intersects with the dimension of user empowerment through the habituation process.

9.2.2 Visual Feedback

Researchers looking at changing behaviour or pursuing other intervention-related studies share a common understanding of the impact of feedback. The particularities of different types of feedback, such as eco-feedback between product and user, have been extensively discussed (Lilley, 2009). Her studies highlight different categories of eco-feedback such as the relationship between the product and the user, the type of product, the context in which the product is used, and the ecological impact of product use. As this thesis was implemented as a DfSB strategy, the DUS sought to attribute the differential effects that visual feedback had on user engagement, of which motivation was one. In the health-behaviour domain, Feedback Intervention Theory (FIT) has been used to explain the differential effects of feedback on performance and motivation (Kluger and Denisi, 1996). Feedback can compare, evaluate and indicate an attitudinal reaction. Most participants found receiving feedback to be daunting and challenging, while others were able to control how they perceived this feedback, leading to positive attitudes and behaviours. This thesis, therefore, acknowledges that the provision of visual feedback is not sufficient to increase motivation or encourage action. How feedback influences behaviour are complex and require further research in order to be understood. FIT assumes that behaviour can be regulated when the feedback provided can be compared with the goals set. During the early stages of the DUS, the visual feedback provided

consequences of instigated behaviour change and progressed to self-regulatory stages for many. Shin (2019) argues that feedback should also account for the function of feedforward, as it empowers users to make more responsible decisions and set goals simultaneously. The style of feedback plays a crucial role in aiding human performance regulation. In the pilot study, the participants perceived feedback to be focused on the task of filling up the LEDs. The pilot only lasted for 4 weeks; hence it can be argued that there was insufficient time for the participants to utilise this feedback information in order to improve their performance of set goals in the longer-term. At the later stages of the DUS, visual feedback led to subconscious behaviour change, which led to the incremental effort. This has been argued by scholars, who suggests that this encourages users to maintain this established effort (Bandura, 1990). Looking at the habituation process shown in Figure 90, visual feedback is also mostly aligned with opportunities rather than challenges, which suggests that this dimension impacts on recipient reaction to stimuli; notwithstanding, this also had an adverse effect on behaviour. For instance, one participant felt that the activity was too difficult for them, struggled to set goals, and expressed a lack of motivation; they decided to abort their activity mid-way constantly. The participant perceived the visual feedback as a task-motivation process, which resulted in feedback-discrepancy; their decision to abort the activity represented a risky way of dealing with feedback. Ilgen and Davis (2000) suggest that challenges such as this, which result in negative feedback, may also lead to purposive thinking. The results from negative feedback contrasted in this study led to an observed attitude which was a shift in choice of activity. Some of these were engagement in other types of behaviours, such as interacting with family members,

or participating in other activities that did not involve screens. Thus, in most cases visual feedback discouraged the user rather than encouraged them.

According to Darby (2008), the feedback has shifted from performance indication tool to contributing to “body of tacit knowledge tool”. Visual feedback, as seen in this thesis, contributed to modification and habitualisation of exercise behaviours. Just as authors like Lilley, (2009) and Wever, and others (2008) added eco-feedback to the array of strategies product designers should adopt in inducing sustainable energy behaviour, this thesis suggests that visual feedback shapes habitualisation when applying a design-led intervention in the domain of health behaviour. This study contributes to the body of knowledge by demonstrating that visual feedback can disrupt the automatic execution of behaviours in other word, support in breaking old habits. Also, the longitudinal analysis, which compared individual changes at different phases, provides rich descriptive information about how the interdependency of these two dimensions presented opportunities for conscious scrutiny in some cases, while leading to enduring behaviour change in others.

9.3 Reflection on the intervention opportunities and challenges

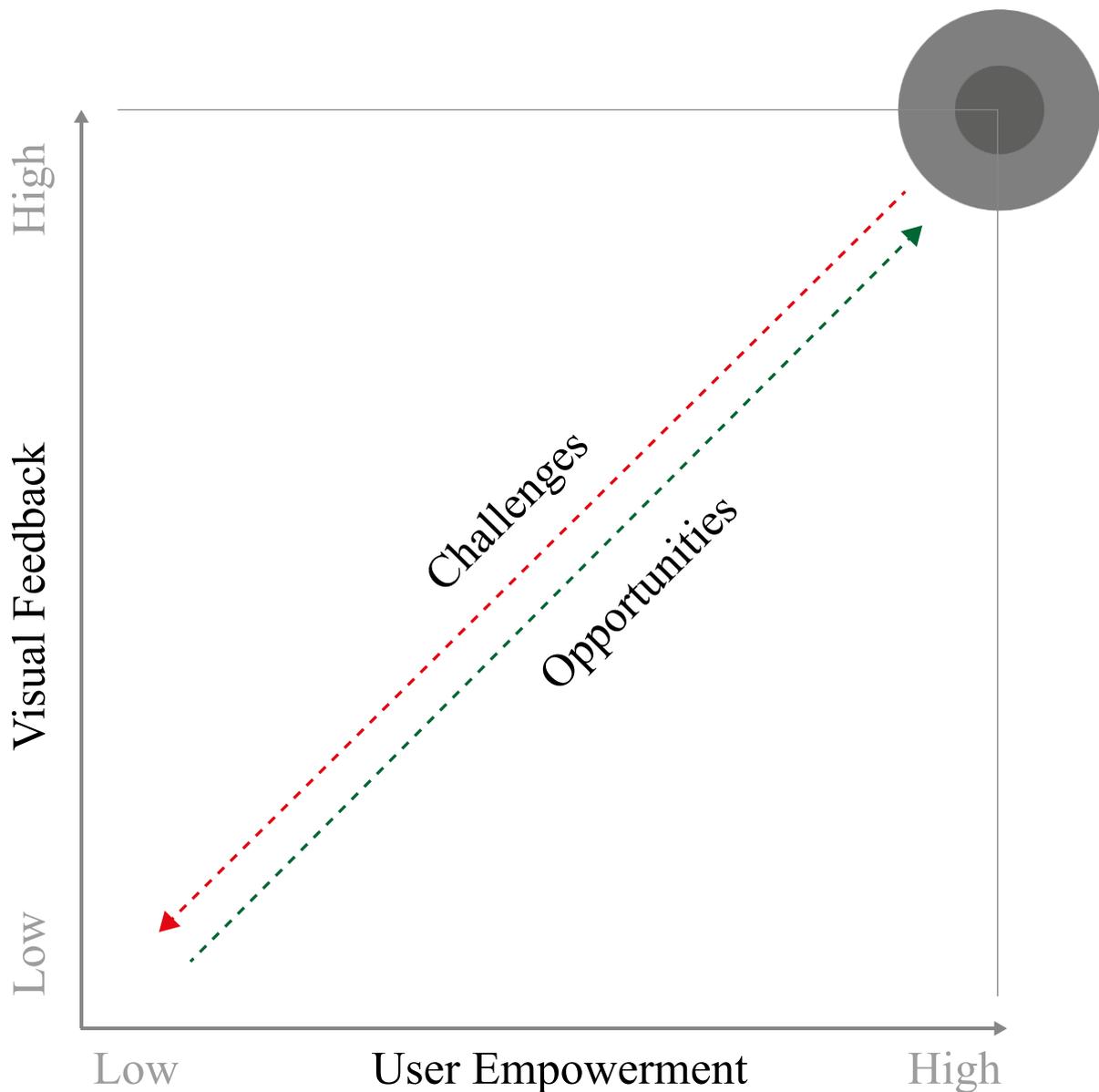


Figure 88 Identifying challenges and opportunities related to the behaviour change process

This section of the thesis reinforces the challenges and opportunities users encounter in order to reach the ellipse point shown in Figure 88. During the thematic analysis, various mechanisms of action of both user empowerment and visual feedback were identified. The premise was that people's behaviour change would shift over time, depending on whether they felt empowered or whether the visual feedback was having an impact on both dimensions together to create a more

substantial impact. Some of them indicated challenges, while others showed areas of opportunity. The concept of empowering users in the bid to motivate them has been widely discussed by behaviour researchers. The assumption is that temporal processes, via feedback loops, will release the implicit knowledge and motivation the user needs to feel empowered to engage in the behaviour. The current intervention deployed in this thesis treated change as a process rather than an event. TTM is one model that illustrates the entire change cycle and stages in which people go through before experiencing a relapse. The borders between the stages of change in TTM are defined by time, and the theory argues that it will take approximately six months for an individual to attain the maintenance stage.

In contrast, the value of the proposed model lies in its ability to segment the challenges and opportunities that contribute to the individual's change process. The impact of visual feedback implies that the user maximises the information provided about their performance to change their behaviour. Further to this, the user begins to understand the impact of their behaviour through the feedback provided, thereby building on their empowerment. The interdependency of these dimensions can range along a continuum where, at the lower end, the user feels less empowered and visual feedback has minimal impact, resulting in limited decision-making capability. At the higher end, engagement is characterised by the shared effects of both visual feedback and empowerment, with the user fully involved in their decision-making. The multiple factors affecting these decisions, whilst progressing on the continuum, have been categorised as either a challenge or an opportunity. As an example, an opportunity was an instance where a participant was motivated to engage in exercise and used the visual feedback as an indication always to increase their daily exercise. In another case, a participant was equally interested in

exercising, but struggled with the incremental speed of the LED (visual feedback); this impacted on their motivation and level of empowerment and was therefore identified as a challenge. This resulted in emphasising on the interrelatedness of these dimensions and will stage-match the challenges and opportunities identified in the current study in the latter part of this chapter. The next section will discuss the utility of regulation in the habitualisation process.

9.4 Regulation

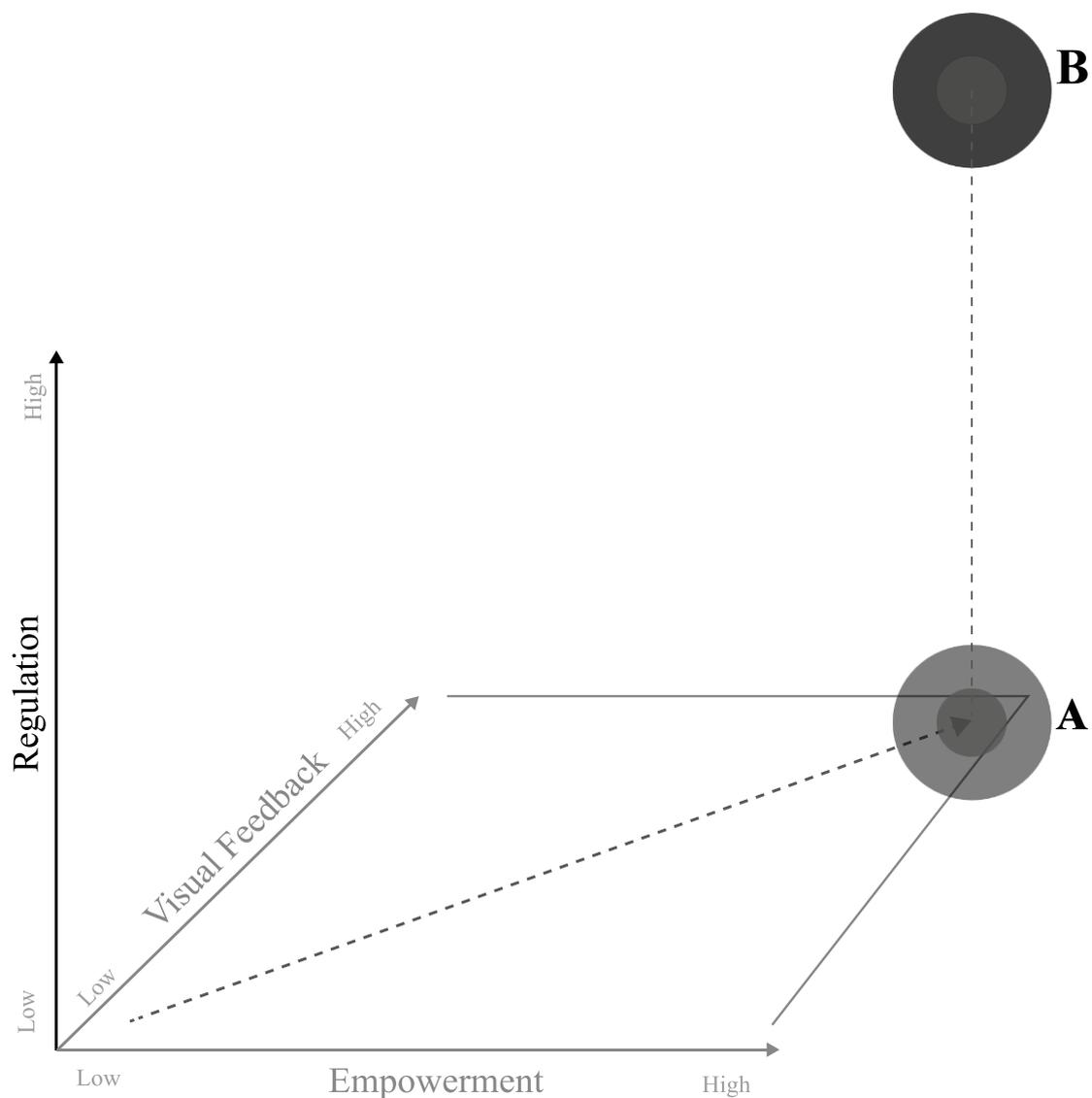


Figure 89 Behaviour habitualisation model

In this thesis, habit was not merely measured by the consistency of the behaviour engagement over time, but also by the user's ability to resist going back to the old routine, which implies that they are regulating the new behaviour. In other words, behavioural change should not be an attempt, but repeated actions must be reinforced to build into a habit. Figure 89 shows that the interaction between visual feedback and user empowerment will result in the user attaining point (A). Further, in the behaviour change process, the user attains point (B) when behaviour is regulated. Thus, behavioural regulation in this thesis is defined by the ability of a participant to control and manage their new behaviour, as indicated by the (B) ellipse in the diagram shown in Figure 89. It is important to emphasise that the model presented above is a concept and has been developed to help understand user behaviour when seeking to attain 'habitualisation'. Drawing from the literature on habit discussed in chapter 3.5, the definition of habitualisation in this thesis is, 'the final phase of the change process whereby people no longer evaluate the relative costs of their behaviour; therefore, can regulate and sustain their behaviour in the absence of cues'.

In current literature, this is very often referred to as "self-regulation". Schwarzer (1999) argued that self-regulation is a generic term that includes promotion and prevention of specific health behaviours when posed with a health threat. Regulation here suggests that a person with high optimism may fall prey to discontinuing their new behaviour when posed with preventive behaviours such as distraction, antecedents and other external influences. Models like Ajzen's (1991) TPB have shown that past behaviours are still strong predictors of future behaviour. Thus, in this habitualisation process, the behaviour patterns are expected to be performed automatically, without being mediated by past behaviours. During the

DUS, antecedents were seen to mediate the behaviour of some participants. This was related to low perceived ability, whereby a person's belief in themselves influenced their behaviour negatively. This was evidenced in Bandura's (1990) self-efficacy, which posits that when people fall short of attaining a certain goal, self-efficacious people increase their efforts, whilst others withdraw. In this thesis, the self-doubters expressed a lack of psychological control, which undermines their autonomy and self-confidence, contributing to their feelings of inadequacy. This was seen to inhibit behaviour initiation and maintenance, as seen in the results presented in Chapter 8.

The representation of the regulation dimension in the habitualisation process can be described as having a triadic pattern which involves the environment, the individual, and the behaviour. These patterns were identified through the empirical data generated throughout this study. In current literature, some challenges presented within self-regulatory approaches are: how to set goals, plans to pursue these goals and decisions around continuing or abandoning these goals (Fujita, 2011). This explains how regulation as a dimension differs in this thesis, as it focuses on the processes involved in adhering to the newly formed behaviour, with strategies to shield the individual from relapsing into past behaviours.

This thesis, suggests that visual feedback and user empowerment are not sufficient to change behaviour; therefore, regulatory strategies are required when the habit is formed in order to maintain the behaviour. The results presented in Chapter 8 show that at least half of the participants consistently performed the exercise behaviour post-intervention, indicating 'regulation' as the underpinning principle of the habitualisation process. Meanwhile, other studies have reported low levels of habitualisation. In one study that followed participants' habit formation for different

behaviours for 12 weeks, patterns of behaviour were measured, and participants had the intention to make some of their behaviours habitual: for instance, eat/drink healthily and exercise more (Lally *et al.*, 2010). The current study can be said to have actualised shifting participants' behaviour from initiation level to habit status, from the data shown in Chapter 8.

On the other hand, performing a behaviour in response to the same cue is argued to reduce the chances of attaining habit status (Wood and Neal, 2007). Following this constraint, the DUS assumed that the specificity of cues was instrumental in behaviour maintenance until the Knudgbox was removed at the end of the intervention. The continuation of the behaviour post-intervention demonstrated that specificity of cues is not instrumental when an individual decides to regulate their new behaviour. It is important to ensure that behavioural regulation is prioritised when desiring habitualisation, as the current study found that participants who regulated their habit were more successful at sustaining their new habit. Other social-psychological approaches that discuss changing habitual behaviours, such as Bandura's Mastery modelling (Bandura, 1961), stress the importance of situational cues. Bandura argued that practising behaviour cues repeatedly over time will prompt 'reflex responses', such that these rehearsed reflexes are encountered without situational cues; the automatic response would be circumventing habitual behaviours. This is also consistent with his social cognitive theory, where he described goal setting as an essential skill for "self-directed change" (Bandura, 1991). Thus, in the current study, when the situational cue (the Knudgbox) was removed, the rehearsal of the behaviour prepared the individuals whose response had become habitual. Mastery modelling also relates strongly to the concept of increased self-efficacy, which 'empowers' the individual to be more willing to

maintain their new behaviour and limit their capacity for deliberation. The proposed model in this thesis emphasises habituation, and the diagram shown in Figure 89 suggests how visual feedback and user empowerment represent different paths to behaviour repetition, indicating that behaviour regulation is key when it comes to habituation.

9.5 Unpacking the behaviour change process in relation to the DUS

Some major defining characteristics of a theory is that it presents a set of interrelated propositions, with explanations of the relationships between the stipulated concepts, and can predict the future occurrence of the event when applied in a given domain. According to Wacker (1998), a theory depicts a clear relationship of how the interrelated proposed concepts of variables predict a specific event. Models, on the other hand, have an inherent limit to how they can be applied in understanding user behaviour. As a result, having put all the elements that predicted participant behaviour together in the context of this thesis, the model presented in Figure 89 explains the logical justification of the concepts that influence behaviour when applying a design-led approach. The relationship between these features or variables is supported by empirical findings gathered in this study. This thesis was designed to instigate exercise behaviour with an emphasis on behaviour maintenance. Therefore, it is fundamental to review how these dimensions evidenced behavioural changes through the different phases of the intervention.

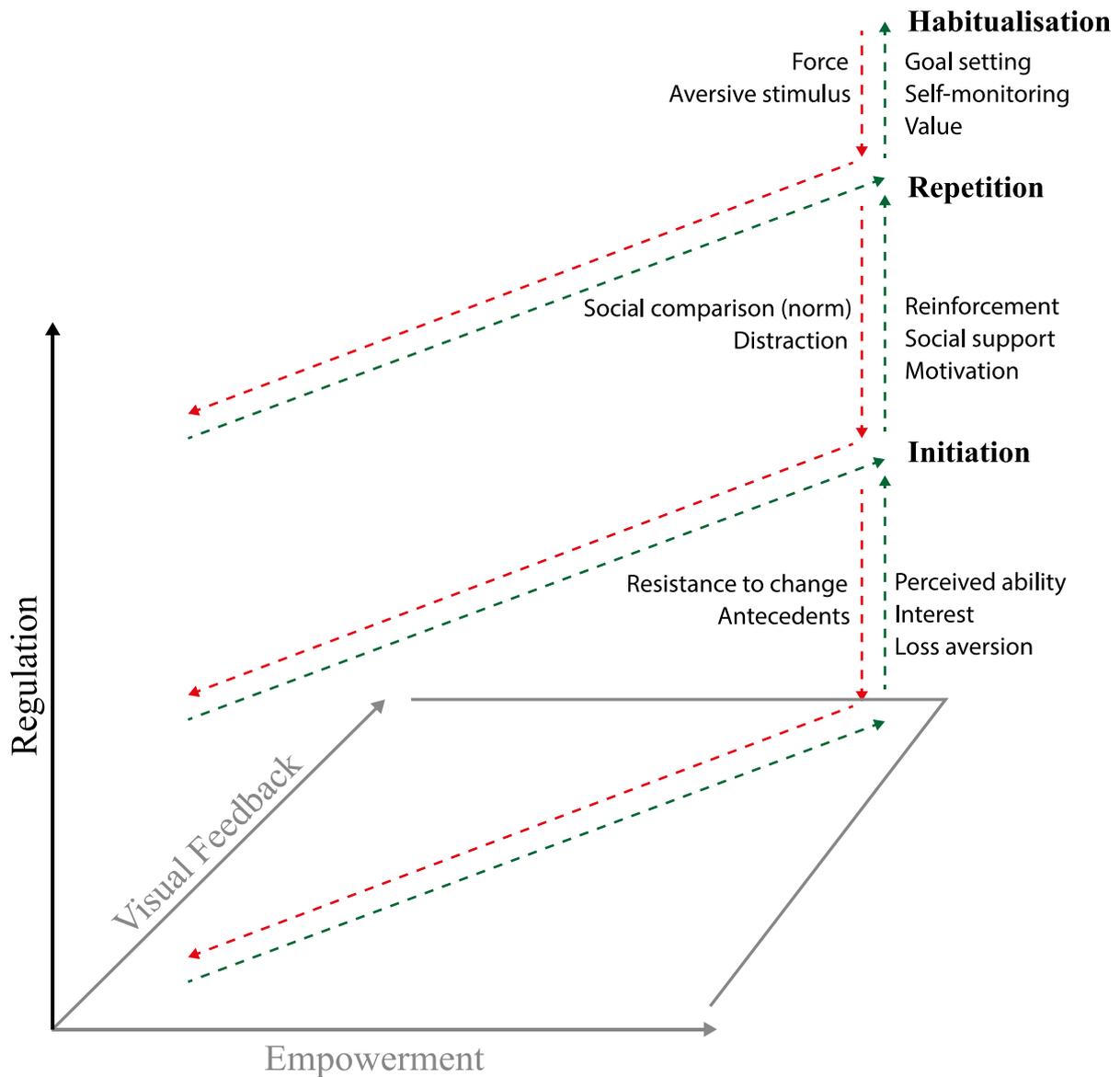


Figure 90 Intervention evaluation by phases

As models have been argued to be applicable in specific contexts, especially in the context in which they were derived, Figure 90 unpacks the different phases where behaviour change is likely to have taken place during the intervention deployed in this thesis. It also highlights the opportunities that facilitated these changes, as well as challenges that had negative impacts on participant action. The discussion in the following sections will provide valuable insights into how and why improving these elements could lead to greater impacts from changing behaviour through design. It elaborates upon the interdependency of these dimensions.

9.5.1 Phase 1 (Behaviour initiation)

Behaviour initiation, in the context of this thesis, is categorised as the first 5 weeks of the DUS⁵⁰ (when the majority of the participants manifested significant change). This stage is seen as significant because it is when people embark on a continuous effort to change their behaviour. In habit formation, the absence of old cues has the effect of providing a window of opportunity for new behaviours to be implemented (Carden and Wood, 2018). In the case of this thesis, there were less chances of eliminating the old cues, mainly because there was an understanding of the importance of children's technological engagement. Therefore, the successful performance of the desired behaviour (exercising and using less ST) served as a clear indication that there was a favourable response from the participant at this stage.

While behaviour adoption is essential for behaviour implementation, some researchers aiming to change behaviour through technology have used models such as TAM⁵¹ to explore initial behaviour acceptance (Thong, Hong and Tam, 2006). As mentioned before, the perceived ability played an imperative role during this stage. While this study used an instrument as central stimuli to instigate a new behaviour, technology acceptance must be situated with ease of use to, therefore, bring success in behavioural initialisation.

The initiation stage is when the users have taken the decision to engage in the exercise behaviour (by consenting to participate in the study) and also encompasses how their initial interaction with the Knudgbox creates a pathway for this new behaviour.

⁵⁰ Domestic User Study

⁵¹ Technology acceptance model

At the behaviour initiation stage, it was observed that most participants would say yes to doing something but still take shortcuts, although this has been argued to be more related to people's rational of choice based on how the options were presented (Lockton *et al.*, 2010). Overall, this could encompass their motivation to perform the behaviour (or not) and how much value they assign to their performance or the heuristics of mental shortcuts people apply in making decisions. This contrasts with the idea that people consider the full implications of the behaviour before initiating it. The participants, being children, were not led by Herbert Simon's *bounded rationality*⁵².

Habit formation theories predict that habitual behaviours are likely to remain stable over time (Rothman *et al.*, 2009). Amongst the behaviour determinants, Figure 89 demonstrates that perceived ability, interest and loss aversion are some of the key drivers of behaviour initiation.

9.5.1.1 Opportunities

- **Perceived ability** – This was drawn from Bandura's self-efficacy, as shown in Chapter 3. Bandura advocates that people can successfully execute the required behaviour when they feel competent in their abilities. In this thesis, this was influential, as participants needed physical abilities as well as general competence to perform the behaviour. This is associated with visual feedback, because the participants in this study suggested that the feedback provided an opportunity for them to improve, thereby improving their feelings of self-efficacy. Evaluative visual feedback was also influential in empowering users, on the premise that their subsequent performance would

⁵² Rationality is bounded due to the limits to human thinking capacity, available information and time (Simon, 1982).

be better. Perceived ability determined both ‘participants’ initiation and continuation, and was a dynamic determinant throughout the intervention. It also predicted how long people would sustain the behaviour, as everyone has perceived ability, just at different levels. Although those participants still initiated the behaviour, their lack of maintenance was determined by low satisfaction in the behaviour outcome. This was tagged as an opportunity because from the analysis it was apparent that perceived ability can be acquired through vicarious experiences, even though it was not a good indicator to predict whether people would consistently repeat the behaviour.

- **Interest** – Patterns of behaviour at the initiation stage relating to interest indicate that this is mostly linked to user empowerment and is different from motivation. For instance, someone might be interested in the idea of exercising to lose weight, but not motivated to do the required amount of exercise. Interest in relation to user empowerment identifies to be a strong opportunity as it promotes the ability for autonomy. From the participants’ perspective, fun=interest, therefore, sustaining the interest can be challenging. However, the design-led intervention has great potential as the visual feedback allows users to interact with the intervention, thereby making it fun to do. Therefore, interest is not merely a form that interacts with the user as momentary, but the form of interaction that changes as well as the type of interests that fluctuates as they build a habit. Thus, progressing from understanding the function and building competence (perceived ability), ability to overcome the influence from immediate environment (control belief) and playing with others (social norm). Therefore, arousing interest is vital in intervention adoption, which in this study ultimately resulted in

participants' initial engagement with the intervention. Generally, most of the participants had a genuine interest, which positively affected their decision to initiate the behaviour. Researchers have argued that interest is considered as one of the key reasons why children and adolescents participate in physical education at school (O'Reilly, Tompkins and Gallant, 2001). Thus, to keep children engaged in future interventions aimed at changing their behaviour, designers must incorporate elements that spark the user's interest.

- **Loss aversion** – This phenomenon states that ‘people are more sensitive to losses than gains. This driver is strongly related to visual feedback and was a vital determinant of the participants’ behaviour. As most participants associated their excess screen engagement with the fear of not wanting to miss out, engaging in the new behaviour had the potential to impact on this. Thus, visual feedback aided participants’ engagement, as they used the performance indicator as a yardstick to engage in just enough exercise to keep their usual ST. For instance, Figure 45 illustrates that exercise engagement was high in Group 1, with significantly higher records for *Participant 1*. Their initial motivation to exercise more was impacted by their focus on avoiding the loss of ST. Loss aversion is synonymous with how most people make their choices. However, it can also be argued that, as this participant progressed, their choice was framed by health gains rather than their heightened fear of missing out on ST. Feedback, in general, increases the awareness of behaviours and is expected to transcend into behaviour automaticity.

9.5.1.2 Challenges

- **Resistance to change** – The idea of this determinant is related to both visual feedback and user empowerment. The visual feedback was delivered in the form of the LED lights, which indicated user performance. Resistance to change stems from the beliefs that the activity is complex, unfamiliar, and the performance indicator does not enhance change. This challenge showed that, when people are faced with change, there is stimuli reaction for them to react to these expected changes, due to them being accustomed to their usual habits. Often, the visual feedback had minimal impact and was a negative influence on behaviour; thus, the users did not feel empowered. To overcome this in future interventions, using a similar deployment tool, a recalibration feature on the device might be useful to ease their level of competence and to minimise the chances of aborting the activity. Facilitation and support from peers and their subjective norm might also help decrease the complexity of these re-act stimuli, in order to increase their perceived ability thereby, moving them up the spectrum of empowerment on the two dimensions.
- **Antecedents** – Although the resistance was also promoted by antecedent behaviours such as spending 8 hours a day playing video games and having to cut back on that, as described in Chapter 8, most participants got into the routine due to the LED feedback indicating their performance. Antecedents are mostly negative constraints relating to old habits that prevented people from exercising. This factor can lower behaviour initiation strength by reducing the interest factor. Gifford (2011) suggests that antecedents could be influenced by either external or internal constraints. During the DUS, the antecedents impacted on the participants' feelings of empowerment as it

influenced their deliberation on whether they had the ability to engage in the target behaviour. This also relates to visual feedback, as the performance indicator mediated their psychological process and was described by some as ‘irritatingly persistent’, thus visual feedback deterred engagement. Therefore, future implementation of this intervention should focus on reinforcing these variables that have distal effects over behaviour initiation. This can be done by providing opportunities for the user to feel in control, causing them to maximise the feedback information, leading to clear user understanding of behaviour consequences that can avail in regulating, or at least planning, their behaviour.

9.5.2 Phase 2 (Repetition stage)

The repetition stage is categorised as the period in which the participant has progressed to routinising the behaviour, from week 5 onwards. Once the participants had routinely performed the desired behaviour, the next phase of the behavioural process was repetition. The intervention was a challenge to many of the participants, based on the general evaluation. This phase was mostly characterised by a tension between strengthening their ability and increasing their motivation to enact this new behaviour repeatedly. This study was intended to instigate a new habitual exercise behaviour, causing participants to behave without conscious intent, which relates to the concept of habituation. Thus, this stage is a crucial period where most users strive to gain a sense of mastery over the new behaviour. The length of time people remain in this phase will need to be studied further, as it could vary across domains, and for this thesis, it varied across participants. The expected gain of this intervention was a slow decrease in unwanted behaviour, considering the culture around general media use and how it affects children’s

interest in other activities that do not involve screens. The intervention was set in a way that included parental vigilance for safety and motivational purposes. It is important also to mention that people's transitioning out of this phase occurred when they reached a level of mastery over their new behaviour and were mostly able to regulate this behaviour with minimal conscious effort. Below are some of the opportunities and challenges identified from the DUS:

9.5.2.1 Opportunities

- **Reinforcement** – Reinforcement can either be positive or negative and increases the likelihood of the behaviour. This determinant relates closely to the visual feedback dimension and is the stimulus that determines the outcome of the behaviour when there is a preceding antecedent stimulus. The visual feedback providing the information on their performance means that the tendency for the participants to engage in the behaviour will be determined by reinforcement. Also, when a person is duly reinforced, their feeling of empowerment increases, leading to them exhibiting a sense of personal control, and their behaviours accordingly exert these controls. Reinforcement in this thesis is different from social support, which will be discussed next. Reinforcement in this context was viewed as an opportunity considering its link to the intended behaviour and consequence; when a user exercises, they get access to ST and vice versa. It is stimulus-dependent, which can either be internal or external. The Knudgbox served as an external stimulus, and one could argue that the presence of this tool was a reinforcer in itself to encourage behaviour change. For instance, a participant gets no access to ST when he does not exercise; he then no longer uses ST without having exercised. No access to ST, and together with the feeling of loss

aversion (worry of losing) is a positive reinforcement facilitated by the tool to enhance this behaviour; the mechanism by which the desired behaviour occurs represents a progressive 'feeling of control'. The participant's continuous engagement will be improved by their attitude and goal-directed actions.

- **Social support** – This describes the supportive actions of the members of an individual's social network (family and peers). Amongst many other factors, it was apparent that the presence of facilitating conditions such as social support either encouraged or constrained behavioural choice. Specifically, it has been hypothesised that parental support may promote behaviour activation (Whittaker *et al.*, 2019). As an example, in this thesis, parents helped the participants breakthrough challenging periods by either exercising with them or acting as enablers, and this was impactful in their change efforts. Facilitation of these networks is related to the user empowerment dimension, as participants who indicated having received external support were more likely to repeat the behaviour, thereby increasing their feeling of empowerment. The social support, in most cases, parents, was also able to monitor any relapse, thus aiding behavioural reactivation.
- **Motivation** – People's motivation for changing their behaviour has traditionally been considered a key determinant in both initiation and repetition of behaviour to form a pattern. Motivation has a similar interpersonal relationship with empowerment, according to Shin and Bull (2019). They argue that when you are highly empowered, you will be highly motivated. However, this study implies that being motivated does not necessarily indicate high empowerment, but does have an interdependency

with the impact of feedback, which will lead to increased feelings of empowerment. External motivation links to when the participant uses the LED indicator as an ‘imposed reward’ for their engagement, while intrinsic motivation is when the feedback indicator is only used as information to track their own progress. Deci & Ryan (1985) have asserted that behaviour is likely to be maintained over time if it is intrinsically driven. Therefore, this study suggests that motivation is a wider concept analysed at a mostly individual level. Motivation is mainly needed at the initiation and repetition stages of behaviour change due to its focus on self-determination and autonomy. The benefit of intrinsic motivation is the autonomy of controlling their behaviour and is less reliant on external reinforcement. When examined with the three-phase evaluation of behaviour change process, it appeared that motivation is differentially observed mostly within the first two phases. At the initiation stage, participants focused more on outcomes they expected; this progressed to future outcomes during the repetition stage. Participants whose behaviour reflected autonomous decision making at the repetition phase suggested having improved on their competence which was evidenced in their regular participation.

9.5.2.2 Challenges

- **Social comparison (norm)** – This was one of the objective constraints, as it was an external factor that prevented the behaviour from occurring at this phase. From the thematic analysis, there was a tendency for participants to appraise themselves concerning the opinions of their social network. Thus, this variable notably relates to the challenges of ‘agency’ and ‘control’ beyond individuals’ influence. Missing out of playing video games with

friends was popularly mentioned as one of the difficulties that impacted on their ability to change their behaviour. While the social comparison may not be as nuanced as social support, it undoubtedly indicates that people's decision making is affected by interactions in their social systems and these interpersonal processes inhibit behaviour. It relates more to the dimension of visual feedback, as an unfavourable social comparison (participants feeling demotivated) which is triggered by reception of performance feedback.

There are dimensions to the social comparison, which may be a positive way of supporting behaviour change. The pilot study revealed that social comparison might not all be negative, as was seen in the form of 'competition', where the participants gauged their engagement against other participants. The downstream behavioural effects of social comparison should be assessed in future interventions as this efficacious tailoring may provide opportunities to maximise the effect of this determinant. To reverse the value of social comparison, future interventions should encourage people to use their social group as facilitators to promote a competitive attitude. There could be the potential to explicitly reward users who perform better, thereby encouraging others.

- **Distraction** – This is related to diverted attention from the behaviour after a given period. It is imperative to say that transitioning through this phase was tough, as behavioural regulation was seen as a challenge. Considering these constraints faced during the intervention, some participants were unable to sustain the focus of their new behaviour failed to progress to the habituation stage. This would also be related to social norm; if many peripherals are not being supportive, such as sister or brother not doing the

same or encouraging the behaviour, then this will distract the participant. It also relates to the surroundings that impede an individual's action, thereby justifying that intended behaviour is not needed. This was a real challenge, and more research will be needed into how to make users indistractable from some of these triggers to reduce relapse.

9.5.3 Phase 3 (Habitualisation stage)

The habitualisation stage in this thesis is the suggested average modelled time it takes to reach automaticity (66 days) in the habit formation process; in the case of this thesis, 9 weeks to the post-intervention stage. This is generally characterised by the 'desire' to sustain the newly formed habit. Overall, from the results presented in Chapter 8, there was an indication that half of the participants repeated this habit over time. The results which are shown in the previous chapter also suggested that people struggled with the challenge of regulating this new behaviour. This indicated that visual feedback and user empowerment were not enough to sustain the change in behaviour over time, because, at this stage, there is a significant shift in the determinants of their behaviour. The study found that, because participants had demonstrated their ability to initiate and repeat the behaviour over time, the decision to habitualise the behaviour was related to their perceived ability and strongly associated with 'value', 'goal setting' and 'self-monitoring'. At this stage, there is little or no concern about performance evaluation (visual feedback) or high ability afforded by the new behaviour. This is not to say that people in this phase do not encounter challenges. The DUS found that most people successfully performed the desired behaviour, but for them to fully habitualise the behaviour, more stimulus was needed. Little empirical evidence was found in the literature about habit stability when it comes to behaviour change, as most people tend to adopt new

behaviours easily, but often fail to maintain these habits over time, especially when intervention is removed. Some researchers argue that, in behaviour change, decisions about behaviour initiation are based on the user's expected outcome, which does not relate to their behaviour maintenance (Rothman *et al.*, 2011). Gardner (2014) suggested that repetition of behaviour in the same context activates mental association, i.e. when one performs the new routine with minimal conscious thought. This study, therefore, suggests that behavioural maintenance involves people's ability to regulate this new pattern of behaviour themselves, by determining whether the new behaviour warrants continued action.

9.5.3.1 Opportunities

- **Goal setting** – Goal setting as an opportunity was mostly related to action plans, whereby participants at this phase took specific actions towards maintaining and being consistent in their new behaviour. Goal-directed behaviour relates to the visual feedback and user empowerment dimension, but leans more on regulatory systems. This is because, when the empowerment strength is high, the user is more likely to use the feedback information to manage their behaviour through goal-directed actions. An example of the goal-setting approach seen at this phase was, *“I'm going to exercise at least 3 times a week whenever I get home from school after the bike is taken away”* (P,17). This goal seems positively framed, and the psychological implication is that a participant who had the intention to set goals to maintain their new behaviour had increased chances of commitment. It is right that motivation is not required at the habitualisation stage, as the individuals are expected to have an innate desire to maintain the behaviour at this phase, irrespective of motivation. Goal difficulty might also hinder

continuation, therefore, can be reversed by encouraging intrinsically motivating goals. Thus, in the case where an individual fails to follow through with their goals, promotion of long-term sustainable goals will be useful in regulating any new behaviour.

- **Self-monitoring** – The evidence provided in this thesis shows that most participants satisfactorily performed the desired behaviour consistently after 5 weeks. Although this can be argued to have reached some degree of automaticity, habit studies suggest otherwise and that more support is needed in the longer term in order to attain a high level of automaticity (Lally *et al.*, 2010). In their study, participants were motivated to perform behaviour repeatedly, and the findings indicate how quickly most participants transitioned across phases. Results from the DUS in relation to regulatory approaches were similar and can be seen in the exercise performance of the two groups in Figure 72 and Figure 73.

The DUS was intentionally deployed as a longitudinal investigation in order to offer participants an opportunity to familiarise themselves with the intervention and build the habit slowly. Simple actions were seen at the initiation stage, such as most participants going on the bike for 10 minutes a day. Self-monitoring, as an opportunity affordance, is the extent to which participants consider the new behaviour, something that requires monitoring and how much continuous effort they commit to the behaviour. Due to the nature of the intervention, ‘filling up the LEDs in order to gain access to screen time’ raises the possibility of ‘ceiling effects’ whereby participants only challenge themselves to switch on the 16 LED lights. For instance, ‘participant 1’ ranked the highest scores in the first week, the thematic

analysis showed that those plateaus at that stage were as a result of the ‘ceiling effect’. Habit scholars consider habit to be a continuum with four distinctive stages. 1st a decision to take action; 2nd the intention to act; 3rd repetition with the same contextual cues; and 4th repetition without the same contextual cues (Lally and Gardner, 2013). This implies that they consider automaticity a strength, not an opposition. In this thesis, the extent to which these participants reached automaticity was as a result of consistency in their self-regulatory approach. Also, the data from the post-study survey suggests that this new behaviour has been self-monitored in a particular group (Figure 83) even in the absence of the same contextual cues (the Knudgbox). In addition, it is done as ‘self’, rather than social influence which evidenced that participants were building intrinsic motivation.

- **Value** – During this phase, it was apparent that people focused on what the behaviour had afforded them, which is related to ‘value’. Like attitudes, value is required for behaviour initiation; a behaviour is likely to be regulated when an individual attribute a utility value to it. Interestingly, the utility of value begins to form at the repetition stage and strengthens (no longer need to verify the value of the exercise) at the habituation stage. From the DUS results analysis, people began to form an integrated assessment of benefits associated with the new behaviour, and this value propelled them to continue. TRA⁵³ suggests that attitudes are a result of linear deliberations, similarly, seen in rational choice theory. TRA considers beliefs to be an antecedent to attitudes and that they are held with the value the individual attaches to those

⁵³ Theory of reasoned action

characteristics. However, TPB⁵⁴, which is an extension of TRA, evolved by suggesting that attitudinal factors are now only minor contributors to behaviour outcomes and continuity. As seen from the empirical findings from the DUS, values are conceptualised as broad indications of behaviour continuation. In linking value to consistency, the continuation of new behaviour indicates that value and goal setting may be considered as multi-linear, as both planning ahead and basing your actions on outcome expectations are essential in the behaviour habituation process. This study places value ahead of attitude in terms of sustaining behaviour, by suggesting that people will maintain a behaviour when they place value on it, thereby by preserving the gains associated with engaging in that behaviour.

9.5.3.2 Challenges

- **Force** – Given that the threat posed by lapse and relapse or dissatisfaction is predicted by lack of regulatory strength, the feeling of force is considered a challenge in continuous commitment to the new behaviour. In the current study, when participants had exercised to a certain level or reduced their ST, the absence of the contextual cue led them to believe they were being forced to continue this new behaviour. Also, the feeling of force may occur when there is an anticipation of a greater responsibility of behavioural control resulting in incongruent behaviours such as ‘resistance’ (throwing a tantrum). Future intervention should, therefore, focus on reinforcing a sense of control, in order to regain optimism whereby the individual reinstates their desire to maintain their behaviour. Perceived ability accounts to a small degree of ‘behaviour constraints’, as the individual’s subjective feeling of lack of

⁵⁴ Theory of planned behaviour

competence increases, this may result to behaviour constraints and the feeling of 'force'. Therefore, this suggests that the responsibility for sufficient behavioural control is placed on the individual's choice and motivation. During the DUS, some participants did not mind being forced, as they took this function positively to reinforce their competence (perceived ability). In contrast, the concept of 'force' did not enable others. However, too much force or a force that does not link with goal-motives or positive social support have a greater chance to fail.

- **Aversive stimulus** – Aversive stimulus can be described as situations where both perceived ability, goal setting, and (all relevant constructs) were omitted or was not situated appropriately, and only force element was reinforced, and as a result of a user never accepted the device. In the transition from repetition to habituation, our psychological mechanism does not respond to force or aversive stimuli (negative reinforcement). This factor was a challenge at the point when the stimulus (intervention) was taken away. Positive reinforcement increased the action of the desired behaviour, and aversive stimuli encouraged the unwanted behaviour of reverting to old habits. In future interventions, this could be countered by productively encouraging strategies that reinforce the desired behaviour, even when the contextual cues that triggered the behaviours have been removed.

9.6 Evaluation of the Knudgbox as the research instrument

The purpose of mapping out the dimensions that impacted on user behaviour was to better design an intervention that would augment the instigation of exercise behaviour. The design-led process incorporates design elements and behavioural intentions to improve user behaviour in a challenging situation. The evaluation

criteria were based on the theoretical framework developed following the literature review, as illustrated in Figure 20. The user's exact requirements may not fully align with the aim and function of the design. Therefore, interventions should not only focus on bringing effective behavioural change, but also to ensure that the changed behaviour is habitualised. From a research perspective, it is integral to evaluate the effectiveness of any identified desired behavioural outcome instigated by the design-led intervention by asking these fundamental questions:

- Did the design-led intervention help in building exercise behaviour?
- Has the user's TV watching behaviour changed as a result of the design-led intervention?
- 'Design for sustainable behaviour'. Has Knudgbox created habitualised sustainable behaviour?

9.6.1 **Did the design-led intervention help in building exercise behaviour?**

This question pertains to an evaluation of design-led in instigating exercise behaviour. By the end of the DUS, the average exercise record for most participants was 3 days a week, which was more than the self-report data pre-intervention. Thus, the question of whether the device functioned as intended in encouraging users to exercise is leaning more towards the affirmative. The evidence shown in Chapter 8 indicates the emergence of two distinct groups representing different kinds of behaviour pattern. *Responsive* group (group 1) showed a consistent habitualisation of exercise behaviour amounting to an overall average of 33 minutes (see appendix 19). *Inert* group (group 2) had a lower exercise record with an overall average of 11 minutes per day. As exercise habitualisation was a primary focus of this research investigation, it is evidenced by the findings that design-led intervention instigated exercise behaviour in both groups. It is also important to note that more at least half

of the participants also continued this habit post-intervention, indicating a robust regulatory strength in managing their new behaviour.

9.6.2 Has the user's TV watching behaviour changed as a result of the design-led intervention?

The intervention resulted in a 78% TV watching reduction rate post-intervention. From the pre-intervention interview, it was seemingly evident that people underestimate how much time they spend on their screen devices. 5 out of the 20 participants underestimated how much time they spent on their screens before this intervention. For instance, on the first day of the intervention, participant 12 (parent) was asked during the interview how much time they thought their child spent watching TV per day, and they said, *"I think she spends around 3 hours"*; their actual ST⁵⁵ record using the energy monitor was 10 hours. Thus, one of the primary objectives was to reduce the amount of time users spent watching TV by replacing some of this time with exercise engagement. Accordingly, this intervention was not only intended to make participants more screen aware but also to be more conscious about switching off idle appliances when not in use, for sustainability purposes. From the researcher's observations and field notes, media and technologies are starting to erode the social fabric of interaction within society. There was a co-dependency, with the participants relying heavily on using their technological devices to keep within the communication loops of their social networks. This implied that most of them were unaware of the government recommendation regarding ST for children, as discussed in chapter 1.3. This did not stop some of the parents from attempting to control their children's ST, even though it was without success. *"I wish I could control his screen use, to be honest, I am*

⁵⁵ Screen time

mostly at work and can't regulate what he does, his mum lets him spend all his time on these devices" (P, 5 parent before intervention). The intervention revived a screen conscious attitude in most of the participants: "Honestly, I think I am better at managing my time now, especially gaming time. I and my mum also work better and fight less hahaha. But I definitely see her point now cos it was kind of difficult to think that I had to work for my screen time" (P, 12).

Unlike before, children of today no longer thrive on maintaining real-life interactions, but rather virtual connections, which explains why they spend the majority of their waking hours on these devices. *"I go straight to playing video games when I get home, and I play with the same friends I have just been with from school" (P, 18). "I have to always play games with my friends so we can talk about it the next day at school" (P, 17). "We watched our kids spend a lot of time on YouTube and realised that this platform is a primary influence on how they behave. The things they consume from the online environment have so much impact on them, and because their friends are doing the same, this norm is difficult to change" (P 1, Parent).*

With the results presented in Figure 59, users' TV watching dramatically reduced post-intervention, and this indicates the success of the intervention in supporting users to govern their actions.

The importance of this design-led intervention is in improving children's ST habit; this is essential, as they consume and navigate the world through technological devices. The design-led intervention facilitated them to rethink the time they spend on these devices and encouraged them to disconnect sometimes, even in some cases where there was no recorded exercise activity.

9.6.3 ‘Design for sustainable behaviour’. Has Knudgbox created habitualised sustainable behaviour?

The third evaluation question relates to how impactful the design-led intervention was in creating habitualise behaviour. Since the current study falls under the domain of DfSB⁵⁶, its effectiveness, therefore, contributes to this domain through the empirical evidence provided. Some of which was the findings on how some participants have successfully built a new habit which contributes to them leading a healthier lifestyle in the home.

Also, evidence provided in Chapter 8, suggests that the participants’ ST significantly reduced, and there has an instigation of exercise behaviour which has contributed to bringing change within the home environment. This was a function of the interrelatedness shown within the dimensions in Chapter 9. From the literature review, the home was identified as a place for prolonged recreational screen use. Therefore, the empirical evidence the current study provides benefits the DfSB domain by suggesting that the home is a place where healthy habits can be adopted as opposed to ubiquitous SB.

Although the design-led intervention reduced TV watching behaviour, a high percentage of parents suggested they would try to keep an eye on their children’s ST going forward, having been made aware of the associated health risks.

The implementation of the design-led intervention has been informed by theory; therefore, the sustainability of this behaviour is tenuous and instinctive and offers an opportunity to build an incremental intervention focused on behaviour change. Therefore, future interventions intending to change behaviours in different domains

⁵⁶ Design for sustainable behaviour

should consider combining the expertise of designers, social scientists and behavioural psychologists, as it is crucial to create interventions that bring about sustainable practises in many different contexts.

9.7 Summary of Chapter

This chapter presented discussions around what was learnt from this novel intervention and how this could be drawn together for the assessment of the design-led intervention. It is enshrined within the sixth objective of this thesis:

Evaluate the efficacy of design-led intervention approach in instigating exercise behaviour, and reducing TV time, highlight evidence for sustainable behaviours.

The discussions explicitly incorporate the dimensions which are shown to be significant in behaviour habitualisation, and the challenges that deter and opportunities that cohere behaviour into patterns of routine.

This chapter also indicated how these dimensions make up the habitualisation process through the implementation of the design-led intervention. These broad dimensions included user empowerment, visual feedback and regulation as the primary utility factors in attaining habit status. This chapter also presented how these dimensions were reflective at various stages of the intervention and discussed the validity of these dimensions in creating maintained behaviour. This chapter summaries that the longevity of performance of new behaviour is increased by the interaction of enhancing feedback and user empowerment, thereby resulting in repeated behaviour. There was an emphasis on regulation being a pivotal dimension to habitualisation because empowerment and feedback might lead to repetition, but to strengthen the new habit autonomy and control is essential, which was collated as

regulation. Thus, the chapter presents that the driving force behind perpetually repeating this behaviour depends on an on-going regulation of one's behaviour. Also, it was apparent that new findings that emerged as a result of this thesis, and discussions of the dimensions relating to behaviour habituation will be useful for further interventions similar to this. The behaviour habituation model highlighted the interdependency of these dimensions in creating sustainable behaviours.

Evaluation of the design-led intervention was also presented using three overarching questions. The discussions of lessons learnt from this intervention led to the conclusion that the design-led intervention was successful in generating new evidence on the patterns of behaviour change and its determinants in the studied domain. The next chapter draws from the discussion presented within this chapter and the discussion from the other chapters, to inform the general conclusion of this PhD research.

Chapter 10 Conclusion

10.1 Beginning of the end...

The commitment for this thesis was to present a nuanced approach to tackling the PIA⁵⁷ and contributing to solving the obesity crisis long term. It has provided empirical information underpinned by evidence and methods, from both design and behaviour studies to promote a multi-faceted approach within the field of PA interventions. As such, this thesis presented that there is a need for other disciplines to weigh into the conversation and provide solutions, more so from designers with an intent to bring about a behavioural change. This chapter will describe how the aim and objectives were accomplished and indicate the results that added to these conclusions. The conclusion chapter also presents the contribution to knowledge in three different areas and indicates where further research will be required.

10.2 Achievement of research aim and objectives

The overall aim of this study is to evaluate the design-led intervention that is designed to reduce sedentary behaviour in the domestic environment. The primary focus of the thesis outcome is to evaluate its effectiveness in instigating habitual physical activity whilst reducing screen time with an emphasis on sustaining this new habit. The literature review provided the knowledge that informed the ideation and development of the intervention, and this was further enhanced following the pilot testing. The knowledge produced as a result of this research indicates that setting contextual cues to break sitting time can contribute to the adaptation of new behaviours such as exercise, hence demonstrating the achievement of the overall research aim. The specified objectives were developed and provided a breakdown

⁵⁷ Physical inactivity

on achieving the overall aim. These objectives were guided through the formulation of the research questions, which were answered in the order described below.

10.3 Research questions

These research questions were answered during the course of this PhD:

RQ1 – What is the current background of research related to PA behaviour, and how does it indicate possible interventions to tackle the obesity crisis?

This research question was addressed in Chapter 2, where an initial comprehensive literature review was presented. The chapter demonstrated an overview of the obesity problem and its drivers, highlighting how PIA is one of the major contributors to this global epidemic. It also explored previous research related to obesity and inactivity interventions in general, domains in which these interventions were targeted, and presented existing challenges and opportunities. Several studies were discussed: they represented different strategies and domains that had been studied to contribute to the knowledge on how to tackle the obesity issue. These studies demonstrated the existence of a gap in the literature, where no identified study had attempted to address the issue from a design viewpoint, although there were identified studies which applied exergaming to getting children active.

RQ2 – How can behaviour change theories create pathways for developing physical activity interventions?

In order to develop an intervention to change people's exercise behaviour, it was essential to explore how designers can adapt behaviour change approaches to be incorporated into the design process. Thus, Chapter 3 and Chapter 5 answered the

second research question. Chapter three provided a detailed view of the various behaviour change theories and models which have been evaluated in changing behaviours in different domains. During this second phase of the literature review, there were specific constructs that emerged from the key theories explored, and these formed the theoretical framework that guided this thesis. These tools were implemented in the prototype development in Chapter 5, and Knudgbox was developed for testing and evaluation.

RQ3 – 3. How can longitudinal investigation identify key behavioural determinants that influences change?

The methodology chapter highlighted the relevance of adopting a longitudinal approach for the empirical study. During the literature review, it was demonstrated that most studies aimed at tackling the obesity and inactivity problem employed a cross-sectional approach, and only limited studies used a longitudinal approach. This thesis adopted a longitudinal approach on the premise that habit formation studies suggest that it takes around 66 days to form a habit. Thus, the participants investigated in this thesis were observed longitudinally for a minimum duration of 90 days. Also, data on behaviour change determinants and motivational drivers were collected at more than one-time point, which is key in any longitudinal study. The material used for data collection logged participants' behaviour consistently and repeatedly to show the behaviour curve that emerged.

RQ4 – What behavioural changes are evident as a result of the intervention?

RQ5 – What are the changes in the measured psychosocial determinants over time?

RQ6 – What are the key effects of the design-led intervention on habit formation and behavioural intention?

The DUS, which was the main empirical study for this thesis, investigated how a design-led intervention instigated participants' exercise behaviour and measured how their motivation changed over time. Chapter 7 show all possible data types that account for how behaviours were instigated, changed, maintained, or refused, using one participant's data. Chapter 8 further elaborated the overall results from all participants, which indicated how each participant changed their behaviour throughout the intervention. Data gathering during this phase comprised of participant daily exercise logs, mid intervention questionnaires and semi-structured interviews, and evaluation of each dataset to understand the changes that occurred.

The results presented here provide some evidence that the design-led intervention helped instigate new exercise behaviours and reduce overall TV watching time. This indicates that this thesis created new insights through the identification and characterisation of habitualisation trajectories in tackling the ongoing obesity crisis by suggesting how the home can be a place to make a change. This chapter concluded that designers could contribute to the field of knowledge on tackling obesity through the modification of lifestyle factors by combining acceptable behavioural approaches to create sustainable changes.

10.4 Theoretical and Methodological contribution for policy and practice

From the beginning of this PhD, there was a consistent reinforcement of the need to create new knowledge that is not only going to be readily accessible by other researchers but also creates a lasting value through its simplicity. The knowledge created as a result of this PhD study has presented the complexities in changing old

habits with demonstration of practical ways of instigating good behaviour patterns while measuring the parameters that influenced this change.

The evidence from the DUS is inconclusive regarding TV watching and its influence on childhood obesity. The studies highlighted in the literature have mostly utilised cross-sectional, randomised control trials and other approaches with limited longitudinal methods in tackling this issue. Therefore, the theoretical and methodological approaches employed in this study constitute one of the key contributions of this study to both academic practise and policy implementation. It established the feasibility of real-time measurement, laying the groundwork for future testing with larger sample size. Given the complexities involved in changing behaviour, the mechanism through which behaviour change interventions can modify and sustain behaviour has been critiqued (Connell *et al.*, 2019). This thesis contributes to the body of knowledge by providing clear evidence on how designed intervention was effective in identifying the problem of inactivity and excess screen use and designed an evaluated the solution which gives people autonomy to manage and maintain these newly adopted behaviours.

It also identified the active ingredients and the process through which change occurred (mechanism of action) through longitudinal evidence. The thesis contributes to PA, obesity and ST research by introducing fresh evidence about how capturing small to medium-sized changes in behaviour longitudinally is useful in evaluating the process of these changes.

At present, most interventions tend to pick a given theory deemed relevant in changing target behaviour. Hence, the relevance of the chosen theory is based on an individual's (or research team's) interpretation of the literature, and this may be

different from the theories other researchers apply within the same context. Thus, this thesis suggests that the selection of theories relevant in the field of behaviour change and merging the pertinent constructs within those theories could be drawn upon to generate data-driven outcomes. It also contributes to the body of knowledge through the development of a theoretical framework which was evaluated throughout the course of thesis. Therefore, through the nuanced engagement with these theories, the thesis contributes to generating a new theoretical concept to inform any future intervention aimed at changing and sustaining new behaviours. This could also be helpful for future researchers aiming to investigate similar phenomenon, to adopt this framework in understanding their concepts and building knowledge through either challenging or validating the constructs within this framework.

10.5 Contribution to Design for sustainable behaviour research

The thesis utilises a design approach to foster ST displacement which, is an entirely new direction within this field of study and the generated knowledge highlighted the key determinants that explain sustainable behaviour when implementing design-led approach. Understanding how children's exercise behaviour can be improved is a global issue, and this thesis contributes to the conversation by offering examples of how product designers can contribute to enhancing this behaviour with the potential of improving their disposition towards exercise. Other design interventions, such as exergaming, have combined exercise with entertainment. This thesis offers a new development: a design-led approach creating a more interactive and autonomous design to improve health in the home environment significantly. Crucially, this thesis demonstrates the importance of using behavioural change theories to enhance the ability of individuals to form and regulate new healthy habits. The findings from

the overall study contribute to the field of design for behaviour change, as it has provided opportunities on what is most important in the deployment of a design-led intervention. The thesis presents challenges and opportunities that stimulate the habituation process and how they can be applied in future interventions aimed at instigating sustainable behaviour. This thesis contributes to the DfSB by identifying factors that affect behaviour change and the distribution of agency divide between the user and product influence. While DfSB study lack in gathering empirical studies to enhance the theories, the data collected through the main study informed real use of the research artefact and contributed to the conversation guiding designing for behavioural change. Another key contribution to the DfSB is the development of the behaviour habituation model, which reflects the process of change and the key dimensions to reinforce when creating intervention on sustaining behaviour. The application of this model can extend to interventions aimed at influencing pro-environmental behaviours and other areas in which sustainable behaviour change is needed, as it provides the process to progress one's actions to an autonomous capacity.

10.6 Contribution to Public Health

The problem this thesis set out to address was to get children to be more active. Design-led intervention has demonstrated that we can make children healthy using this approach. This thesis provides a framework for thinking about interdisciplinary collaboration and how this can be maximised in designing for health behaviour change. Public health departments and other health agencies allocate large amounts of funds to intervene in health issues at population and community levels, which yield a varying degree of success in most cases. The UK government changed its direction after 2010 and suggested it would no longer set these targets as it was

considered too prescriptive and led to perverse incentives that encouraged negative health behaviours (Mears, 2014). It, therefore, stated three health outcome frameworks for measuring all health indicators related to health and social care, public health, NHS outcomes and adult social care outcomes framework. Within the public health domain, health outcomes were set out to be monitored at a local level using five key indicators, of which one is 'health improvement and positively promoting the adoption of 'healthy' lifestyle'. Ten years on, the adverse trend in lifestyle behaviours is likely to be responsible for the worsening health picture.

The importance of this study was to evaluate and monitor how the proposed intervention could yield intended and unintended outcomes while improving people's lifestyle behaviour (exercise). Therefore, this thesis contributes to facilitating this domain by monitoring lifestyle inequalities through health promotion in a highly ignored domain (home). The literature review established that lifestyle-related issues are contributing to the rise in diseases, thereby increasing the challenges that public health faces in the world today. The thesis also contributes to the field of public health by implementing an intervention in a setting (home) that has been ignored amongst other 'healthy settings' such as 'school' and 'workplace', as stipulated in the whole system approach according to WHO. The health setting approach builds on the principles of participation and empowerment and ignores the impact of individualistic methods to foster action. The outcome of the empirical study contributes to the body of knowledge through the combination of diverse approaches in building exercise routine into children's daily life, and by creating a supportive home environment, which is a key part of the health promotion emblem. The current study, from a health promotion perspective, has contributed to the reorientation in the strategy of how health behaviour change interventions should be

conducted going forward. Thus, the focus of health policies should not just be about the medical expenditure or scientific approach to tackling these challenges, but rather an investment in reducing the health determinants in various domains with more emphasis on the home. This includes giving people some degree of control over the state of their health to ensure healthy and longer lives.

10.7 Study strengths and limitations

There were several key strengths to this study, which will be described below. One was the ability to obtain an actual screen and exercise record every 5 minutes during the intervention exposure; this was possible with the longitudinal investigation, which helps uncover patterns over time. Also, the in-depth questioning via interviews and questionnaires enabled understanding of the underlying decision making and habit formation processes. The extensiveness of the data coding was a definite strength. Coding for the interviews was done both manually and automatically (using the NVivo software). For the numerical data, MATLAB and other statistical analysis tools (such as Excel and SPSS) were used to obtain a robust interpretation. MATLAB was an excellent tool for consolidating a considerably high volume of data. Despite having some limitations, MATLAB was effective in running multistep analysis and generating publication-ready graphics with minimal effort.

Inevitably there were some limitations to this study, such as the boundaries of the use of a design-led intervention as a strategy to motivate behaviour change. Most research which has attempted to encourage exercise behaviour has used scientific research tools, even though these studies are often framed on simple metrics and series of laboratory tests without real-world applications. Design-led intervention, on the other hand, presents evidence about how designers can contribute to what has

been classed a complex issue (obesity and inactivity) with a novel real-world approach. Even though there is a need to validate the design-led approach for human behaviour sustainability and their interrelationship, some of the results from the empirical study in this thesis indicate that design-led interventions can contribute to addressing the inactivity problem. It also addresses some issues of complex sustainability abstract to intended behaviour, such as participants switching off their technological devices when not in use. The variation in TV output was also another limitation which was identified at the prototyping stage. The attempt to overcome this limitation was to program the device to subtract the screen credit from the user accumulated log when any device was plugged in. However, this was not feasible as this would mean that if the TV was left on standby, credit would still be deducted. Although one of the new behaviour participants adopted was switching off their devices when not in use, it was still worth considering the 'human forgetful' factor, which could discourage the participants. Due to the nature of the data collection and the domain in which the study was conducted, it was difficult to decipher who went on the bike., Most of the participants reported themselves as the main user, but in minor instances, parents were pedalling the bike to test and also to motivate their children to exercise, despite being strictly guided to avoid that situation. This could have been avoided via adding additional monitoring measure, but this option was eliminated due to privacy reasons and to lessen the participation pressure. One methodological limitation is that the empirical study took a considerable amount of time and the number of participants, which is a known disadvantage of longitudinal studies. The measurement of TV watching time in cases where there were multiple devices in the household for proper use of screens, such as educational use was also one of the limitations encountered in this study.

Another key limitation was the inability to log eating habits; food intake is highly associated with obesity since this study focused on making a contribution in the domain of design research to instigate exercise behaviour changes. Logging food intake can be a whole new set of research that would provide interesting findings and may offer more ways to instigate health behaviour change.

10.8 Suggestions for future studies

While it appears as though the current research has presented within this thesis a new ground for design-led interventions, it is also certain that further research is required in order to fully explore, repeat and validate the findings presented in this study. This study, therefore, suggests that design-led intervention could also be explored in a different way to increase the potential for its applicability in various domains.

From the results presented, one recommendation includes joining forces with people in the fields of public health, psychology, and sustainability, to develop further interventions that build on the work presented in this thesis. The results and lessons from this thesis can be applied in future behaviour change interventions within the field of design and other disciplines in the following areas:

- Measuring the health and wellbeing impact of the observed behaviour changes and how this can be implemented in wider policy.
- Future studies should not only measure the health and wellbeing impact but should also consider whether the design-led intervention mediates other outcomes like morbidity/mortality.

- Further exploration and validation of the magnitude effects and the multidimensional categorisation of behaviour archetypes using the habitualisation model.
- More studies are needed to explore and criticise the habitualisation model and consider its application within other domains and to assess whether it's reliability can be applied in practice.
- Enhancement of the Knudgbox to create a more durable, reliable and portable device, able to interface with more current technology, is essential and the visual feedback loop needs to be enhanced.
- A better data capturing element is needed to reduce the need for onsite research visits for data collection.
- As this study has provided information on the change parameters, a more extensive longitudinal study (over 6 months) would be recommended to investigate whether the behaviour patterns are stable over time and possibly investigate the health and wellbeing impact.

There is an opportunity for future studies to examine the role of parents in instigating the same or similar behaviour change as attempted in this study. The study of the DUS can be extended beyond the age group recruited in this study, as obesity is not a sole problem for children but for broader citizens around the globe.

10.9 Concluding remarks

The researcher's journey through the entire PhD has been a rather insightful one. Part of the learning process was exploring and understanding human behaviour through literature, and with no prior knowledge in this field. It examined ways through which design can contribute to changing and sustaining a new habit. Nevertheless, the thorough and intuitive prototyping process, the fieldwork and

meeting several lovely families, combined with the rich empirical data gathered, has made the end of the journey rewarding. In retrospect, the entire process has been a learning curve, with so much experience and productivity improvement, and this has been gratifying and life changing. Being invited to different homes and having the opportunity to observe and document their experiences in the most fascinating way has been thrilling. The home is an important agent of socialisation within the society structure and the researcher, having been raised in a different cultural background, was keen to understand the diverse parental practises and how they absorb their role in exclusively scaffolding their children's behaviour. On the other hand, the researcher had previous limited experience in observing children, so was delighted to have picked up some tips on working with children, especially with regards to asking them questions in order to get the required information. This project also provided the researcher with an understanding of how the family structure can be helpful in promoting and sustaining healthy behaviours. The knowledge and experience gathered from participation in this project have inspired the researcher to continue to lead the debate on how parents play a critical role in preventing childhood obesity. Doing a PhD has taught the researcher patience and tolerance and, above all, that there are no limits to what can be achieved with commitment. The candidate is delighted to have summoned up the courage to embark on the PhD journey and to have maintained the bravery to rise above all periods of amotivation continuously. There were times when the process became tough, but with the unwavering support from the supervisory team, it was possible to make it to the end.

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Appendix 1: Participant Recruitment Flyer

A blue-tinted graphic for a recruitment flyer. At the top, the text 'PARTICIPANTS NEEDED' is written in large, bold, white capital letters. Below this, on the left, is a circular inset showing four children of diverse backgrounds gathered around a laptop, looking at the screen. To the right of the inset, the text 'Do you want to encourage your children to become healthier and more physically active?' is written in white, bold, sans-serif font. The background of the graphic shows faint images of people's faces.

PARTICIPANTS NEEDED

Do you want to encourage your children to become healthier and more physically active?

- Is your child watching too much TV?
- Do you find it difficult to regulate their screen time?
- Are they exercising enough?

We may have a solution.

Researchers from Nottingham Trent University are looking for volunteers for a project which aims to enhance your child's health and well-being, by encouraging home exercise, via a device that allows you to monitor their screen time according to how much indoor physical activity was done

Eligibility:
Aged 10-15
Any gender

NOTTINGHAM
TRENT UNIVERSITY 

If interested to participate please contact

Phone no 

Email: florence.nwankwo@ntu.ac.uk

Appendix 2: Participant Information Sheet



Participants Information Sheet

1. Research Project Title:

Enhancing health and well-being through encouraging home exercising.

2. Purpose of study

Recent research have revealed that childhood obesity is on the increase as a result of excessive sedentary activities. Predominantly children who watch TV for 3= hours per day have a 65% chance of being obese than those who watch for <1 hour. However, if children play more video games, watch TV and indulge in screen activities they have a higher chance of becoming obese.

This research project aims to investigate relationships between the roles of design as a tool in mitigating sedentary behaviour in a household environment and overall achieve a sustained behaviour change. Thus, the project aims to better understand the correlates of too much sitting and its evidence in obesity trends.

3. Invitation

I would like to invite you to take part in this research study. Before you make that decision, you need to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask questions if there is anything you are not clear about or on areas you would like more information. Please take time to decide whether or not you wish to participant. Thank you in advance.

4. How the study will be conducted?

The research require participants to engage in a form of Physical activity ranging from boxing, jumping mat, stationary bike to exert a certain amount of energy to gain access to digital entertainment such as Ipad, TV etc. The targets and goal reached will be clearly represented in front of the artefact to enable user plan and maximise its benefits.

5. Why have I been invited?

You have been chosen because the research targets any household with people aged between 8-14 and will focus on assessing their sedentary lifestyle (TV viewing) using a white box system.

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

You will be asked to kindly complete a web-based questionnaire which we estimate will not take more than 20 min. You may also be asked to agree to a follow up interview to find out more about your thoughts on the research subject.

7. What will I have to do?

Please answer the questions in the questionnaire. There are no specific commitments or lifestyle restrictions related to your participation.

8. What are possible benefits of taking part?

Whilst there will be no immediate tangible benefits for those participating in this research project, most participants will experience some dramatic improvement of their physical activity routine. More so, the result gathered will be shared with participants to encourage choosing a healthy and sustained behaviour. And we hope that the information gathered will significantly contribute to research evaluating its viability.

9. What are the possible risks of taking part?

There is no anticipated discomfort or disadvantages associated with participation in this research. The potential physical and psychological distress will be same as any experienced daily.

10. What happens when the research study stops?

You will be notified if the research stops earlier than planned and we will explain why as well as let you know if you are affected in anyway as a result.

11. What will happen to the results of the research?

The results of the research will be published via research publication channel such as conference and journal articles. You reserve the right to request for the results of this research as a participant.

12. Do I have to take part in this research?

It is up to you to decide whether you'd like to participate. Should you decide to take part, you will be able to keep a copy of this information sheet and you should indicate your agreement to the online consent form. Please also note that you are free to withdraw your child from this study at any time.

13. What if there is a problem?

If you encounter any problems during the research or have any complaints about the project, in the first instance its best to contact any member of the research team. If you feel unsatisfied afterwards, please feel free to contact Nottingham Trent University's Registrar and Secretary to take your complaint further.

14. Will my taking part in the study be kept confidential?

All information collected about the participants during the research will be kept strictly confidential. You will not be able to be identified or identifiable in any reports or publications. Any data collected about you in the online questionnaire will be stored online in form of a protected by passwords and other relevant security processes and technologies.

15. Contact Details of research team

Florence Nwankwo
Researcher
N031720@my.ntu.ac.uk
07 [REDACTED]

Thank you for taking time to read the information sheet and for taking part in this research.

NB- For monitoring purposes, please note that parental guidance is highly recommended during the home survey and therefore you will be responsible for any damages incurred as a result of neglect.

Signed

Date

Appendix: 3 Consent Form



CONSENT FORM

Investigator name: Florence Nwankwo
Affiliation: School Of Architecture, Design and Built Environment

Title of project: Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box (es) and signing and dating this form

1. I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research

2. I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights

3. I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project

4. I agree to take part in this project

Name of respondent

Date

Signature

Name of researcher taking consent

Date

Signature

Appendix: 3.1 Signed consent forms

1



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

Name of respondent: [Redacted] Date: 27/4/19 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 27/04/2019 Signature: [Redacted]

2



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

Name of respondent: [Redacted] Date: 23/4/19 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 27/04/2019 Signature: [Redacted]

3



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

Name of respondent: [Redacted] Date: 12/4/2019 Signature: [Redacted]

Name of researcher taking consent: FLORENCE NWANKWO Date: 12/04/2019 Signature: [Redacted]

4



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

Name of respondent: [Redacted] Date: 14/4/19 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 14/04/2019 Signature: [Redacted]

Appendix: 3.2 Signed consent forms

5
6



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

26/03/2019 [Signature]
 Date Signature
Florence Nwankwo 26/03/2019 [Signature]
 Name of researcher taking consent Date Signature



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

1/5/19 [Signature]
 Date Signature
Florence Nwankwo 1/5/19 [Signature]
 Name of researcher taking consent Date Signature

36 replace box
7



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

28/06/17 [Signature]
 Date Signature
Florence Nwankwo 28/06/2017 [Signature]
 Name of researcher taking consent Date Signature



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

14/07/19 [Signature]
 Date Signature
Florence Nwankwo 14/07/19 [Signature]
 Name of researcher taking consent Date Signature

Appendix: 3.3 Signed consent forms

8



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted Name] 26/04/19 Jiang Yi
Name of respondent Date Signature

Florence Nwankwo 20/04/19 [Signature]
Name of researcher taking consent Date Signature

9



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted Name] 28/04/2019 [Signature]
Name of respondent Date Signature

Florence Nwankwo 28/04/19 [Signature]
Name of researcher taking consent Date Signature

10



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted Name] 02/05/19 [Signature]
Name of respondent Date Signature

Florence Nwankwo 02/05/2019 [Signature]
Name of researcher taking consent Date Signature

11



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted Name] 03/5/19 [Signature]
Name of respondent Date Signature

Florence Nwankwo 03/05/2019 [Signature]
Name of researcher taking consent Date Signature

Appendix: 3.4 Signed consent forms

12



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted] 25/06/19 
 Name of respondent Date Signature
 Florence Nwankwo 26/06/19 
 Name of researcher taking consent Date Signature

13



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted] 24th May 2019 
 Name of respondent Date Signature
 Florence Nwankwo 24/06/2019 
 Name of researcher taking consent Date Signature

14



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted] 28-05-2019 
 Name of respondent Date Signature
 Florence Nwankwo 01/06/2019 
 Name of researcher taking consent Date Signature

15



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project
- I agree to take part in this project

[Redacted] 30th May 2019 
 Name of respondent Date Signature
 Florence Nwankwo 31/05/19 
 Name of researcher taking consent Date Signature

Appendix: 3.5 Signed consent forms

16



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research.
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights.
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project.
- I agree to take part in this project.

Name of respondent: [Redacted] Date: 07/11/19 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 07/11/19 Signature: [Redacted]

17



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research.
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights.
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project.
- I agree to take part in this project.

Name of respondent: [Redacted] Date: 11/11/19 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 11/11/19 Signature: [Redacted]

18



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research.
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights.
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project.
- I agree to take part in this project.

Name of respondent: [Redacted] Date: 15-2-19 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 16/1/19 Signature: [Redacted]

19



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research.
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights.
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project.
- I agree to take part in this project.

Name of respondent: [Redacted] Date: 21-01-2019 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 21/01/19 Signature: [Redacted]

20



CONSENT FORM

Investigator name : Florence Nwankwo
Affiliation: School Of Architecture, Design And Built Environment

Title of project : Enhancing health and well-being through encouraging home exercising.

Please read and confirm your consent to being interviewed for this project by initialling the appropriate box(es) and signing and dating this form

- I confirm that the purpose of the project has been explained to me, that I have been given information about it in writing, and that I have had the opportunity to ask questions about the research.
- I understand that my participation is voluntary, and that I am free to withdraw at any time without giving any reason and without any implications for my legal rights.
- I give permission for the interview to be tape-recorded by research staff, on the understanding that the tape will be destroyed at the end of the project.
- I agree to take part in this project.

Name of respondent: [Redacted] Date: 15-02-2019 Signature: [Redacted]

Name of researcher taking consent: Florence Nwankwo Date: 18/1/19 Signature: [Redacted]

Appendix: 4 Questionnaire for parents regarding their children's screen time

Parents' views on children's screen time and physical activity habits.

Researchers at Nottingham Trent University are investigating the relationships between children's screen time and their lack of physical activity. The research aims to use a device that monitors prolonged sitting within the home environment. Thus, the study will use a device designed to leverage screen activities in the home to gradually encourage the user to embrace a more physically active lifestyle.

Your honest response to the survey questions will be highly appreciated as this will contribute towards creating a framework for the study. Also note that we are targeting children up to 17 years of age and if your child is above the stated age, we will kindly ask that you do not participate in the survey.

All questions have been written in clear and concise English, please be sure you understand the question fully before responding.

Please be rest assured that your responses are anonymous and will be treated in a confidential manner. Thank you in advance.

Principal Investigator
Florence Nwankwo
florence.nwankwo@ntu.ac.uk
Nottingham Trent University.

* Required

1. How many children do you have? *

Mark only one oval.

- 1
 2
 3
 4
 >5

2. What is the age group of your children? *

Check all that apply.

- 0-4 Years
 5-9 Years
 10-15 Years
 16 and above

3. What is the gender of your child/children? *

Mark only one oval.

- Female
 Male
 Male & Female

4. On a typical weekday, how many hours do they spend on screen related activities? TV, Ipad, mobile phones, video/computer games? (Please select two answers only) *

Please select only two options*
Check all that apply.

- Less than 2 hours (Term-time)
- 3-5 hours (Term-time)
- 6 hours- more (Term-time)
- Less than 2 hours (Holiday period)
- 3-5 hours (Holiday period)
- 6 hours- more (Holiday period)

5. On a typical weekend day, how many hours do they spend on screen related activities? *

Mark only one oval.

- Less than 2 hours
- 3-5 hours
- 6 hours or more

6. Which of these screen devices do they spend the most time on?

Check all that apply.

	TV	Tablets(Ipad etc)	Computer (Play station etc)	Mobile phones	Others
6 hours or more	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3-5 hours	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Less than 2 hours	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

7. The amount of time my children spend on these screen devices are concerning to me as a parent.

Mark only one oval.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

8. Spending too much time on screens deter my child/children from being physically active.

Mark only one oval.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

9. What do you consider the greatest barrier in limiting screen time in children? for instance, influence of other family members, addiction, friends etc

10. **My child/children consume food such as; snack and beverages whilst watching TV.**

Mark only one oval.

- Always
- Often
- Sometimes
- Rarely
- Never

11. **Childhood physical activities is important in physical development and health of children.**

Mark only one oval.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

12. **I would consider a child-focused physical activity intervention as this will encourage my child to be more physically active.**

Mark only one oval.

- Strongly disagree
- Disagree
- Neutral
- Agree
- Strongly agree

13. **In order to encourage the physical activity of your children, how much do you spend on average on a monthly basis? This could include after-school exercise programs, swimming lessons, gym membership etc.**

14. **According to World Health Organisation (WHO) guidelines, children and young people aged up to 17 years old should accumulate at least 60 minutes of moderate to vigorous-intensity physical activity daily. My child/children do not meet these physical activity recommendations**

Mark only one oval.

- Strongly agree
- Agree
- Neutral
- Disagree
- Strongly disagree

15. If your child/children do not meet the WHO guidelines for physical activities, how much more time do you feel your children should spend on physical activities in a day?

Mark only one oval.

- 1 Hour
- 2 Hours
- 3 Hours or more

16. What country do you reside in? *

Appendix: 5 End of Pilot study semi-structured questionnaire

Domestic User Experiment (End of pilot testing evaluation)

PERCEPTION

1. The device helped me reduce my screen time.

Mark only one oval.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

2. My physical activity increased from using this device

Mark only one oval.

- Strongly disagree
- Disagree
- Neither agree nor disagree
- Agree
- Strongly agree

3. How would you rate the idea of generating your own screen time. *1 being not very good and 10* being Excellent.

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not a great idea	<input type="radio"/>	Excellent idea									

4. Describe the best and worst part of using the device in the past month.

Motivation

5. This device keeps me motivated to engage in daily physical activities.

Mark only one oval.

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

6. Having used the device for the past one month, describe any changes you have noticed in your screen time.

7. Describe how the device made you feel about physical activity as part of your daily routine.

Goal setting

8. How good was your initial goal in helping you increase your physical activity level?

Mark only one oval.

	1	2	3	4	5	6	7	8	9	10	
Not great	<input type="radio"/>	Excellent									

9. How did it make you feel when you achieved your daily goal?

Mark only one oval.

- Very satisfied
- Satisfied
- Neither satisfied nor dissatisfied
- Dissatisfied
- Very dissatisfied

10. How did it make you feel when you did not meet your daily goal?

Mark only one oval.

- Very satisfied
- Satisfied
- Neither satisfied nor dissatisfied
- Dissatisfied
- Very dissatisfied

11. Describe how your goal setting has changed from the start to the finish of the study

User experience

12. Was seeing the screen credits on the device helpful in increasing your physical activity?

Mark only one oval.

- Extremely important
- Very important
- Somewhat important
- Not so important
- Not at all important

13. My view on being more physically active has changed since the start of the study.

Mark only one oval.

- Better
- About the same
- Worse

14. Did competing with your siblings high score motivate you to get more screen credits?

Mark only one oval.

- Always
- Usually
- Sometimes
- Rarely
- Never

15. How was the general user experience in the last one month of using the device?

Mark only one oval.

- Very good
- Good
- Bad

16. What would you add to the device and what would you take away in order to improve the user experience?

17. What are your thoughts on the amount of cycling required to gain screen credits?

Behaviour change

18. Since the start of this study, how aware have you been on how much time you spend in front of the screen?

Mark only one oval.

- Extremely aware
- Very aware
- Somewhat aware
- Not so aware
- Not at all aware

19. Since the start of this study, what have you noticed about your time in front of the screen?

Mark only one oval.

- Increased
- Stayed the same
- Decreased

20. Describe how using the device has influenced the above answer (*question 19)

21. Will you continue to use this device if given the opportunity? Please briefly explain why.

Mark only one oval.

- Yes
- No
- Maybe
- Other: _____

Appendix: 6 Pre-intervention Interview Guide

Q.01. Can you tell me a little bit about your exercise routine?

Speaker

Q.02. How much do you think you should do at home?

Speaker

Q.03. Can you think of different activities you do around the home that require sitting?

Speaker

Q.04. Do you think you could do other things at home besides sitting and doing the above activities? TV, Tablet use, phone use

Speaker

Q.05. Do you have any general screen time rules around the house?

Speaker

Q.06. Are you aware of the recommended ST for children around your age?

Speaker

Q.07. Are you aware of the recommended PA for children around your age?

Speaker

Q.08. Would you consider the concept of having to exercise in order to earn your screen time?

Speaker

Q.09. Why? Above

Speaker

Q.10. How would you describe the idea of nudge-box helping you generate your own screen credits in order to reduce your screen time?

Speaker

Q.11. On a scale of 1 -10 how confident are you that you can do these activities for 1 hour a day?

Speaker

Appendix: 7 Week 5 and 10 Questionnaire for Empirical Study

Domestic User Study- Behaviour Modelling Questionnaire

Thank you for your continuous cooperation in this research participation. We are interested to know how you are getting on with the device and how your exercise routine is coming along. Please could you complete the below questionnaire as honest as you can. For each of the following statements, please indicate how true it is for you, using the following scale;-

1-Not at all and
7-Very True

All your responses will be held in confidence and will only be used for our research purposes. Please try and respond to all the questions as they are all important Please click next to begin.

* Required

Perceived Ability

1. **1. I had the opportunity to exercise regularly before this study was introduced. ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

2. **2. After a few weeks of using the device, I am satisfied with my exercise performance so far and I hope to maintain this lifestyle ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

3. **3. I believe the device is easy and clear to use ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

4. **4. I am good at setting goals for my daily exercise now ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

Social Norm

5. 5. My mum/dad think I should exercise often before I can watch TV **Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

6. 6. My friends think that the idea of exercising before I can watch TV is cool **Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

7. 7. My siblings like the idea of exercising to watch TV **Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

8. 8. It was challenging to increase my exercise habit **Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

9. 9. It was challenging to decrease my screen time habit **Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

Control Beliefs**10. 10. I often encounter events that stop me from exercising ****Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

11. 11. Please give examples of events. *

12. 12. It is very difficult for me to form an exercise habit because of the above events. **Mark only one oval.*

1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True					

13. **13. I believe exercising daily could be very valuable to me ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

14. **14. I did this activity because I had to watch TV or play video games with my friends or charge my mobile phone ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

15. **15. I exercised when I noticed my LEDs are reaching near zero ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

Interest/Motivation

16. **16. After 5 weeks of using this device, I find this exercise method interesting ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

17. **17. I am happy with the amount of exercise I am doing ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

18. **18. I am motivated to continue with this new habit because it's very valuable to me ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

Forced Functionality

19. **19. I tried hard not to let my TV shut off by itself. ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

20. **I formed a new habit to prevent my TV/Screen time from going off by itself ***
Mark only one oval.

1 2 3 4 5 6 7

Not at all Very True

21. **21. Please give example of new habit. ***

22. **22. I was frustrated when my TV went off all the time. ***
Mark only one oval.

1 2 3 4 5 6 7

Not at all Very True

23. **23. I know exactly how much exercise I need to do for me to watch a certain amount of TV. ***
Mark only one oval.

1 2 3 4 5 6 7

Not at all Very True

24. **Participants first name or Box number;
Please this will be kept confidential as it is
just for the researcher to tag the responses
to each participants accordingly. ***

Appendix: 8 End of Empirical Study Interview Guide

Q.01. Can you please tell me how your experience of using this device was in the first month?

Speaker

Q.02. Could you describe any changes you observed during the use of this device?

Speaker

Q.03. How would you describe the ease of use of the device?

Speaker

Q.04. How would you describe your exercise habit now?

Speaker

Q.05. What changes did you observe with your screen time use?

Speaker

Q.06. How would you describe your motivation to exercise using this device? Were there any external influences?

Speaker

Q.07. What changes did you notice on your screen time habits?

Speaker

Q.08. Are you satisfied with the new habit that has resulted from this activity?

Speaker

Q.09. Do you think there has been better negotiation of screen time use?

Speaker

Q.10. Could you tell me about any time that something stopped you from exercising?

Speaker

Q.11. *Did you think your general exercise habit improved by using this device?*

Speaker

- ▲ Q.12. *Can you describe a time where you felt you needed to exercise because you needed to use your phone/watch TV/play video games?*

Speaker

Q.13. *Do you consider the LED reaching zero as a reason to get back on the bike to exercise?*

Speaker

Q.14. *Can you describe the things that motivated you during the use of this device? Did you generally enjoy it? Did you feel like it was a reward/punishment? Did you feel like you did it cos you knew the importance of exercise?*

Speaker

Q.15. *Would you consider this new exercise routine a habit that you would like to maintain? Why?*

Speaker

Q.16. *Do you believe you met your exercise goals? Remind them of the goal set prior to the start of the study.*

Speaker

Q.17. *Did you consider the TV shutting itself when your screen credit is finished a motivation to exercise?*

Speaker

Q.18. *What new habits did you form while using this device?*

Speaker

Q.19. *Would you consider the feature of your TV shutting out a turn off? Was there any time you felt like you needed to watch less TV because of this study?*

Speaker

Q.20. Would you consider the use this device a forceful way to get you off your TV/smartphones?

Speaker

Q.21. Because we are taking the bike away, there is no need to exercise more. Do you think you will keep up this new habit of exercising at home?

Speaker

Q.22. What suggestions do you have to help improve the design and use of this device?

Speaker

Appendix: 9 Post-study Questionnaire

Post-study Domestic User Study- Behaviour Modelling Questionnaire

Once again, thank you for your participation and completion in the study.

I would like to invite you to complete this short post-study questionnaire.

Please can you answer as honest as possible.

The scale in the questionnaire represents;

1-Not at all

7-Very True

1-Decreased

7-Increased

All your responses will be held in confidence and will only be used for our research purposes. Please respond to all questions.

* Required

1. **1. My exercise habit has been maintained since after the experiment. ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

2. **2. Tell us about your current exercise time since the end of the experiment (average 1 hour). ***

Mark only one oval.

	1	2	3	4	5	6	7	
Decreased	<input type="radio"/>	Increased						

3. **3. My screen time habit has been maintained since after the experiment. ***

Mark only one oval.

	1	2	3	4	5	6	7	
Not at all	<input type="radio"/>	Very True						

4. **4. Tell us about your screen time use since the end of the experiment (TV, Video gaming, tablet use) average 2 hours. ***

Mark only one oval.

	1	2	3	4	5	6	7	
Decreased	<input type="radio"/>	Increased						

5. **5. House number or name**

Appendix: 9.1 Intrinsic Motivation Inventory Scale description

Intrinsic Motivation Inventory (IMI)

Scale Description

The Intrinsic Motivation Inventory (IMI) is a multidimensional measurement device intended to assess participants' subjective experience related to a target activity in laboratory experiments. It has been used in several experiments related to intrinsic motivation and self-regulation (e.g., Ryan, 1982; Ryan, Mims & Koestner, 1983; Plant & Ryan, 1985; Ryan, Connell, & Plant, 1990; Ryan, Koestner & Deci, 1991; Deci, Eghrari, Patrick, & Leone, 1994). The instrument assesses participants' interest/enjoyment, perceived competence, effort, value/usefulness, felt pressure and tension, and perceived choice while performing a given activity, thus yielding six subscale scores. Recently, a seventh subscale has been added to tap the experiences of relatedness, although the validity of this subscale has yet to be established. **The interest/enjoyment subscale is considered the self-report measure of intrinsic motivation;** thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, it is only the one subscale that assesses intrinsic motivation, per se. As a result, the interest/enjoyment subscale often has more items on it than do the other subscales. The perceived choice and perceived competence concepts are theorized to be positive predictors of both self-report and behavioral measures of intrinsic motivation, and pressure/tension is theorized to be a negative predictor of intrinsic motivation. Effort is a separate variable that is relevant to some motivation questions, so is used if it is relevant. The value/usefulness subscale is used in internalization studies (e.g., Deci et al, 1994), the idea being that people internalize and become self-regulating with respect to activities that they experience as useful or valuable for themselves. Finally, the relatedness subscale is used in studies having to do with interpersonal interactions, friendship formation, and so on.

The IMI consists of varied numbers of items from these subscales, all of which have been shown to be factor analytically coherent and stable across a variety of tasks, conditions, and settings. The general criteria for inclusion of items on subscales have been a factor loading of at least 0.6 on the appropriate subscale, and no cross loadings above 0.4. Typically, loadings substantially exceed these criteria. Nonetheless, we recommend that investigators perform their own factor analyses on new data sets. Past research suggests that order effects of item presentation appear to be negligible, and the inclusion or exclusion of specific subscales appears to have no impact on the others. Thus, it is rare that all items have been used in a particular experiment. Instead, experimenters have chosen the subscales that are relevant to the issues they are exploring.

The IMI items have often been modified slightly to fit specific activities. Thus, for example, an item such as "I tried very hard to do well at this activity" can be changed to "I tried very hard to do well on these puzzles" or "...in learning this material" without effecting its reliability or validity. As one can readily tell, there is nothing subtle about these items; they are quite face-valid. However, in part, because of their straightforward nature, caution is needed in interpretation. We have found, for example, that correlations between self-reports of effort or interest and behavioral indices of these dimensions are quite modest--often around 0.4. Like other self-report measures, there is always the need to appropriately interpret how and why participants report as they do. Ego-involvements, self-presentation styles, reactance, and other psychological dynamics must be considered. For example, in a study by Ryan, Koestner, and Deci (1991), we found that when participants were ego involved, the engaged in pressured persistence during a free choice period and this behavior did not correlate with the

self-reports of interest/enjoyment. In fact, we concluded that to be confident in one's assessment of intrinsic motivation, one needs to find that the free-choice behavior and the self-reports of interest/enjoyment are significantly correlated.

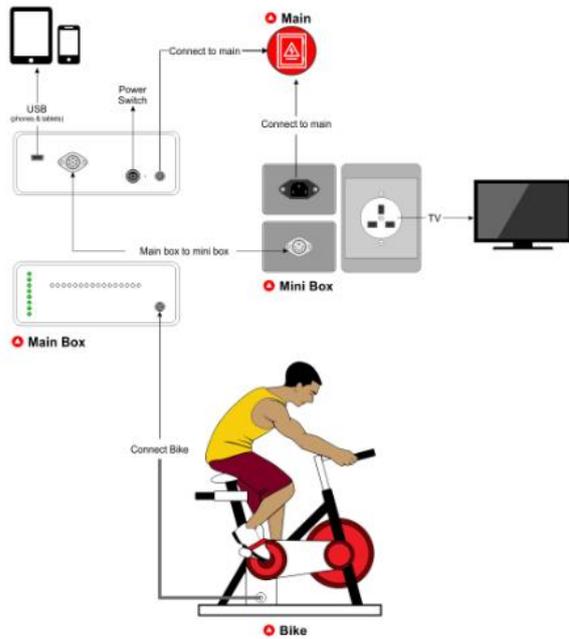
Another issue is that of redundancy. Items within the subscales overlap considerably, although randomizing their presentation makes this less salient to most participants. Nonetheless, shorter versions have been used and been found to be quite reliable. The incremental R for every item above 4 for any given factor is quite small. Still, it is very important to recognize that multiple item subscales consistently outperform single items for obvious reasons, and they have better external validity.

On The Scale page, there are five sections. First, the full 45 items that make up the 7 subscales are shown, along with information on constructing your own IMI and scoring it. Then, there are four specific versions of the IMI that have been used in past studies. This should give you a sense of the different ways it has been used. These have different numbers of items and different numbers of subscales, and they concern different activities. First, there is a standard, 22-item version that has been used in several studies, with four subscales: interest/enjoyment, perceived competence, perceived choice, and pressure/tension. Second, there is a short 9-item version concerned with the activity of reading some text material; it has three subscales: interest/enjoyment, perceived competence, and pressure/tension. Then, there is the 25-item version that was used in the internalization study, including the three subscales of value/usefulness, interest/enjoyment, and perceived choice. Finally, there is a 29-item version of the interpersonal relatedness questionnaire that has five subscales: relatedness, interest/enjoyment, perceived choice, pressure/tension, and effort.

Finally, McAuley, Duncan, and Tammen (1987) did a study to examine the validity of the IMI and found strong support for its validity.

Appendix: 10 Prototype User Guide

USER GUIDE



Basic Functions

Horizontal LEDs indicates the amount of exercise performed, which we call 'credit'. The more credit you earn, the LEDs will indicate the amount within ranges of 16 LEDs.
8 Vertical LEDs indicates the intensity of performing exercise.
TV should be connected to the Mini box during your exercise.
You can plug your Screen related devices such as iPad using the USB plug.

The Use

The credit will allow you to have power access to screen devices (e.g. TV or iPad/mobile phone charging). If no credit is available, you will have no power access to these devices.

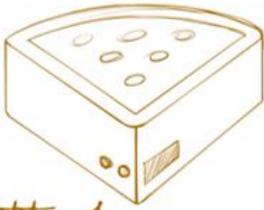
Things to Keep in Mind

The prototype is safe to use and have passed the electrical testing.
Please store or fold the bike at your own discretion to avoid any safety risks.
Please ensure you connect the bike cable to main box during your exercise.
Do NOT try to physically open the boxes.
Try not to unplug the main power of box unless there is a need.

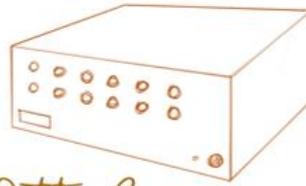
For any problem with the device, please contact:

XXXXXXXXXX

Appendix: 11 Conceptual Sketches for Prototype



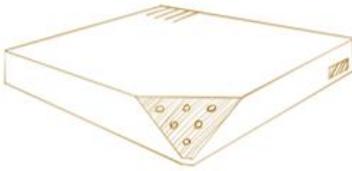
Prototype 1
Pizza concept



Prototype 2
Juke box concept



Prototype 3
towering cuboid concept

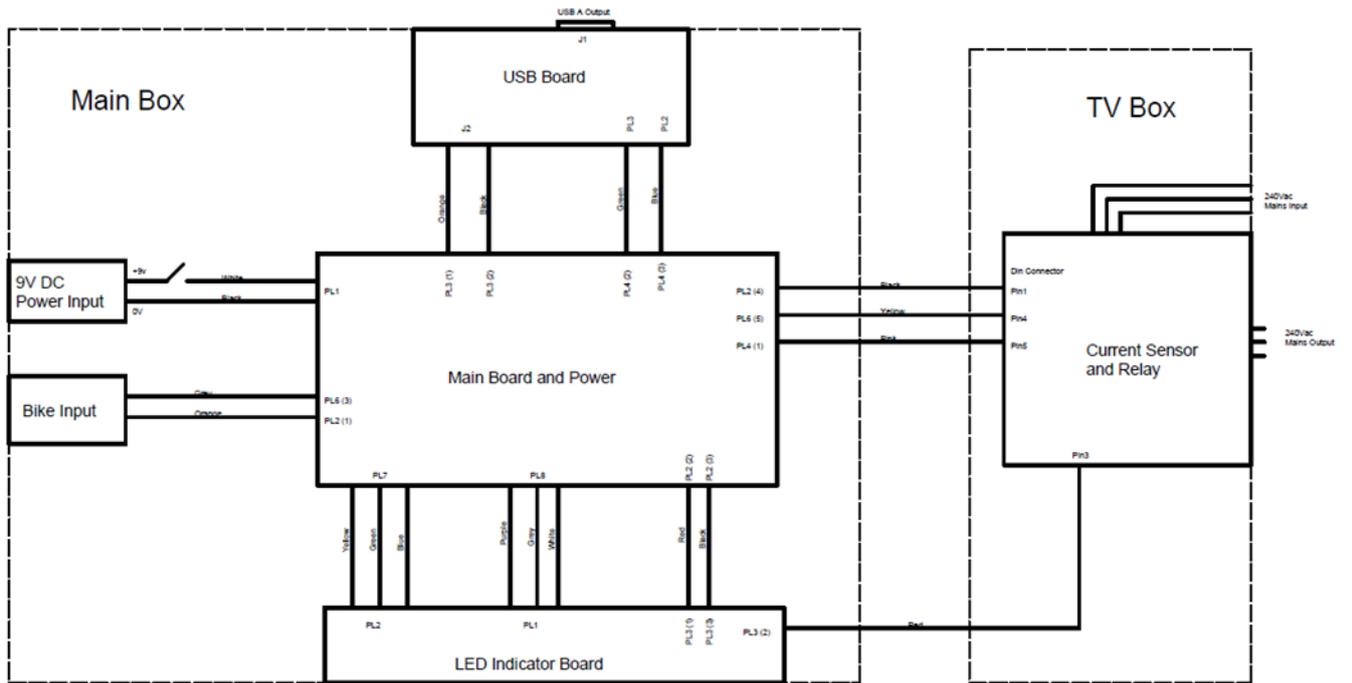


Prototype 4
Chip off concept



Prototype 5
White box concept

Appendix: 12 Technical diagram of Knudgbox



Appendix: 13 Energy Monitor reading for all houses





13



14



16



17



18

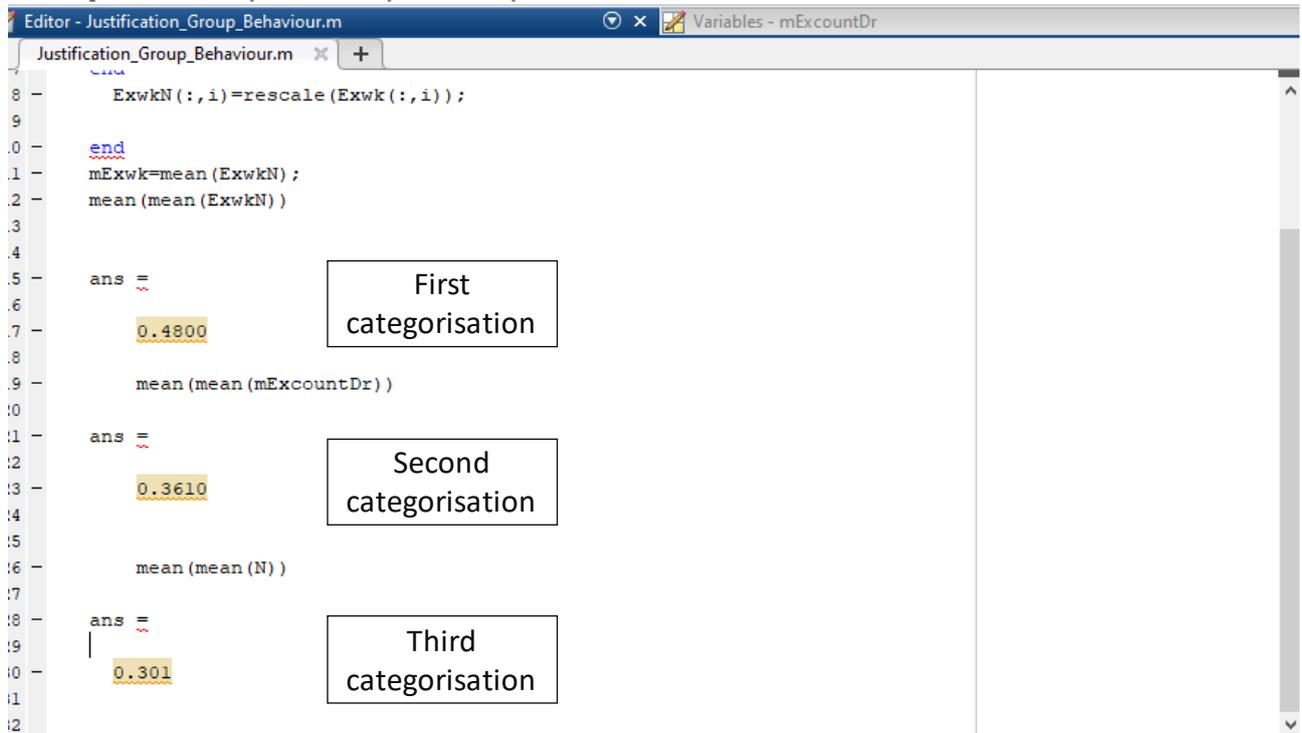


19



20

Appendix: 14 Screenshot from MATLAB showing justification for Group threshold



The screenshot shows the MATLAB Editor window for a file named 'Justification_Group_Behaviour.m'. The code in the editor includes a rescaling step, an 'end' statement, and two nested 'mean' functions. The output window displays three results, each with a corresponding label in a box:

```
8 ExwkN(:,i)=rescale(Exwk(:,i));
9
10 end
11 mExwk=mean(ExwkN);
12 mean(mean(ExwkN))
13
14 ans =
15 0.4800
16
17 mean(mean(mExcountDr))
18
19 ans =
20 0.3610
21
22 mean(mean(N))
23
24 ans =
25 0.301
```

First categorisation

Second categorisation

Third categorisation

Appendix: 15 Participant Home set-up (not included in the body of the work)



Appendix: 16 Snapshot of DUS thematic analysis node using NVivo 12 Pro

Nodes		Search Project	
Name	Files	References	
1. Perceived ability	0	0	
Habit	3	5	
Initial behaviour	3	4	
Low perceived ability	1	2	
2. Social norm	1	1	
Mum enagagment	18	89	
Sense of self worth	0	0	
Social norm	1	4	
3. Control beliefs	2	2	
External influence	5	13	
Parental control	1	1	
4. Interest and motivation	0	0	
Awareness	2	3	
Child awarness	2	4	
Enjoyment and fun	4	10	
Interest Motivation	1	2	
Motivational element	1	1	
Reward	1	1	
Value	2	3	
5. Forced functionality	1	3	
Ease of use	1	1	
Feedback	3	3	
Forced function	3	9	
Punishment	3	5	
6. Action or inaction	0	0	
All exercise reference	20	423	
Behaviour maintenance	2	3	
Collaboration	1	1	
Extrinsic	1	1	
Interview questions	0	0	
Planning	1	1	

Appendix: 17 Case classifications snapshot from thematic analysis

Case Classifications

- Name
- 1. Perceived ability
- 2. Social Norm
- 3. Control beliefs
- 4. Interest and motivation
- 5. Forced functionality
- Participant group and demographic data
 - Name
 - Gender
 - Age
 - Group category
- Themes
 - Name
 - Parent node

Appendix: 18 Exemplar text frequency query from DUS thematic analysis

[<Files\02. Box Post>](#) - § 2 references coded [4.23% Coverage]

Reference 1 - 3.17% Coverage

He then went on holiday with is dad for 8 days and when he came back, we needed to get back into another routine but this wasn't smooth at all. We then resorted back to shouting when he is on his Xbox for too many hours.

Reference 2 - 1.05% Coverage

I may not keep up with this habit to be honest. Cos I think I'm too lazy.

[<Files\03. Box Post>](#) - § 1 reference coded [1.37% Coverage]

Reference 1 - 1.37% Coverage

When I heal, definitely would consider buying an exercise equipment for the house.

[<Files\01. Box Post>](#) - 5 2 references coded [1.96% Coverage]

Reference 1 - 1.22% Coverage

I quite enjoyed it and I played on it a lot of the time and I couldn't stop going on cos I thought the idea was fun

Reference 2 - 0.73% Coverage

Although sometimes we took turns to do the cycling which was also fun

[<Files\03. Box Post>](#) - 5 3 references coded [3.75% Coverage]

Reference 1 - 1.67% Coverage

It was fun to use and I enjoyed using it and really hoped I used it more. All my siblings enjoyed it.

Reference 2 - 0.76% Coverage

When I used it in the really days it was here.

Reference 3 - 1.32% Coverage

I enjoyed the cycling bit and started to observe that I felt better in myself.

[<Files\04. Box Post>](#) - 5 2 references coded [1.73% Coverage]

Reference 1 - 0.51% Coverage

So I would say I got on okay with the box in general

Reference 2 - 1.22% Coverage

Yes, I did fill the box up a lot of times and it took me roughly an hour to do that. I didn't do it in one go through hahaha

[<Files\\02. Box Post>](#) - § 1 reference coded [4.28% Coverage]

Reference 1 - 4.28% Coverage

Well, most of the times, I did consider that. Like there was one time when I had two stars one and wanted to play game one game last for like 20 mins, when one of the stars dropped I had to get on the bike and pedal whilst playing game because I didn't want to be killed off when my TV shuts off.

[<Files\\03. Box Post>](#) - § 1 reference coded [3.20% Coverage]

Reference 1 - 3.20% Coverage

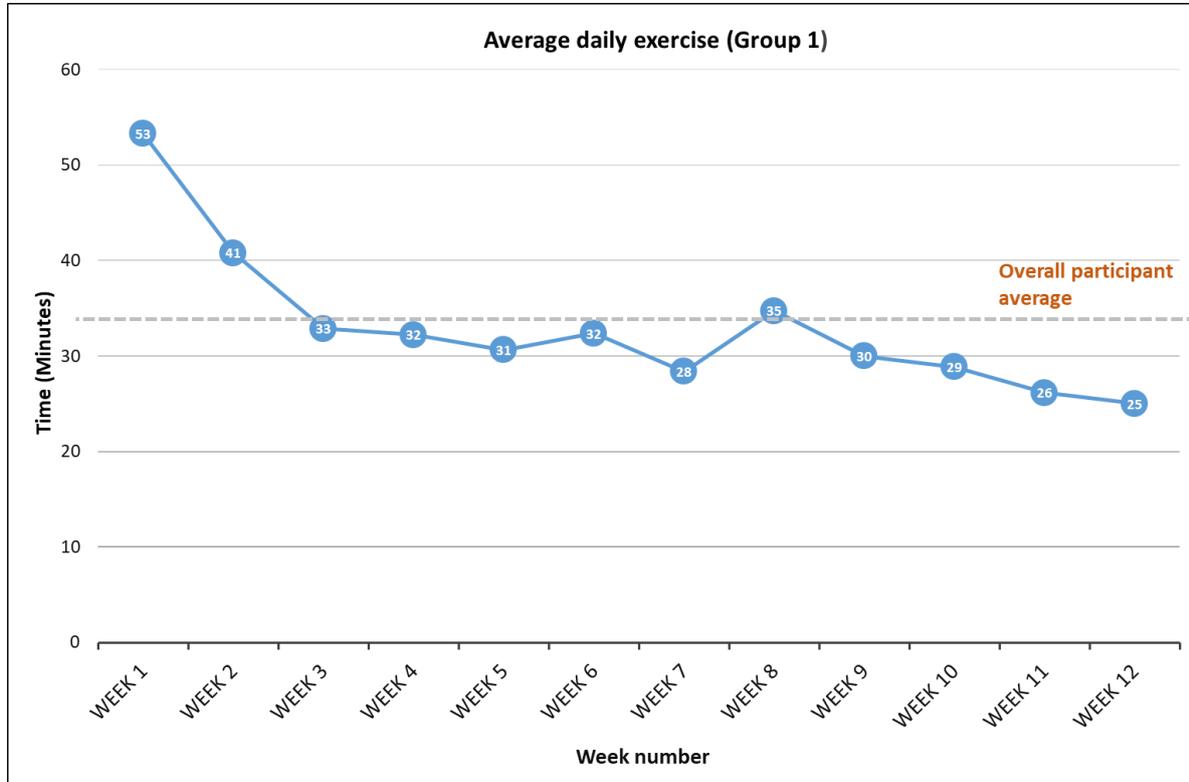
The light it a motivation and when you see one light on it makes you want to get more. I would also like to see a motivational message for the user. Different colours for how well you are doing.

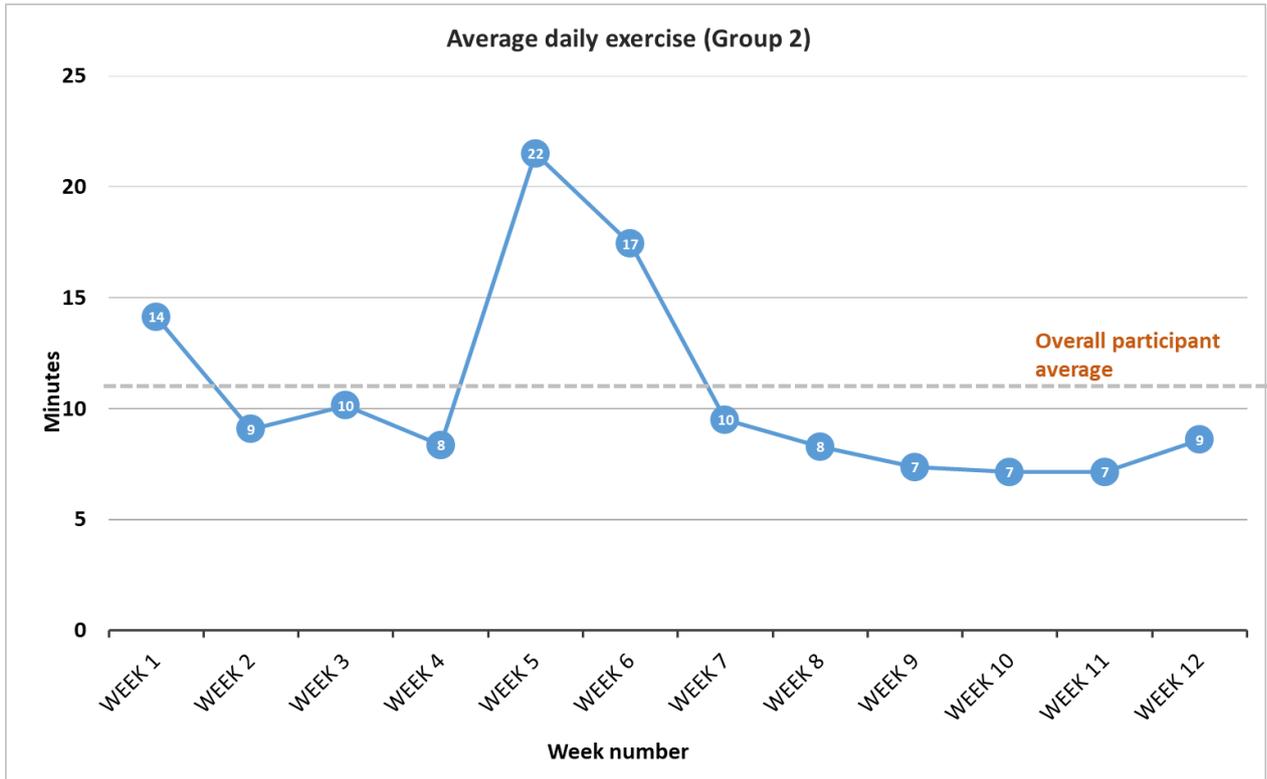
[<Files\\06. Box Post>](#) - § 1 reference coded [2.95% Coverage]

Reference 1 - 2.95% Coverage

It was only once my light finished and I went back on the bike because I was playing a serious game but I lost in the end so yea...I wasn't very happy about that but it is not the end of the world.

Appendix: 19 Weekly breakdown data





Appendix: 20 Other attempted statistical analysis

Correlations

		Total Ex Duration/mins	Total TVW duration
Total Ex Duration/mins	Pearson Correlation	1	.747**
	Sig. (2-tailed)		.000
	N	20	20
Total TVW duration	Pearson Correlation	.747**	1
	Sig. (2-tailed)	.000	
	N	20	20

** . Correlation is significant at the 0.01 level (2-tailed).

ANOVA^a

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	4601.721	1	4601.721	22.754	.000 ^b
	Residual	3640.356	18	202.242		
	Total	8242.076	19			

a. Dependent Variable: Total Ex Duration/mins

b. Predictors: (Constant), Total TVW duration

Coefficients^a

Model		Unstandardized Coefficients		Standardized	t	Sig.
		B	Std. Error	Coefficients Beta		
1	(Constant)	8.335	5.369		1.552	.138
	Total TVW duration	.298	.062	.747	4.770	.000

a. Dependent Variable: Total Ex Duration/mins