Physical, Psychological and Emotional Effects of

Nature-Based Affordances of Green Physical Activity

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ABSTRACT

Physical inactivity and mental disorders are considered to be two urgent health challenges and strongly associated with non-communicable diseases in today's highly urbanised society (World Health Organization, 2010a). Green Physical Activity (PA) is suggested to be a tangible means to effectively promote physical health and mental wellbeing for urban residents (Pretty, 2004). In order to increase the probability of application for a wider urban population, this thesis focused on the first level of green PA (viewing nature indoors) for designing indoor PA environment. Lacking an appropriate underpinning theoretical framework, the ecological dynamics theory was proposed to guide the experimental setting and offer theoretical explanations. The aim was to examine the experience and effects of nature-based affordances for green PA. A theory-guided PA setting was created to examine varying richness of nature-based information (dynamic or static images, presence of visual-only or visual-acoustic information, single or multiple videos) with qualitative and quantitative data collected and compared to a more representative PA environment in three studies. The same physical measurements were made in all PA conditions, including heart rate, estimates of energy expenditure, speed, distance and rated perceived exertion. Responses to two questionnaires for psychological and emotional assessments were recorded, along with follow-up interviews with a sub-sample of participants in each study.

In Study 1, three PA conditions that were designed included: two types of visual-only nature information (involving a dynamic and a static nature image) and use of self-selected entertainment to examine the physical, psychological and emotional effects and experiences of participants. A group of 30 individuals with diverse demographic backgrounds were recruited (mean ± SD: age 27.5 ± 9 years; mass 67.6 ± 11.1 kg; stature 173.7 ± 8.2 cm; BMI 22.2 ± 2.1) and completed all trials. Sixteen participants of the same group took part in follow-up interviews. Findings suggested that the appropriateness of nature information for treadmill running was vital for PA quality and experience because strong engagement with the dynamic image had positive and negative effects. Study 2 explored further the significance of the dynamic images effects on participants during physical activity. Another two types of nature information were investigated with increasing richness of information resources (a collection of ten short dynamic images with and without sounds) compared to an audio-only self-selected entertainment using the same measurements. A mixed-background group of 24 participants were recruited (mean ± SD: age 30 ± 6.9 years; mass 68.1 ± 10.7 kg; stature 172.0 ± 8.6 cm; BMI 23.0 ± 2.9) and completed all trials. Eight participants took part in follow-up interviews. Results indicated that personal preferences and the diversity of nature information presented in the dynamic images were proposed to be influential factors to when designing indoor PA environment. In both studies, running with diverse nature videos with sound was found to provide the most beneficial PA environment for a bout of running for 20-minutes. A preliminary study (Study 3) was performed to examine whether these effects might last for an extended period of time. Participant experiences were investigated when undertaking PA with multiple nature videos (9 participants) or with self-selected music (6 participants) over a longer experimental period (6 weeks). All 15 participants completed the follow-up interviews. No physical performance differences were observed, but the nature group reported greater psychological benefits and the music group reported that they received emotional benefits improvement. In terms of experience, participants developed their personally-favoured PA behaviours over time when running with rich and diverse nature-based information but no such observation was found in the music group.

Overall, this programme of research endorses the benefits of green PA designed for an indoor environment between one to six weeks. Findings suggested that the essential considerations included the diversity of nature information a used in dynamic displays, with inclusion of nature sounds. Results highlighted that personal preferences of nature information are important when designing green PA programmes for promoting physical health and mental wellbeing.

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STATEMENT OF ORIGINAL AUTHORSHIP

I declare that the work in this thesis was carried out in accordance with the regulations of the Sheffield Hallam University and is original except where indicated by the specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Hsiao-Pu Yeh

RESEARCH OUTPUT

Peer-reviewed journal articles

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PRESENTATIONS AND CONFERENCES

Yeh H-P, Stone JA, Churchill SM, Brymer E, Davids K.

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CHAPTER.1

INTRODUCTION AND THESIS STRUCTURE

1.1 *RESEARCH OVERVIEW*

Physical inactivity has been identified as the fourth leading cause of global mortality and is strongly associated with non-communicable diseases (World Health Organization, 2010) and mental disorders (World Health Organization, 2001). The rapid development of urban society is proposed to be the main contributor to physical inactivity and mental disorders because humans have experienced dramatic physical environmental changes from rural life to highly urbanisation living (Whiting & Unwin, 2008). This change results in a weak human-nature relationship and prevents urban residents for participating in exercise. Due to increased urbanisation there is now little connection between humans and nature in modern society. As a result this population is less likely to benefit from the nature environments contribution to the maintenance of physical health and mental wellbeing.

In the literature, there is evidence of numerous benefits (e.g. improved mood, reduced stress and exertion level) of various experience with natures in different scenarios, including daily living environments (homes, offices, hospitals and neighbour areas) and various nature or urban environments (forest, urban parks or allotments). Three dominant theories offer explanations. The biophilia hypothesis suggests that humans have an innate tendency towards nature as a result of constant contact with nature throughout millennia of evolution (Kellert & Wilson, 1993). Attention restoration theory proposes that nature elements can have a restorative effect on the brain's ability to focus (Kaplan & Kaplan, 1989). Stress recovery theory advocates the healing power of nature that lies in an unconscious, autonomic response to nature elements without recognition and most noticeably among stressed people (Ulrich, 1983). These theories provided important understanding of the merit and effects of nature; however, the role of PA is neglected which is vital for the purpose of PA promotion. Green PA is defined as any bodily movement that is produced by skeletal muscles and is engaged with nature elements, with three distinct levels of engagement with nature (viewing nature indoors, being in nature and actively interacting with nature). In this thesis, an ecological dynamics theoretical framework is proposed to underpin the effects of green PA, provide principles for experimental design and offer theoretical explanations for findings (Brymer & Davids, 2013). This framework was chosen because it prioritises the person-environment relationship as the appropriate scale of analysis for understanding the emergence of human behaviours. This scale of analysis implicates the

effects of personal, task and environmental constraints on shaping behaviours, such as physical actions, psychological processes and emotional responses, through a complex interactive process which is needed to consider the role of PA, individual and nature together. In order to increase the tangibility of applying green PA programmes in urban areas, the first level of green PA (viewing nature indoors) was the main scope of this programme of research. Three laboratory-based studies were conducted in this thesis to experimentally test the effect of various types of nature-based information and thereby expand the knowledge of green PA and with mixed methods applied to gain a more comprehensive understanding of, and answer to the research question.

1.2 *THESIS OUTLINE*

This thesis comprises seven chapters. **Chapter 1** outlines the structure and overview of this thesis and highlights the key contributions of this programme of research. In order to effectively expand the understanding of green PA building on previous research, a literature review was conducted in **Chapter 2** to identify research gaps in understanding related to different types of nature-based information and underpinning theories. The literature was searched using combinations of different keywords (green, exercise, PA, urban, built, environment, self-paced, exertion and PANAS, etc.) in numerous search engines, including Google Scholar, Scopus, Medline, EBSCO, SAGE journals online, Springer Link, ResearchGate and Mendeley, as well as setting 'article alter' for updates. In addition, a snowball method was also used for collecting relevant literature and alerts were set to allow key peer-review journals to be searched regularly for new relevant articles. An ecological dynamics perspective is proposed as the supporting theoretical framework with the research aim and objectives presented. To address the research question, three experimental studies were conducted, each using the same methodology presented in **Chapter 3**. Mixed methods were employed to collect qualitative and quantitative data with an experimental setting guided by the proposed theoretical perspective and a more representative PA environment as the control condition was included to enhance the validity of this thesis. The first study in this thesis examined two types of visual-only, nature-based information for treadmill running (using either a static or dynamic nature image) on the physical, psychological and emotional variables compared to a self-selected entertainment environment. This design supported the presentation and further exploration of the PA experiences with semi-structured interview data, reported in **Chapter 4**. Building on the findings of Chapter 4, effects

and experience of two different types of visual-only or visual-audio, nature-based information for treadmill running were investigated (a collection of ten short nature video with or without sounds). These task constraints were compared to effects of PA in an audio-only, self-selected entertainment condition and related PA experiences of three designed environments were explored and presented in **Chapter 5**. Collective results from Chapter 6 suggested that running in the presence of nature videos and sounds provided the most beneficial PA environment. However, there is a need to examine whether the observed effects last over extended periods of time, when designing efficient exercise interventions. Therefore, the examination of a nature-based PA environment for 12 bouts of treadmill running over 6 weeks compared to a music-only self-selected environment was presented in **Chapter 6** alongside the related PA experiences. The final chapter, **Chapter 7**, provides an epilogue which reviews the main findings of the work presented and provides future directions following on from this programme of research.

1.3 *SIGNIFICANCE OF THE THESIS*

The programme of research contained within this thesis provides novel theoretical and methodological knowledge and findings on green PA with rigorous examinations of five types of nature-based information over different lengths of time (one session in a week or twelves sessions over six weeks). The main criticism of the theoretical explanations in green PA was limitation in its psychological perspective and the neglect of the role of PA. To respond to this limitation, a sound theoretical framework, an ecological dynamics perspective, was proposed in this thesis. This theoretical perspective with its three features for understanding green PA: emergence of behaviours from multiple subsystems, interacting constraints, and affordances was suggested to offer a more sophisticated explanation without ignoring the roles of environment, PA and individuals (Yeh et al., 2015). This underpinning theory also provided principles to guide the experimental setting in this thesis. Methodologically, mixed methods were applied in this programme of research and were believed to collect rich information to advance the understanding of green PA. In particular, mixed methods collected novel information about participants' PA experiences and different physical, psychological and emotional effects. A more representative PA environment was introduced to increase the validity of this research programme as the control environment to reflect a typical indoor PA environment. An important advance of study design was that no extra verbal instruction

was offered to participants for immersion with the presented information which was different from previous research asking participants to immerse to the nature information. The work completed within this thesis offers important knowledge for practical implications by highlighting the different physical, psychological and emotional effects accrued by various types of nature-based information compared to the popular self-selected entertainment condition and the different reported PA experiences of each designed environment. These findings provide essential information for engineers, designers, planners and psychologists to take into consideration when creating PA environments or scheduling PA programmes or interventions to enhance the efficacy of PA maintenance and adherence. The physical settings of this thesis were designed to be easily re-created at low cost in any indoor environments for people who might have limited access to outdoor greenspace, safety concerns, time constraints or who may be intimidated by typical gym environments. At the time of submission, this thesis has yielded three published peer-review journal articles and multiple conference and lecture presentations.

CHAPTER.2

LITERATURE REVIEW

This chapter is based on the following peer-reviewed journal article: Yeh H-P, Stone JA, Churchill SM, Wheat JS, Brymer E, Davids K. 2015. Physical, Psychological and Emotional Benefits of Green Physical Activity: An Ecological dynamics Perspective. Sports Med [Internet]. Available from: http://link.springer.com/10.1007/s40279-015-0374-z%5Cnhttp://dx.doi.org/10.1007/s40279-015-0374-z VN- readcube.com

2.1 *INTRODUCTION*

In modern society, physical inactivity and mental disorders are recognised as urgent health concerns because of their high association with chronic diseases, mental illness and premature mortality (World Health Organization, 2010a). The rapid development of urbanisation is considered to contribute to a weak human-nature relationship because of the dramatic changes between humans and their living environments which have significantly reduced the time humans spend in nature spaces and results in unhealthy environments and behaviours (Maas, Verheij, Groenewegen, de Vries, & Spreeuwenberg, 2006; Natural England, 2016b).

Nature is vital to humans, by providing food, water, air and shelters. It not only offers sources for human needs but also provides threats to human lives, because of humans' heavy reliance upon these nature environments and consequently affects human behaviours. The reciprocal nature-human relationship is mainly built on constant physical interactions. Our ancestors were hunters and gatherers, who lived in caves and hid in hollows from predators and who also needed to migrate regularly from one place to another place (Lieberman et al., 1993). This lifestyle was probably extremely physically demanding due to the need to perform prolonged PA for survival, such as endurance running for hunting (Pickering & Bunn, 2007). With the development of civilisation and agriculture, human settlements started to merge which allowed a less active lifestyle as farmers (Larsen, 2006). Although humans did not need to undertake a high level of PA for survival, the pursuit of health via different PAs was observed in different cultures. For example, in China, the earliest record of PA promotion for health and disease prevention was found from Hua-To in 2500 B.C. Hua-To was a Chinese doctor who encouraged exercise, such as Kung Fu, as a type of medical gymnastics for health promotion (MacAuley, 1994). In Greece, both Hippocrates (460 BC-370BC) and Galen (200-129 BC), a Greek physician and a Greek doctor, respectively, emphasised the critical relationship between PA, exercise and disease. The ancient Greeks identified the importance of physical wellbeing, fitness and a healthy active lifestyle (MacAuley, 1994).

4600 years later, humans still aim to pursue a healthy lifestyle and a desire to maintain physical health and mental wellbeing. Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity (World Health Organization, 2013). Health should be understood and maintained from multiple

viewpoints and participating in PA is viewed as one of the fundamental requirements with abundant benefits. The benefits of regular PA or exercise are well documented, such advantages include improvements of muscular, bone and cardiorespiratory health, reduction of risks of hypertension, coronary heart disease, stroke, diabetes, breast and colon cancer (The Academy of Medical Royal Colleges, 2015; World Health Organisation, 2016) as well as being fundamental to energy balance and weight control (World Health Organization, 2010a). In addition, it is also beneficial for increasing self-esteem and improving cognitive function among children and adolescents (Biddle & Asare, 2011). The beneficial effects of PA on depression and anxiety have been proposed in multiple papers (Fontaine, 2000; Fox, 1999; Paluska & Schwenl, 2000; Taylor, Sallis, & Needle, 1985). However, deliberate efforts of maintaining sufficient PA level or regular exercise would be needed to achieve this goal because high levels of urban development have contributed to a hectic lifestyle and a weak human-nature relationship, consequently making an impact on human health, especially for urban residents (Elliott, 2016). The new human-nature relationship reflects a loss of contact with nature which is believed to hamper the pursuit of health (Natural England, 2016a). The next section illustrates how urbanisation changes humans' lifestyles and causes health challenges.

2.1.1 Urbanisation

Urbanisation, defined as the increase in the number of cities and urban population, is not only a demographic movement but also includes social, economic and psychological changes that constitute the demographic movement (Srivastava, 2009). The urban population of the world has grown rapidly since 1950 when 30% of the global population were urban residents. In 2014, 54% of the world's population was residing in urban areas and by 2050, 66% of the world's population is projected to be urban (United Nations, 2014). Lifestyle changes related to PA can be simply observed in daily life with the physical environment. A national survey indicated that people stayed in enclosed spaces for 20 hours during a day in the USA (Klepeis et al., 2001). The duration of screen-based activity is on average more than 7.5 hours a day for youth populations which is slightly shorter than adults (10 hours a day) in USA (Rideout, Foehr, & Roberts, 2010). In the UK, it is reported that adults spend up to 8.5 hours a day sitting (Healy et al., 2011). This is reflected in that there are lower possibilities that people need to go outside and also limited time for people to spend outdoors or in

nature environments. Even within daily mobility, urban residents mostly travel by car (64% of trips) compared with walking (22%), public transport (9%) and cycling (2%) (Sharkey & Meierotto, 2016). This lifestyle is inclined to reduce PA, which is made difficult by a variety of urban factors including overcrowding, high-volume of traffic, heavy use of motorized transportation, poor air quality and lack of safe public spaces as well as recreation/sports facilities (World Health Organization, 2010b).

Urban residents are also more likely to be disconnected with nature because the available physical space is limited for other commercial, residential or transportation purposes in cities. Due to the nature of cities, the enhancements to the quality of life, improvements in system efficiency, or reductions in environmental impacts are the main goals of urban designers and transportation planners rather than the personal health of its residents (Handy, Boarnet, Ewing, & Killingsworth, 2002). People nowadays are surrounded by more artificial elements in their environments, such as concrete buildings, skyscrapers, traffic noise and polluted air rather than nature environments, like woodland or forests, trees, flowers and birds or rivers. The whole layout of our living environment has undergone massive changes compared to those in which our ancestors lived; therefore, the way people engage with physical environments has changed. This fundamental change of physical engagement might be the catalyst of physical inactivity we face today. The rapid cultural transformation from rural to modern society is also considered to be one of the reasons for psychological disorders (Gullone, 2000; Srivastava, 2009). Many researchers have reached the conclusion that humans may not be fully adapted to urban living and the stress related to such a lifestyle suggests that urban environments are not optimal habitats for humans (Cordero, Masia´, & Galve, 2014; Kellert & Wilson, 1993). In conclusion, many people now live in overcrowded urban areas with hectic lifestyles and disconnection from nature which might evoke the serious health issues we face today, such as physical inactivity and mental illness.

2.1.2 Physical inactivity and the prevalence of mental disorder

Based on WHO guidelines, children and young people aged 5–17 years old should complete at least 60 minutes of moderate-to-vigorous-intensity of PA daily (World Health Organization, 2010a). Adults aged 18–64 years should do at least 150 minutes of moderate-intensity aerobic PA throughout the week, or at least 75 minutes of vigorous-intensity aerobic PA throughout the week, or an equivalent combination of moderate and vigorous-intensity activity (Townsend, Wickramasinghe, Williams, Bhatnagar, &

Rayner, 2015). In 2010, 23% of adults (aged 18 and above) were not active enough (men 20% and women 27%) and 26% of men and 35% of women were insufficiently physically active in high-income countries, as compared to 12% of men and 24% of women in low-income countries (World Health Organisation, 2016). In the UK 44% of adults never do any moderate PA (Townsend et al., 2015). Globally, physical inactivity has been identified as the fourth leading risk factor for global mortality, responsible for approximately 3.2 million deaths each year and is implicated in the prevalence of non-communicable diseases such as cancer and cardiovascular defects (World Health Organization, 2010a). More specifically, physical inactivity is the main cause for approximately 21–25% of breast and colon cancers, 27% of diabetes and 30% of ischaemic heart disease burden (World Health Organization, n.d.).

Financially, physical inactivity is also being recognised to add a catastrophic burden to society leading directly to chronic diseases (Scholes & Mindell, 2012). For example, type 2 diabetes accounts for 90% of all diabetes (World Health Organization, 2005). The total cost of direct patient care for diabetes in 2010/2011 is estimated at £9.8 billion. The indirect costs associated with diabetes are estimated at £13.9 billion (Hex, Bartlett, Wright, Taylor, & Varley, 2012). Spending on Medicare beneficiaries rose between 1987 to 2006 and had been attributable to chronic conditions such as diabetes, arthritis, hypertension, and kidney disease in USA (Thorpe, Ogden, & Galactionova, 2010). In addition, many people with long-term physical health conditions are two to three times more likely to experience mental health problems, such as depression and anxiety, than the general population (Naylor et al., 2012).

Besides physical inactivity, the prevalence of mental disorders is another urgent health challenge. One in four people in the world are affected by mental or neurological disorders at some point in their lives, placing mental disorders among the leading causes of ill-health and disability worldwide (World Health Organization, 2001). Psychosocial factors, such as adverse living conditions, can influence the onset and persistence of depressive episodes apart from genetic and biological factors (World Health Organization, 2001). In England, mental health is a major economic challenge because of the increasing number of residents with mental disorders and the high cost of treatment. The number of people in England who experience a mental health problem is projected to increase by 14.2% from 8.65 million in 2007 to 9.88 million in 2026 – a rise of more than 1.2 million people (McCrone, Dhanasiri, Patel, Knapp, & Lawton-Smith, 2008). Direct costs of mental health are now around £22.5 billion a year in

England. That includes spending in health and social care and a variety of other agencies, but not the indirect costs of the impact on the criminal justice system and in lost employment (McCrone et al., 2008). A more recent report indicated that the costs of mental health problems to the UK economy are estimated to amount to £70-£100 billion each year (Natural England, 2016b).

According to the 2010 Global Burden of Disease Study, the most predominant mental health problems worldwide are depression and anxiety (Whiteford, Ferrari, Degenhardt, Feigin, & Vos, 2015). In 2007, around 1.24 million British people suffered from depression and the cost was around £7.5 billion including service and lost earnings (McCrone et al., 2008). People with mental disorders experience disproportionately higher rates of disability and mortality. It was reported that people with major depression and schizophrenia had a 40% to 60% greater chance of dying prematurely than the general population, owing to physical health problems that were often left unattended (such as cancers, cardiovascular diseases, diabetes and HIV infection) and resulted in suicide (World Health Organization, 2013). However, the aforesaid financial statistics data were used for treatment and related loss rather than for prevention. Most importantly, individuals with serious mental illness are at high risk of chronic diseases associated with sedentary behaviour, including diabetes and cardiovascular disease (Richardson et al., 2005) which are also the consequences of physical inactivity. Therefore, the prevalence of physical inactivity and mental disorders can be viewed as two entwined health challenges and should be taken in to consideration together when seeking solutions.

From rural life to high urbanisation, the intimate nature-human relationship is weak because of dramatically physical environmental changes and the innovation of transport and technology. With this hectic lifestyle and limited chances of exposure to nature in the modern society, urban populations suffered numerous urgent health challenges, especially the prevalence of physical inactivity and mental disorders which required immediate actions. Although it might be difficult to repair the nature-human linkage completely, it is possible to increase the interaction with nature to improve physical health and mental wellbeing with the abundant benefits of experience with nature. The following section aims to present the various benefits of experiences with nature across different scenarios.

2.2 *BENEFITS OF EXPOSURE TO NATURE*

Nature environments have been suggested to promote active living via enhancing attitudes toward PA and perceived behavioural control via positive psychological states and stress-relieving effects, leading to firmer intentions to engage in PA (Calogiuri & Chroni, 2014). Compared to people who do not regularly walk in nature environments, regular walkers are associated with lower levels of depression, perceived stress and negative affect, as well as enhanced positive affect and mental wellbeing (Marselle, Irvine, & Warber, 2014). It has also been found that people who were in regular contact with nature in childhood presented fewer symptoms of depression in adulthood (Snell et al., 2017). Even childhood experiences of visiting nature environments could be an influential factor in the willingness to visit green spaces or woodlands as adults (Thompson, Aspinall, & Montarzino, 2008). When people have good access to green space (perceived or actual), they are 24% more likely to be physically active (Natural England, 2009). Even when the experience with nature occurred in urban green spaces, there is also considerable impact on the population's health. Up to a further 7% of cases of depression and 9% of high blood pressure cases could be prevented if all city residents were to visit green spaces at least once a week for an average duration of 30 minutes or more (Shanahan et al., 2016). The residents of the greenest urban neighbourhoods are at lower risk of poor mental health than those in the least green areas, and the results suggest a dose-response relationship (Richardson, Pearce, Mitchell, & Kingham, 2013).

With the increasing research investigating the relationship between humans and nature, the term "nature" was not often been strictly defined. In a systematic review, Ives et al. (2017) indicated that there were three types of human-nature relationship (viewing the human-nature relationship as *mind*, *experience* and *place*) and it was also challenging to define nature (and non-nature) conditions across different disciplines. In this thesis, the term "nature" will be defined as the phenomena of the physical world collectively, including plants, animals, the landscape, and other features and products of the earth, as opposed to humans or artificial human creations (Soanes & Stenenson, 2008). Nature environments include the physical environment allowing individuals to be exposed to different non-human phenomena (trees, plants, grass, mountains, water, and animals) found in gardens and parks through to woodland and forests, and also including environments such as university campuses (Bowler, Buyung-ali, Knight, & Pullin,

2010; Calogiuri & Chroni, 2014). 'Green' is referred to in this thesis as the physical environment covered with grass or other vegetation. As such, greenspace could be viewed as a place with nature vegetation and in this thesis, greenspace and nature environment are terms used interchangeably. Based on this definition, Green PA has been defined as undertaking PA whilst being directly exposed to nature (Yeh et al., 2015), which could encompass all kinds of experiences with nature. There are three levels of Green PA (see section 2.4.2) which is determined by the different types of engagement with nature, involving different richness levels of nature information including visual, acoustic, olfactory and other sensory inputs in indoor, outdoor, urban or nature spaces.

Green PA has been documented to have positive contributions to human' physical health and mental wellbeing (Hartig, Mitchell, de Vries, & Frumkin, 2014; McMahan & Estes, 2015; Pretty, Rogerson, & Barton, 2017; Shanahan et al., 2016; Van den Berg et al., 2016). In addition, the current research on effects of nature on health has typically focused on outdoor nature or urban environments (Mcsweeney, Rainham, Johnson, Sherry, & Singleton, 2015). These environments included forests, woodlands, mountains, beach, wildlife reserves, university campuses, gardens and parks. For example, Pretty and colleagues (2007) investigated the effects of ten types of green PA (including walking, cycling, horse-riding, fishing, and canal-boating and conservation activities) in four regions of the UK and found improvement in self-esteem and mood as a result of participating in the various green exercise activities. Furthermore, participants with poor self-esteem would benefit even more from green PA than people with higher initial self-esteem values (Pretty et al., 2007). Mackay and Neill (2010) examined the effects of 8 types of green PA (road and mountain cycling, mountaineering and cross-country running, orienteering, boxercise, kayaking and walking) on state anxiety and the role of duration, intensity and greenness. Results showed that green PA reduced anxiety and a higher reduction occurred when participants perceived themselves to be exercising in more nature environments. Four types of environment (beach, grasslands, riverside and heritage) were examined to understand the different effects on self-esteem, perceived stress and mood while doing a 5 kms run. In this study, running in any of the different nature settings was found to improve self-esteem, mood and reduce stress(Rogerson, Brown, Sandercock, Wooller, & Barton, 2015).

More specifically, the multiple benefits of green PA also have been examined and compared to urban or indoor spaces across different physical settings and scenarios in the literature.

2.2.1 The benefits of exposure to nature in nature spaces compared to urban or indoor space

There is a large body of research focusing on examining the multiple benefits of physical interaction with nature by comparing the same PA performed in a nature, urban space or indoors across physical and psychological aspects. Kinnafick and Thøgersen-Ntoumani (2014) conducted a two phase study examining the different affect states (positive and negative affect, energy, and tension) of sitting or walking in nature or urban environments. In that study, each participant first sat in the chosen environment for 20 minutes and was required to pay attention to the surroundings followed by a 20-minute walk. Results showed that the nature environment enhanced the positive effects of PA compared to the urban environment. Walking increased the levels of energy and decreased tiredness whereas sitting decreased the levels of energy but had no effect on tiredness. However, participants can benefit from walking in the urban environment in terms of feelings of energy and tiredness over time compared to sitting in the urban environment. The positive effect of walking in nature compared to an urban walk was found on the ability to reflect on a life problem (Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009). Krinski and colleagues (2017) examined psychological and physiological responses of women with obesity during self-paced walking in two exercise settings (treadmill and outdoors) for 30 min and found that participants displayed higher externally focused attention, positive affect, and lower ratings of perceived exertion, followed by greater enjoyment and future intention to participate in outdoor walking during outdoor exercise. Walking in forest environments (6 hours in two days) was found to be beneficial for the immune function and lasted for more than 1 week, and sometimes even 4 weeks, compared with walking in urban environments (Li et al., 2008). A further study found that walking in forest environments (4 hours in a day) might lower blood pressure by reducing sympathetic nerve activity (reducing urinary noradrenaline levels) and increasing parasympathetic nerve activity compared to walking in an urban area (Li et al., 2011).

From the preceding discussion, it can be concluded that the benefits of walking in a nature space compared to walking in an urban environment or indoors included

increasing feelings of positivity and energy (Kinnafick & Thøgersen-Ntoumani, 2014), enhancing the ability to reflect on a life problem (Mayer et al., 2009), accruing greater enjoyment and future intention to exercise (Krinski et al., 2017), strengthening immune function and lowering blood pressure (Li et al., 2008, 2011) over different walking durations (10 minutes, 30 minutes, 90 minutes, 4 hours and 6 hours). The comparison between nature and urban or indoor environments of the above reported studies were the outcomes of multiple environmental factors of these two types of environments including temperature, air, climate, humidity or surrounding views and biological diversity. Therefore, the finding was a comparison of all combined environmental factors rather than the influence of one single factor. However, when conducting studies outdoors, it is challenging to precisely control the intensity of PA of all participants which was considered as an influential factor of PA experiences (Asztalos, De Bourdeaudhuij, & Cardon, 2010). A laboratory-based study might be criticised as lacking representative design (the arrangement of conditions of an experiment so that they represent the behavioural setting to which the results are intended to apply) when directly compared to outdoor or nature environment for examining human behaviours (Araújo, Davids, & Passos, 2007). However, the strength of a laboratory-based environment is that it allows examination of one single factor and precisely controlled exercise components, such as intensity level of PA.

In the group of research with intensity of PA controlled, nature space was still proposed to be more beneficial on mental and physical health for various modes of PA. For example, Focht (2009) found that people reported greater pleasant affective states, enjoyment, and intention for future participation with outdoor walking compared to conducting the same 10 minute self-selected intensity walk in a laboratory environment. In another study, two groups of recreational and competitive runners were recruited to run 5 kilometres on a treadmill in the laboratory and in a nature environment with various psychological measurements recorded. Recreational runners were found to have higher scores on pride scale when running in the nature environment than running in the laboratory environment (Kerr et al., 2006). In terms of cycling, Rogerson et al. (2016) compared a range of psychological outcomes of riding stationary bikes in green outdoors and indoors settings including directed attention, mood, perceived exertion, social interaction time, intention for future exercise behaviour and enjoyment. Participants were paired and cycled together within a nature environment or in a laboratory on different days. Findings indicated that better directed attention and longer

social interaction time were found in the outdoors condition, but no differences were observed in mood, enjoyment, perceived exertion or intention due to the environments. A review article concluded that compared with exercising indoors, exercising in nature environments was associated with greater feelings of revitalization and positive engagement, decreases in tension, confusion, anger, and depression, and increased energy (Coon et al., 2011). However, the results suggested that feelings of calmness may be decreased following outdoor exercise. Participants reported greater enjoyment and satisfaction with outdoor activity and declared a greater intent to repeat the activity at a later date. In line with this statement, several studies have been conducted to examine the effects of stress reduction in the workplace (An, Colarelli, Brien, & Boyajian, 2016; Brown, Barton, Pretty, & Gladwell, 2012, 2014). It was found that under the same workload of exercise, undertaking exercise (bike ride and circuit training) in a nature environment for office workers showed greater potential for restoration than the indoor PA environment, which was associated with greater psychological benefits at post-exercise for the nature group, with higher ratings of positive affect as compared to the indoor group (Calogiuri et al., 2016).

Physically interacting with nature space seems more beneficial than undertaking the same PA in urban or indoor environments whether the comparison was made with or without rigorous control of exercise intensity. However, urban residents might have limited chances to physically visit and interact with nature frequently. Hence examination of how urban residents can interact with nature is an important area of research.

2.2.2 The benefits of exposure to nature on a daily basis in urban spaces

The benefits of green environments can be observed on a daily basis in numerous scenarios, such as in prison, office, home, neighbourhood areas, university, school and hospital. For example, a classic study by Moore (1981) reported 24% fewer sick cell visits for prisoners located in farmland and tree facing cells in comparison to cells that faced the prison yard. Shin's (2007) study of office workers indicated that nature views through windows had positive effects on job stress and satisfaction compared with others facing non-nature views, such as paved areas, adjacent buildings, parked cars and other built elements. Furthermore, Wells (2000) investigated effects of the level of greenness of home environments on cognitive function of children living in low-income urban areas and found that children who relocated to a greener environment tended to

have higher levels of cognitive function. Several similar studies all suggested that the accessibility of green space within the daily living environment provides positive influences on human health, including higher PA and better self-reported health (Coutts, Chapin, Horner, & Taylor, 2013; Maas et al., 2006; Maas, Verheij, Spreeuwenberg, & Groenewegen, 2008; Public Health England, 2017). Benfield et al. (2013) examined students' perception, academic performances and attendances of a college writing course across multiple sections in two distinct classroom settings, those with a view of a nature setting and those with a view of a concrete retaining wall. Students with a view of a nature setting reported a more positive perception and better grades compared to students who had no nature view, with no differences in attendances between both groups. Holden and Mercer (2014) examined students' knowledge retention and mood when exposed to and not exposed to nature elements in the learning environment. Each group was exposed to such physical setting once and also re-tested after a week. Findings indicated that students in the nature-infused condition scored higher on the test of knowledge than those in the artificial environment for only a week. For elementary school students, having nature landscapes for play, learning and green views, they showed more positive moods and reduced stress, anger, inattention and problem behaviours (Chawla, Keena, Pevec, & Stanley, 2014). The similar positive effect of visual exposure to nature views was also observed among hospital patients by Ulrich (1984). By comparing patients whose windows faced nature elements (trees) and brick walls respectively, Ulrich (1984) reported that the nature view group had faster recovery, less negative feedback and lower analgesic dose requests. Gardening has also been found to be an efficient method to promote health and wellbeing, especially allotment gardening which is a popular urban-based activity with physical contact with nature. Compared to non-gardeners, the allotment gardeners were found to have better self-esteem, mood, and general health and expressing less depression and fatigue and more vigour (Wood, Pretty, & Griffin, 2015). It was also found that gardening activity could be classified as low to moderate-high intensity PAs based on their metabolic values which in fact would contribute to disease prevention and health promotion in older populations (Hawkins, Smith, Backx, & Clayton, 2015).

Humans actively or passively interact with the existing nature elements in the physical environment when undertaking daily tasks. The observed benefits of exposure to nature in daily lives include lower rates of illness for prisoners (Moore, 1981), lower stress levels and higher job satisfaction for office workers (Shin, 2007), better cognitive

performances for low-income children (Wells, 2000), better self-reported general health (Wood et al., 2015), higher levels of PA (Sandercock, Angus, & Barton, 2010), better academic performance and mood for university students (Benfield, Rainbolt, Bell, & Donovan, 2013; Holden & Mercer, 2014) and faster recovery for post-surgery patients (Ulrich, 1984) for the youth, adults and the elderly. Therefore, the aforementioned research demonstrated the influential merit of experiences with nature for human.

2.3 *THEORETICAL FRAMEWORKS FOR GREEN PA*

The diverse benefits of green PA were presented in section 2.2 across various modes of PA (e.g. sitting, walking, running, and cycling) in different environmental settings (home or working environments, nature, urban / built or indoor environment) among adults, children and elderly people. In this section, three dominate theories will be outlined to illustrate how they support the merit of experiences with nature regarding the concepts and applications.

2.3.1 The Biophilia hypothesis

Biophilia means "love of life or living systems" (Fromm, 1964), referring to the psychological tendency in humans to be attracted to all that is alive and vital (Simaika & Samways, 2010). This notion was endorsed by Edward Wilson (1984) who defined Biophilia as the innate tendency to focus on life forms and life-like processes (Kellert & Wilson, 1993). Wilson argued that these affiliations are the result of millennia of human evolution in a nature environment, where repeated contact with, and dependence on life and life-like processes was crucial for hominin survival and reproduction (Joye, 2007). In such environments, biophilic tendencies were adaptive because an organism had clear evolutionary benefits when it was hardwired to focus on and to respond emotionally to certain survival-relevant living elements (Joye, 2007). Therefore, during evolution, humans associated the rewards and the dangers with nature settings, favouring individuals who readily learned and remembered various adaptive behaviours including both approach (biophilia) and avoidance (biophobia) responses to specific nature stimuli and configurations (Gullone, 2000). The human need for nature is linked not just to the material exploration of the environment, but also to the influence of the nature world on our emotional, cognitive, aesthetic, and even spiritual development (Kellert & Wilson, 1993). Kellert (1993) further described nine dimensions of the biophilia tendencies: the utilitarian, naturalistic, ecologistic-scientific, aesthetic, symbolic, humanistic, moralistic,

dominionistic, and negativistic (Gullone, 2000; Kellert & Wilson, 1993). This proposition suggested that human identity and personal fulfilment somehow depend on our relationship to nature (Kellert & Wilson, 1993).

The Biophilia hypothesis has been applied to support the benefits of human health and wellbeing when in contact with nature and other forms of life across various fields (Akers et al., 2012; Chen, Tu, & Ho, 2013; Kahn, 1997; Lohr, 2010; Melson, 2003; Nicholas, 2001; Simaika & Samways, 2010). The colour "green", a visual information representing nature was found to be beneficial compared to other non-nature representative colours (i.e. grey and red) on the same footage when cycling (Akers et al., 2012). Results showed that positive emotional benefits and lower exertion were found because the propensity to experience positive moods in nature surroundings is an innate instinct in which greenness has a particular significance. A similar nature affiliation of humans is observed on placing plants indoors which represents nature with physical existence. The indoor plant, one type of the nature life, was suggested to be beneficial in various aspects for human health, including cleaner, healthier air to breathe, lower level of indoor air pollutants, a healthier and more comfortable level of humidity of the interior space and potentially reduced noises in certain conditions. Mentally, people tended to feel less stressed, more productive and happier with the presence of indoor plants (Lohr, 2010). With physical interaction with nature, the attributes of horticultural activity as a form of Biophilia leisure were examined and it was found that positive effects and feelings, such as concentration improvement, enjoyment, pleasure, optimism, relaxation and tranquillity were experienced (Chen et al., 2013). The authors suggested that this inherent human trait is like a deep and enduring urge to make contact with nature and enjoy the company of other creatures (Chen et al., 2013).The Biophilia hypothesis also provided theoretical explanations for the human-animal bond (Melson, 2003), animal therapy (Nicholas, 2001), biodiversity conservation (Simaika & Samways, 2010) and nature landscape (De Groot & Van Den Born, 2003; Kellert, Heerwagen, & Mador, 2008; Ryan, Browning, Clancy, Andrews, & Kallianpurkar, 2014).

The Biophilia hypothesis was suggested to be compelled by purely evolutionary logic because, in more than 99% of human history, people have lived intimately with other organisms (Kellert & Wilson, 1993). Therefore, it seems plausible that the Biophilia hypothesis supports the positive effects of various types of nature-human connection across humans, plants, animals and nature environments simply out of evolutionary affiliation to other forms of life. However, scientific examinations have failed to offer

the justification for this hypothesis (Johnson, 1994; Simaika & Samways, 2010). It, therefore, appears to be weak in placing positive human feelings for life and life-like processes in a narrow evolutionary psychology framework. It seems that the theory has overestimated the evolutionary origins of these feelings and has neglected arguments and research that speak against it (Joye & de Block, 2011). A clear point in the direction of evolved needs and preferences for life and life-like processes would be more persuasive with robust findings of evolutionary psychology (Joye & de Block, 2011). This hypothesis also has been questioned due to the absence of clear definitions of this concept, resulting in criticisms (Joye & de Block, 2011). For example, there is confusion between the terms "life" and "life-like process" when applied in empirical studies. If "life" was understood as biological and "life-like" could be similar to biological entities, then it would be unclear to classify the non-biological nature elements, such as water and earth/mud. Furthermore, the absence of a detailed conceptual analysis of the terms "life", "life-like" and "nature" result in unclear understandings when these were frequently and interchangeably used in the related research (Joye & de Block, 2011). Therefore, with the confusion existing with this hypothesis and no rigor in the scientific examination it may not justify or be convincing enough to offer explanations of different experiences with nature with this single hypothesis.

2.3.2 Stress reduction theory

The effect of viewing different outdoor environment scenes on stress was examined by Ulrich (Ulrich, 1979). In this study, two sets of outdoor environment photographs with and without green vegetation were presented to two groups of mildly stressed participants and findings suggested that stressed individuals felt significantly better after exposure to nature scenes rather than the urban scenes lacking nature elements. Ulrich (1981) further examined the psychological effects of different types of visual exposure to nature (i.e. nature scenes with water; nature scenes dominated by vegetation; urban scenes without water or vegetation). Results showed that exposure to these types of nature scenes, especially with water, had a greater influence on psychological states compared to the urban scenes. In a later study, Ulrich et al. (1991) further examined the effects of viewing nature videos among stressed individuals compared with urban environment videos. The conclusion was drawn that recuperation was faster and more complete when participants were exposed to the nature settings rather than the various

urban environments. Ulrich indicated that most unthreatening nature views may be more arousal reducing and tend to elicit more positively toned emotional reactions for people who experience stress or anxiety than the vast majority of urban scenes, and hence are more restorative in a psychophysiological sense (Ulrich, 1983). The Stress Reduction Theory was therefore proposed and supported by a series of exploratory work (Ulrich, 1979, 1981, 1984, 1991). This theory posits a healing power of nature that lies in an unconscious, autonomic response to nature elements that can occur without recognition and most noticeably in individuals who have been stressed before the experience (Bratman, Hamilton, & Daily, 2012). Ulrich proposes that perceiving particular qualities and contents in a scene can support psychophysiological stress recovery (Ulrich, 1983). Such particular qualities of the viewing scenes were for example, the presence of a focal point with moderate complexity and gross depth properties that require little inference. The nature contents included vegetation and water which can evoke positive emotions, sustain non-vigilant attention, restrict negative thoughts, and so aid a return of autonomic arousal to more moderate levels (Hartig, Evans, Jamner, Davis, & Gärling, 2003; Ulrich, 1983). It was also suggested that these particular nature places (especially those along watersides and with visible horizons) would trigger positive affective response. This was because our species viewed the places with the presence of water as basic need and clear visual ability was to erase the hidden threats which were showing greater rates of survival from an evolutionary basis (Bratman et al., 2012; Hartig et al., 2003).

The Stress Reduction Theory is widely applied in clinical healthcare environments or in patient treatments programmes (Andrade & Devlin, 2015; Kjellgren & Buhrkall, 2010; Ulrich et al., 2008; Ulrich, Simons, & Mies, 2003). For example, Ulrich et al. (2003) examined the effects of healthcare environments on stress reduction during blood donation by displaying four types of information on the television monitor, including nature and urban videos, normal television programmes and nothing (Ulrich et al., 2003). Results showed that heart rate was lower in the nature condition compared to the urban condition. Participants showed higher levels of stress when viewing normal television shows compared to showing no information on screen. Both blood pressure and heart rate data supported that low stimulation (nature / viewing nothing) alleviated stress to greater extent than high stimulation (urban / television shows) which proposed the benefits of stress reduction of viewing nature scenes in a healthcare environment. Another supporting study was conducted with a different target group. Eighteen

participants diagnosed with stress or burnout syndrome were recruited to examine the restorative effects of two different nature-exposure experience, sitting in a nature park for half hour or looking at photograph slideshow of the same environments indoors (Kjellgren & Buhrkall, 2010). Findings showed that these two types of nature-exposure experiences are equally efficient in reducing stress, but that physically sitting in a nature space resulted in a higher degree of altered states of consciousness and increased energy than the indoor simulated nature environment. This theory has also been applied in other fields, such as environmental design and wellbeing (Chawla et al., 2014), virtual environment (Annerstedt et al., 2013; Schutte, Bhullar, Stilinović, & Richardson, 2017) and workplace wellbeing (Shin, 2007). For instance, the effect of virtual reality nature with and without sound on inducing physiological stress recovery was examined compared with a control condition of viewing no information (Annerstedt et al., 2013). Results indicated that stress recovery can be facilitated by the addition of sounds of nature to a virtual green environment in a laboratory setting. Furthermore, the restorative effect of nature sounds has also been examined. Alvarsson, Wiens and Nilsson (2010) tested the stress reduction effect of nature sound compared to environmental noises. This study suggested that nature sounds facilitate recovery from sympathetic activation after a psychological stressor.

Stress Reduction Theory was supported by the aforesaid research which had examined different types of experiences with nature among different populations. However, the theory tends to highlight affect and stress-related components of the individual's relationship with landscapes and consequently encourages a body of research to examine the effects of stress and nature exposure in various settings which might be viewed as stressful environments, such as hospitals or work places. Therefore, this theory might be inadequate to offer explanations on experiences with nature occurrence in non-stress scenarios, such as exercising in the habitual nature environment.

2.3.3 Attention restoration theory

Attention Restoration Theory, developed by Kaplan and Kaplan (1989), examines the ways in which exposure to nature could have a restorative effect on the brain's ability to focus (Bratman et al., 2012). This theory uses theoretical constructs dating back to the work of the psychologist William James, resting upon the proposal that attention can be separated into two distinct components voluntary (directed) and involuntary attention (Bratman et al., 2012; Kaplan, 1995). Directed or voluntary attention is the ability to

focus on task that requires effort, whereas involuntary attention is a form of attention that requires no effort. To avoid confusion, fascination was proposed to substitute the term "involuntary attention" (Kaplan, 1995). Directed attention requires the use of cognitive control and this ability would lead to fatigue with prolonged use. When attention was fatigued, people would become fragile, less effective, less patient, and irritable, and had difficulties in decision making and problem solving (Kaplan, 1995). In order to recover and restore attention, an environment needs to allow individuals a chance to be away from everyday stress, experience expansive spaces and contexts, engage in activities that are compatible with our intrinsic motivations and critically experience stimuli that are softly fascinating (Duvall, 2011; S. Kaplan, 1995; Ohly et al., 2016). Nature environments were suggested to be a powerful environment for attention recovery (Kaplan, 1995).

Attention Restoration Theory was applied in various nature settings among different populations with various exposure durations (Berman, Jonides, & Kaplan, 2008; Duvall, 2011; Gamble, Howard, & Howard, 2014; Hartig et al., 2003; Kuo & Taylor, 2004). A nationwide study was conducted by Kuo and Taylor (2004) on ADHD children's after-school and weekend activities in green outdoor, urban outdoor and indoor settings for identifying a potential treatment with nature involved in USA. Findings indicated that exposure to ordinary nature settings in the course of common after-school and weekend activities may be widely effective in reducing attention deficit symptoms in children. Berman et al. (2008) firstly examined the effects of interaction with (walking in) an urban and a nature environment on cognitive performance and found, compared to urban environments, better cognitive performances were in the nature condition. In the same study, the researcher further examined the three types of attentional functions by exposing participants to nature and urban pictures. During the exposure, participants were asked to rate each group of pictures to confirm their engagement with the viewing media. Executive attention (requiring more cognitive control) was found to be improved when viewing the nature pictures compared to urban photographs (Berman et al., 2008). In another study with the similar design of Berman's study, the same positive effect of executive attention when viewing nature photos was found among an older age group compared to urban photos (Gamble et al., 2014). Duvall (2011) further investigated the effects of cognitive engagement strategies on behaviour and psychological well-being in outdoor walking. Various awareness plans were offered to encourage participants to have better cognitive engagement with the environment when walking outdoors.

Although the total walking time of these two groups was similar (the cognitively engaged group and the normal walking group), the engagement group reported significant increases in attentional function and feelings of contentment during the treatment period along with a significant decrease in feelings of frustration (Marselle, Irvine, Lorenzo-Arribas, & Warber, 2015). There is diverse research advocating the merit of Attention Restoration Theory, the majority of research investigating the effects of different nature exposure (mainly visual information) on attention capacity with numerous cognitive tests. This body of research offers valid understanding of the effects of experiences with nature on attention restoration without taking PA into account.

Ulrich emphasises the importance of a reduction in arousal, with physiological evidence showing decreased stress levels in subjects when viewing nature versus urban images. This contrasts with Attention Restoration Theory, which is more concerned with a replenishment of attentional capacities (Bratman et al., 2012). Although these two theories indicate the causality of the benefits from experiences with nature, the interpretation might be limited to psychological and cognitive response, which may draw a narrow boundary around the effects of experiences with nature. This is an issue of theoretical importance since it is possible that people might not get the same psychological effects when they walk to school in an urban district compared to wandering around the forest. Hence a more comprehensive theory which incorporates the multiple dimensions which might affect the role of nature and exercise is required.

2.3.4 An ecological dynamics perspective

The above three nature-based theories might offer different explanations on human-nature relationship but a lack of theoretical underpinning to ascertain whether different physical environments, with various layouts, surfaces, textures, objects and terrains, might support the emergence of different sensory perceptions, emotions and feelings when examining human behaviours (Yeh et al., 2015). Furthermore, when different modes of PA involved, the related experience might be changed. This is another concern relating to previous theories, which have lacked consideration of different types of PA. The involved physical tasks of green PA in aforementioned research are limited to sitting, walking and cycling, which could be different to mountain biking or field running. For example, a walker and a field runner might both feel positive of their experiences with nature due to different nature elements or contexts even in the same environment and exposed to the same the sunlight, air, temperature, the vegetation and

the nature view. But the demands of the PA they performed or individual differences, such as intentions of exercise performance or preferences of viewing scenes made them pick up or utilise different environmental information. The walker might spend more time and less effort to enjoy the nature scenery on a hiking trip and feel positive or alleviation of stress whilst the field runner is concentrated on the environmental information highly related to the exercise, such as the rocks, the route and the path to avoid injury. The visual attention of the runner might be limited to 10 to 20 meters in front of the running steps rather than looking at the nature scenery. The runner might still feel positive regardless of the limited nature views from the run; whereas a skilled runner might be able to focus on looking further along a field run. These examples reflect the potential factors of PA and individual differences which were not covered in previous theories.

Similarly, in the field of PA and health, the interaction of PA and the individual has been explored in the dimensions of PA initiation, maintenance and cessation, mostly in intervention designs for behaviour changes in health promotion. There are more than twenty theories proposing how to initiate and maintain PA for behaviour change, including social cognitive theory, the transtheoretical model, relapse prevention, self-efficacy theory, expectancy-value theory and theory of planned behaviour (Scott, 2014). These theories mainly focus on the interaction of the individual in different PA intervention designs. One of the two most popular theories, social cognitive theory (Bandura, 1999) assumes that cognitions precede motivation and action. Self-efficacy beliefs and outcomes expectations are the core of this theory. The theory predicts that behaviour will change if one has confidence in their actions, perceived control over the outcome and limited external barriers. The theory is criticised for not specifically focusing on behavioural maintenance and, therefore, does not outline the mechanisms or strategies for this phase of behaviour change (Scott, 2014). The transtheoretical model (TTM) (Prochaska & Velicer, 1997) provided different constructs: stages of change, processes of change, decisional balance (i.e., the pros and cons of behaviour change), and temptation and confidence for behaviour change. With an extra maintenance phase offered by this theory, TTM had been criticised for not providing an accurate account of PA behaviour change (Hutchison, Breckon, & Johnston, 2009). Several empirical studies have also tested or proposed various determinants for successful or unsuccessful PA maintenance including demographic, psychological, behavioural and health related factors (Scott, 2014). For example, gender (Bauman et al., 2012), performer's intention

or perceived control of behaviour (Godin, Amireault, Bélanger-Gravel, Vohl, & Pérusse, 2009; Maartje M. et al., 2009), feedback and goal setting to enhance self-efficacy (Ashford S, 2010).

Furthermore, in the field of health promotion, the behavioural epidemiology framework was suggested to be a valid model to explore human health behaviours by offering a general sequence of studies that leads to evidence-based public health interventions (Sallis, Owen, & Fotheringham, 2000). The five research phases are: (1) establish links between behaviours and health, (2) develop methods for measuring the behaviour, (3) identify factors that influence the behaviour, (4) evaluate interventions to change the behaviour and (5) translate research into practice. This model has been applied in research on different topics alongside PA promotion including studying the effects of sedentary behaviour among adults (Owen, 2012) and children and adolescents (Biddle, Gorely, & Stensel, 2004), children's mental health (Tercyak et al., 2006) and in persons with multiple sclerosis (Dixon-Ibarra, Vanderbom, Dugala, & Driver, 2014). This framework offered sound but general, phases for evidence-based health research to guide research steps which might be particularly beneficial in assessing the development of a research topic instead of providing theoretical explanations for dose-response relationships or hypothesis examinations.

With the aim of exploring PA promotion for human health incorporating nature, it is important to consider the role of PA, nature and humans together because human behaviour is a complex process which might change due to various factors. Hence, a more appropriate theoretical framework, the ecological dynamics perspective, is proposed in this thesis because it focuses on person-environment interactions as the basis for understanding the emergence of behaviours. It also considers that affordances provide opportunities for interacting with complex, dynamic environments, supporting exploration of varied behavioural tendencies, involving social, psychological and emotional dimensions (Brymer et al., 2014).

Ecological dynamics is a framework that integrates key ideas in dynamical systems theory and ecological psychology (Araújo et al., 2009; Brymer, Davids, & Mallabon, 2014). Dynamical systems theory views humans as a complex, biological system composed of many independent but interacting systems and the interaction can produce a richer order within the system through a process known as self-organization under constraints (Davids, Button, & Bennett, 2008). Ecological psychology proposes that a

perceiver would directly pick up environmental information specifically relevant to the individual for behaviour and this performer–environment interaction is mutual and reciprocal, in which both combine to form a whole ecosystem (Araújo, Davids, & Hristovski, 2006). Integrating these two theories, ecological dynamics emphasises the role of environmental and task constraints or characteristics which shape different behaviours in individuals, and the individual-environment relationship is proposed as the relevant scale of analysis for understanding human development (Brymer et al., 2014).

2.3.4.1 *Affordances-the central concept of ecological psychology*

An affordance is formed between the environment and the observer. The medium, substances, surfaces, objectives, places and other animals existing in the environment have affordances for a given animal (Gibson, 1986). Different environmental layouts afford different behaviours for different animals, and different mechanical encounters. An affordance is an invariant, dynamic and unique relationship between environment and organism. The affordance of something does not change with the needs of the observer, which implies that the affordance is invariant, not relying on the observer. The environment must have certain properties in relation to the acting animal, its bodily constitutions and its capabilities. "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill" (Gibson, 1986, p 127). To perceive an affordance is to detect an environmental property that provides opportunity for action and that is specified in an ambient array of energy available to the perceiver (Gibson & Pick, 2000). Gibson (1986) stated that the basic affordances of the environment are perceivable and are usually perceivable directly, without an excessive amount of learning. Humans perceive affordances directly from surroundings and pick up opportunities for behaviours. A specific environment exhibits its specific properties which can constrain behaviours and actions and each person perceives these opportunities for action from his /her own unique perspective (Brymer & Davids, 2013). Such properties provide opportunities for action, defined across the complementary relationship between the environment and animals (Gibson, 1986). For example, a grassed, flat lawn may be food for sheep, a place to lie down for adults and for children it may be a place to run or kick a ball.

2.3.4.2 *Multiple subsystems, self-organisation and constraints*

Complex systems are highly integrated systems that are made up of many interacting parts, each of which is capable of affecting other parts; in systems, states of order emerge under constraints (Davids et al., 2008). Human movement systems can be modelled as complex systems able to exploit surrounding constraints, allowing functional patterns of behaviour to emerge in specific performance contexts (Davids, Araújo, Vilar, Renshaw, & Pinder, 2013). The dynamic interaction between components can actually enhance the intrinsic system organization. These interactions can produce a rich order within the system through a process known as self-organisation (Davids et al., 2008). Self-organisation processes exemplify the coordination tendencies that are inherent in many complex systems and are influenced by many constraints that act on the system.

Newell (1986) provided a classification of constraints into three distinct categories: organismic, environment and task. Organismic constraints refer to as person's characteristics, such as genes, height, weight, muscle-fat ratio, cognition, motivation and emotions. Environment constraints are global, physical variables in nature, such as ambient light, temperature, or altitude. Task constraint is more specific to performance contexts than environmental constraints and includes task goal, specific rules associated with an activity, activity-related implement or tools and surfaces (Davids et al., 2008). During activity, the performer's responses self-organise, based on the interaction of various system subcomponents (e.g. past social experiences, emotional readiness, current communication readiness) and the ability of these subcomponents to naturally adjust and adapt to each other (Brymer & Davids, 2013). Each individual is considered as a unique complex system composed of many interacting subsystems which support thinking, perceiving, learning and acting. Everyone arrives in a specific situation with unique set of intrinsic dynamics (unique dispositional characteristics) that include physical, cultural, social, psychological and emotional influences that act as constraints on the acquisition of new behaviours (Brymer & Davids, 2013).

Ecological dynamics is an integrated framework with three features of significance for understanding green PA: emergence of behaviours from multiple subsystems, interacting constraints, and affordances. This theoretical framework focuses on the interactions of individuals with affordances of nature environments, including multiple dimensions, such as physical, psychological and emotional behaviours, which can be

explored at three interacting levels, i.e. at the level of the individual, environment and task. The interactions between the three categories of constraints will influence affordances for behaviours that emerge from undertaking physical activities in nature environments. Nature environments were viewed as a rich landscape of intense and various affordances which can enhance psychological health and wellbeing (Brymer et al., 2014). Green PA can be described as PA resulting from the realisation of affordances that comes about as a direct result of interacting with nature environments which lead to multi-dimensional responses and coupling in positive perception-action (Brymer et al., 2014). Affordances in nature provide multiple information sources and action possibilities for participants to adopt for their own preferences and may invite different behaviour from individual to individual. The effects of green PA on human behaviour can be explained from several interacting constraints related to the individual, environment and task.

Figure 2.1 described the core concepts of ecological dynamics perspective for understanding effects of green PA. Here, the example of running in a forest was used compared with on a treadmill in a gym to highlight each of the four points, as follows. (1) Embracing variability highlights that activity environments can provide varying levels of variability such as running in a forest with diverse options for running routes. The variability of each route will present different affordances compared with gym facilities. (2) By sampling rich and functional information sources, forest runners can experience different ambient conditions induced by weather and temperature changes, different topography, slope, ledges, surfaces, gaps or rocks, and interaction with other animals, which formulate richer information sources in nature than the temperature-controlled, 'weather-free' and limited changes in topography of a gym environment. (3) Recognising individual differences means that each individual will have varying preferences for activity environments due to variations in behavioural capacities. Hence, these must be considered in examining green PA. For example, runners with different skills will create varying actions to run on different running paths (clambering on steep trials and loping on downhill slopes) compared with running on a standard gym treadmill. (4) Context-dependent decisions will need effort to carefully design training schedules during green PA, allowing users to build up their action capabilities over time. It is important for designers or researchers to examine green PA effects with the relationship between participants and tasks. This figure was proposed to function as a guideline when evaluating green PA programmes or designing environments for green

PA. Although an increasingly number of bodies of research offered data to advocate the positive effects of green PA, further investigations on different variables, such as different populations, different types of nature environments or different intensity level of the involved PA are still needed for a more comprehensive understanding.

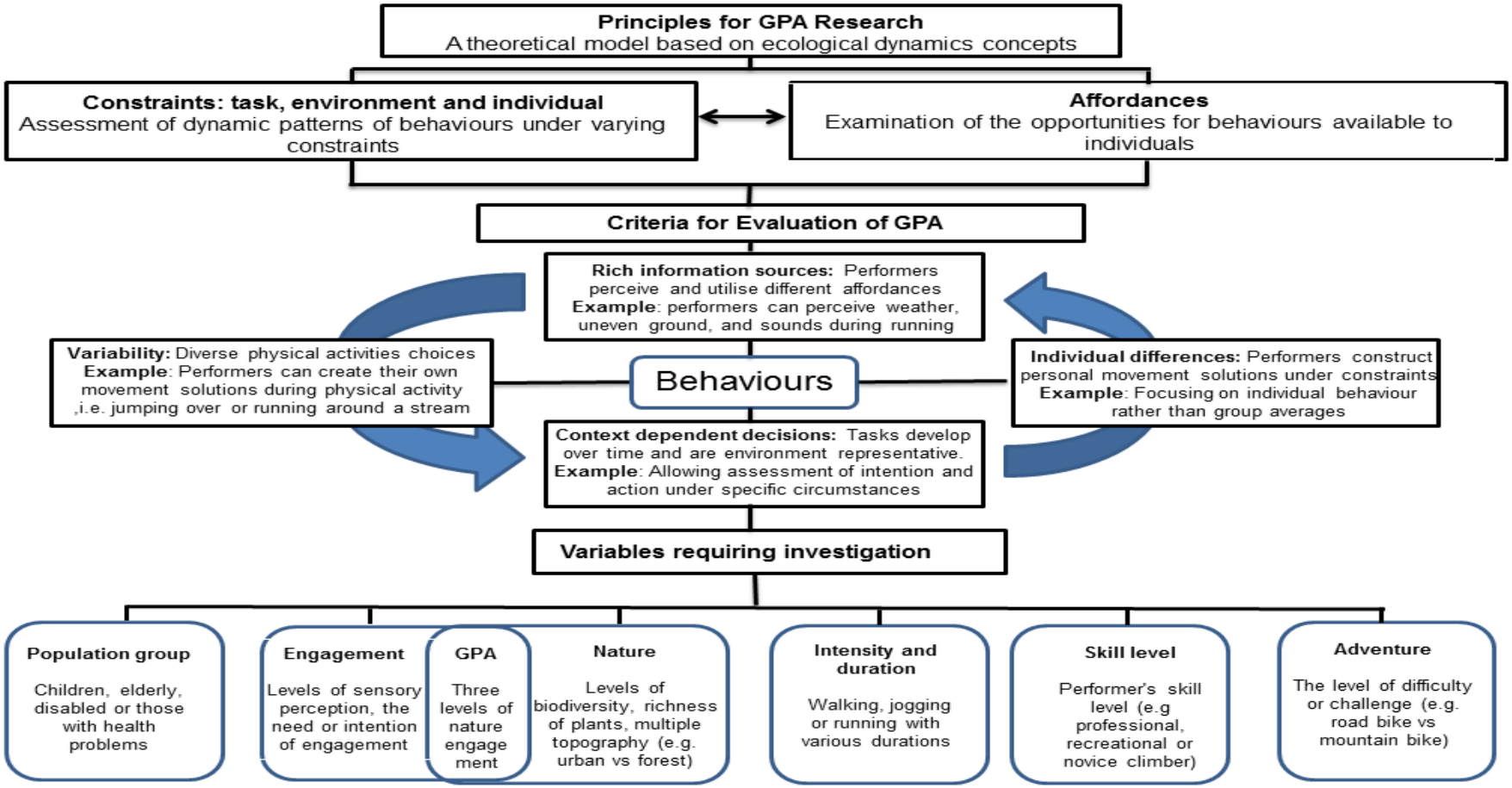

Figure 2.1. The theoretical model of principles for green PA (GPA) research from an ecological dynamics perspective (Yeh et al., 2015).

2.4 *A TANGIBLE MEANS TO PROMOTE PHYSICAL AND MENTAL HEALTH FOR URBAN RESIDENTS*

Exercising indoors is becoming increasingly popular amongst active individuals, with proportionally less PA undertaken outdoors and shifted indoors to use of gymnasia, sports hall or within homes (Gladwell, Brown, Wood, Sandercock, & Barton, 2013). This shift might be due to the hectic lifestyles as long working hours might deprive the chance to exercise outdoors during the day and encourage people to perform indoor PA in a gym or at home instead. Furthermore, there are several environmental factors which are linked to urbanisation and also contribute to physical inactivity, such as fear of violence and crime, high-intensity traffic, pollution, and insufficient sport or recreational facilities (World Health Organisation, 2016). For urban dwellers, indoor environments might be the most convenient option for undertaking PA. In fact, gym or gym-related fitness activities account for around 35% of British adults' monthly PA, just below walking for leisure (41%) (Sport England, 2017). A gym is the most popular exercise venue for exercisers who are 16 years old and above, (Sport England, 2016). As discussed in section 2.1, urbanisation is a continuing trend which has the potential to exacerbate the disconnection between humans and nature, the abundant benefits of nature (see section 2.2) and the potential theoretical explanation (see section 2.3). With the discussion shown in three sections, the adaptation and adjustment to human-nature interaction is proposed to be necessary for maintaining physical health and mental wellbeing in the modern society. With the popularity of indoor exercise in the majority of global populations in urban areas, it might be feasible to target urban residents to improve physical health and mental wellbeing and to focus on the effects of indoor environment for green PA.

2.4.5 Factors influencing indoor PA environment design

When designing a PA environment, a careful consideration of how to inform an effective environment to accrue expected benefits or outcomes of exercise is vital. The consideration would be across various aspects affecting the effectiveness of exercise such as the presentation of essential information, available physical activities, exercise intensity, duration, and the target group. These factors would influence the quality and effectiveness of, and adherence to, PA (Davids, Duarte, & Brymer, 2016; Rogerson, 2016; Yeh, Stone, Churchill, Brymer, & Davids, 2016). Therefore, a clear

understanding of the causality and consequence of different factors for different target groups is essential. Hence, identifying the effects of different nature-based information in PA contexts that more effectively engages individuals and maximises PA benefits is important for ensuring the effectiveness of indoor PA environment design.

2.4.6 Green exercise vs. green PA

PA is any bodily movement produced by skeletal muscles that requires energy expenditure including working patterns and housework (World Health Organisation, 2016). Exercise is a subcategory of PA that is planned, structured, repetitive and aims to improve or maintain one or more components of physical fitness (Caspersen, Powell, & Christenson, 1985). Therefore, green PA was defined as any bodily movement that: (1) is produced by skeletal muscles resulting in energy expenditure from the utilisation of perceived information, and (2) emerges from engagement with nature environments, e.g. gardening and walking in a park to recuperate from work (Yeh et al., 2015). In comparison, green exercise is defined as green PA that is planned, structured, rigorous, repetitive and purposive, with the aim to improve or maintain one or more components of physical fitness (Caspersen et al., 1985). Three distinct levels of green PA were classified by the engagement of nature whilst undertaking PA (Pretty, 2004), as below:

(1) Viewing nature through a window or an image, or on television or in a book

(2) Being in the presence of, but not directly engaging with, nature, such as reading in a garden or cycling to work

(3) Active interaction and involvement with nature, e.g. gardening, trekking, camping and running

Although each level of green PA might result in different benefits to individual's physical health and psychological wellbeing, the first level of green PA would be the main scope of this thesis because the focus is to promote physical health and mental wellbeing from urban population via improving indoor PA environments.

Based on the above definition (Pretty, 2004), the first level of green PA is that people are visually exposed to nature-based information, whether real or virtual nature, while undertaking any PA indoors. The range of nature-based information could be varied from real or virtual nature views, still or dynamic photographs, single or multiple photos or video footage. Although nature sounds were not included within the initial definition (Pretty, 2004), the effects of auditory information are suggested to be included because

of the merit of nature sounds. Rogerson (2016) proposed that the initial suggestion of the three categories was made related to individuals' decision-making processes and the physical description of human activity relative to an environment not necessarily reflecting an individuals' sensory environmental experience or psychological engagement with an environment. Therefore, the concept of engagement does resonate somewhat with the concept of immersion. Although it might seem that people are exposed to a restricted degree of nature-based information, the benefits of viewing nature were observed on various physical, physiological and psychological outcomes. The next section outlines related research, being conducted with different physical tasks (e.g., treadmill running, ergometer cycling or sitting) in various exercise durations (20, 15 or 5 minutes) when viewing diverse types of nature-based information among adults to support the benefits of the first level of green PA.

2.4.6.1 *Exposure to nature-based visual / visual-audio information in a laboratory environment*

In this section, a collection of studies were presented in detail to show the differences in duration of exposure to nature (5, 10 or 20 minutes), measurements (e.g., automatic control of heart, stress, heart rate, blood pressure and self-esteem), presented information (nature vs. urban) and formats of information (visual-only images or videos). For example, Gladwell et al. (2012) examined the effects of viewing nature and built scenes (still photos) on the autonomic control of the heart. Twenty-nine participants were asked to lie down in a laboratory for 5 minutes while viewing nature and built scenes. A positive benefit was found by simply viewing nature scenes with an increase in vagal activity whilst blood pressure and heart rate showed no differences (Gladwell et al., 2012). A similar comparison of viewing different scenes (still nature and built photos) was conducted on stress reduction and other psychological variables (heart rate, blood pressure, self-esteem and positive and negative affect). Twenty-three participants were asked to view these two sets of environmental images (10 minutes for each set of scenes) followed by a challenging cognitive task in two occasions with one week apart. Results indicated that viewing nature can elicit improvements in the recovery processes following periods of mental stress compared with viewing images of built environments, especially in the first 5 minutes (Brown, Barton, & Gladwell, 2013). The effects of viewing nature and urban images on physiological variables were examined in Kim et al. (2010). Thirty participants who had both rural and urban life experiences were required to view two sets of extreme living environment (still

photographs), e.g. rural and urban for differentiating the brain activation associated with neural responses and examining perceived subjective feelings about the scenes presented (Kim et al., 2010). Results of this study suggested that participants had different perceived feelings when viewing two distinct image sets. When viewing the rural scenery, 90% of participants felt peaceful, 6.7% of participants felt accustomed and 3.3% of participants felt suffocated whereas 0 participants felt peaceful, 53.3% of participants felt accustomed and 46.7% of participants felt suffocated when viewing the urban scenery. Functional magnetic resonance imaging (fMRI) data showed that rural scenes could be considered as pleasant stimuli whereas urban scenery were associated with negative emotions related to urban environments. This study suggested an inherent preference towards nature-friendly living. These three studies indicated the physiological effects of viewing nature for short duration and the stress reduction. Similar to comparisons between viewing nature and urban scenery, different formats of nature and urban information have been examined with videos for a longer duration on restoration effects. A 20-minute nature video with various nature sounds and an urban video with different man-made sounds were used to examine the effects of attention restoration and heart rate on both environmental stimuli. Findings of this study supported the restoration of nature environment and less spatially selective attention engendered in the nature group (Laumann, Gärling, & Stormark, 2003).

Overall, in the above selected studies, the main physical task is sitting or lying down while viewing the presentations of nature or urban still photos except one study which offered different presented information (Laumann et al., 2003). The main findings advocated the positive effects of nature-based information on physical and psychological outcomes, especially on stress reduction and attention recovery when compared to urban scenes regardless of the different formats of information (photos and videos). These are promising findings on mental health but might not be ideal for promoting PA. However, the exposure time to nature in the above studies were limited to twenty minutes which reflects a need to examine the effects of prolonged nature exposure as Brown (2013) specifically pointed out the first 5-minutes exposure duration might be the most efficient period. Furthermore, the main focus was placed in the visual-based nature information which potentially neglects other sensory inputs, such as auditory information.

2.4.6.2 *Exposure to nature-based auditory information in a laboratory environment*

Although the scope of the first level of green PA might be constrained within visual information, studies have proposed the merit of nature sounds (Alvarsson, Wiens, & Nilsson, 2010; Annerstedt et al., 2013). These nature sounds were viewed to be pleasant and beneficial for stress reduction, perceived restoration and mood recovery. Forty participants were exposed to four-minute sounds from nature (water sound and birds tweeting) or noisy urban environments (dense traffic sounds) after a stressful mental arithmetic task on physiological variables (skin conductance level and heart rate variability) (Alvarsson et al., 2010). In this study, no effects were shown on heart rate variability but skin conductance level recovery tended to be faster during nature sound than noisy urban environments which suggested that nature sounds facilitated recovery from sympathetic activation after a psychological stressor. A similar study was conducted later to investigate the effect of various types of nature mixed with man-made sounds (i.e. no sound, nature, human voice, motorized) on mood recovery after a stressful task without visual information presented (Benfield, Taff, Newman, & Smyth, 2014). The data showed that individuals experiencing 3-minute nature sounds (in the absence of any relevant visual cues) showed enhanced mood recovery compared to those hearing no sounds or those hearing anthropogenic sounds (motorized or voices). To extend the understanding, Medvedev, Shepherd and Hautus (2015) conducted two related studies using real world sounds to examine the impact of soundscapes on physiological measures obtained after a stressor or a period of rest and 5 subjective affects. In the first study, four different four-minute recordings were created: a forest at dawn (birdsong), waves recorded on a calm day at a beach (ocean), a busy motorway intersection (road noise), and at a building construction site (construction). In the second study, the effects of six 2-minute soundscapes (construction, bird song, motorbike racing, heavy aircraft, breaking waves on a calm day, orchestra playing) on autonomic function at rest were tested. Both studies failed to find the statistically relevant differences between soundscape and physiological data; although, this might be because of individual variability. Both studies indicate that the relationship between sound characteristics and subjective assessment are important when considering soundscapes in public spaces. The above studies offered the understanding of the effects of nature sound on stress reduction but were limited to studies without any presentation of visual information over short duration and with no exercise performed. There were

also limited further explorations about participants' responses which can be enriched with different methods (interviews).

Jahncke, Eriksson and Naula (2015) compared different acoustic information (nature sounds, quiet, broadband noise, office noise) with the combination of two sets of visual information (overlooking an open-plan office, or a view of an urban nature environment) on restoration. Each setting lasted for a minute during testing. Results indicated that nature sounds have more restorative potential than ambient noise, or office noise; urban nature picture was more appealing to the participants and had higher likelihood for restoration than the open-plan office picture. Furthermore, the acoustic and visual stimuli interacted to some degree, that is, the urban nature picture was more sensitive to the influence of auditory stimuli than the office picture but the nature picture was perceived as less restorative when a sound with less restorative qualities was added (i.e. broadband noise, office noise). The similar examination on the restoration effects of nature was conducted via presenting a 15-minute virtual nature video with and without corresponding sounds after a stress test (Annerstedt et al., 2013). However, only the virtual video with sound condition facilitated the stress recovery compared to other two conditions (virtual video without sound and a control condition). This study did not make any comparison to urban environment but indicated the importance of the additional benefits of nature sounds.

In the above research, the main experimental design was to expose participants with nature and man-made sounds while sitting down for a short duration on psychological effects. These studies could give credence to the mental benefits of nature sounds after experiencing stress; however, the exposure duration is fairly short (within 5 minutes) without any exercise involved. Therefore, it is unclear about the effects of a longer exposure of nature sounds, how long the effects would stay and what changes would be observed when exercise was involved. Furthermore, the combination of a visual scene and acoustic sounds might produce a different outcome when compared to a visual-only or an auditory-only condition, which would need to be further explored.

2.4.6.3 *Exposure to nature-based visual information while exercising in a laboratory environment*

Although the previous sections suggested the benefits of experience with nature regardless of visual-only, audio-only or visual-audio information for various exercise duration, it is vital to involve exercise when examining effects with the purpose of

promoting the level of PA level. This section presents a body of research to show the multiple benefits of viewing nature-based information while undertaking different exercises with various durations among adults on physical, physiological and psychological measurements, such as self-esteem, mood, blood pressure, perceived exertion, energy expenditure, heart rate and directed attention (Akers et al., 2012; Pretty, Peacock, Sellens, & Griffin, 2005; Rogerson & Barton, 2015; Wooller, Barton, Gladwell, & Micklewright, 2015).

One hundred adults were recruited and divided into five groups (rural pleasant, rural unpleasant, urban pleasant or urban unpleasant and control group) for examining the different types of nature views on blood pressure, self-esteem and mood (Pretty et al., 2005). This study used multiple static images with different psychological features (pleasant and unpleasant) to test the synergistic effects of green PA. Participants in each group performed a 20-minute treadmill run at their own "fairly light" level based on Borg's scale for twenty minutes while heart rate was continuously recorded. Self-esteem and mood were measured immediately after the run and blood pressure was taken after 5 minutes. Participants were instructed to concentrate on absorbing and assimilating as much of the individual pictures as they could during the run. When compared with the control group (exercise while viewing a blank wall), findings showed that running with different views was beneficial to blood pressure, self-esteem and mood. More specifically, rural pleasant scenes had the greatest effects in reducing blood pressure and improvement of self-esteem, which like urban pleasant scenes produced a more positive effect than exercise alone. The control group (exercise with a blank wall) produced a greater improvement in self-esteem than the two unpleasant treatments (rural and urban), implying that the latter have a depressive effect on self-esteem relative to exercise alone. Exercise alone slightly reduced blood pressure (systolic, diastolic and mean arterial) and had a positive significant effect on four of six mood measures. Viewing rural pleasant scenes during exercise produced consistent, though not always significant, improvements relative to viewing other scenes whereas viewing urban pleasant scenes also resulted in improvements in all six mood measures (five of six were significant). Exercise whilst viewing urban unpleasant scenes produced significant reduction for anger-hostility, confusion-bewilderment and tension-anxiety; and rural unpleasant scenes during exercise showed negative effects on three mood states ($p < 0.05$ for tension-anxiety), the most for any type of scene. In summary, viewing scenes appears to modulate the effects of exercise on mood but consistent effects are difficult to discern.

Rogerson and Barton (2015) conducted two related studies with the same design but different intensity levels of treadmill running among the same participants. Firstly, twelve adults were recruited to perform 15-minute treadmill running (at their own 60% VO_2peak output) while viewing nature and built videos or a blank wall with energy expenditure, perceived exertion and directed attention assessed. Participants were instructed to engage with the content of the videos during the exercise. Then participant returned to the treadmill and ran at individual 85% VO_2peak until voluntary exhaustion. In these studies, the positive effect of green PA on directed attention was supported while no differences on energy expenditure, respiratory exchange ratio and heart rate were reported. There were also no differences on perceived exertion and time to exhaustion between conditions.

To further explore the positive effect of green PA on cognitive functioning, Akers and colleagues (2012) recruited fourteen participants to perform a 5-minute cycling task (at individual 50% peak power output) while watching video footage of a rural cycling course with its nature green colour and filtered with red and grey colours. The main purpose was to investigate which colour, as a primitive visual feature, contributes to the positive effects of green PA. Participants were randomly exposed to three video PA conditions with heart rate, oxygen uptake, respiratory exchange ratio, and ratings of perceived exertion during the last 30 seconds of each 5-min cycling trial and mood state was measured immediately after each cycling trial. The main finding was that participants showed lower total mood disturbance and perceived exertion in the colour green PA condition compared to other two exercise conditions. Higher anger was observed in the colour red exercise condition. This study indicated that the colour green might be one of the indicators to predict positive influences from nature.

To identify the relative contribution of sight, sound and smell on the perceptual and psychological effects of green PA, a study was conducted by Wooller and colleagues in 2015. In this study, three exercise conditions were created to examine the differences between visual, olfactory and auditory occlusion compared to full-sensory input while cycling. Twenty-nine healthy adults were randomly allocated to three groups but performed the same physical task. All participants cycled at individual 40% peak power output for two sets of 5 minutes with first full-sensory experience and then occluded condition with a rest period in between bouts of exercise. Each participant would repeat the same procedure three times. A woodland video was offered with corresponding acoustic information and pine oil was applied to create the forest smell. Mood, heart rate

and perceived exertion were measured at the end of each session. Results showed that sensory-occlusion negatively influenced mood, perceived exertion and heart rate. These effects were strongest when the sounds of nature were blocked out, followed by the olfactory group and last came the visual-occluded group. An important suggestion is that other sensory inputs might also be vital for the positive effects of green PA except visual information (Wooller et al., 2015).

Jones and colleagues (2014) expanded the experimental designs by introducing a different type of auditory information: music. 34 participants were asked to perform a 10-minutes cycling in four conditions: music-only, music-and-video, video-only and no visual-sound information at two levels of intensity (10% of maximal capacity below ventilatory threshold and 5% above). The nature video was presented from a cyclist point of view from a pleasant woodland park. The music was particularly selected based on the level of motivation for exercise. Affect valence, state attention and enjoyment were measured during task and after the task. The music-only and music-and-video conditions exhibited the highest scores for affective valence and there were no differences between these two conditions. The music-and-video condition promoted more dissociative thoughts than the remaining three conditions and there were more dissociative thoughts in the 10% below ventilatory threshold condition than the 5% above condition. Participants experienced greater exercise enjoyment in the music-only condition and music-and-video conditions when compared with the video-only and control conditions. Participants experienced greater enjoyment at 10% below ventilatory threshold when compared to 5% above. In short, this study indicated that both the music-only and music-and-video conditions could enhance the affective responses of recreational exercise participants. Within comparisons, the video-only condition was not as effective to accrue positive effects as previous studies which seem to be contradictory. However, the required intensity of PA or the context of the selected video might both contribute to the inconsistent results.

In summary, the studies above showed evidence of the positive effects of the same category of green PA (viewing nature indoors) across cognitive, physical and mental aspects among adults with distinct study designs. To be more specific, this foregoing research examined two formats of nature-based information (i.e. still or dynamic nature images) for various exercise durations (20, 15, 10 or 5 minutes) at different intensity levels and mode of PA (e.g. 60% or 85% VO_2peak output of treadmill running or 40% and 50% peak power output of stationary bike). Also, two types of nature-based

information, i.e. visual and acoustic information, were examined. Some studies instructed participants to actively engage with presented information while other studies did not instruct participants to immerse with nature which might contribute to different outcomes in terms of information detection and utilisation. In addition, there were limited data examining the engagement with nature in current research and limited qualitative data were collected (Mcsweeney et al., 2015). Requiring participants to exercise whilst viewing a blank wall as the control condition was presented in some of the above studies (Pretty et al., 2005; Rogerson & Barton, 2015) while others did not include a control group (Akers et al., 2012; Wooller et al., 2015).

2.5 *THE NEED FOR A REPRESENTATIVE COMPARISON DESIGN*

In section 2.4, the main discussion is given concerning the collective effects of nature-based information in different study designs. The main criticism was that the use of control condition by asking participants to view a blank wall was considered as lacking representative design and might result in having depressive effects. Typical gym-based exercisers might perform their activity whilst exposed to various types of information depending on personal preferences or exercise habits. Some exercisers might prefer to exercise while watching television programmes, news or movies, or listening to music available in the external environment or on their own music devices. However, it should note that different forms of media offer different information which in turn influences exercisers' perception, performance and experience in different ways. For instance, listening to music during treadmill running might influence runners' performance differently than watching television programmes (Hallett & Lamont, 2015). Different forms of the same entertainment media might also result in different PA outcomes. Fast or loud music can encourage treadmill runners to perform faster or for a longer time (Bharani, Sahu, & Mathew, 2004; Edworthy & Waring, 2006; Tenenbaum et al., 2004) whereas slow or quiet music has not been associated with any beneficial physical outputs for treadmill runners (Edworthy & Waring, 2006). Annesi (2001) tested the effects of various exercise entertainment modalities on distraction, adherence, and physical outputs in adults over 14 weeks (music, television, television-music and no entertainment as the control group). Participants in each group were allowed to self-select their entertainment within the allocated category except the control group. These four groups experience the same level of distraction. The lowest dropout rate was found

in the television-music group and this group also improved most in terms of oxygen uptake and increased in exercise duration. There were no differences in distraction among groups but the success of the combined entertainment group here suggested it was due to the presence of fun and enjoyment participants experienced from the PA condition. In another qualitative field study, sixteen gym exercisers were interviewed regarding the autonomous use of music while exercising in the gym (Hallett & Lamont, 2015). Results suggested that the majority listened to music, integrating it with exercise to enhance the quality of their workout. Other participants were ambivalent towards music; this group also demonstrated a tendency to chat or watch television because these activities made the time go quicker and facilitated dissociation from the exercise which was believed to reduce the effort perception.

A body of research suggested multiple effects of music on PA experiences, for instance, improved mood, arousal control, reduced perceived exertion, enhanced work output, improved skill acquisition, flow states, dissociation from feelings of pain and fatigue (Karageorghis & Priest, 2012a, 2012b; Terry & Karageorghis, 2008). These studies examined the effects of music with various factors, such as tempo of music (Silva et al., 2016; Waterhouse, Hudson, & Edwards, 2010) and the volume of music (Edworthy & Waring, 2006) on various intensities of PA (Dyrlund & Wininger, 2008; Fritz et al., 2013; Jones, Karageorghis, & Ekkekakis, 2014) among different group (Brownley, McMurray, & Hackney, 1995). The combination of music and music-video was also examined in literature (Barwood, Weston, Thelwell, & Page, 2009; Bird, Hall, Arnold, Karageorghis, & Hussein, 2016; Chow & Etnier, 2016; Loizou & Karageorghis, 2015). A related conceptual framework was developed by Karageorghis et al., suggesting four factors contributing to the motivational qualities of a musical piece including rhythm response, musicality, cultural impact and association (Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 1999; Terry & Karageorghis, 2008). Therefore in the assessment of the effect of a PA environment, there is a need to improve the control condition to be a more representative design.

2.6 *CONCLUSION*

This chapter has outlined the diverse benefits of experience with natures from empirical studies and theories, suggesting that green PA might be an efficient vehicle for promoting physical health and mental wellbeing underpinned by an ecological dynamics perspective. This project was believed to be particularly useful in a highly

urbanised society. The positive effects of the first level of green PA (viewing nature indoors) mainly remained consistent when compared to exercise with urban scenes or a control condition (exercise with nothing) in the literature. The effects of green PA were unknown when compared to a more representative gym PA condition (i.e. self-selected entertainment). Moreover, various factors (i.e. types of nature-based information, sources of information, intensity of PA and prolonged exercise effect) are not clearly examined in the literature. From an ecological dynamics standpoint, each factor could be viewed as a constraint which would make differences to the quality and outcome of exercise performance when manipulated. In addition, limited qualitative research was conducted to advance the understanding of participants' PA experience such as engagement with nature during exercise.

The identified gaps in literature are as follows,

- A need to compare the nature-based PA environment to a more representative design as control condition, because the most popular control condition in literature, viewing nothing, could be a depressing PA environment leading to a negative experience
- Lack of understanding of the differences of different visual nature-based information, such as one single or numerous static nature images, still or dynamics nature images
- Absence of understanding of acoustic nature-based information combined with visual information for green PA, especially nature sounds which is proposed to be beneficial for stress reduction or mood recovery with no exercise involved
- A need to examine the effects of nature-based PA environment over time to offer novel knowledge for sustainable applications
- A need to formulate an efficient PA environment without giving instruction to exercisers for engaging with nature. This is because in practice, it is unlikely that people would be given instruction before exercise to concentrate on picking up presented information
- Deficient knowledge of PA experiences, especially the engagement with nature during green PA

Based on these identified gaps and the proposed theoretical framework, three separate but linked studies were conducted to investigate the effect of different nature-based affordances for treadmill running environment designs on physical, psychological and emotional measurements compared to a more representative control PA condition. The

novel information collected from the project was expected to contribute to future application of promoting PA and improving mental health.

Aim and objectives

Research Aim: Investigate the physical, emotional and psychological effects and PA experiences of different nature-based affordances for indoor treadmill running.

Research objectives:

Objective 1: Create an indoor treadmill running environment which allows examination of different nature-based affordances (Chapter 2 and 3).

Objective 2: Examine physical, emotional and psychological effects and experiences of two types of nature-based affordances (i.e. a single static and dynamic nature image) for treadmill running (Study 1).

Objective 3: Examine physical, emotional and psychological effects and experiences of a range of nature-based affordances (i.e. a collection of ten different nature videos with and without corresponding sounds) for treadmill running based on the findings of objective 2 (Study 2).

Objective 4: Examine physical, emotional and psychological effects and experiences of the new nature-based affordances (i.e. a list of 24 nature videos with corresponding sounds) for treadmill running based on the findings of objective 3 over time (Study 3).

CHAPTER.3

METHODOLOGY

3.1 *INTRODUCTION*

A PA environment was created based on the main concepts of the proposed theoretical framework in this study. By presenting specific information in the environment (nature-based information) and limiting other information (information of running distance, speed and heart rate), this designed environment aimed to investigate different richness of the nature-based information for affordances for indoor treadmill running (details see the section 3.2).

Combining qualitative and quantitative methods allows a deeper understanding of the research questions that goes beyond singular methods, and hence mixed methods were employed in this project to examine various effects and PA experiences of green PA under this designed environment (Creswell, Klassen, Clark, & Smith, 2011). Although these two approaches have been perceived to be incompatible because of the philosophical differences, some researchers have advocated and argued that mixed methods could be used effectively to form a more holistic understanding of the research question (Atieno, 2009; Olsen, 2004; Sparkes, 2015). Different integrations have been proposed when using mixed methods, such as merging, connecting or embedding data (Creswell et al., 2011). The processes of data collection followed a concurrent mixed methods design, such that qualitative and quantitative data collections were conducted in a sequence with quantitative measurement collection first and followed by qualitative interviews which purposely recruited the same participants (Creswell & Plano Clark, 2011). By embedding qualitative and quantitative data together in this research of programme, the findings of one study informed the design of the following (for example the results of Chapters 4 was used to develop the study conducted in Chapters 5).

In this thesis, to investigate the effects of different nature-based affordances for PA, quantitative methods were applied and a range of physical variables in conjunction with two questionnaires designed to assess psychological and emotional outcomes were used. The collection of physical, psychological and emotional data was used to examine the relationship of green PA and discussed with an ecological dynamics perspective. The findings were expected to advance the theoretical understanding and offer practical applications of green PA. The qualitative exploration set out to obtain a deeper understanding of the experiences of green PA which is absent in the literature but critical for designing and applying physical health and mental wellbeing research programmes. The qualitative approach is appropriate for exploring participant

experiences (Atieno, 2009). Semi-structured interviews were used to collect qualitative data which allowed for the specific investigation of the research question with the flexibility to generate new or unexpected discussions or reflections.

All research studies were conducted with the approval of Sheffield Hallam University's Faculty of Health and Wellbeing Research Ethic Committee. All studies used the same experimental setting and measured the reoccurring variables, but differed with respect to the study design and experimental conditions used (Table 3. 1). The three studies were carried out in an indoor laboratory-based design so as to be similar to the gym setting and to be representative of future applications for urban residents. Further details of the experimental conditions specific to each study are described in each study's respective chapter.

Table 3. 1. Examinations of different nature-based information and experimental design in each study.

Experimental Study	Type of information	Experimental conditions	Design
1	Visual-only information Dynamic, static images	A nature video filmed from a runner's perspective along the path of a park. A single static frame from the same nature video Self-selected entertainment condition, including watching movies, television programmes or listening to music	A 2×3 repeated measures within design (Time: pre and post; Conditions: video, image, self-selected entertainment) A twenty-minute trial for each condition
2	Visual-only, visual-acoustic information Dynamic images	A collection of ten short nature videos with nature sound A collection of ten short nature videos without sound Self-selected audio-only condition	A 2×3 repeated measures within design (Time: pre and post; Conditions: video with sound, video without sound, self-selected audio entertainment) A twenty-minute trial for each condition
3	Visual-acoustic information Dynamic images	A collection of 24 nature videos with corresponding sounds Self-selected music-only condition	A 2×2 mixed within-between design (Time: pre-and post; Conditions: video with sound, self-selected music) 12 twenty-minute trials for each condition over 6 weeks

3.2 *STUDY DESIGN AND EXPERIMENTAL SETTING*

An indoor treadmill running environment was created to allow the examination of various types of nature-based information for affordances compared to a self-selected entertainment PA condition. The experimental task for participants was to perform a self-paced, twenty-minute treadmill run at a comfortable level to each individual. Participants were allowed to change speed at any point of the run. The intensity of exercise varied from individual to individual but this self-selected intensity was believed to be more beneficial for exercise adherence with positive PA experiences (Huberty et al., 2008; Williams, 2008; Williams et al., 2008). This approach was distinct from previous studies, which controlled the exercise intensity of the physical task (Plante et al., 2006; Pretty et al., 2005). Participants were asked to self-assess their exertion level every 5 minutes with the Borg's scale (Borg, 1982), which was expected to, not only encourage participants to be aware of their physical condition, but also allow the researcher to confirm the perceived comfortable level running speed of each participants. Twenty minutes of exercise has been found to be sufficient duration to identify the effects of the exercise (Hansen, Stevens, & Coast, 2001).

The physical setting of a treadmill running environment used in the programme of research was adapted from previous studies in the literature (Plante, Cage, Clements, & Stover, 2006; Pretty et al., 2005) and amended according to an ecological dynamics perspective. Partitions were placed each side of the treadmill and a large screen (60 inches) positioned in front of the treadmill presenting nature-based information, e.g. nature videos or images (Figure 3.1). With the two partitions and a large screen in this setting, the semi-enclosed environment was created and unnecessary distraction from the laboratory during running sought to be avoided. The treadmill's display was covered to hide the information of distance, speed and time from the participants. The control panel was available for participants to adjust the pace at any time during the run to maintain a personal comfortable speed. The physical setting was designed to offer the functional affordances (nature-based information) while constrain other confounding information (running related information and other irrelevant information in the laboratory). In this physical setting, participants (n = 69) were expected to be more engaged with the presented nature-based information because of the enclosed feeling and the prominent presentations of nature-based information. Without offering information of distance and speed during running, participants were expected to be

more sensitive to perceptions of their own physical conditions, to the environmental information offered, and the interactions with their mental conditions during the running experience (e.g. feelings, perceptions and needs). Therefore, this created experimental setting was expected to encourage participants to be more engaged with the nature-based information rather than the running and thereby undergo a more positive experience. No extra verbal instructions were provided to ask participants to immerse them in the designed environment because a well-designed environment would efficiently accrue the expected effects. The effectiveness of immersion of this designed PA environment would examinable with the collected qualitative data.

Figure 3.1. The experimental setting view from the back; Right: The testing shot from the back. The red box shows how the control panel of the treadmill was covered during the testing

The distance between the top-edge of the treadmill to the screen was tested and decided upon in pilot tests to create a comfortable viewing distance. Due to physical limitations, the distance was 3 m in Chapter 4 but 1.6 m in Chapter 5 and 6. However, these two different distances between the treadmill and the screen were not considered to have had major influences on PA experiences based on discussions with participants involved in the pilot tests.

A more representative control condition, i.e. the self-selected entertainment condition was introduced in this thesis as previous studies asked participants to exercise while

viewing a blank wall (discussion can be found in Chapter 2). The current PA environment was considered to be more representative of a real life PA environment. For example, in a typical gym environment people would exercise with their self-selected entertainment, such as music, movie or television programme rather viewing a blank wall as in the previous studies (Pretty et al., 2005). The format of self-selected entertainment was changed accordingly with the results of each previous study (Chapter 4 informed Chapter 5).

3.2.1 Participants

Participants were recruited from website advertisements, campus posters, personal networking, and emails. In total, 69 participants were recruited in this thesis for three studies and greater details of participants' information are presented in each separate chapter describing each study (30, 24 and 16 participants completed all trials in Study 1, 2, and 3, respectively). Considering future applications to a wider urban population, participants were recruited with criteria for people who were confident and volunteered to complete a bout of self-paced treadmill running for twenty minutes without current injury, regardless their active levels, exercise habits or backgrounds. Before participation, volunteers were given an information sheet (Appendix 1) detailing the aim of each study, the experimental procedure, task and the required duration of commitment. Each participant was given a full explanation of the study and had the opportunity to ask study-related questions. After providing informed consent (Appendix 2), participants completed a PA Readiness Questionnaire form (PAR-Q; Appendix 3) to assess their suitability for the study. Participants were fully advised of their right to withdraw their participation at any time. All participants were required to wear sports kit and running shoes for each visit. Before attending each trial, participants were asked to avoid any conditions causing extreme exhaustion immediately prior to the test sessions in order not to contaminate the findings within experimental period. The sample size of Study 1 and 2 was based on previous studies in the green PA literature (Brown, Barton, Pretty, & Gladwell, 2014). Owing to time constraints of this study, a smaller sample size was recruited in Study 3 (9 participants in the nature group and 6 participants in the music group).

3.2.2 Procedure

Participant personal information (height, mass and date of birth, personal exercise habit form) was collected in the first trial by the researcher. Participants' height and mass were measured with a digital stationmeter (SECA 274, Birmingham, UK) by the researcher. Figure 3.2 depicts the general procedure used. In each session, participants were asked to put on a heart rate monitor (Polar RS400, Polar Electro, Kempele, Finland) then quietly sat down for 5 minutes to get a measure of resting heart rate. Pre-exercise questionnaires were completed during this resting stage. The post-exercise questionnaires were completed immediately after the run. Interview willingness was sought from all participants in the last trial. The same procedure was followed in every trial for each participant in the three studies of the thesis (Chapter 4-6).

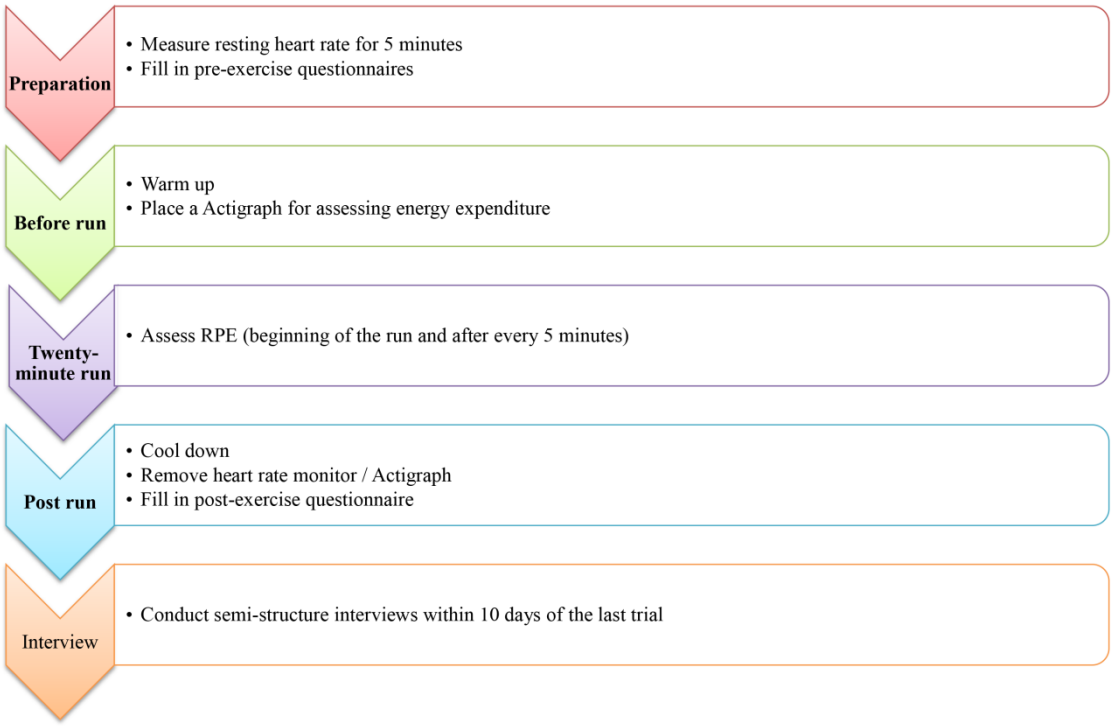

Figure 3.2. The experimental procedure for each trial, including the preparation, warm-up, running and cool-down stages.

3.2.3 Measurements

Data on five physical variables (heart rate, energy expenditure, speed, distance and rated perceived exertion) were collected in each trial and two questionnaires (the Positive and Negative Affect Scale and Sport Emotion Questionnaire) were used to assess psychological and emotional effects (Jones, Lane, Bray, Uphill, & Catlin, 2005; Watson, Clark, & Tellegen, 1988). Data on all variables were measured in Chapter 4

and 5 in each trial but in Chapter 6, these two questionnaires were used to a specific schedule aiming to reduce participants' burden over time. Greater details about the data collection on different variables were presented in Chapter 6.

3.2.3.1 *Physical measurements: speed, distance and heart rate*

The real-time running distance (m) and speed of each run (km/h) were measured using the treadmill's software (i.e., h/p/cosmos para control 4.1.0) but remained unknown to participants. A Polar heart rate monitor was positioned on the participants' chest to record the twenty-minute continuous heart rate (recording every second) with a synced Polar watch (Figure 3.3) and output using Polar Pro Trainer 5. No participants reported uncomfortable feelings wearing the heart rate monitor or stripe.

Figure 3.3. *Left*: The position of a polar heart rate monitor strip for recording heart rate. *Top right*: a close-up of the heart rate sensor. *Bottom right*: the Polar watch.

3.2.3.2 *Physical measurements: energy expenditure*

Energy expenditure was recorded with an Actigraph (wGT3X-BT, ActiGraph, FL, USA), positioned around participants' waist (Figure 3.4). Participant information and anthropometrics were collected in the first trial and entered by the researcher when setting up the Actigraph. This information included mass, stature, birthdate, race, date of testing, start and finish time (duration of the run). Actigraph has been suggested to yield accurate prediction of energy expenditure for treadmill activity (Berlin et al., 2006) and is a reliable tool in laboratory environments and free-living situations (i.e.

conducting studies outside the laboratory in daily life) (Jimmy, Seiler, & Maeder, 2013; Kelly et al., 2013; Santos-Lozano et al., 2012).

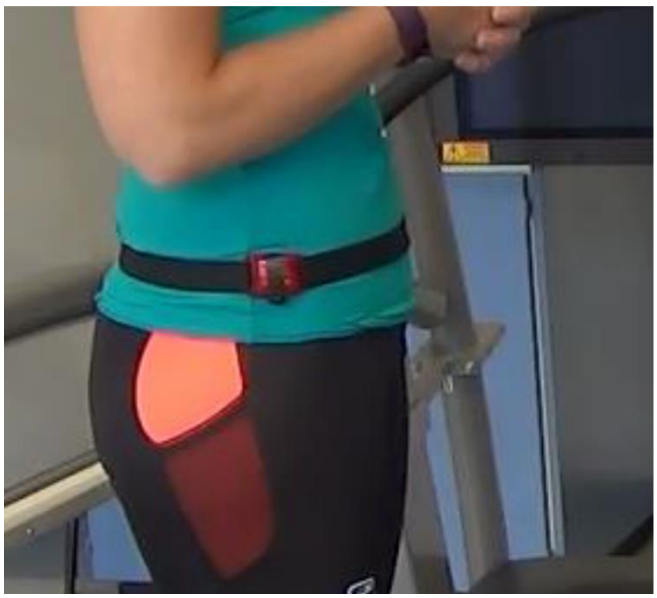

Figure 3.4. An ActiGraph was placed on each participants' waist

3.2.3.3 *Physical measurement: perceived exertion*

Rated perceived exertion (RPE; Borg, 1982)) is a method by which individuals can describe the physiological intensity at which they perceive themselves to be working at a given moment (Rogerson, 2016) and could be viewed as an indicator of physical strain. In this study, perceived exertion was assessed at five points during each run: at the beginning of the run and after every 5 minutes of the run. The Borg scale (Borg, 1982), is a widely used, reliable indicator to monitor and guide exercise intensity for measuring rated perceived exertion. The scale ranges from 6 to 20 and could be used to denote heart rates ranging from 60-200 beats/min. Previous studies of green PA used Borg's scale for evaluating the self-perceived intensity of PA in different experimental settings (Akers et al., 2012; Focht, 2009; Gladwell & Rogerson, 2016; Mackay & Neill, 2010; Pretty et al., 2005; Rogerson & Barton, 2015). In this study, the RPE acted as a confirmation assessment for physical exertion between various environments alongside the objective physical variables, such as distance or energy expenditure.

3.2.3.4 *Sport emotion questionnaire*

A meta-analysis undertaken by Bowler and colleagues indicated that the most commonly reported benefit of green PA (indoors or outdoors) was the enhancement of emotions (Bowler et al., 2010). In their review, emotions were considered to be broad

feeling states and measured by particular tools such as the Profile of Mood States (POMS). The POMS is a popular tool to examine the mental health benefits of green PA. Although both mood and emotions are important indicators of mental health, they are not interchangeable concepts. Mood is defined as diffuse, slow-moving feeling states that are weakly tied to specific objects or situations. By contrast, emotions are quick-moving reactions that emerge when organisms encounter meaningful stimuli that call for adaptive responses (Ekkekakis, 2012; Rottenberg, 2005). Therefore, mood is objectiveless whereas emotions are directed at an object and might also change in relation to the object (Ekkekakis, 2012; McCarthy, 2011). In this thesis, the researcher was particularly interested in investigating the emotional responses to different environments and exercise events, since positive emotions have been linked to experiences with nature and adherence and uptake of PA (Plante et al., 2006; Rogerson, Gladwell, Gallagher, & Barton, 2016). However, the POMS was initially developed for use within the clinical population so that this scale mainly assessed negative moods and was a non-sport-specific scale.

Therefore, the sport emotion questionnaire (SEQ; Appendix 4) was chosen for the current programme of research because it was specifically developed to assess emotion in exercise contexts rather than mood or affect, more generally. The SEQ is a sport-specific measure of precompetitive emotion grounded in the experience of athletes that assesses anger, anxiety, dejection, excitement, and happiness, in a 22-item questionnaire (Jones, Lane, Bray, Uphill, & Catlin, 2005). The SEQ showed evidence of good validity and reliability, and represented a range of emotions with greater emphasis on positive emotions (Jones et al., 2005) and was examined to establish its theoretical validity (Latinjak & Cook, 2013). The SEQ has been mainly used for athletes' emotions and competitive performances or achievement, either individual sport or team sport (M. S. Allen, Jones, & Sheffield, 2009; Dewar & Kavussanu, 2011; Proios, 2014; Turner, Jones, Sheffield, & Cross, 2012). Although the SEQ was a PA and sport-specific measure originally designed for the sports competition context, it has also been effectively used as a measure of emotions in the broader exercise context (Arnold & Fletcher, 2014). Therefore, it was believed that SEQ would be an appropriate tool to assess participants' emotions when engaging PA, and also take into account that participants can experience a range of intense positive and negative emotions during their competitive experiences, measures such as the POMS may not adequately capture the emotional spectrum that exists in this specialized context whereas this 5-factor

structure of the SEQ allowed participants to report on a broader range of emotional states than the Positive and negative Affect scale (PANAS) which was evaluated just two sides of affects (see next section). There are five subscales of SEQ, including anxiety, dejection, excitement, anger and happiness.

3.2.3.5 *Psychological measurement: positive and negative affect scale*

Affect can be a component of emotions and moods but it can occur in a pure form (Ekkekakis, 2012) and is considered to capture broad emotions related to preferences, emotions, and moods (Jones et al., 2005). The PANAS (Appendix 5) was developed to capture two dominant dimensions of affective structure and was considered as a mixture of emotions, mood and affects. This scale was developed to measure the positive and negative affects more economically compared to other positive or negative affect scales (Watson et al., 1988). The PANAS is a 20-item scale that is divided into two separable, ten-item, positive and negative affect scales. Positive affect reflects the degree to which a person feels enthusiastic, active, and alert. High positive affect is a state of high energy, full concentration, and pleasant engagement, whereas low positive affect is characterized by sadness and lethargy. Negative Affect is a general dimension of subjective distress and unpleasant engagement that subsumes a variety of aversive mental states, including anger, contempt, disgust, guilt, fear, and nervousness, with low negative affect being a state of calmness and serenity (Watson et al., 1988).

Participants rate the degree to which they were presently experiencing each affect state using a modified Likert-type scale (1 = very slightly or not at all, 5 = extremely) (Watson et al., 1988). The PANAS has been one of the main tools to previously measure the psychological effects of green PA (Berman, Jonides & Kaplan, 2008; Brown, Barton & Gladwell, 2013; Kinnafick & Thøgersen-Ntoumani, 2014; Marselle, Irvine & Warber, 2013; Mayer, Frantz, Bruehlman-Senecal & Dolliver, 2009; Pretty et al., 2005; Schutte, Bhullar, Stilinović & Richardson, 2017; Yeh, Stone, Churchill, Brymer & Davids, 2016). Therefore, the PASAN was selected because it was a short but effective tool to capture a wide range of psychological responses.

3.2.4 ***Materials and Apparatus***

From a practical perspective, it was considered important for the information presented to participants, i.e. the nature-based information, to be highly accessible for exercise designs available for the general population. Therefore, the presented nature-based

information in Chapter 6 and 8 was downloaded from YouTube by searching nature-related keywords, such as “nature video”, “nature sounds”, “rain” or “oceans”. Any nature videos that contained music were not included in this study because the corresponding sounds would be needed for the other PA condition. Details of the nature videos that were used are in Study 2 and 3 could be seen in Appendix 6. Equipment used in this thesis for the experimental setting and details can be found in Table 3.2.

Table 3.2. The apparatus administered in each experimental chapter.

Equipment/ Software	Chapter 4	Chapter 5	Chapter 6
Heart rate monitor / watch (Polar RS400, Polar Electro, Kempele, Finland)	✓	✓	✓
Polar Pro trainer 5- the commercial software for heart rate output (Polar Pro trainer 5, Polar Electro, Kempele, Finland)	✓	✓	✓
Treadmill (h/p/cosmos, Germany)	✓	✓	✓
h/p/cosmos para control- the treadmill remote control software (version 4.1.0, H/p/cosmos, Germany)	✓	✓	✓
A wall-mounted white board/ A projector	✓	-	-
A GoPro camera (Hero3+, GoPro, CA, USA)	✓	-	-
A 60 inch television (Panasonic, Japan)	-	✓	✓
A wireless headphone (MDR-ZX770BN,Sony, Japan)	-	✓	✓
A touch screen laptop (Envy 13-ab008na, Hp, USA)	-	-	✓
ActiGraph (wGT3X-BT, ActiGraph, FL,USA)	-	✓	✓
Actilife-the commercial software for ActiGraph to assess energy expenditure (Actilife, ActiGraph, FL, USA)	-	✓	✓
An audio recorder	✓	✓	✓
Nvivo (QRS version 10)	✓	✓	✓

3.2.5 *Data processing and analysis*

For quantitative data, Microsoft Excel (Version 14.5.5, Microsoft Cooperation, United States), was used to calculate descriptive statistics for variables, including mean distance, speed, heart rate, perceived exertion of each run at 5 different timings (see Appendix 7 for data collection sheet). Energy expenditure was measured using an ActiGraph and data exported with its commercial software (Actilife, FL, USA). A statistical package of software (IBM SPSS 24.0, Chicago, IL, U.S.A.) was used for all statistical analyses and an alpha value less than 0.05 was used to indicate significant difference levels, with Partial eta squared used for effect size calculations. Bonferroni correction was used for post hoc analysis because it was suggested to be powerful at control the Type I error rate (Field, 2009). The normality of each measurement was

examined by the Shapiro-Wilk test. Repeated measurement ANOVA test was used to analyse data and presented in Chapter 4 and 6 (comparisons of PA environment) where Friedman's test was used for non-normal distributed data. The Greenhouse-Geisser corrected estimate of sphericity was used when Mauchley's test of sphericity was violated in analyses of two or more variables in repeated measures designs. The Levene's test was used to examine the assumption of homogeneity of variances when mixed ANOVA was used.

3.2.6 Semi-structured interviews

The purpose of using mixed methods in this research programme was to gain a more comprehensive understanding of the research question and the role of qualitative research was to collect participants' experiences from the designed PA environments. The PA experiences would show information about the processes and meaning associated with events, specifically the experience from the participants' view point. This information is vital for designing a PA environment that will accrue benefits effectively, especially for a better understanding of the design of environments for green PA as there is currently limited information. In the literature, previous studies examined various factors (e.g., colours of nature images, sources of nature information) of the environmental setting with few theoretical explanations (Stress Reduction Theory and Attention Restoration Theory). These studies mainly collected data on exercise outcomes with quantitative methods without exploring the participants' experiences. Qualitative research is appropriate for exploring processes and meanings associated with particular events (Atieno, 2009). The present study, therefore, conducted interviews with participants in order to better understand the experience of participants. The interviews aimed to explore perceptions on engagement, as well as participant thoughts and feelings about the different PA environments (interview guide can be found in Appendix 8)

A semi-structured interview process was chosen for this research because this method can be used to investigate research interests with predetermined questions, whilst also remaining open if participants wish to discuss information not asked for but which they feel is relevant. This structure provided the opportunity to explore the issues that arise spontaneously and allowed the consideration of new questions which emerged during the interview that may not have been considered initially (Doody & Noonan, 2013). By carefully designing questions to elicit the interviewee's ideas and opinions on the topic

of interest, semi-structured interviews gave the researcher a license to talk freely about unspecified areas during the conservation as opposed to leading the interviewee toward preconceived choices (Zorn, 2008).

Participants who agreed to be interviewed in the last trial had face-to-face interviews which were conducted within 10 days of completing the running trial by the researcher in a quiet and safe environment and audio recorded. The sample size of each study can be found in the respective chapter.

3.2.6.1 *Interview guide*

The interview guide was developed by the researcher to understand PA experiences in an exploratory way. It focused on the PA experiences by setting questions that looked at engagement, thoughts, and feelings. To form a nature conversation, the interview guide began with an introductory question such as “Could you please briefly share with me your experience about this study?” The first section of interview guide aimed to explore participants' engagement and included questions on attention span such as "What was your focus while running? / "What were you looking at when running with the video/ music/ picture), their thoughts such as "What were you thinking when running on the treadmill with the video / image?" and finally interaction like "How did you run with the video/ music?" The second section of the interview guide explored participants' feelings and included questions such as "How did you feel when you just started running, during and after running?" and responses ("What did you think about running with nature video/ music?"). The last interview question was designed to serve as an opportunity for participants to share experiences not previously identified like "Was there anything you would like to share with me that has not been asked before?". During the interview, follow-up questions and probes were used by the researcher to gain further information on topics. The order of the questions was not fixed but followed the conversation and the role of the guiding questions was designed to encourage interviewees to freely express their opinions.

The contents of questions were changed to match the specific experimental designs in each chapter, for example,

Study 1: What was your focus while running with the static image/nature video/ television programme?

Study 2: What was your focus while running with the nature video with sound/ the nature video without sound/ your own music?

Study 3: What was your focus while running with different nature video with sound / your own music?

The contents of questions were changed for different elements involved in the research, i.e. the nature-based information, self-selected entertainment, the PA environment, personal physical condition and the run. These questions changed according to various elements such as "What was your focus while running with the video/ picture/ self-selected entertainment/ the treadmill/ the laboratory/ yourself/ the run?"

Prior to the interviews being conducted, the interview guide was developed with the research team, who have expertise in qualitative research in order to ascertain the appropriateness of the questions. Pilot interviews were conducted by the researcher to test the validity of the interview questions and subsequently discussed with the research team. The final version of the interview guide consisted of open-ended questions designed to investigate participants' PA experiences from two main aspects: participants' engagement and feedback.

3.2.6.2 *Qualitative data processing and analysis*

After completing the first interview with each participant, the researcher listened to the audio recordings to assess the need for a second interview. If required, another interview was arranged with the interviewee (one interviewee in Chapter 4 and three interviewees in Chapter 6 were interviewed for a second time). The recordings were then transcribed by the researcher (Chapter 4, 5, and 6) and a research assistant (Chapter 6). The transcripts were checked with the audio recordings before emailing to the interviewees for accuracy confirmation. The interviewees were sent the transcripts of their own interview and asked to confirm accuracy and advised to carry out any editions where they deemed relevant (details of interviewee responses were shown in each experimental chapter). After receiving confirmation of accuracy and any editions, the transcriptions were used for data analysis.

Thematic analysis is a method that seeks to describe patterns across qualitative data which can be guided by theoretical frameworks or emerge from the data and can be used to interpret experience and meaning (Braun & Clarke, 2006). In this research, this approach was chosen to inductively ground findings of various PA experiences with six

types of PA environments within the data. Interviews were analysed to identify key themes emerging from the data. During the process, the researcher focused on information relating to the research aim of investigating the PA experiences in each analysis stage without looking for any particular content related to the proposed theoretical framework. The researcher also kept reflectively questioning the link between the code and the research aim when coding in order to assure the association. The emergent themes were considered against the ecological dynamics perspective in the discussion sections where appropriate. However, the researcher was aware of the fact that it was impossible to conduct the data analysis with theory-free knowledge (Smith & McGannon, 2017). At each stage the research team discussed the emergent themes to assure the inductive analysis process.

The qualitative data in this programme was analysed using thematic analysis and following Braun and Clarke's (2006) procedure,

- Phase 1: familiarising data. In this stage, the researcher transcribed the interview in person and listened to the recordings twice and re-read the documents three times for familiarity. While re-reading, potential ideas were noted down and underlined in the documents and then all transcripts were uploaded to Nvivo (QRS version 10) for the next step. For example, "*I definitely had different feelings going in but after the run, I always felt better*"-Participant 1in Chapter 6.
- Phase 2: generating initial codes. The researcher reread all transcriptions in Nvivo and any relevant information to PA experiences was coded via the node structure in Nvivo across the entire data set. For example, information related to visual or audio foci, physical awareness, environments, emotions, feedback or thoughts. Other interesting information considered to be related to the research aim would be coded, such as personal exercise habits, actual PA experiences or personal preferences or memory. When coding, all transcription were read and coded one by one (When one participant's transcript finished coding and started another participant). In this stage, any potential themes would be written down in a notebook.
- Phase 3: searching for themes. All codes were read by the researcher and allocated into potential themes for developing a hierarchical structure of high-order and low-order themes using the node structure in Nvivo. When all of the coding was completed for the transcriptions, the researcher would check the initial themes written down in the previous stage and created a temporary theme

in Nvivo. This temporary theme would be used to house all relevant codes. The exact steps were, take feelings as an example, any codes indicated as an emotion, such as happy, relaxed and enjoy grouped together first and saved in the temporary theme. This searching action for similar codes would be carried out through the entire dataset. After the searching was completed, the relevant codes in the temporary theme would be read through again and renamed with a more appropriate name. Each potential theme would be searched, grouped and renamed in the same procedure until all potential themes were completed.

In this phase, the initial themes were generated by using paraphrases or codes to summarise the interpretations of text concerning determinants.

- Phase 4: reviewing and refining themes. Two steps in this stage were conducted by the researcher; after the completion of the initial themes in the previous stage, all generated themes were checked for their suitability in relation to coded extract (level 1) and to the entire data set (level 2) by the researcher. All the grouped themes were double checked individually by the researcher in Nvivo and the code reallocated to a more appropriate theme if needed. At the same time, another member of the research team would generate their initial themes. The generated themes from two researchers would be compared and discussed regarding the difference and the relationships between different themes. This discussion would continue until agreements were reached about the generated initial themes including removing or adding themes based on the suitability related to the research topic. Based on the agreed themes in the meeting, all themes would be allocated to higher-order and lower-order themes housed by general dimensions. Using the same example, the initial themes related to emotions might be feelings such as happiness, enjoyment, annoyance and boredom. This theme would be regrouped as two themes, i.e. positive feelings and negative feelings as a higher-order theme under the feelings as the general dimension.
- Phase 5: defining and naming themes. After reaching agreement in the previous stage, each theme might be renamed to capture the whole theme. The task would be carried out the researcher. For example, "*Reasons for video choices"* was renamed to *"Purposely chosen video"* to better outline the story of this theme in Study 3.
- Phase 6: producing the report. A table was produced to outline the generated themes to show different orders of the theme and results would be written with

selected quotes to support and offer examples by the researcher. This report would be read by the research team for triangulation.

3.2.6.3 *Research rigor and trustworthiness*

To facilitate effective research rigor and trustworthiness, the researchers included member checking and investigator triangulation. The research team including the researcher, a research assistant and the supervisor, who has expertise in qualitative research, provided investigator triangulations (Carter, Bryant-Lukosius, DiCenso, Blythe, & Neville, 2014). The research team worked closely together throughout the whole research process to support the rigor of this study (details about how the investigator triangulation occurred in each step were presented in the above analysis stages). The collected qualitative data were discussed with the collected quantitative data where possible.

CHAPTER.4

PHYSICAL, EMOTIONAL AND PSYCHOLOGICAL EFFECTS AND EXPERIENCE OF VISUAL-ONLY NATURE-BASED AFFORDANCES ENVIRONMENTS (STUDY 1)

This chapter was based on the following two peer-reviewed journal articles:

Yeh, H.P., Stone, J.A., Churchill, S. M., Brymer, E., &Davids, K. (2016) Designing Physical Activity Environment to Enhance Physical and Psychological Effects. *Procedia Engineering, 147*,793-798. http://doi.org/10.1016/j.proenh.2016.06.313

Yeh, H.P., Stone, J. A., Churchill, S. M., Brymer, E., & Davids, K. (2017). Physical and Emotional Benefits of Different Exercise Environments Designed for Treadmill Running. *International Journal of Environmental Research and Public Health.* https://doi.org/10.3390/ijerph14070752

4.1 *INTRODUCTION*

A well-designed indoor environment to enhance physical and mental benefits in the urban areas could be useful for tackling the prevalence of physical inactivity and mental disorders. Instead of changing the physical setting or layout of indoor PA environments, it is more practical and flexible to change the information people might pick up and utilise from the environment when undertaking indoor PA in terms of application.

Green PA is suggested to be a tangible method to tackle physical inactivity and mental disorders because of its multiple physical and psychological benefits (Duncan et al., 2014; Krinski et al., 2017; Pretty et al., 2017; Van den Berg, 2017; Yeh, Stone, Churchill, Brymer, & Davids, 2017). For example, running or cycling while viewing nature images can reduce blood pressure and heart rate (Duncan et al., 2014) and improve mood and self-esteem (Pretty et al., 2005). Although multiple benefits have been reported in some empirical studies, this field was lacking a sound underpinning theoretical rationale to explain how benefits of green PA emerge. The theoretical explanations applied in previous researches mainly focused on the psychological effects of green PA and neglected the influential role of PA. This thesis highlights a theoretical framework, an ecological dynamics perspective, which could provide better understanding of how green PA might benefit human health and wellbeing. The theoretical framework emphasises the person-environment relationship, affordances, as the basis of understanding emergence of behaviour. The key concept of affordances is important to understand how the continuous interaction of perceptual and action systems can lead to different physical and psychological states emerging in the relationship between an individual and a PA environment (Yeh et al., 2015). Affordances are opportunities or invitations for behaviours (Withagen & Chemero, 2012) that exist in different environments to be utilised by people during goal-directed behaviours. The relationship between an individual and environment can be understood from multiple dimensions (Brymer & Davids, 2013). For example, a surface can be sat or stood upon (physical availability), offering relaxation and support when needed (positive psychological feelings), but it also can be viewed as a challenge to ascend (positive perception), or an obstacle or barrier to overcome (negative psychological perceptions), existing in a distinct place (physically unavailable for some people such as the elderly or infants).

The majority of green PA research to date has been conducted outdoors or has compared the differences between urban or nature environments which has left the effects of green PA indoors ambiguous (please see chapter 2 for details). Hence, for targeting urban residents, there is a need to better understand the effects of designing green PA in indoor environments, especially in gyms. When designing indoor green PA environments, previous studies mainly investigated the effects of different types of visual information, such as dynamic or static images compared to viewing a blank wall during PA. This study design might be considered as lacking in representative design (Araújo, Davids, & Passos, 2007) because people rarely perform exercise while viewing a blank wall. Furthermore, participants might experience boredom during such an experimental task which might contribute to the positive effects of any nature-based information condition in the same study. This study aimed to improve this methodological issue.

Whilst, many examples demonstrate the positive evidence of viewing nature while exercising or undertaking PA (i.e. the first level of green PA), few studies have focused on distinguishing the effects of different types of viewing nature-based information. Based on the current definition (Pretty, 2004), the first level of green PA includes various viewing media with a variety of nature-based information, such as through a window, in a book, a painting or on a television. However, these diverse viewing media with diverse nature-based information might not provide the same sensory inputs and functionality of affordances. Through the utilisation of information as well as satisfying individual constraints, the interactions may result in unequal effects on physical, psychological and emotional aspects. For example, it might not accrue the same psychological responses or achieve the similar physical outcomes if you run on a treadmill in a gym while viewing nature photographs compared to viewing your own garden from the window. Both instances are classified in the first level of green PA but the physical environments and viewing media are different which means diverse information and sensory inputs such as visual perception, auditory information and proprioceptive input may all be distinct. It remains unknown if this discrepancy causes any differences on physical or mental effects. More specifically, the different physical environments and viewing media might elicit different physical, psychological and emotional outcomes. It is ambiguous as to whether there are different effects of viewing static or dynamic images of nature during green PA, which is important to understand since previous work in ecological psychology has revealed differences in evaluation of

environmental scenes when viewing static and dynamic displays (Heft & Nasar, 2000). A static image is a frozen moment of the optic flow whereas a dynamic image offers a continuously changing optic flow experience. Multiple static images accumulate various discrete images from different optic flows. Therefore, dynamic images should logically offer richer information for perceivers to utilise than static images. However, to the best of my understanding, no studies have examined the effects of these two types of nature-based information (i.e. a static or dynamic image) which requires further exploration in future study.

Confusion existed when classifying the three levels of green PA based on previous definition in the literature (please see chapter 2, section 2.4.2) because the engagement with nature was not specified from a physical or psychological perspective. Rogerson (2016) proposed that the concept of engagement does resonate somewhat with the concept of immersion He suggested that, when participants are psychologically immersed in nature environments with physical engagement, there is greater scope for psychological influence than either simply viewing or time spent at rest in nature environments. Therefore, the immersion or engagement of nature-based information should be considered from both physical and mental aspects. This includes how people pay attention, think about and respond to the environments physically and psychologically during the PA. To understand this question, there is a need to explore participants' PA experiences regarding their perception of engagement, thoughts and feelings during the PA, from the perspective of the environment and the physical task. Qualitative research is appropriate for exploring processes and meanings associated with particular events, such as PA experiences (Atieno, 2009). With advanced information regarding experiences of green PA, it would be beneficial to identify influential factors which would result in physical and mental benefits for exercisers and exclude unhelpful components that hinder PA when designing PA environments. Currently, the available evidence of experiences of green PA is predominantly quantitative which might fail to provide as much detailed information of participants' personal experiences (Mcsweeney et al., 2015). Therefore, a follow-up interview was designed to recruit participants from the same pool used in each study to collect data on their experiences.

To respond to the aforementioned issues, there is a need to examine the effects and experience of two types of nature-based information, these being a static and dynamic image (both within the first level of green PA) to advance the knowledge of green PA

and collect qualitative data. In addition, an improved experimental design was proposed in this study by comparing these two experimental conditions to a more representative design PA condition (i.e. a self-selected entertainment condition). This study acts as a fundamental base to compare with the following studies of this programme.

4.2 *AIM*

The aim of this study was to examine physical, psychological and emotional effects and experience of two types of nature-based affordances, a single static and dynamic nature image, for treadmill running compared to a self-selected entertainment PA environment.

4.3 *METHOD*

4.3.1 Participants

Thirty participants were recruited from university students and personal networks (church community and running group). The descriptive data of participants is shown in Table 4.1. This group of participants were from diverse backgrounds and had different levels of being active: 23 of them were undergraduate or postgraduate students, while the others were external participants who worked in different occupations. From a self-reported PA survey, 14 participants reported undertaking exercise durations of 3 hours a week, 9 participants exercised for 3 to 6 hours a week and 7 participants exercised for 6.5 hours and above a week. Participants performed diverse types of exercise including road and field running, weight lifting, cycling, power walking and gym fitness sessions. For exploring the specific experience of the designed PA environments, sixteen participants out of the thirty participants agreed to take part in followed-up interviews, aged between 19 and 54 (28 ± 9 years; 9 females and 7 males).

Institutional ethical approval was granted by the Research Ethics Committee (Appendix 9). The sample size was based on previous studies (Brown, Barton, Pretty, & Gladwell, 2014). All participants were required to wear sports kit and running shoes.

Table 4.1. The descriptive data of participants (mean ± SD)

Variables	Male	Female	All
Number	18	12	30
Age (years)	27.4 ± 8.8	27.7 ± 9.9	27.5 ± 9.1
Stature (cm)	178.2 ± 6.4	167.2 ± 6.0	173.8 ± 8.2
Mass (kg)	74.7 ± 8.0	57.1 ±5.0	67.7 ± 11.1
BMI ($kg \cdot m^{-2}$)	23.5 ± 1.7	20.4 ± 1.0	22.3 ± 2.1

4.3.2 Study design

In a counterbalanced design, all participants were asked to perform a twenty-minute treadmill run at a comfortable self-selected speed. Participants completed three treadmill runs in different PA environments. Three PA environments (conditions) were designed to offer different affordances whilst participants ran on the treadmill.

The nature video condition involved running on a treadmill while viewing a dynamic nature image (Figure 4.1.). The static image condition involved running on a treadmill while viewing one static nature image (Figure 4.2.) and the self-selected entertainment condition (control condition) involved running with self-selected entertainment, including music from a personal device or internet, television programme and movies.

The three experimental conditions were designed to differentiate between two types of nature-based affordances for treadmill running and the control condition was designed to simulate the real PA conditions in people's daily life. Participants were informed that they could changes their speed during the twenty-minute run from the treadmill controlled panel as long as they felt comfortable. During each trial, participants were asked to report their perceived exertion every five minutes (Borg's scale) and heart rate was recorded by the polar heart rate monitor (Polar RS400, Polar Electro, Kempele, Finland) continuously for the whole twenty-minutes. There was at least seven days between conditions to 'wash out' condition effects and avoid fatigue. Follow-up interviews were conducted by the researcher within ten days of the last trial of the last participant.

Figure 4.1. Twelve screen shots of the video condition.

Figure 4.2. The static image used in the image condition which was one frame of the nature video and used throughout the whole twenty minutes in the image condition.

4.3.3 Procedure

Initial consent forms from each participant were obtained and testing dates arranged. In each trial, participants followed the same procedure (please see Chapter 3 for details): placing heart rate monitor for resting heart rate, pre-exercise questionnaire, run, cool down and post-exercise questionnaire. Heart rates, distance, speed and perceived exertion were recorded by the researcher during data collection. PANAS and SEQ were completed before and immediately after each experimental trial. Follow-up interviews were conducted with volunteer interviewees. Each participant engaged in a semi-structured, face-to-face, audio-recorded interview in a quiet place.

4.3.4 Measures and apparatus

The physical variables were collected in this study, including running distance, speed, perceived exertion and heart rate while PANAS and SEQ were used to assess mental effects and the same experimental setting and equipment were utilised (details please see Figure 3.1 and Table 3.2). For the dynamic image condition, a nature video was recorded at the Sheffield Botanical Gardens which aimed to represent a first person perspective of running through the gardens. A GoPro camera (Hero3+, GoPro, CA, USA) was placed on a helmet of a cyclist moving along a path in the gardens. It was filmed at 8.4 km/h to present a moderate level of PA (Kilpatrick et al., 2009). The video was filmed on a sunny afternoon in April, 2015 and many visitors in the garden were also presented. The static image was one screenshot from the video (Figure 4.2).

4.3.5 Interview guide

The same semi-structured interview guide (Appendix 8) was used throughout this study (see Chapter 3). Modifications were made to the questions regarding the presented information in the different designed environments, for example: "what was your focus while running with the nature video/ the static nature image / your chosen entertainment?"

4.3.6 Data collection, processing and analysis

Data processing and analysis were followed using the procedure presented in Chapter 3. Each participant completed three trials in total. Due to technical problems, six participants' heart rate data was removed in each condition. The general methods for

data processing and analysis are given in Chapter 3. One Friedman test was used to examine the difference between conditions for heart rate. Two separate one-way ANOVAs were used to examine the differences between conditions for distance and speed. Eight, separate two-way repeated measurement ANOVAs (time × condition) were used to examine the difference between conditions for perceived exertion, five subscales of SEQ (Anxiety, Dejection, Excitement, Anger and Happiness) and the positive and negative subscales of PANAS

The total time for interviews for all participants was 5 hours, 57 minutes and 5 seconds. Only one interviewee conducted the interview for second time because further clarification was needed. For transcriptions accuracy, 10 participants confirmed accuracy with no changes required, one person amended the transcriptions regarding grammar or spelling mistakes and five participants did not reply. To ensure the rigor and trustworthiness of this study, member checking for the accuracy of transcriptions and investigator triangulations for interview guideline and data analysis were applied (please see Chapter 3 for details).

4.4 *RESULTS*

The majority of self-selected entertainment involved a mixture of acoustic and visual entertainments, such as listening to music and watching television programmes or movies (**Error! Not a valid bookmark self-reference.**.).

Table 4.2. The choice of the self-selected entertainment for all participants.

Type of selected entertainment	N
Music with headphones	19
One single photo (Friends)	1
Music with speakers	2
YouTube music	2
Television programme/ short movie/ music video	6
Total	30

4.4.1 Physical measurements

The descriptive data of speed, distances and heart rate and the perceived exertion at 5 different times during the run in each condition can be found in Table 4.3

Table 4.3. The average running speed, distances, heart rate and 5 different times of rating perceived exertion in three different conditions (mean ± SD)

Variables	N	Video	Image	Self-selected entertainment
Speed (km/h)	30	9.0 ± 2.1	8.5 ± 2.1	9.3 ± 2.1
Distance (m)	30	2891.6 ± 631.4	2767.2 ± 662.6	3066.8 ± 688.5
Heart rate (bpm)	24	141 ± 18	138 ± 21	147 ± 18
RPE level at 0^{th} minute (start)	30	7.0 ± 1.6	6.6 ± 1.2	6.5 ± .9
RPE level at 5^{th} minute	30	9.1 ± 1.9	8.9 ± 1.2	9.2 ± 1.9
RPE level at 10^{th} minute	30	10.9 ± 2.1	10.8 ± 1.9	11.0 ± 2.0
RPE level at 15^{th} minute	30	12.0 ± 2.4	12.0 ± 2.1	12.0 ± 2.3
RPE level at 20^{th} minute	30	12.8 ± 2.7	12.8 ± 2.6	13.0 ± 2.5

4.4.1.1 *Running distance*

Condition had a main effect on running distance, F (2, 58) = 10.572, $p < 0.05$, $p\eta^2$ = 0.267. Participants in the self-selected entertainment condition (3066.8 m) ran longer distances than participants in the image condition (2767.2 m) but not the video condition (2891.6 m).

4.4.1.2 *Speed*

There were differences between the three conditions for speed, F (2, 58) = 8.183, $p < 0.05$, $p\eta^2$ = 0.220. Participants ran faster in the self-selected entertainment (9.3 km/h, $p < 0.05$) than they ran in image condition (8.5 km/h) but not in the video condition (9.0 km/h, $p > 0.05$). People ran slowest when they viewed the static image out of the three PA conditions (Figure 4.3.)

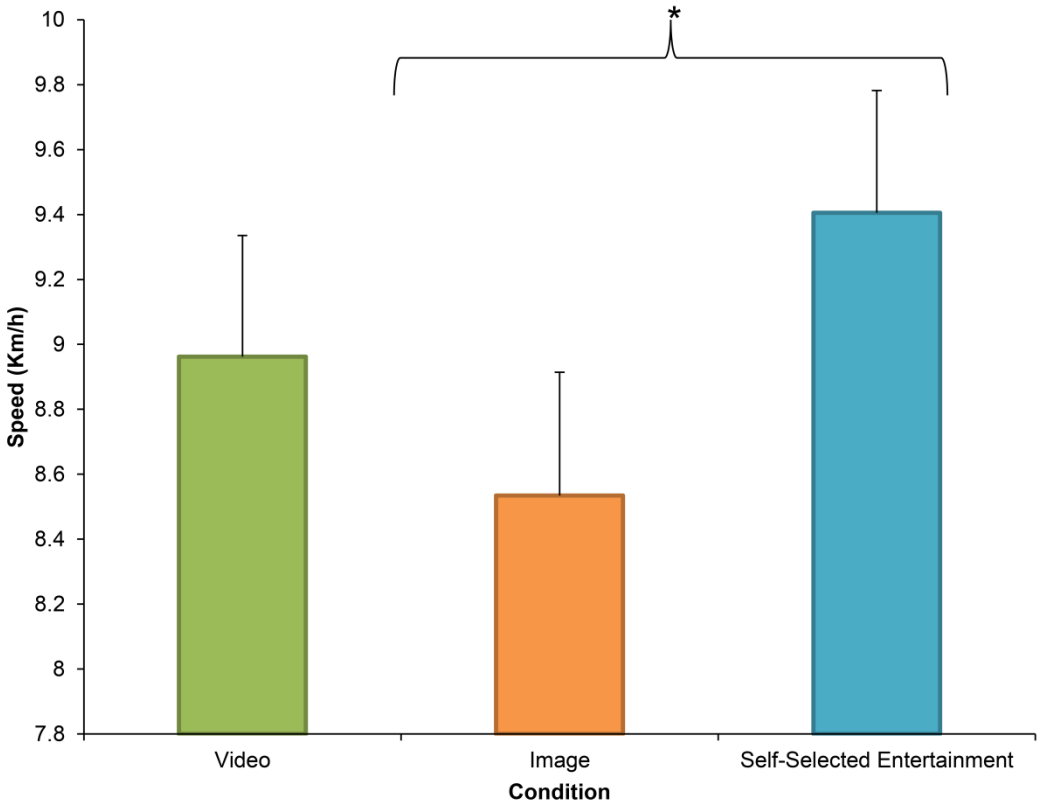

Figure 4.3. Mean running speed of three conditions (mean ± SE); * indicates the condition effect ($p < 0.05$)

4.4.1.3 *Heart rate*

There was a difference between heart rates for the three conditions, χ^2 (2) = 10.750, p <0.05. Participants had higher heart rate when running with the self-selected entertainment (*Mdn* =149.11) than people who were running in the image condition (*Mdn* =142.03), T = 22, $p < 0.05$ and the people running in the video condition (*Mdn* =140.52), T = 20, $p < 0.05$ (Figure 4.4).

4.4.1.4 *Perceived exertion*

A main effect was found on time, F (1.533, 116) = 127.670, $p < 0.05$, $\eta p^{2 =}$ 0.815, but not on conditions, F (2, 58) = 0.176, $p > 0.05$, $\eta p^{2 =}$ 0.006. No interaction was found, F (8, 232) = 0.922, $p > 0.05$, $\eta p^{2 =}$ 0.031. Bonferroni correction revealed that people reported different exertion level with time after running for 5 minutes. The exertion level was increasing with time (Figure 4.5)

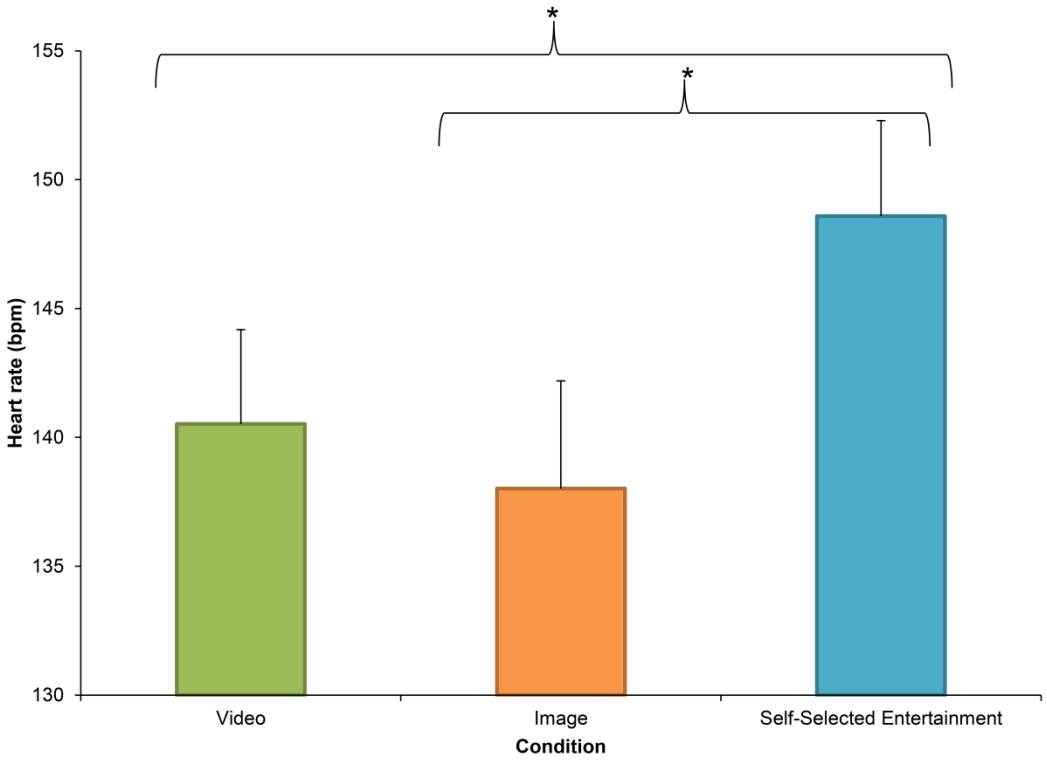

Figure 4.4. Mean running heart rate of three conditions (mean ± SE); * indicates the condition effect ($p < 0.05$); bpm = beats per minute

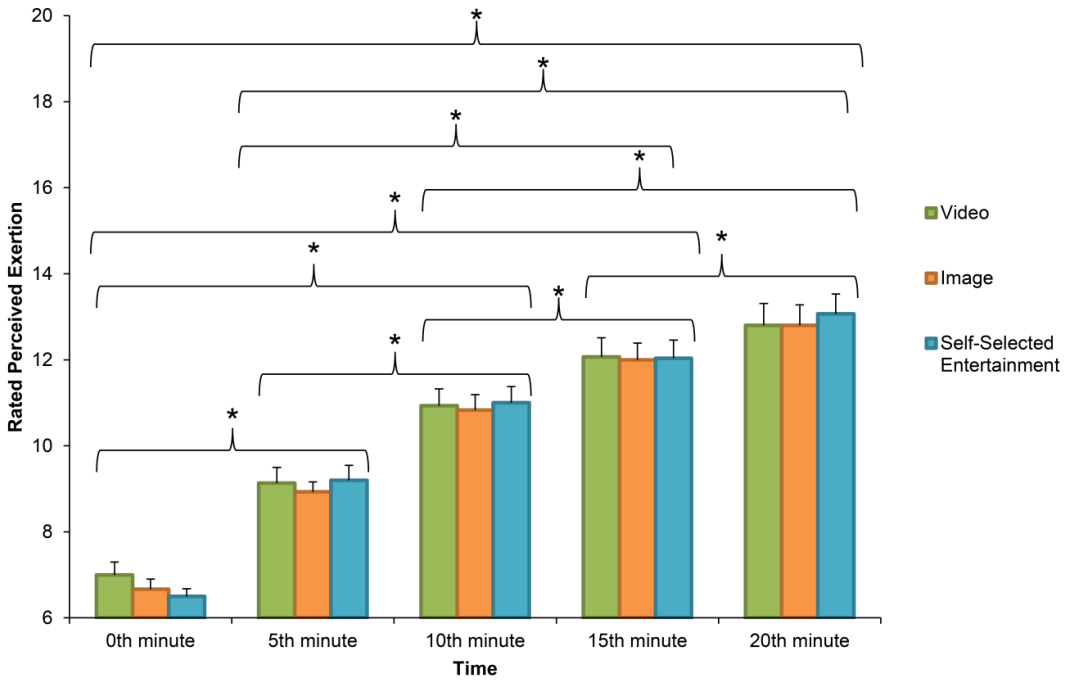

Figure 4.5. Perceived exertion level at five different time in each condition during treadmill running; * indicates the time effect ($p < 0.05$).

4.4.2 Psychological and emotional measurements

The descriptive data of the pre-and-post test scores of PANAS and SEQ in each condition are presented in Table 4.4.

Table 4.4. Descriptive data of pre-and-post-test scores of PANAS and SEQ in three PA conditions (mean ± SD).

	N	Video	Image	Self-selected entertainment
Positive affect Pre-test	30	26.8 ± 8.1	25.4 ± 9.1	24.3 ± 8.3
Positive affect Post-test	30	28.2 ± 7.2	28.9 ± 7.5	28.9 ± 7.3
Negative affect Pre-test	30	12.4 ± 4.4	11.4 ± 1.9	11.1 ± 2.2
Negative affect Post-test	30	11.6 ± 1.6	11.9 ± 1.8	11.6 ± 1.7
Anxiety Pre-test	30	0.5 ± 0.7	0.5 ± 0.7	0.4 ± 0.5
Anxiety Post-test	30	0.2 ± 0.3	0.2 ± 0.3	0.3 ± 0.3
Dejection Pre-test	30	0.2 ± 0.5	0.1 ± 0.2	0.2 ± 0.3
Dejection Post-test	30	0.04 ± 0.1	0.02 ± 0.1	0.1 ± 0.2
Excitement Pre-test	30	1.1 ± 1.0	1.0 ± 1.1	0.8 ± 1.0
Excitement Post-test	30	1.8 ± 0.9	2.1 ± 0.9	1.9 ± 0.7
Anger Pre-test	30	0.2 ± 0.6	0.2 ± 0.5	0.1 ± 0.3
Anger Post-test	30	0.1 ± 0.2	0.1 ± 0.2	0.1 ± 0.2
Happiness Pre-test	30	1.8 ± 0.9	1.8 ± 0.9	1.4 ± 0.9
Happiness Post-test	30	2.1 ± 0.8	2.2 ± 0.9	2.0 ± 0.9

4.4.2.1 *Pre-and-post test of the positive affect scores*

Time had a main effect on reported positive affect scores, F (1, 29) = 18.267, $p < 0.05$, ηp^2 = 0.386, showing that people reported higher positive affect scores after running (pre-test 25.511 ± 1.255; post-test 28.711 ± 1.169). There was no main effect for condition on reported positive affect scores, F (2, 58) = 0.254, $p > 0.05$, ηp^2 = 0.009; however, there was an interaction between time and conditions on reported positive affect scores, F (2, 58) = 3.230, $p < 0.05$, ηp^2 = 0.10. Figure 4.6 showed a similar pattern in all three condition; scores of the positive affect increased after running compared to pre-running. Increased scores between pre-and-post tests were greatest in the self-selected entertainment condition (pre-test 24.3 ± 8.3; post-test 28.9 ± 7.5), followed by the image condition (pre-test 25.4 ± 9.1; post-test 28.9 ± 7.5) and were lowest in the video condition (pre-test 26.8 ± 8.12; post-test 28.2 ± 7.2). Differences in positive affect scores between the video and self-selected entertainment conditions narrowed at post-test compared to pre-test which reflected that participants felt more

positive after running in the self-selected entertainment condition compared to the video condition. A similar pattern was shown in the Figure 4.6 which was that participants reported higher post-run positive affect scores in the image condition compared to post-run positive affect scores in the video condition.

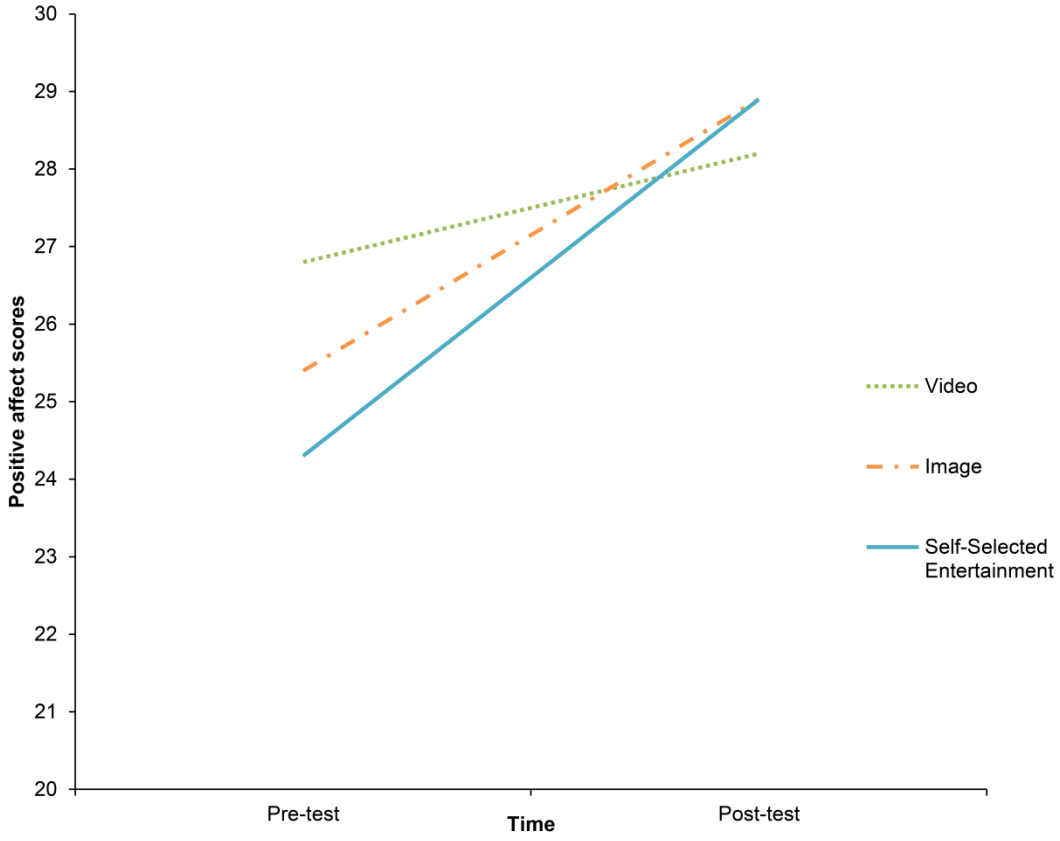

Figure 4.6. Interactions between three conditions of pre-and-post-test scores of positive affect scores.

4.4.2.2 *Pre-and-post-test of the negative affect scores*

No main effect was revealed on the reported negative affect scores either for conditions, F (1, 29) = 0.976, p > 0.05, ηp^2 = 0.001 or time, F (2, 58) = 0.017, p > 0.05, ηp^2 = 0.033. There were no interactions between time and conditions on reported negative affect scores, F (2, 58) = 2.504, p > 0.05, ηp^2 = 0.079. The negative scores did not change across the video condition (pre-test 12.4 ± 4.4; post-test 11.6 ± 1.6), the image condition (pre-test 11.4 ± 1.9; post-test 11.9 ± 1.8), and the self-selected entertainment condition (pre-test 11.1 ± 2.2; post-test 11.6 ± 1.7). Therefore,

participants did not experience any negative affect scores changes before and after the run in any of the three conditions.

4.4.3 Emotional measurement

4.4.3.1 *Anxiety*

Time had a main effect on reported feelings of anxiety, F (1, 29) = 16.256, $p < 0.05$, $\eta p^2 = 0.259$. Participants felt less anxious after running (pre-test 0.5 ± 0.1; post-test 0.2 ± 0.04) regardless of any of the three conditions. There was no main effect for condition on reported feelings of anxiety, F (2, 58) = 0.190, $p > 0.05$, $\eta p^2 = 0.047$. There was no interactions between time and conditions on reported feelings of anxiety, F (2, 58) = 0.322, $p > 0.05$, $\eta p^2 = 0.016$.

4.4.3.2 *Dejection*

Time had a main effect on reported feelings of dejection, F (1, 29) = 10.296, $p < 0.05$, $\eta p^2 = 0.262$. People felt less dejected after running (pre-test 0.2 ± 0.03; post-test 0.05 ± 0.01) regardless of any of the three conditions. There was no main effect of condition on reported feelings of dejection, F (2, 58) = 0.645, $p > 0.05$, $\eta p^2 = 0.022$, which showed that people report similar feelings of dejection across three conditions. There were no interactions between time and conditions on reported feelings of dejection, F (2, 58) = 0.356, $p > 0.05$, $\eta p^2 = 0.012$.

4.4.3.3 *Excitement*

Time had a main effect on reported feelings of excitement, F (1, 29) = 97.054, $p < 0.05$, $\eta p^2 = 0.770$. People felt heightened level of excitement after running (pre-test 0.9 ± 0.1; post-test 1.9 ± 0.1) regardless in any of the three conditions. There was no main effect of condition on reported feelings of excitement, F (2, 58) = 0.459, $p > 0.05$, $\eta p^2 = 0.016$, which indicated that people reported the similar feelings of excitement across the three conditions. There were no interactions between time and conditions on reported feelings of excitement, F (2, 58) = 1.318, $p > 0.05$, $\eta p^2 = 0.043$.

4.4.3.4 *Anger*

Time had a main effect on reported feelings of anger, F (1, 29) = 4.563, $p < 0.05$, $\eta p^2 = 0.136$. People felt less angry after running (pre-test 0.2 ± 0.05; post-test 0.07 ±

0.02) regardless of any of the three conditions. There was no main effect for condition on reported feelings of anger, F (2, 58) = 0.190, $p > 0.05$, $\eta p^2 = 0.047$, which indicated that people reported the similar feelings of anger across the three conditions. There were no interactions between time and conditions on reported feelings of anger, F (2, 58) = 0.322, $p > 0.05$, $\eta p^2 = 0.011$.

4.4.3.5 *Happiness*

Time had the main effect on reported feelings of happiness, F (1, 29) = 27.185, $p < 0.05$, $\eta p^2 = 0.484$. Participants felt happier after running (pre-scores 1.7 ± 0.9; post-scores 2.1 ± 0.9). There was also a main effect of condition on reported feelings of happiness, F (2, 58) = 3.656, $p < 0.05$, $\eta p^2 = 0.112$. Bonferroni correction was used for post hoc analysis, however, the pairwise comparison failed to reveal the sources of the difference (difference between video and image conditions, $p = 0.063$; video and self-selected conditions, $p = 0.093$; image and self-selected conditions, $p = 1.000$). The average scores of happiness of each condition regardless of time were highest in the image condition (2.0 ± 0.1) followed by the video condition (2.0 ± 0.1) and last the self-selected entertainment condition (1.7± 0.1). There were no interactions revealed between time and conditions on reported feelings of happiness, F (2, 58) = 2.337, $p > 0.05$, $\eta p^2 = 0.075$.

In this study, participants' PA experiences including their engagement, feeling, and feedback after completing three bouts of twenty-minute self-paced treadmill running in different environments were explored. A total of 267 raw data codes were extracted from the transcripts in Stage 2 (initial coding, please see Chapter 3 for analysis procedure) which were grouped into higher-order themes and lower-order themes and housed in different general dimensions. Three different tables displayed the outlines of the generated themes for each PA environment (**Error! Reference source not found.**, REF _Ref489520273 \h * MERGEFORMAT **Error! Reference source not found.** and **Error! Reference source not found.**) and a selection of quotes was shown as examples.

4.4.4 PA experience of the nature video condition

A total of 103 codes were allocated in two higher-order themes and 11 lower-order themes in three general dimensions. The generated themes of the PA experiences in the nature video condition are displayed in Table 4. 5.

Table 4. 5 The generated themes of the PA experiences in the nature video condition.

Lower-order theme	Higher-order theme	General dimension (video)
Video contents (path and people) Personal tasks Running/ time	Shifting attention with the repetitive video	Focus
Motivated people keep running Forgot the physical tiredness Video as the running pacer	Perception-action connection led to positive effects	Immersion
Physically react to video with safety concerns Video acted as barrier to hinder performances Aware physical tiredness	Perception-action incongruity led to negative effects	
Enjoyment/ Energetic Boredom/ disappointment/demotivated	Mixed emotions	Feelings

4.4.4.1 *Focus*

Focus was phrased as one of the general dimension to establish participants' engagement. Engagement with the presented information was discussed from various viewpoints, including participants' visual attention on the environment, the nature of the presented information and personal physical conditions during the run. In the video condition, participants reported a range of foci, for example *"the focus was in the video and I was following the route in the video"* (Participant 12), *"looked at the surroundings. The path, flowers. People they came and passed"* (Participant 6), "*trees and people, a puddle on the road and the weather it was raining and I can see the water drip on the camera."* (Participant 9) and the landscapes.

Participants described a strong engagement with the presented video because they not only had to pay attention to details but were also desired to respond to the video. For example, Participant 14 discussed,

"I was looking at all the trees and different things going around. Each time, there are different people passing by. There is a puddle and each time I really want to jump over the puddle but I was on the treadmill."

And Participant 3 "*felt like I need to move out of the way, not to bunch others*" when watching the video. Participants also tried to predict the running direction of the route and pictured themselves in that environment.

In addition, participants also paid attention to running the time and personal tasks (daily tasks or plans). Some of the participants commented that this attention shifting occurred

due to the repetitive contents shown in the video. For example, Participant 10 indicated that "*it's repeating. I got less and less focused on it. Toward the end, I was more thinking about how much time was left or did I run well. I was thinking more about the running than the video."*

4.4.4.2 *Immersion*

Immersion was phrased as one of the general dimensions to demonstrate how engrossed participants were in the presented virtual environment. Participants described how they actively absorbed different information from the video and reacted to the virtual environment, physically and mentally. However, this immersion was associated with two different experiences and effects. First, participants felt a strong perception-action connection which accrued numerous benefits. The dynamic changing contents of the video were able to retain participants' interest in continuing to run. For example, "*it was just enough sensory action and you would just keep track on what's going on and if the video was continuing and I would just keep running*." (Participant 2)

Participants also expected to feel the fresh air or hear the surrounding sounds and thought that they were running outdoors. Participants described an instinctive desire to synchronise their movement to the video; therefore, the video acted as a pacer leading the speed which enhanced physical performance and negated physical tiredness. For example, *"for the video, I felt like I was going faster when the video goes faster. It is sorted of following the camera"* (Participant3), "w*hen the video went downhill, I was thinking that I need to go faster. I touched the front part of the treadmill."* (Participant 8) and "y*ou kept noticing that the environments changes, then you didn't think about how tired you were or how long you ran."* (Participant 1)

However a negative aspect identified was that, the video somehow acted as a barrier by hindering their performances or behaviours because of the perception-action incongruity. Participants attempted to physically respond to the video whilst worrying about their safety of staying on the treadmill but were also annoyed by the disconnection of perception and action. For instance, Participant 4 said that she *"couldn't stay on the treadmill when I was watching the film. Because I was thinking I was outside, I want to turn around or avoiding things. So, I wanted to stop and then I didn't fall off."* These safety concerns became barrier for undertaking the physical task and participants were more sensitive to the physical tiredness when the connection with video reduced.

4.4.4.3 *Feelings*

Feelings were phrased to reflect participants' emotional states related to the experimental testing. Mixed positive and negative emotions were reported by the participants, including enjoyment and energy, boredom, and disappointment and they reported being less motivated primarily due to the repetition of, and the rain in, the video. For example, Participant 8 mentioned that "*I found it was quite disappointing when the video repeated itself."* and Participant 2 said that *"you start to lose the inquisitiveness of what's next."*

4.4.5 PA experience of the static image condition

A total of 55 codes were extracted from transcripts into three higher-order themes and 12 lower-order themes in three general dimensions. The generated themes are displayed in **Error! Not a valid bookmark self-reference.**.

Table 4. 6 The generated themes of the PA experiences in the static image condition.

Lower-order theme	Higher-order theme	General dimension (image)
The image	Wandering mind	Focus
Daily lives, assignments or personal tasks		
Physical environment (lab)		
Running (concentrating on running)		
Self-motivated	Develop coping strategy	Positive responses
Increase speed		
Not physical exhausted		
Physical tiredness		Negative responses
Less motivated	Physical and mental barriers	
Just want to get it done		
Harder		
Boredom		

4.4.5.1 *Focus*

Focus was phrased as one of the general dimensions to outline participants' physical and mental engagement. Participants' attention shifted between the image, daily lives or everyday tasks, the laboratory and running. During the first 5 minutes in the static image condition, people paid attention to the static image but quickly lost interest, and shifted focus to personal tasks or daily lives as a consequence; for example, *"the photo, I got bored eventually and started to think about my coursework and tried to figure out what was doing wrong."* (Participant 13)

Participants also noticed the physical environment where they were running. They looked around the laboratory, the wall, the cameras hanging inside the room and the two partitions. They also concentrated on the run, including footsteps on the treadmill, breathings, arms or postures. For example,

"The static image which made me think about my technique when I was running because there is not much to distract you and it's just there. It maybe makes me think about how my body was when I was running whether I was doing anything funny. So, that maybe makes me focus on my running as a skill."-Participant 4

4.4.5.2 *Positive and Negative responses*

Responses were used to illustrate participants' feedback, thoughts, and emotions related to running with a static image. When running with one static image, participants developed different coping strategies to complete the task when they realised the image failed to retain their interest. Therefore, some participants tried to increase the speed and one participant used a self-motivation strategy in order to complete the run. Two participants expressed their enjoyment in the PA environment because they were not physically exhausted and then were able to use the time to think or plan another task during running. For example,

"Actually I found that was really good. I was looking at the image but my mind was off in another place. I was thinking my own research project and the time seemed to be going really quickly. I felt quite in control of my speed and my breathing. I felt the last one [static image condition], the actual time went quicker. I was more in my own head and did not pay attention to what's outside of me."-Participant 14

Negative responses were also given by participants. With one single nature image, participants felt the task was boring, hard, less motivating and they were aware of physical tiredness which led to a feeling of not being in control and therefore "just wanted to get it done". For example, participant 7 said "*I just tried to get it done as soon as possible. I wasn't motivated to go faster but I don't want to walk either.*"

4.4.6 PA experience of the self-selected entertainment condition

A total of 82 codes were extracted from interview into two higher-order themes and 15 lower-order themes in three general dimensions (**Error! Not a valid bookmark self-reference.**). In the self-selected entertainment environment, most of the interviewees

chose to listen to music with headphones on while running on the treadmill. Some participants ran while watching short movies or television programmes on an adjacent monitor.

Table 4. 7 The generated themes of the PA experiences in the self-selected entertainment condition.

Lower-order theme	Higher-order theme	General dimension (self-selected)
Self-selected media	Diverse attention allocation	Focus
Others thing in the laboratory		
Personal tasks		
Running		
Satisfied/Happy	Positive emotions	Feelings
Enjoy		
Energetic		
Motivated		
Self-motivated with music	Physical and mental benefits	Effects
Music as the running pacer		
Physical performances reinforce		
Easy task		
Forgot physical tiredness		
Physical tiredness/ hard	Physical and mental barrier	
Distracting to safety concerns		

4.4.6.1 *Focus*

Focus aimed to outline the participants' engagement including their attention allocation and thoughts. During the run, participants paid attention to their chosen media regardless of the format of the self-selected entertainment whether it was music, movies or news. For the people who ran with music, *"I focused on the songs and tended to forget a bit that I was running. I became a bit automatic or animation. Sometimes I would go back that I am running but it would not last long and again I would be in the songs "*(Participant 10) *or "I knew the piece of music and I was expecting what's coming next."*(Participant 4) Participants listened to the beat and lyrics (pop music) or predicted the coming melody (classic music). On occasions, participants forgot that they were running on the treadmill because they were focused on the selected entertainment.

Some participants mentioned that their attention was focused on personal issues, running or the physical environment, such as checking running posture, steps, time, and equipment in the laboratory. For example, *"The music wasn't that stimulating for me. So, I was looking at the wires on the floor and waiting for you to check my exertion; I just noticed that I was paying more attention to how time was going."* (Participant 14)

4.4.6.2 *Feelings*

Feelings were used to describe participants' emotions during the run with their own selected entertainment. A variety of positive emotions were reported by the participants, including enjoyment, motivation, energy, happiness and satisfaction. The enjoyment was from paying attention to their selected entertainment and ignoring the physical task. The choices of music also made participants feel happy, motivated and energetic so as to exercise harder or sustain longer. For example, here Participants 12 pointed out *"the music would change within the twenty minutes, so that gives another tempo and motivation, another good feeling in your ears. I could keep doing that for more than twenty minutes."*

4.4.6.3 *Effects*

Positive and negative effects were reported by participants. Participants shared positive effects accrued from music. The music functioned as the running pacer to allow exercisers to simply following the beat or the tempo to lead their running cadences without thinking of the run. Participants said that they physically responded to the music and attempted to synchronise their movement to the tempo for cadence or breathing. Participant 11 said that *"I run with the particular playlist I had for running kept me 90 beats per minute and it sort of kept me running at that pace."* In this case, she deliberately produced a running-specific playlist to maintain the cadence.

Music not only led the pace of running, but also reinforced performances. For some participants, a desire emerged, driving people to exercise harder or run faster. For example, Participant 3 said that *"when it [music] came to the certain bit of the song and you know it, I found out that I put so many efforts into it with my PA. I can go up to three or four levels of running, just by that part of the song."* An additional encouragement was given by the music to perform the exercise.

Two participants shared a self-motivation strategy when running with the selected music because the setting encouraged them to have internal conversations. Compared to the other two PA environments, participants advocated that running with music (in the self-selected entertainment condition) was the easiest PA environment for them. Participant 6 said that "*I thought the music might be my favourite out of the three and also the one I thought was the easiest one.*"

However, two interviewees also expressed negative effects in the self-selected entertainment condition. These participants felt the task was hard and noted physical tiredness because they physically ran harder with the encouragement from music. Participant 8 shared that *"At the same time, the music condition was harder than other two cause I always wanted to go faster. I realised that I was going too fast but I can't go back cause I still listened to the music."*

A safety concern was raised from one participant who considered as he was over concentrating on the chosen movie. He realised the chosen entertainment was the wrong option for treadmill running because the movie was too distracting and he was unable to continue running on the treadmill. Participant 2 reflected that he made the wrong choice for self-selected entertainment because *" that was clear the video was the wrong one to have on because I have to say to myself: don't pay too much attention to it. I could have just stood and watched it once it was on."*

4.5 *DISCUSSION*

This study examined physical, psychological and emotional effects and experience of different indoor treadmill running environments, involving different affordances emerging from presentation of dynamic and static images of nature compared to the self-selected entertainment (using headphones to listen to music or watching television programmes or movies on a screen). Quantitative results showed that participants who ran with their self-selected entertainment displayed better physical performances compared to participants who ran with the single static image condition. But this finding was not replicated in the dynamic image condition, except for heart rate values. While there were no changes in negative affect scores in any conditions regardless of time, a positive psychological effect of green PA was partly supported by the results due to the static image condition accruing similar benefits as the self-selected entertainment but not the video condition. All environment designs for treadmill running enhanced participants' emotional wellbeing in this study, as measured by decreases in anxiety, dejection and anger and increases in excitement and happiness. From interview data, the three types of PA environment created distinct experiences regarding participants' engagement, thoughts, and feelings. Different types of self-selected entertainment were used in this study and a strong connection between self-selected entertainment and running was reported by the participants with positive and negative responses. In the dynamic nature image environment, participants experienced a strong immersion with

the presented video and this engagement led to positive and negative effects which acted as the cause and consequence throughout the whole PA. In the static image environment, participants reported a "wandering mind" during the run and diverse negative responses, especially after five minutes of running. From an ecological dynamics perspective, there were different types of presented information for affordances in three environments and the different functionality of affordances in each environment invited different behaviours.

Physically, participants ran longer distances and faster with a higher heart rate in the self-selected entertainment condition, compared to the static nature image condition. However, this perceived exertion only increased with time regardless of the PA environments. Previous studies investigating the physical benefits of indoor PA environment with the presence of nature have shown inconsistent findings with various physical measurements. Some studies have advocated enhanced physical effects, such as lower perceived exertion (Akers et al., 2012; Wooller, Barton, Gladwell & Micklewright, 2015) and reduced blood pressure levels (Pretty et al. 2005; Duncan et al. 2014) while other research found no differences on energy expenditure (Rogerson & Barton 2015; Yeh et al. 2016), perceived exertion (Rogerson & Barton 2015) and heart rate (Duncan et al. 2014; Rogerson & Barton 2015). These inconsistent results might be due to the different modes of PA such as cycling and running, different exercise duration including 5 minutes, 15 minutes and 20 minutes, different levels of intensity (maintain 70-80 rpm or cycling at 50% personal peak power output) and different groups (children and adults) used in previous studies. This study differed from previous studies controlling the intensity of physical task, as it was designed to find out how people would respond and interact with different PA environments by perceiving and detecting presented information from the physical setting without any specific given instructions but with a self-paced intensity of PA (participants were instructed to run at a personal comfortable speed). This design was important because it was considered to be more likely to create an enjoyable PA experiences associated with exercise adherence (Huberty et al., 2008; Rose & Parfitt, 2012). Furthermore, the varying benefits of green PA found in previous research might be also associated with the control conditions used in previous research of green PA. In the present study, by introducing a more representative designed control condition (the self-selected entertainment) rather than imposing a control condition, such as asking participants to view a blank wall or urban images, it enabled the examination of the effects of a nature-

based environment compared to a typical gym environment. This is important, as individuals performed gym-based PA environment would normally engage with a self-selected entertainment rather than viewing urban images or a blank wall. This comparison would be beneficial when translating research findings into practice.

The physical benefits observed in the self-selected entertainment condition were supported by the interview data. For the participants who chose to run with music, the tempo functioned as a pacer to lead the running cadence or breathing and reinforced physical performances with motivation and enjoyment via listening to music. One interviewee even purposely created a running specific playlist to maintain a similar running speed. This physical benefit of music was in line with previous findings in the literature (Almeida et al., 2015; Bird et al., 2016) and the asynchronous use of music; that occurs when an individual makes no conscious effort to synchronise their movements to its rhythm (Karageorghis & Priest, 2012a). Self-selected, motivational and simulative music has been shown to enhance enjoyment, reduce ratings of perceived exertion, improve energy efficiency and lead to increased work output, during repetitive, endurance-type activities (Barwood et al., 2009; Bharani et al., 2004; Dyrlund & Wininger, 2008; Jones et al., 2014; Karageorghis & Priest, 2012a). Because participants enjoyed listening to music and were motivated by the music, a potential effect to sustain longer or higher intensity of exercise was suggested by the interviewees (Fritz et al., 2013). Conversely, this physical enhancement was also caused awareness of physical tiredness. A lost balance control between the virtual (movie) and real information (running on a treadmill) led to safety concerns which were shared by the participants from interview data as additional information. In terms of the two nature-based PA conditions, some information was shared by the interviewees to expand the understanding of the positive and negative physical effects when running on a treadmill while viewing nature information. In the dynamic nature image environment, participants concentrated on the video and desired to physically and mentally react to the video, including an attempt to predict the running direction, to avoid a collision with pedestrians, to jump over the puddle on the path and being annoyed by the rain. The perception-action connection led to positive effects, as participants focused on the video, forgot physical tiredness and wanted to synchronise their running speed to the video. This connection also encouraged participants to keep running. However, some participants also reported negative responses for physical performances because of the perception-action incongruity. In the static image condition, participants switched their

attention inward to plan their daily schedule, their assignment or personal tasks and took notice of the external environment, such as the cameras in the laboratory in this study. Attention on the running or time were also mentioned by the participants. Still attempting to complete the run, participants developed their own strategies (self-motivation or increasing running speed to keep interests) to overcome the difficulty they faced. This variety of attention allocations reported by participants might also explain why participants ran at a slower speed and shorter distances because they were not focusing on running (LaCaille, Masters, & Heath, 2004).

Psychologically, although negative responses were reported in the interview data in three conditions, there were no statistically differences for the negative affect scores in any of the three conditions. This finding was in line with Mayer et al. (2009) comparing three groups who walked in a nature environment and walked indoors while viewing a dynamic nature or urban image, with no differences on negative affect found. People who walked in the nature environment reported similar negative affect scores compared to people walking with nature video but not the urban video group. This suggested that green PA was less likely to accrue negative effects either in nature or virtual nature environments. This current study also suggested higher positive affect scores in the static image and self-selected entertainment conditions but not the dynamic image condition. This finding was supported by the interview data, interviewees expressed positive responses, such as enjoyment or energetic from running with self-selected entertainment. This positive psychological effect of the static image condition was in line with previous research (Horiuchi et al., 2014; Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009; Pretty et al., 2005). Pretty and colleagues (2005) used thirty static images (four categories, pleasant and unpleasant urban vs. nature, 120 images in total) in a rotating slideshow during cycling which offered a different level of affordances for performers to utilise. The main discrepancy in the current study and in Pretty's work was that a static nature image, multiple static nature images and a dynamic nature image for indoor exercise offered different affordances with various richness of nature-based information. A static image was a frozen moment of the optic flow whereas a dynamic image offered a continuously changing optic flow experience while multiple static images accumulated various discrete images from different optic flows. Therefore, the inconsistent positive effects of two nature-based PA environments might be the different richness of information offered by static or dynamic images and was supported by Heft & Nasar (2000). In the study conducted by Horiuchi and colleagues (2014),

people were asked to sit in a forest with a limited viewing scene or sit in an enclosed environment. In this setting, people could perceive rich and continuous affordances from visual, auditory and olfactory systems albeit from a limited visual area compared to exclusion of visual information. In Mayer and colleagues' work (2009), they found exposure to nature increased positive emotions in outdoor environments. These studies explored green PA with various levels of nature-based affordances and all evidenced that positive effects would be accrued when participants performed PA in a higher level of nature-based information. With richer nature-based information and multiple sources of information for affordances, exercisers should be more likely to accrue positive effects of green PA. However, the controversial findings of the present study might because of a high degree associated with the content of video presented in this study and led to a dissonance between perception and action from the interview data. Another consideration is that the presented video was limited to visual information only and lacking in other sensory input which also may have contributed to negative effects. This was in line with findings reported by Dinh and colleagues (1999) who proposed that adding different sensory inputs (tactile, olfactory and auditory information) in a virtual environment would increase the sense of presence rather than simply increasing the level of visual details. The lack of rich sensory inputs in this study might be because participants expected a more authentic life experience. This finding indicated that the changes in positive affect scores could be achieved by other presented information when designing PA environments rather than dynamic or static imagery.

Emotionally, in terms of SEQ, three PA conditions all decreased the level of anxiety, dejection and anger and increases the degree of excitement and happiness. This finding indicated that nature-based designs for PA were just as effective as self-selected entertainment which participants were most familiar or enjoyed. As mentioned before, the use of music during PA is not a new concept and multiple benefits were proposed in the literature (for a review please see Karageorghis & Priest, 2012). Such benefits included enhancing affect, reducing ratings of perceived exertion, improving energy efficiency and leading to increased work output (Bharani et al., 2004; Bird et al., 2016; Chow & Etnier, 2016; Karageorghis & Priest, 2012a). Yet, these studies mainly examined the effects of music-only, music-video or nothing during PA in various levels of exercise intensity. Jones et al. (2014) conducted a study which was closer to the design and results of the present study. Four types of PA environments (music-only, nature video-only, music-nature video, and nothing) were tested with two intensity of

indoors cycling (10% of maximal capacity below ventilatory threshold and 5% above) for 15 minutes cycling. This study found that the music-only and music-nature video conditions led to the highest valence and enjoyment scores during and after exercise regardless of intensity. It was worth noting that higher scores of happiness were observed in the two nature-based conditions compared to the self-selected entertainment condition. However, the post hoc test (i.e. Bonferroni correction) failed to identify the sources of differences which might due to the strict control of familywise error rate when correcting the level of significance. It was taken into consideration that Bonferroni correction was more conservative in the type I error rate for each comparison, it also increased the chance to overlook a genuine differences in the data (Field, 2009). Hence, it was difficult to identify the source of difference. It could be deduced the all the three conditions contributed to the condition effect but further investigation might be required. Participants experienced lower level of anxiety, dejection, and anger but higher level of excitement in all three exercise designs after twenty minutes of running supporting the notion that exercise has positive emotional benefits. This results were in line with the extant research about the emotional benefits of green PA (Akers et al., 2012; Calogiuri et al., 2016b; Jones et al., 2014; Pretty et al., 2005) but not with other studies (Duncan et al., 2014; Wood, Caroline, Jules, Gavin, & Jo, 2013). No emotional benefits of green PA were proposed when the target groups were children or adolescents instead of adults. Results from children and adolescents have found inconsistent outcomes which were contrary to adults on the benefits of mood. Wood et al. (2013) recruited twenty-five adolescents to assess the effects of viewing nature or building views while cycling demonstrating improvements on mood due to exercise but no effects of viewing different environmental scenes. Duncan et al. (2014) also found similar results that children did not report positive mood changes by cycling while viewing a green environment video compared to exercise alone. These authors provided an explanation that younger generation might have lower connectedness to nature than the old generation (Duncan et al., 2014; Wood et al., 2013). Nowadays the young generation may be relatively less connected to nature and spend more time on screen-based activities, such as watching TV, surfing the Internet or social websites and playing smart phone games (Rideout, Foehr, & Roberts, 2010). This assumption requires further investigations in the future research.

These positive emotional benefits seemed to be partly supported by the interview data for the dynamic image condition but were contradicted in the static image condition

because of the different engagement with nature. The nature video group mainly engaged with the dynamic image and did not concentrate on the running, time or other personal tasks. This immersion encouraged positive PA experience and suggest that individuals paid attention to external information, i.e. dissociated attention and neglected physical exertion (Brick, MacIntyre, & Campbell, 2014; Johnson & Siegel, 1992). However, the safety concerns (tripping over from the treadmill) and the repetition of video context could be considered as a constraint for engagement with nature. Some interviewees even reported the desire to experience the multiple sensory inputs they would receive when physically running in outdoor environments. This finding was supported with Hervik and Skille (2016) who proposed that sensory experience of nature and fresh air were two main reasons why people love to be outdoors. The video was continuous (not on a playback loop, but the path taken in the video included several laps of the same path within the gardens). The information perceived from the video might not have closely matched the physical task, treadmill running, as the recording was made while cycling in the park and as a consequence required that information and corresponding reactions would be different. For example, a cyclist might not change his cycling route simply because a small puddle in the middle of the path but runner would possibly want to jump over or go around the same puddle to avoid getting wet feet. The speed of the video might offer one particular pace which was not matching the various running speeds to all participants. Therefore, the suitability of the information offered by the dynamic image might need to be considered in further work on treadmill running (Yeh et al., 2016). In contrast, the engagement between participants and the presented nature image was less strong and less intense compared to the nature video condition, especially after five minutes of running. This finding was supported by the Brown et al (2013) study that the first five minute of viewing nature was the most effective time to recover from stress.

From an ecological dynamics perspective, the information for affordances in these three PA conditions was different and consequently different functionalities of affordances invited different behaviours. The information of self-selected entertainment constantly offered new information for participants to pick up and utilise which kept the engagement and participants also used the information as a pacer and motivator to enhance physical performances but also identified as brought out the physical tiredness (functionality of affordances in the self-selected entertainment). In the static nature image condition, participants detected the same visual information with minor changes

from the physical environment over twenty minutes. In this case, the same visual information from the static image might have become less functional, without providing further inspiration for PA. That is, participants might detect the information initially as the functions of the information did not disappear (affordances are invariant) but the detected information was not useful anymore when participants' physical and mental states changed with time (information still existed for affordances but not considered as useful by participants). This interpretation supports results of previous research which examined the physiological benefits of nature-exposure duration during exercise and found the first 5 minutes was more efficient than the second 5 minutes in eliciting improvements in the recovery process following a stressor (Brown et al., 2013). Another example in line with the ecological dynamics perspective is that some participants enjoyed the PA environment because of the low physical demanding but other participants needed to different coping strategies to complete the run. This showed that affordances were individual-specific relationships even in the same physical setting. The static nature image was not as functional as the nature video at keeping participants' attention and led to shifting attentions including the image, the run, personal tasks and the physical environments (chose to pick and utilise other information for affordances and different functionality of affordances of the image environment). This self-developed coping strategy might be aligned to the self-organisation concept in an ecological dynamics perspective because this PA environment was considered to be less motivating and participants just tried to "get it done". However, two participants said that they enjoyed this PA environment due to a lower physical exertion. This contradiction showed the same presented information would lead to different effects due to individual differences.

It seems plausible that participants detected richer visual information from the nature dynamic image during running which would accrue greater benefits. The rich visual information of the video facilitated strong engagement with participants during the run which not only strengthen but can also hamper the physical performances. For example, participants might have found that the richer information in the dynamic image condition resulted in some dissonance between perception and action. This was due to that fact that they were dealing with two sets of information at the same time. One set of information from the viewing media (video) and the other set of information from the physical environment (the laboratory). Both sets of information related to the physical task (running) but invite different behaviours. Two sets of information (virtual and real

information for affordances) both invited participants to respond and participants were given choice to detect and utilise the information from the video to keep running and forgot physical tiredness (functionality). However, when these two sets of information contradict to each other, the information (a puddle) invited participants to respond (jump) but the safety concern (trip over) constrained the action to emerge and participants chose to ignore the detected information form video (puddle) and respond to the treadmill (stay running) but the information still existed (affordances stayed invariant).

When comparing the three PA environments, the sources of information for the participants were different. The two types of nature-based affordances offered visual-only information whereas mixed visual-only, visual-acoustic or acoustic-only information were presented in the self-selected entertainment condition. Hence, it could be concluded that people seem to react differently to various types of information sources during exercise and a supported study conducted by Wooller et al. (2015). In their study, participants were assigned to exercise in three conditions, removed visual information (a nature video), sound occlusion (bird songs) and smell occlusion (pine oil), and compared to a condition with full sensory availability (the same nature video with sounds and pine oil smell). Results showed that the least influential factor on psychological states was visual information but that acoustic information had a clear effect on mood, heart rate and perceived exertion. Results in Wooller et al (2015) and the current study can be explained theoretically by the utilisation of different affordances. Therefore, a thorough consideration of the presentation information is required regarding the content and sources of information when designing PA environment because different information would offer different affordances for participants and consequently accrue different benefits.

Taking the quantitative and qualitative data together, the qualitative data offered explanations for some findings but it was important to remember that the interview data was a collective description of personal experiences and did not generalise or include a wider population. The quantitative data was not fully supported by the qualitative data for the two nature-based environments. Higher positive affects scores were showed in the static nature image condition rather than in the video condition. More negative feelings were expressed in the static nature image condition whereas positive mixed negative feelings were reported in the video condition. For example, participants experienced boredom, less motivation or were aware of physical tiredness because of

the limited and minor changes of information from one single static image. For the dynamics image condition, various reasons were found about the inconsistent results across psychological and emotional benefits. For instance, people who run on a treadmill might find it hard or annoying because of some dissonance between the two sets of information, such as the self-selected running speed and the running speed filmed on the dynamic image. The similar content of the video also discouraged positive feelings. Fear of tripping over from the treadmill when perceiving and reacting to two sets of information at the same time also resulted in negative responses. Participants in the self-selected entertainment and nature video environments both received encouragement to run and there were no differences found on physical achievement except in heart rates. Regarding the mental effects, the nature video environment showed the lowest positive affects scores between pre-and-post run. The perception-action incongruity led to negative effects and might support the low positive affects because the nature video environment showed a strong engagement but in fact, participants were forced to disengage with the video for safety concerns. The static image environment was found to be the least physically encouraging environment in terms of physical achievement as it recorded the shortest distance and slowest speed. This might be because participants did not receive any motivation from the static image which contributed to a lower physically exhausted condition with extra time for planning daily task or assignments and the enjoyment of this PA environment. This low physical exertion and additional time might explain the greater positive affect scores. Limitation observed in this study was the comparison between two specific nature environments which might limit the findings to different types of nature environments. The uneven number of self-selected entertainment in this study might bias the effects of the major choice rather than represent all types of self-selected entertainment.

Finding in this study offered certain specific determinants when designing PA environments. Dynamic displays of nature could be more immersive which is advantageous in accruing benefits. The positive immersive experience with the video or space and time to think from the static image environment might contribute to PA maintenance (Allen & Morey, 2010). Selecting the presented information enabling retention of the exerciser' interest over time would reduce the perception of exertion and increase the possibility to have positive PA experience to enhance PA participation and adherence. The PA designers are also suggested to re-assess exerciser' experience and outcomes of the designed PA programme or environments, especially the functionality

of designed affordances for participants would change and regular re-assessment would avoid to produce negative experience to hamper PA maintenance.

4.6 *CONCLUSION*

This study advanced understanding of the physical, psychological and emotional effects and experience of different affordances for indoor treadmill running. The results advocated the use of self-selected entertainment for physical enhancement with a potential to experience physical exhaustion but the positive influences of green PA on mental health from nature information. The strong immersion with nature video can be a powerful tool to promote PA and mental health, a carefully selection of presented information for PA environment to accrue the expecting positive effects would be important, especially for PA environments designers. Additionally, the presented information might offer irrelevant cues to the PA to encourage the occurrence of immersion leading positive PA experience which would need to be further investigated. This study was limited to examining one specific nature environment and only offers one source of information; the results might be different when participants are exposed to a richer nature-based information environment, such as various types of nature environment or multiple sources of information (visual and acoustic information).

CHAPTER.5

PHYSICAL, PSYCHOLOGICAL AND EMOTIONAL EFFECTS AND EXPERIENCE OF VISUAL-ACOUSTIC NATURE INFORMATION FOR INDOOR TREADMILL RUNNING (STUDY 2)

5.1 *INTRODUCTION*

The effects of green PA for improving physical health and mental wellbeing has been well-documented across different age groups in indoor and outdoor environments (Benfield, Rainbolt, Bell, & Donovan, 2013; Calogiuri et al., 2016; Gladwell et al., 2012; Gladwell & Rogerson, 2016; Mayer, Frantz, Bruehlman-Senecal, & Dolliver, 2009; Pretty, 2004). The prevalent research of green PA has mainly investigated the effects in outdoor or nature spaces (see chapter 2, section 2.2) and limited studies examined the effects of green PA indoors. For promoting PA level among urban residents, the scope of this programme of the thesis was to investigate the effects of different types of nature-based information for affordances in indoor PA environments. This investigation would be beneficial for designing an indoor PA environment which would be practical for promoting PA and mental health among urban residents.

In Chapter 4, two types of visual-only nature-based PA environment (a static or dynamic nature image) were examined and compared to a self-selected entertainment PA environment. Results suggested that one single static nature image accrued more positive psychological benefits than the dynamic nature image. Participants expressed their negative responses partly because the presented video was not considered to be appropriate for treadmill running due to the perception-action incongruity participants experienced promoted negative effects in the dynamic image condition. Most participants reported their strong immersion in the video and desired to react to the video mentally and physically while being concerned about their safety. Therefore, a more appropriate selection of presented videos was suggested to avoid offering confusing information to obscure the benefits of green PA.

Wooller et al. (2015) conducted a study to identify the relative contribution of sight, sound and smell to green PA. Results showed that the acoustic information was the most influential factor on mood, followed by the olfactory information and least was the visual information. Wooller et al. (2015) suggested the merit of nature-based auditory information during PA indoors. In the body of research, investigating the effects of nature sounds, such as bird calls or running water, is proposed for mental benefits, especially the restorative benefits, stress recovery and mood recovery (Alvarsson, Wiens, & Nilsson, 2010; Benfield, Taff, Newman, & Smyth, 2014; Ratcliffe, Gatersleben, & Sowden, 2013). However, the investigations were mainly conducted without involving exercise and the exposure duration of nature sounds was short (5

minutes), which would not be appropriate to directly compare with an exercise-engaged study. From the viewpoint of information for affordances, only perceiving visual information or auditory information would be a distinct experience compared with picking up visual-auditory information at the same time. Participants might respond or behave differently in each of the aforementioned conditions. Therefore, further investigation of the different effects of visual-auditory information or visual-only information for exercise is required.

In order to improve the suitability of selected nature video of study design in Chapter 4 and expand the understanding of different nature-based information of green PA, two new types of nature-based PA environment (a collection of ten short nature videos with and without sounds) were created to deliberately offer the non-task specific nature-based information. Here, the effects of these two conditions on physical, psychological and emotional measures were evaluated against a control condition. Furthermore, follow-up interviews of the participants' experiences of the created PA environment were conducted to gain a more holistic understanding of the research question.

5.2 *AIM*

The aim of this study was to examine two types of nature-based information for treadmill running (a selection of ten short nature videos with and without sound) compared to a self-selected audio-only entertainment PA environment on physical, psychological and emotional variables and PA experience.

5.3 *METHOD*

5.3.1 Participants

Twenty-four participants completed all the data collection and were recruited from university students (n = 8), university staff (n = 5) and the lead researchers personal network (n = 11) (church community and running group). The descriptive data of the participants are shown in Table 5. 1. This group of participants had diverse backgrounds and active levels. From a self-reported PA survey, 12 participants reported exercise duration of 3 hours a week, 7 participants exercised 3 to 6 hours a week and 5 participants exercise 6.5 hours and above a week. Participants performed diverse types of exercise including football, netball, running, strength training, cycling, climbing and

gym fitness sessions. Institutional ethical approval was granted by the Research Ethics Committee (Appendix 10). The sample size was based on a previous study (Brown et al., 2014). All participants were required to wear sports kit and running shoes. Before attending each trial, participants were asked to maintain normal lives by avoiding any conditions causing extreme exhaustion.

Table 5. 1 Descriptive data of participants (mean ± SD)

Variables	Male	Female	All
Number	13	11	24
Age (years)	29 ± 4.8	32 ± 8.7	30 ± 6.9
Stature (cm)	178. 4 ± 5.5	164.4 ± 4.2	172.0 ± 8.6
Mass (kg)	74.8 ± 8.6	60.2 ± 6.9	68.1 ± 10.7
BMI ($kg \cdot m^{-2}$)	23.6 ± 3.3	22.3 ± 2.2	23.0 ± 2.9

For exploring the specific experience of the designed PA environments, eight participants (29.9 ± 6.13 years; four males and four females) volunteered for post-run interviews to explore their perceptions of the different PA experiences and their engagements with nature. The sample of transcriptions is supplied in Appendix 11.

5.3.2 Study design

In a counterbalanced design, all participants were asked to perform three sessions of a twenty-minute treadmill run at a personal comfortable self-selected speed under three PA environments with different types of information. The two nature-based experimental conditions (video-sound and video-no sound) were designed to enable the differentiation between two levels of nature-based information with two types of information resources. The control group was designed to simulate representative PA conditions in people's daily life but were limited by the information type by offering permission for audio-only entertainment, such as listening to music, an audio book or a radio station instead of only staring at a blank wall which might bring out negative effects from participants due to boredom. The selection of nature videos in the current study attempted to offer diverse types of nature videos which would provide nature-based information but not task specific information which would attempt to avoid confusing participants as was proposed by the findings in Chapter 5. During each trial, participants were asked to report their perceived exertion every five minutes and their heart rate was recorded by a polar heart rate monitor (Polar RS400, Polar Electro, Kempele, Finland) continuously for the full twenty-minutes. There was at least 7 days

between conditions to 'wash out' condition effects and avoid fatigue. The video-sound condition involved running on a treadmill while viewing a collection of ten different nature clips with sounds, including beach scenes with wave sounds, sheep wandering in a field making sounds, birds rustling in the leaves of trees and twittering, geese swimming in a lake with bird and geese sounds, a running waterfall with water sound and thunderstorm and rain sounds, running streams and forest scenes with birds twittering (Figure 5. 1) and the list of videos please see Appendix 6. The video-no sound condition involved running on a treadmill while viewing the same dynamic image collection in the video-sound condition without sound. The self-selected audio entertainment condition involved running with self-selected audio entertainment, such as personal selected music, a radio station or no audio information if preferred. Semi-structured interviews were conducted by the researcher within ten days of the participant completing their last exercise trial. After obtaining informed consent, each participant engaged in a face-to-face, audio-recorded interview in a quiet place.

5.3.3 Procedure

In each trial, participants followed the same procedure (see Chapter 3 for details) which involved first measuring resting heart rate, then completion of pre-exercise questionnaires. Participants were then fitted with an Actigraph, ran in each prescribe condition, cooled down and completed a post-exercise questionnaire.

5.3.4 Measures and apparatus

Data on physical variables were collected in this study, including distance, speed, energy expenditure, perceived exertion and heart rate, while PANAS and SEQ were used to assess mental effects. The same experimental setting and equipment were utilised (Figure 3.1 and Table 3.2). For the video-sound condition, ten different nature videos were downloaded from YouTube and were edited by the researcher with the video editing software (Premiere Pro CS6, Adobe System Incorporated, CA, USA). Each clip was edited to two minutes in duration with the whole edited video duration being twenty minutes long. The video was projected onto a 60-inch television screen (Panasonic, Japan) in front of a treadmill and the distance between participants and screen was 1.6 metres. Participants wore a pair of wireless headphone (MDR-ZX770BN, Sony, Japan) to listen to the sounds of the video in the video-sound condition.

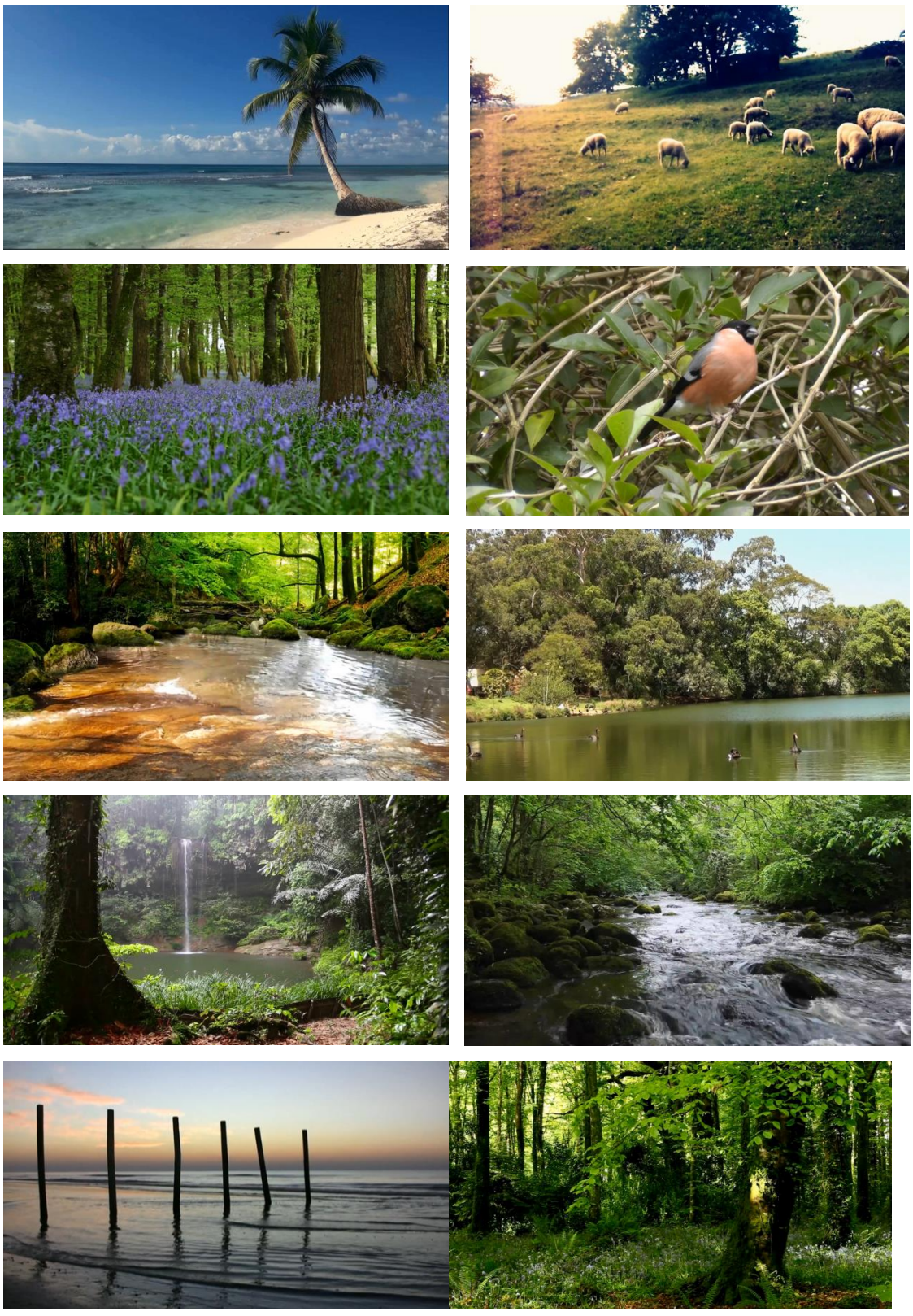

Figure 5. 1. Still frames from the ten nature clips used in the video-sound and the video-no sound conditions.

5.3.5 Interview guide

A similar semi-structured interview guide (Appendix 8) as previously used in chapter 3 was used in this study (see Chapter 3) with modifications made according to the three designed PA environments in Chapter 5. Modifications were made regarding the presented information such as "what was your focus while running with the nature video with sound / the nature video without sound / your chosen entertainment?"

5.3.6 Data processing and analysis

Due to technical problems, 3 participants heart rate data and 2 participants energy expenditure data and were excluded from the data analysis. Four, separate repeated measurement one-way ANOVA tests were used to examine the differences between conditions for energy expenditure, speed, distances and heart rate. Eight, separate two-way repeated measure ANOVAs were used to examine the difference between time and conditions for perceived exertion, five subscales of SEQ and the positive and negative subscales of PANAS.

Interview data processing and analysis followed the same procedure presented in Chapter 3. The total time for interviews for all participants was 3 hours 34 minutes and 37 seconds. For transcriptions accuracy, seven participants confirmed the accuracy with no changes required with one participant being none responsive. To ensure the rigor and trustworthiness of this study, member checking for the accuracy of transcriptions and investigators triangulations for interview guideline and data analysis were applied (please see chapter 3 for details).

5.4 ***RESULTS***

5.4.1 Physical measurements

The descriptive data on speed, running distances, energy expenditure, and heart rate in each condition and the perceived exertion of at the five different times during the run in each condition are displayed in Table 5.2. For the self-selected entertainment choice, 19 participants chose to run with their own music with headphones, two participants chose to run with a podcast with headphones and three participants preferred to run with no audio entertainment.

Table 5. 2. The mean running speed, distances, heart rate in each condition and five different times of perceived exertion in each PA condition (mean ± SD).

Variables	N	Video-sound	Video- no sound	Self-selected audio entertainment
Speed (km/h)	24	9.2 ± 1.4	8.7 ± 1.7	9.9 ± 1.6
Distance (m)	24	3035.5 ± 464.7	2845.1 ± 564.1	3255.1 ± 531.6
Energy expenditure (kcal)	22	216.7 ± 49.8	217.4 ± 47.8	218.1 ± 46.0
Heart rate (bpm)	21	147 ± 22	143 ± 19	155 ± 20
RPE level at 0^{th} minute (start)	24	6.8 ± 1.8	6.7 ± 1.7	6.8 ± 1.6
RPE level at 5^{th} minute	24	9.5 ± 1.8	9.6 ± 1.7	9.7 ± 1.9
RPE level at 10^{th} minute	24	11.4 ± 1.8	11.2 ± 1.6	11.8 ± 2.1
RPE level at 15^{th} minute	24	12.7 ± 2.1	12.3 ± 2.1	13.1 ± 2.6
RPE level at 20^{th} minute	24	13.8 ± 2.5	14.7 ± 2.4	14.0 ± 2.2

5.4.1.1 *Speed*

Condition had a main effect for speed, F (2, 46) = 9.578, $p < 0.05$, $p\eta^2 = 0.294$. Participants in the self-selected audio entertainment condition (9.9 km/h) ran faster than participants in the video-no sound condition (8.7 km/h, $p < 0.05$), but not the video-sound condition (9.2 km/h, $p > 0.05$). There were no differences between the video-sound condition and the video-no sound condition on speed ($p > 0.05$; Figure 5. 2).

5.4.1.2 *Running distance and energy expenditure*

Condition had a main effect for running distance, F (2, 46) = 9.311, $p < 0.05$, $p\eta^2 = 0.288$. Post-hoc testing showed that participants in the self-selected audio condition ran a longer distance (3255.1 m) than participants in the video-no-sound condition (2845.1 m, $p < 0.05$) but not the video-sound condition (3035.5 m, $p > 0.05$). There were no differences between the video-sound condition and the video-no sound condition on speed ($p > 0.05$).

Condition had no main effect for energy expenditure, F (2, 42) = 0.05, $p > 0.05$, $p\eta^2 = 0.002$

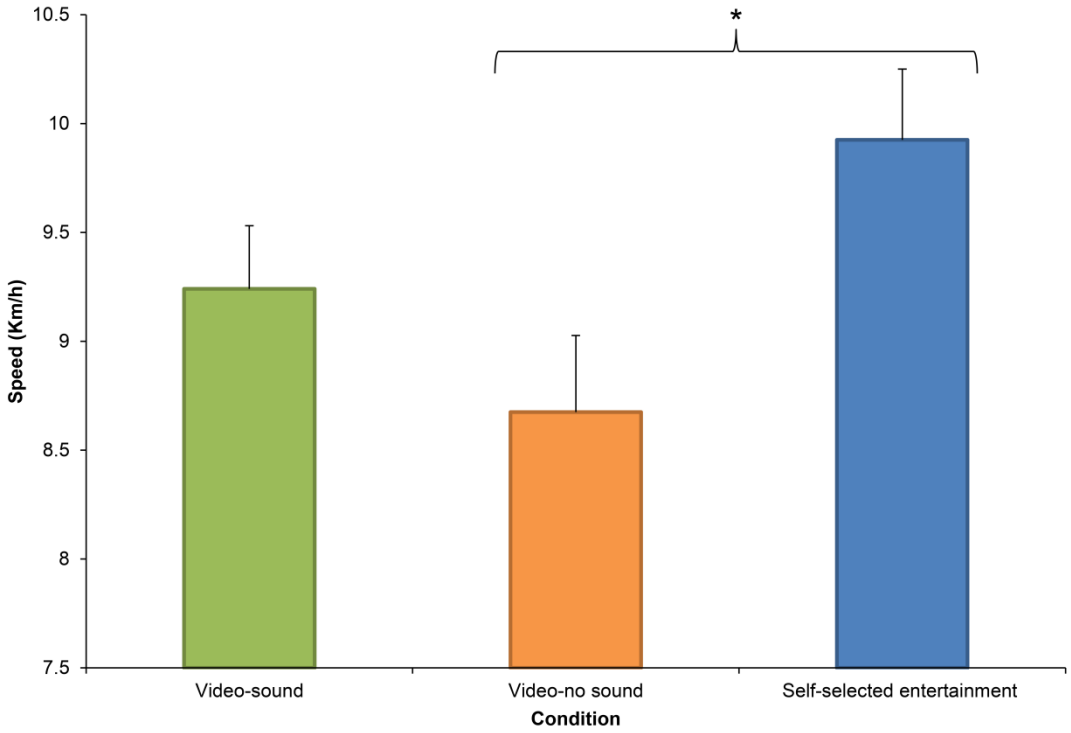

Figure 5. 2. Mean speed of three PA conditions (mean ± SE). * indicates the time effect ($p < 0.05$).

5.4.1.3 *Heart rate*

Condition had a main effect for heart rate, F (2, 40) = 10.842, $p < 0.05$, $p\eta^2 = 0.352$. Participants in the self-selected audio condition had higher mean heart rates (155.6 bpm) than participants in the video-no sound condition (144.0 bpm, $p < 0.05$) and the video-sound condition (147.7 bpm, $p < 0.05$). There were no differences in mean heart rate between the video-no-sound condition and the video-sound condition ($p > 0.05$; Figure 5. 3).

5.4.1.4 *Perceived exertion*

A main effect was found on time, F (1.438, 33.067) = 142.309, $p < 0.05$, $\eta p^2 = 0.861$, but not on conditions, F (2, 46) = 1.133, $p > 0.05$, $\eta p^2 = 0.047$. No conditions or interaction effects were found, F (8, 184) = 0.783, $p > 0.05$, $\eta p^2 = 0.033$. Post hoc analysis revealed that people reported increased exertion level over time after running (Figure 5. 4).

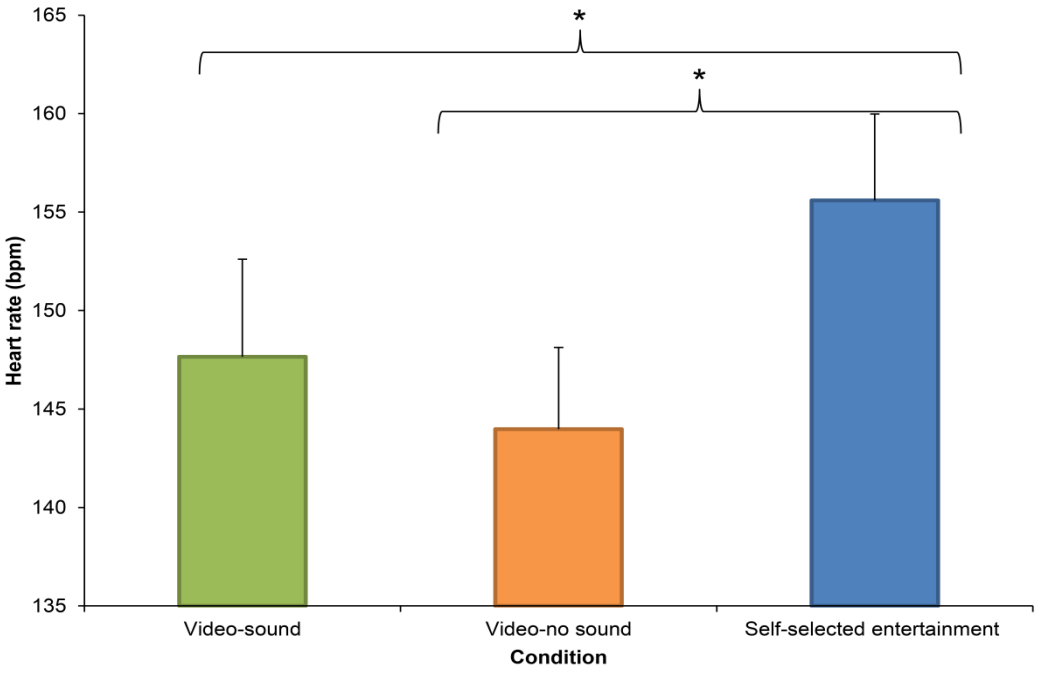

Figure 5. 3. Mean running heart rate of three conditions (mean ± SE); * indicates the condition effect ($p < 0.05$); bpm = beats per minute.

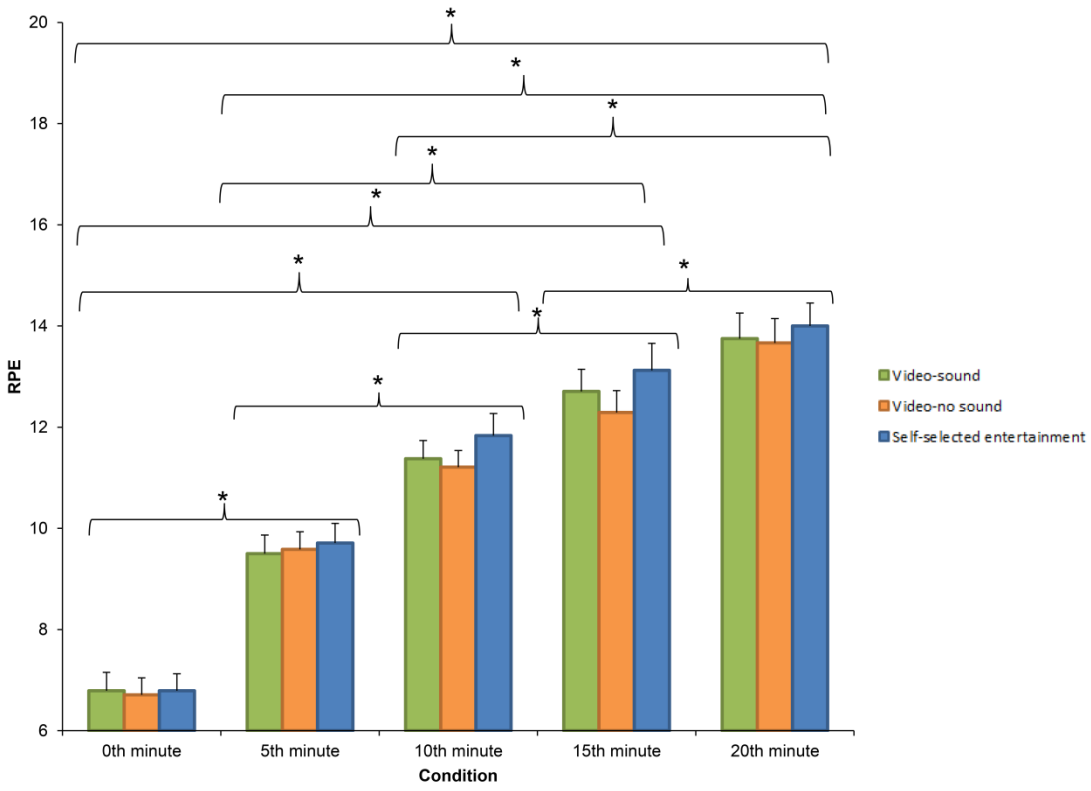

Figure 5. 4. Perceived exertion level at five different times in each condition during treadmill running (mean ± SE); * indicates the time effect ($p < 0.05$).

5.4.2 Psychological and emotional measurements

The descriptive data of the pre-and-post test scores of PANAS and SEQ in each condition are presented in Table 5.3. In general, for psychological measurements, time played the main role in the positive affect (higher positive affect scores shown in post-run test) whilst PA conditions showed no influences. No differences were found in the negative affect regardless of time or conditions.

Table 5. 3. Descriptive data of pre-and-post-test scores of PANAS and SEQ in three PA conditions (mean ± SD).

	N	Video-sound	Video-no sound	Self-selected audio
Positive affect Pre-test	24	25.1 ± 9.2	23.4 ± 9.0	25.8 ± 9.2
Positive affect Post-test	24	31.0 ± 8.8	29.0 ± 8.4	30.7 ± 9.4
Negative affect Pre-test	24	11.6 ± 2.5	11.4 ±1.5	11.1 ± 1.5
Negative affect Post-test	24	10.8 ± 1.8	10.3 ± 0.7	10.6 ± 1.0
Anxiety Pre-test	24	0.5 ± 0.4	0.4 ± 0.4	0.4 ± 0.5
Anxiety Post-test	24	0.2 ± 0.3	0.1 ± 0.2	0.2 ± 0.3
Dejection Pre-test	24	0.2 ± 0.3	0.2 ± 0.3	0.1 ± 0.1
Dejection Post-test	24	0.1 ± 0.3	0.1 ± 0.3	0.2 ± 0.9
Excitement Pre-test	24	1.3 ± 0.8	1.1 ± 1.0	1.4 ± 0.9
Excitement Post-test	24	2.1 ± 0.9	1.9 ± 0.9	2.1 ± 1.1
Anger Pre-test	24	0.2 ± 0.3	0.1 ± 0.1	0.1 ± 0.2
Anger Post-test	24	0.04 ± 0.1	0.04 ± 0.2	0.1 ± 0.1
Happiness Pre-test	24	1.7 ± 1.0	1.6 ± 1.0	1.9 ± 0.9
Happiness Post-test	24	2.4 ± 0.3	2.1 ± 0.9	2.3 ± 0.1

5.4.2.1 *Pre-and-post test of the positive affect scores*

Time had a main effect for positive affect scores, F (1, 23) = 21.944, $p < 0.05$, $\eta p^2 = 0.488$, showing that people reported higher positive affect scores after running (pre-test 24.8 ± 9.0; post-test 30.2 ± 8.8). There was no main effect for condition on reported positive affect scores, F (2, 46) = 1.221, $p > 0.05$, $\eta p^2 = 0.046$. There was also no interaction between time and conditions on reported positive affect scores, F (2, 46) = 0.220, $p > 0.05$, $\eta p^2 = 0.009$ (Figure 5. 5).

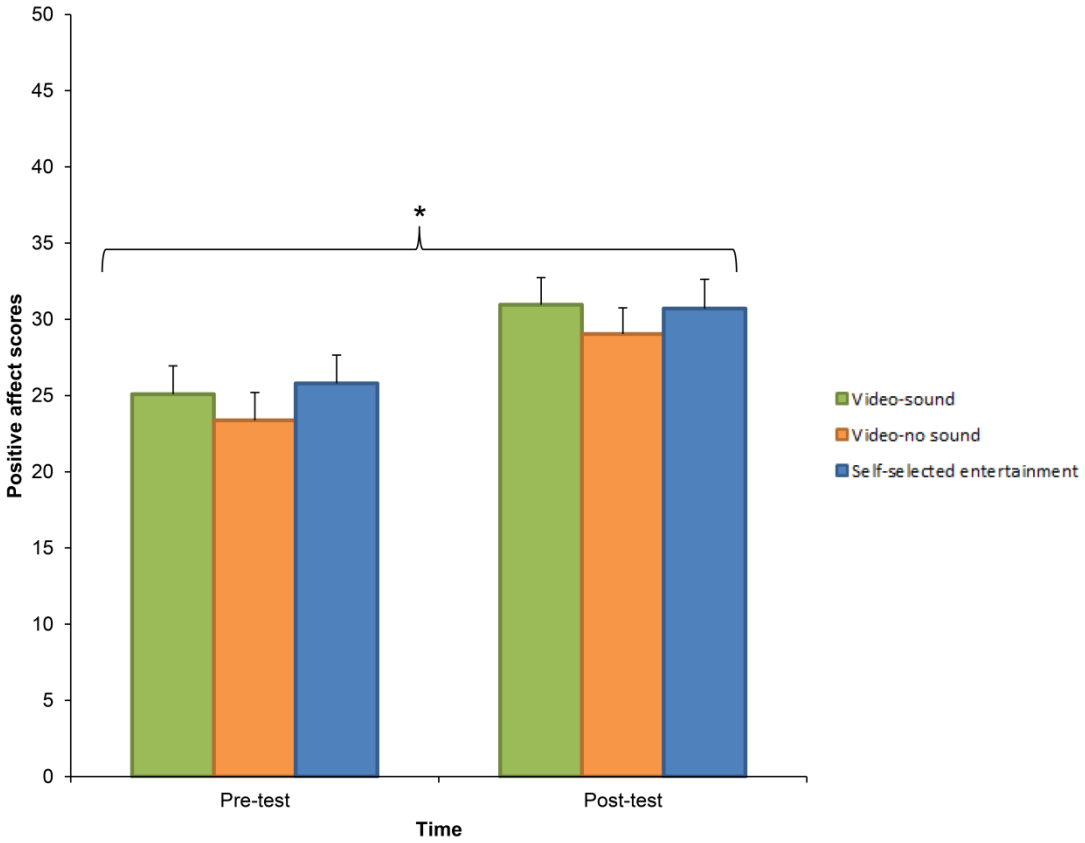

Figure 5. 5. The scores of the positive affect scale pre-and post in each condition (mean ± SE); * indicates the time effect ($p < 0.05$).

5.4.2.2 *Pre-and-post-test of the negative affect scores*

Time had a main effect for negative affect scores, F (1, 23) = 19.382, $p < 0.05$, ηp^2 = 0.457, showing that people reported higher negative affect scores after running (pre-test 11.4 ± 1.9; post-test 10.5 ± 1.2). There was no main effect for condition on reported negative affect scores, F (1.557, 35.802) = 0.697, $p > 0.05$, ηp^2 = 0.029. There was no interaction between time and conditions on negative affect scores, F (1.431, 32.916) = 1.243, $p > 0.05$, ηp^2 = 0.051.

5.4.3 Emotional measurements

5.4.3.1 *Anxiety*

Time had a main effect for reported feelings of anxiety, F (1, 23) = 20.802, $p < 0.05$, ηp^2 = 0.475. Participants reported lower feeling of anxiety after running (pre-test 0.4 ± 0.05; post-test 0.2 ± 0.3) regardless of the conditions. There was no main effect for condition on reported feelings of anxiety, F (2, 46) = 0.210, $p > 0.05$, ηp^2 = 0.009,

which indicated that people reported a similar level of anxiety across the three conditions. There were no interactions between time and conditions on reported feelings of anxiety, F (2, 46) = 0.109, $p > 0.05$, $\eta p^2 = 0.005$.

5.4.3.2 *Dejection*

Time had no main effect for reported feelings of dejection, F (2, 46) = 0.245, $p > 0.05$, $\eta p^2 = 0.011$. There was no main effect for condition on reported feelings of dejection, F (2, 46) = 0.029, $p > 0.05$, $\eta p^2 = 0.001$, which indicated that people report the similar reported feelings of dejection across all three conditions. There were however interactions between time and conditions for reported feelings of dejection, F (2, 46) = 3.668, $p < 0.05$, $\eta p^2 = 0.138$. In Figure 5. 6, the patterns of reported feelings of dejection for two-nature based conditions were similar, declining after running but there was a contrasting trend shown for the self-selected audio condition.

5.4.3.3 *Excitement*

Time had a main effect for reported feelings of excitement, F (1, 23) = 41.864, $p < 0.05$, $\eta p^2 = 0.645$. People felt more excited after running (pre-test 1.2 ± 0.9; post-test 2.0 ± 0.9) regardless of the conditions. There was no main effect for condition on reported feelings of excitement, F (2, 46) = 1.857, $p > 0.05$, $\eta p^2 = 0.075$, which indicated that people report a similar level of excitement across all three conditions. There were no interactions between time and conditions for reported feelings of excitement, F (2, 46) = 0.070, $p > 0.05$, $\eta p^2 = 0.003$.

5.4.3.4 *Anger*

Time had no main effect for reported feelings of anger, F (1, 23) = 2.300, $p > 0.05$, $\eta p^2 = 0.091$ and no main effect for condition on reported feelings of anger was found, F (2, 46) = 0.783, $p > 0.05$, $\eta p^2 = 0.033$. No interaction between time and condition on reported feelings of anger was shown, F (2, 46) = 2.452, $p > 0.05$, $\eta p^2 = 0.096$.

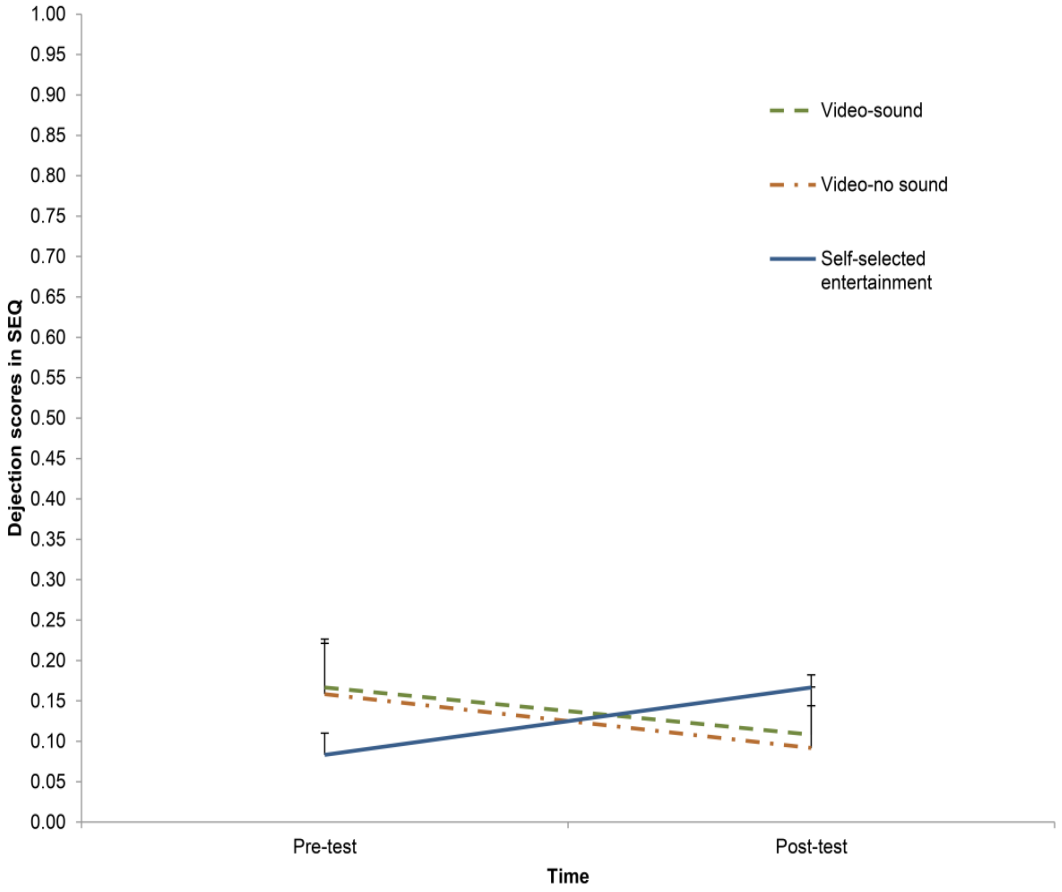

Figure 5. 6. Interactions between three conditions of pre-and-post-test scores of Dejection subscale (mean ± SE). In order to clearly show the interaction, the scale of this figure is showing from 0 to 1.

5.4.3.5 *Happiness*

Time had a main effect for reported feelings of happiness, F (1, 23) = 34.629, $p < 0.05$, $\eta p^2 = 0.601$. People felt happier after running (pre-test 1.7 ± 1.0; post-test 2.3 ± 0.9) in all of the three conditions. There was no main effect for condition for reported feelings of happiness, F (2, 46) = 1.609, $p > 0.05$, $\eta p^2 = 0.065$, which indicated that people reported similar feelings of happiness across the three conditions. There were no interactions between time and conditions on happiness, F (2, 46) = 2.418, $p > 0.05$, $\eta p^2 = 0.095$.

5.4.4 The video-sound condition

The thematic analysis of the interview transcripts in relation to the video-sound condition revealed a total of 76 initial codes that were allocated into 16 lower-order

themes, three higher-order themes and 3 general dimensions. The generated themes of the PA experiences in the nature video condition are displayed in Table 5.4.

Table 5. 4. The generated themes of the PA experiences in the video-sound condition.

Lower-order themes	Higher-order themes	General dimension (Video-sound condition)
Video and sounds	Unequal attention allocation	Focus
Past memory		
Warmth and headphones		
Safety		
Exciting		Feelings
Happy		
Relaxed		
Comfortable		
pleasant/ interested/ motivated/ calm		
Feel like running outside or in the environment	Physical and mental encouragements	Feedback
Related to past good experiences		
Changing images motivate running		
More related to habitual experience		
Enjoyment		
Forget running on the treadmill		
Clear my mind		
Encouraging engagement with the video	Sound as the influential factor	

5.4.4.1 *Focus*

Focus was used to exhibit participants' engagement. The engagement was discussed from various perspectives, including participants' visual and acoustic attention on the environment, presented information and personal physical conditions during the run. Participants reported an unequal attention allocation because the video and sounds dominated their attention and led to different ways of engaging physically and mentally. For example, here a description was given by Participant 3 about how he engaged with the video and sound, *"with visual and sound, I was just focusing on that. I was in that nice environment. I like the beach and sand, I can visualise myself running across this beach and listening to the wave while I am doing it"*. Participants were actively engrossed in the virtual environment, for example, "*though that wasn't the real environment and I felt like that I was in it"* (Participant 5). In addition, for some participants, the video and sounds brought back past memories, for example, Participant 1 shared that *"when I saw the images, I was thinking about being in my friend's cabin, went to swim in a lake, went to a waterfall, watching the stream and went hiking. Twenty minutes was enough time to go into that world"*. For some participants, specific

ways of studying the scenery was discussed, for example, "*I found myself focusing on a specific part of the image and I was trying to run toward that point."* (Participant 3).

Although participants' dominant attentions were allocated to the video and sounds, participants also were aware of information from the laboratory, such as the temperature or having to wear headphones. Participant 3 would occasionally check her foot placement on the treadmill for safety reasons. For example, she stated that "*sometimes I would look at my feet and try to make sure that I was making good contact with the treadmill and not to touch the front part of the treadmill, safety stuff, really".*

5.4.4.2 *Feelings*

Feelings were used to show participants' emotional states to reflect their feeling when running with the video and sounds. Participants listed numerous positive emotions they experienced, for example, Participant 3 stated that "*just felt a bit more excited after I finished. I felt happier after got off the treadmill"* or Participant 2 said that *"I actually enjoyed that and it did make me feel quite relaxed and I was actually enjoying the run".* Participants reported a well-engaged experience with the videos which led to positive feelings, for example, "*I definitely get into a zone and forgot I was running and felt really comfortable and I really enjoyed it. I didn't notice the time and just got into a rhythm"* (Participant 7). The multiple changing scenes also led to positive emotions because "*it felt like that I wasn't running long for that one and it's more pleasant to run because I was just waiting for the next image to come up."* (Participant 3). Some participants also indicated that they felt interested, motivated and calm during the run.

5.4.4.3 *Feedback*

Feedback illustrated participants' responses and thoughts related to the run with the videos with sounds, including the received physical and mental encouragements and identifying the sounds of nature as an influential factor. Participants indicated numerous reasons regarding the physical encouragements they received in this designed PA environment. For example, the participants felt that "*it [the video and sounds] really brought you into that place"* (Participant 1) and "*you can almost imagine yourself in that actual scenario "*(Participant 4) *or "I was able to do the run and enjoyed it, enjoyed the sounds, enjoyed the environment and I could run longer."* (Participant 2). *"The distraction [the video and sound] was enough and I didn't feel as tired "*(Participant 1). The other reasons included that Participant 3 said that "*specifically with the water stuff*

because I can relate to it, so I felt that I was pushing myself a bit more ", " *I focus less on my biomechanics because I was interesting in that environment and interesting in where I am going next"* (Participant 5) *or "there were some reminders me a lot about the peak district and I really like the little birds"* (Participant 7). Participant 6 specifically pointed out that "*I was, like, stopping thinking actually as a way to clear my mind. I felt most clear in that one*". In this PA environment, participants identified that running with the video and sound brought out physical and mental benefits because of the feelings of visualising themselves running in the similar environments where they preferred, building a connection to the past or habitual experience, forgetting that they were running on a treadmill, enjoying the running and the run cleared their mind. The constantly changing videos were able to retain their interest on the videos rather than on the physical task and to motivate them to keep running. The sounds of nature of the video were endorsed by the participants as they felt that it contributed to a deeper engagement with the video because "*the sound makes the place come more alive and dragged me into something"* (Participant 1).

5.4.5 The video-no sound condition

A total of 60 codes were allocated into five higher-order themes and 23 lower-order themes in three general dimensions. The generated themes of the PA experiences in the nature video condition are displayed in Table 5. 5.

Table 5. 5. The generated themes of the PA experiences in the video-no sound condition.

Lower-order themes	Higher-order themes	General dimension (Video-no sound condition)
Running	Internal attention	Focus
Physical conditions		
Physical environment (treadmill, lab)	External attention	
Time		
Video		
Personal stuff		
Reflection from TV screen		
Replicate audio information of the Video contents		
Video-as a tool		
Motivation	Changing scenery led to benefits	Feelings
Enjoyment from the preferred clips		
Relaxed		
Tired		
Bored		
Distressed		
Jarring		
Lethargic		
Familiar with video sequences	Familiarity	Feedback
Matching habitual experiences		
Dislike-Sounds of treadmill	The missing information	
Difficult		
Stuck inside on a treadmill		

5.4.5.1 *Focus*

Focus was used to demonstrate how participants allocated their attention on both external and internal information. For example, here Participant 1 stated that he" *was focusing on running"* and Participant 3 *"was more aware of breathing without the audio "*. Participant 4 *was "more thinking about own thoughts because there was no noise to distract you."* Participants also "*realised that I was on the treadmill and noticing that you were kind of being pulled back by the treadmill"* (Participant 6). Participant 8 felt *"a really nice breeze coming across the top between the two boards" and was "wondering when the testing was going to be done"*. Some of the participant paid attention to the reflection in the television screen. For example, here Participant 6 described that he actively used the reflection in the television to correct his running form and Participant 1 became more aware of the fact that he was running on a treadmill because of the reflection.

Owing to the counterbalanced design of this study, some participants experienced the video-sound condition first rather than the video-no sound condition, which showed the

familiarity of the video led to different usages of the video. For example, Participant 7 "*was trying to look for more details and even counting some trees"* and other participants "*was trying to use the information got from last session to help to make that run a bit easier"* (Participant 3). Participant 3 especially tried to replicate the sounds in her mind that she heard before in the previous session, for example, she stated that *"I am just trying to image what the sound was and try to put it on."*

5.4.5.2 *Feelings*

Feelings were named to show participants' emotional states related to the experimental testing. Mixed positive and negative emotions were reported in this PA environment. With the ten different video scenes, participants enjoyed certain scenes and felt motivated by the changing videos and were able to relax. A wider range of negative emotions were identified by participants. The visual-no sound condition was considered to offer inadequate attractions and participants sensed "*feelings of fatigue*" (Participant 2), "*got bored quite quickly*" (Participant 5) and "*distressed because cannot find rhythm"* (Participant 5) *or "missing information"* (Participant 4). Participant 8 felt the PA experience was "*a bit more lethargic and less energy because there was less kind of to lift me up"* and Participant 6 opposed the visual (video) and audio (treadmill) information mismatched and felt "*it was more jarring*."

5.4.5.3 *Feedback*

Feedback here was aimed to capture participants' responses regarding running with video-only PA condition. The familiarity of the video sequences was considered as beneficial because "*I knew the sequences, so, I can tell that I was about half way now or I might nearly finish and I can run a bit faster"* (Participant 4) and *" It was nice to look at nature video because it is how I normally run."* (Participant 7). The missing information (no sounds) meant that participants could hear the treadmill sound which they recorded as a dislike in the information, as they felt like they were stuck in the laboratory and therefore found the task was difficult.

5.4.6 The self-selected audio-only entertainment condition

A total of 67 codes were allocated into six higher-order themes and 23 lower-order themes in three general dimensions. Five participants ran with their own music, two

with the podcast and one participant chose to run with no entertainment. The generated themes of the PA experiences in the nature video condition are displayed in Table 5. 6.

Table 5. 6. The generated themes of the PA experiences in the self-selected audio-only entertainment condition.

Lower-order themes	Higher-order themes	General dimension (Self-selected audio-only entertainment)
Running Self-selected information Reflection from TV screen Time Physical conditions Physical environment (treadmill, lab) Daily tasks Self-mental imagery as motivation	Attention shifting led to a variety of physical and mental engagements	Focus
Psyched up Happy	Positive feelings	Feelings
Boredom Tired Annoyed- the run could be better Hard Stressed Disorientated Felt stuck on treadmill	Negative feelings	
Enhance physical performances Clear my head by running Motivation-pushing myself	Physical and mental rewards	Feedback
Expecting better exercise performance	Wrong choice	
Leading cadence Block out noise	Function of music	

5.4.6.1 *Focus*

As defined previously, focus was phrased to outline a variety of participants' thoughts and their attention span of numerous aspects. This included the physical task (the run), self-chosen information (conversation on the podcast, volume or rhythm of the music), reflection in the television screen, exercise duration, physical states (e.g., tiredness, heavier breathing or muscle fatigue), physical conditions, the physical environment (the treadmill or the laboratory) or thoughts of personal tasks or mental imagery. Participants not only physically engaged with the experimental task, environmental setting, and personal physical states but also mentally engaged with the refection in the television screen and noted any personal thoughts related to the task or not.

Participants were paying attention to the physical task (the run) because "*I tried to push myself. I was more thinking about my running and my muscle fatigue"* (Participant 2) and the reflection in the television also contributed to more concentration on running *"I can see myself running*" (Participant 7) or even *"trying to correct my running through being able to see myself in the screen."* (Participant 3). Here participants were showing the mental engagement with the run because they were pursuing a better physical performance or because the visual information presented in this experimental setting encouraged them not only to mentally engaged but also physically respond to the reflection.

Different ways of mentally engaging with the PA environment were reported during the run, for example, *"I did find myself using mental imagery for certain things like running across a finish line, playing football and score a goal"* (Participant 2) and "*the audio kept my interests but actually I used it to kind of gauge the time.*" (Participant 4). Participants also noted their own physical condition (heavy breathing or physical tiredness) for example, Participant 3 said that "*I can feel my breathing getting a bit harder."* or thoughts about their daily tasks or schedules.

5.4.6.2 *Feelings*

Feeling was used to describe participants' emotional states during the run with their own chosen audio-only information. A variety of negative emotions were expressed by the participants with different reasons, such as boredom because the run "*felt monotonous"* (Participants 3), tiredness due to *"I was not interested in it"* (Participant 6), and annoyance and "*felt quite harder or push more*" (Participant 4). Participants also felt the experimental task was hard, stressful, disoriented and a sense of being stuck on the treadmill. Conversely, some of the participants indicated the music "*gave me more energy to run"* (Participant 8) and "*felt quite psyched up, quite ready* to run" (Participant 2). Participants also felt happy because "*being able to think of my day*" (Participant 1) or because they "*achieved something*" (Participant 2).

5.4.6.3 *Feedback*

Feedback was named to capture participants' opinions related the experiences of running with their own chosen audio information. Physical performance enhancements and mental rewards of this running experience were supported by the participants because "*something there [music] prompted to accelerate and made me speed up"* (Participant

5) or "*the music was quite up-beat and that makes me want to run faster"* (Participant 2) and *"It often really helped me mentally to clear my head."* (Participant 1).

Some participants felt they could have performed better on the run but they did not because they had chosen the wrong audio entertainment to run with. Some of the participants used music for running because the tempo or the rhythm of the music derived their running strides and Participant 1 tended to use music to block out background noise while running and attempt to plan daily tasks during running.

5.5 *DISCUSSION*

This study aimed to examine the effects of two types of nature-based information for treadmill running (a selection of ten short nature videos with and without sound) compared with an audio-only self-selected entertainment environment using a mixed-method approach to examine physical, psychological and emotional outcomes. Quantitative results showed that participants who ran with their self-selected entertainment had better physical performances outcomes compared to participants who ran with the video-no sound condition but not the video-sound condition except for heart rate. The specific PA environments did not result in differences of positive and negative affect scores. However, undertaking the exercise (i.e. time factor) resulted in affective response changes between pre and post scores. All environment designs for treadmill running enhanced participants' emotional wellbeing in this study, as measured by decreases in anxiety and increases in excitement and happiness. The two nature-based environments decreased participants' dejection level while increased dejected level was observed in the self-selected entertainment environment. From the interview data, there were three distinct types of experiences regarding the physical and mental engagement participants chose to have. Participants experienced a variety of feelings and reported different opinions regarding the three environments. In the video-sound environment, participants were physically and mentally fond of the visual and audio contents receiving positive benefits. Both in the video-no sound and self-selected audio-only conditions, interviewees showed a diverse attention allocation on the physical task, the presented and chosen information, reflections in the television screen, personal physical states and the laboratory, exercise duration and personal thoughts. A mixture of positive and negative responses was reported in both conditions; especially a sense of missing information in the video-no sound condition and a feeling of regret on audio entertainment choices were reported from interviewees. These different experiences

reflected different effects and functionality of affordances when perceiving and utilising varying information from an ecological dynamics perspective.

Physically, no differences were observed for energy expenditure, heart rate, distance, speed and perceived exertion between the two nature-based environments for indoor treadmill running. Viewing visual information of the video was as effective as viewing a nature video with sound for participants to achieve the similar physical outputs. This might be in line with Hoegg and Alba (2007) who proposed that visual information was suggested to be a more dominant sensory input rather than other senses. With only the visual information, the changing images were proposed to motivate participants and produce positive experiences (Reese et al., 2016). For some of the participants, the familiarity of images sequences brought out benefits because participants would be able to gauge time (knowing when to finish). This benefits accrued by having familiar PA experience was also suggested by Rose and Parfitt (2012) focusing on sedentary women on enhancing self-efficiency and competence. Although participants received extra acoustic information for affordances in the video-sound condition, no additional physical benefits were found when comparing these two nature-based conditions. This might be because those nature sounds provided in the video failed to act as a motivation for running or that the sounds of nature were irrelevant cues for running. In line with Wooller et al. (2015), they found that the different information inputs of nature-based information (visual, audio and olfactory) of green PA had influences on mood but not for heart rate and perceived exertion. However, Wooller and colleagues also found that the acoustic information was the most influential factor instead of the visual information which was different from the aforementioned discussion. The inconsistent findings in the current study and in Wooller et al (2015) might be because the methods used to block out audio information in these two studies were different. Sound was blocked using a combination of foam in ear plugs with commercial ear defenders over the top in Wooller et al. (2015) whereas the nature sounds were just muted in the current study. Participants still heard the sound from the laboratory, treadmill or other environmental noises in the current study which was supported by some interviewees in the interview data. Furthermore, only one interviewee attempted to replicate the sounds when the acoustic information was removed.

It was worth noting the significant differences of physical benefits found between the video-no sound condition and the self-selected audio entertainment condition. Participants ran shorter distances at slower speeds with lower heart rates when they

were in the video-no sound condition. Compared to the self-selected audio entertainment, perceived exertion and energy expenditure were found to be similar between the two PA conditions. Possible explanations are that compared to the video-no sound condition, participants are more likely to detect and utilise the continuously changing and rich information of audio entertainment whereas the video-only information might be less dynamic. Participants might also just not focus on running. This might be supported by the interview data as participants were unable to retain their focus and shifted between a variety of degrees of attention including internal information (running and physical states) and external information (personal thoughts, experimental setting, video, duration and reflections in the screen). Paying more attention to external information was suggested to be beneficial for lower exertion but might hinder performance (Maters & Ogles, 1998). Although from interview data, people who ran with their own audio selections showed diverse attention allocations (physical task, the chosen information, reflection in the television screen, personal physical states and the laboratory, duration and personal thoughts), the chosen music might functionally motivate participants to enhance physical performances (Karageorghis & Priest, 2012a). For example, some of the participants were motivated by the up-beat music, wanted to run faster and felt happy or psyched-up while mentally visualising exciting moments (*running across a finish line, playing football and scoring a goal;* Participant 2).

Similar physical effects were found between the video-sound and the self-selected audio entertainment conditions for energy expenditure, running distance, speed and perceived exertion except heart rate. Higher heart rates were recorded in the self-selected audio entertainment condition compared to other two nature-based conditions. These results suggested the effective use of a collection of nature videos with corresponding sounds compared to individual preferred audio entertainment. The ten nature video were considered to offer information irrelevant to the physical task to avoid offering conflicting information to hamper participants' performances built on the findings in Chapter 4. These ten different selections of nature videos were providing participants with various nature scenes and sounds with a higher degree of similarity in the contents of each video. For example, participants would see the constantly running stream from the same filming angle in the same environment or the same beach with waves continuously hitting the sand back and forth. Only three out of the ten selections were presenting more diverse contents of the videos which were birds jumping around

different branches, sheep walking around the field or swans swimming around a pond. Therefore, in each clip, participants might perceive a very similar set of visual-acoustic information with minor changes over time. The findings in the current study are aligned with previous research suggesting that participants tend to have lower heart rates when viewing nature scenes compared to viewing urban scenes (Laumann et al., 2003). Conversely, participants were constantly exposed to rich audio information in the self-selected audio entertainment condition with the majority of participants running with their own choice of music (19 out of 24). Within one running session, participants would at least listen to 5 or 6 different songs which were considered to offer diverse and frequently changing information compared to the collection of ten nature clips. The richness of the audio information might be due to the different types, tempos, lyrics and melodies of music which were more likely to encourage participants' physical performances. In literature, music is found to encourage physical performances with certain features. For example, the asynchronous use of music means participants synchronised their movements with the tempo of the music tempo without any conscious effort (Karageorghis & Priest, 2012a). Music has been proposed to reduce perceived exertion and prolong duration to physical exhaustion (Bharani et al., 2004) and enhance core affects (Bird et al., 2016). Furthermore, participants might choose specific music for physical enhancement which would potentially influence their performances and may benefit from further examination. Unlike music, nature sounds, such as bird calls or sounds of water running, raining or thunders might not have particular tempo or rhythm for people to follow or to synchronise their movements. Therefore, music and nature sounds showed different features of acoustic information for participants to utilise. Although these two types of acoustic information offered distinct information for affordances for participants during running, similar physical benefits were observed which expanded the merit of nature-based PA environments for indoor treadmill running as an alternative option.

For mental benefits, participants reported higher positive affects scores after running and no differences for the negative affect scale regardless of the conditions. For SEQ, no differences were found in anxiety, excitement and happiness in any of the three PA environments. Participants did not express any anger before or after running. However, the level of dejection increased in the self-selected audio entertainment condition but decreased in other two nature-based environments after the run. This finding required careful interpretation due to the rating scores of the dejection being very low in each

condition. It would not be wise to conclude that exercise with music generated dejected feelings due to the complexity of the PA in relation to music. Potential reasons might be found in the interview data. When running with participant's own audio information, they discussed a mixture of positive and negative feelings and opinions because of the experimental setting and the chosen information participants ran with from their personal experience. For example, some of the participants reflected that their audio information was the wrong choice to run with and felt annoyed. This might explain the slightly higher dejection scores observed in this study. Personal experiences were also played an influential factor for the negative responses; for example, Participant 6 recalled his initial tiring PA experiences because of the similar setting to the study. This negative affective response was considered as an influential factor for exercise adherence (Williams, 2008) when put into practice. When comparing the three PA environments together, distinct sets of information for affordances were offered, with participants improving mental wellbeing as a whole in terms of quantitative data. In line with previous works, green PA has been proposed to be beneficial for mental wellbeing, such as improving mood (Akers et al., 2012; Nieuwenhuijsen et al., 2014; Pretty et al., 2005) and affect (Bratman et al., 2015; Focht, 2009; Mayer et al., 2009). However, the similar mental benefits between the video-sound and video-no sound conditions were observed in this study which seemed inconsistent to previous research proposing the mental benefits of nature sounds. These included mood recovery (Benfield et al., 2014), perception of restoration (Jahncke et al., 2015; Ratcliffe, Gatersleben, & Sowden, 2013) and stress recovery (Ratcliffe et al., 2013). The different exposure durations and involvement of PA compared to previous studies might be the reasons for the inconsistency. Conversely, the qualitative data showed supporting evidence regarding the above positive psychological and emotional improvements, especially comparing the video-sound and video-no sound conditions. In the video-sound condition, participants were physically and mentally fond of the visual and audio contents of the video and received positive benefits. This finding was in line with a previous study which suggested the improved enjoyment and reduced stress when participants viewed nature video without PA involved (Olafsdottir, Cloke, & Vögele, 2017). In particular, participants negated their physical tiredness via visualising themselves in the similar environments when viewing preferred clips or creating links to past memories. Such experiences indicated that participants concentrated on external information and perceived lower physical exertion (Maters & Ogles, 1998). This positive connection with the video experience made participants consider that running with the videos and

sounds was exciting, relaxing, pleasant, interesting, happy and comfortable. These mental benefits might be in line with Jahncke et al. (2015) that the perceived restoration was improved when matched visual and audio nature-based information were presented. The changing images were advocated by the participants as a motivation and the corresponding nature sounds added extra benefits in facilitating the engagement with the video shown in this statement: "*the sound makes the place come more alive and dragged me into something"* (Participant 1). These experiences were supported by Reese et al. (2016) who found that clear sounds, a variety of setting and moving images were important features which contributed to mental wellness, such as reminiscing about positive memories and relaxing from the most popular YouTube nature video. When running with missing nature sound, a wider range of negative feelings and responses were given because of the missing information. Therefore, in terms of PA experience, the merit of the corresponding sound of the video appeared as an influential factor to instigate the connection with the videos. When this important information was missing, participants felt bored and tired. To be more specific, there were more types of positive feelings reported in the video-sound condition (exciting, happy, relaxed, comfortable, pleasant, interested, motivated and calm) compared to other two conditions (motivated, enjoyment and relaxed in the video-no sound condition; psyched-up and happy in the self-selected condition). Participants felt calm, relaxed and pleasant in the two nature-based PA environments which was aligned to the literature matching the nature environments offered space for being away, reducing stress or lowering anxiety (Chawla et al., 2014; Kaplan & Kaplan, 1989). This was again evidenced especially with the additional nature sound in the video-sound condition, more positive emotions were proposed which were in line with the literature to advocate the benefits of nature sounds (Alvarsson et al., 2010; Ratcliffe et al., 2013). The inconsistent findings between qualitative and quantitative data regarding the additional nature sounds might because the limitation of emotions measured with SEQ.

These three types of PA environment encouraged participants to have different physical and mental engagements. Participants were predominantly engrossed in the nature video and endorsed the additional merit of the corresponding sounds. This finding was proposed the merit of multiple sensory inputs to increase the realism of presentation in the virtual environment (Dinh et al., 1999) and it was also aligned with the Yeh et al. (2015) who proposed that rich information source was important criteria when design green PA programme. In the video-no sound or the self-selected audio-only conditions,

participants demonstrated a diversity of attention distribution with similar negative feelings reported in both conditions. This might suggest the information presented in the video-no sound and self-selected condition failed to retain attention (lost functionality of affordances). Yet, the interview data was not able to offer solid explanations to state the differences shown in quantitative data that participants had better physical performances in the self-selected audio-only condition than in the video-no sound condition. Interviewees only actively reported the physical enhancements they received in the self-selected audio-only condition but none in the video-no sound condition. Furthermore, the interview data was only collected from 8 participants rather than the whole group of the participants who took part in the study. Another similar finding from Chapters 4 and this chapter was that when the presented information lost its merit to retain participants' interest, attentions shifted to notice the run and physical states (internal information) and negative feelings were more likely to appear, such as boredom or tiredness (Brick et al., 2014; Johnson & Siegel, 1992).

An important finding was that regardless of the conditions, personal preference was a key factor which heavily influenced participants' PA experiences. For example, participants reported the wrong choices of music negatively affected their run and the dislike of the sounds of the treadmill resulted in negative feelings about the run. Participants explained that the preferred clips of the video motivated them to keep running and triggered positive feelings even though the audio information was missing; deeper connection was built when participants visualised themselves in the similar environment they preferred and accrued positive emotions. This type of aesthetic attribute has identified as one environmental factor associated with PA engagement (Humpel, 2002). Exposure to personal preferred music and images was found to reduce disordered behaviours and improve engagement for dementia patients (Eggert et al., 2015). This user-centred concept is also an important when designing PA programme (Scott, 2014).

From an ecological dynamics perspective, this finding demonstrated the affordance was an individual-specified relationship with the environment and individual differences should be considered when designing green PA programmes (Yeh et al., 2015). Firstly, the offered environmental information needs to be considered as beneficial or preferred by individuals regardless of the physical or mental encouragements and then further utilisation of information added to facilitated engagement, such as the immersion in the video-sound condition or the leading cadence in the self-selected condition. Another

important feature of affordances was that it varies from individual to individual even when utilising the same information. For example, every participant would hear the treadmill sound in the video-no sound condition but some of the participants reported a negative effect of the sound while others were not influenced. Therefore, it was important to take into consideration the diversity of the presented information when designing PA environments because it would be more likely to satisfy a wider population when undertaking physical activities in the same setting.

With the combined qualitative and quantitative data collected in this study, of the visual-sound condition it was evident that this created a more positive PA experience across physical outcomes and mental response compared to other two conditions being examined in this study. Quantitative data indicated the positive effects accrued in the self-selected audio entertainment while more negative feedback across physical and mental aspects were observed in the qualitative data. The visual-no sound condition was found to be as beneficial as the visual-audio condition on mental responses from the quantitative data but more negative replies from the qualitative data similar to the self-selected audio-only entertainment condition. When considering the four examined nature-based environments together (two environments in Chapter 4 and two environments in this chapter), the similar observation was that when the presented information offered rich and changing information (the nature video of running through a park in Chapter 4 and the collection of ten short nature clips in this chapter), participants physically and mentally engaged with the video and were deeply influenced. Based on Chapter 4, improving the appropriateness of the selected information without confusing participants in this study was supported because participants endorsed the experience of running with the ten selected nature videos and no differences found on physical performances and mental benefits between the video-sound condition and the self-selected audio-only condition.

The presentations of information for affordances in the control conditions of the current study and the study shown in Chapter 4 were different in terms of the choices of self-selected entertainment. To be more specific, participants in the current study were advised to only be exposed to acoustic information, regardless of the format of audio information, such as music or radio. However, participants in Chapter 4 were able to choose other formats of self-selected entertainment, such as a short movie or television programmes offering visual-audio information. These two types of information for affordances (audio-only or visual-audio) would instigate different behaviours even

when undertaking the same physical task because different sensory inputs detected by exercisers would trigger different responses. To limit the differences, the permission of self-selected condition choice were restricted to audio-only but two participants chose to run with a podcast and three participants ran with no audio entertainment compared to the other 19 participants who ran with their own music. These three types of information for exercise might still contribute to different behaviours; therefore, further research should take this into consideration and design the self-selected entertainment condition with caution.

There were some limitations to this study. The nature video was limited to the selected ten clips presented in this study and uneven numbers of different contexts of video were included (water, animals or mountains views) which might be different when other types of video were presented to participants and thereby change the PA experiences. For future research, the presented videos could be pre-selected by participants to satisfy personal preferences to enhance the engagement with the video and accrue more physical or mental benefits. Or a diverse and richer video selection could be provided to increase the likelihood to satisfy a wider population without knowing the individual preferences. In order to collect richer information to facilitate a more comprehensive understanding of the PA experiences, the future research should endeavour to recruit more interviewees. The PA experiences described here were specific to the designed PA environments and the recruited participants in this study which might not be appropriate to be directly compared to other PA environments with distinct presented information or different mode of PA. Another limitation was that participants were exposed to each PA condition only once which might have a potential risk of novelty effect and future investigation might be needed to investigate the longer term effects of the environment design. Furthermore, this research conducted only short exposure duration (twenty minutes).

In terms of application on PA environment or programme designs, this study proposed to present rich nature information from more than one information resources to enhance the PA outcome and quality. Personal preference was also noted as a critical factor to enhance PA performance and experience which can be improved by undertaking pre-session discussion or by preparing diverse information options for presentation to please a wider population to promote PA maintenance. This sense of being in control of the PA experience or user-centred approach was suggested to be important for PA engagement for patients (Kosteli et al., 2017).

5.6 *CONCLUSION*

The self-selected audio entertainment condition showed physical benefits compared with the video-no sound condition but not the video-sound condition. However, higher heart rates were observed in the self-selected audio entertainment condition compared to two nature-based conditions, which was consistent with Chapter 4. For mental wellbeing, these three PA environments created similar positive experiences of treadmill running except for the minor higher feelings of dejection observed in the run with self-selected audio entertainment condition which aligned with the finding in Chapter 4. The video-sound condition might be concluded as the most beneficial treadmill running environment when compared to all the designed environments examined in Chapter 4 and 5. Therefore, this type of nature-based environment was supported to be tangible to promote PA for a general population. As findings in this study suggest, when designing PA environment, the rich and diverse presented information in dynamic format might be more beneficial on PA maintenance. Personal preferences of the presented information were also an important factor to facilitate the engagement with environment. However, running with nature videos might be considered as an exciting or new experience for treadmill runners and the short exposure period of exercise which might also be a potential contribution to the observed positive finding in this study. A longer exposure period or multiple exposures will be the direction for future study to confirm the observed positive effects of green PA.

CHAPTER.6

EFFECTS AND EXPERIENCE OF AFFORDANCE-BASED ENVIRONMENTS FOR INDOOR TREADMILL RUNNING OVER TIME (STUDY 3)

6.1 *INTRODUCTION*

Different types of nature-based information (static or dynamics images, with or without nature sounds, viewing virtual or real scenes from nature) for green PA had been examined in the literature, suggesting multiple benefits, such as higher levels of positive affect and greater perception of restorativeness (Schutte et al., 2017), better stress reduction (Brown et al., 2013) and lower autonomic arousal (lower heart rate for longer period) (Laumann et al., 2003), lower exertion and a more positive mood (Akers et al., 2012).

In Chapter 4 and 5, four types of nature-based information (static and dynamic images, nature videos with or without sounds) were examined and compared with two types of self-selected entertainment for treadmill running. The collection of ten short nature videos with sounds was found to be the most beneficial setting for a self-paced twenty-minute run out of the six designed environments by the quantitative and qualitative data. However, the research in the literature and the work presented in Chapters 4 and 5 of this thesis had examined green PA over a short exposure time (one session) which might suggest that the risk of the "novelty effect "contributed to the observed positive effects of green PA. Thus, there is an absence of understanding of the effects of green PA over time.

Building on the findings of previous two chapters and the need to explore the effects and experience of green PA over a longer time period, this study aimed to examine the longer term effects of green PA by offering visual-acoustic nature-based information for treadmill running with qualitative data. This study also sought to provide clarification about how long the effects would last or how people engaged with nature would change over time. In addition, qualitative data would be collected to offer details of participants' experience, especially the relationship between the engagement and the presented information over time and influential factors contributing to positive or negative effects over time. When designing this study, an important consideration was to carefully select the presented information for affordances in order to maintain the functionality of affordances over time to avoid the depressive effects and offer rich and diverse information as suggested in previous Chapters in the thesis.

6.2 *AIM*

The aim of this study was to examine the physical, psychological and emotional effects and experience of nature-based information for affordances for treadmill running compared with music-based affordances for PA environment over six weeks.

6.3 *METHOD*

6.3.1 Participants

Fifteen participants were university students and completed all sessions. The descriptive data of participants are shown in Table 6. 1. All participants were university students. From the self-reported PA survey, 4 participants reported exercise duration of 3 hours a week, 10 participants exercised 4 to 8 hours a week and 3 participants exercise more than 8 hours a week. Participants performed diverse types of exercise including yoga, running, weight lifting, parkour, cycling, climbing, gym fitness sessions and playing tennis. Institutional ethical approval was granted by the Research Ethics Committee (Appendix 12). All participants gave participation consent and completed a PAR-Q form before the first testing. Before attending each trial, participants were asked to avoid any conditions causing extreme exhaustion. All participants were required to wear sports kit and running shoes. Two experimental conditions were designed and participants could choose their own preferred group (a nature group and a self-selected music-only group). Nine participants chose the nature group and six participants chose the music group. All fifteen participants volunteered for post-run interviews to explore their perceptions of the different PA experiences and their engagement with nature.

Table 6. 1. Descriptive data of participants in two conditions (mean ± SD).

	Nature	Music
Number	9 (4 females/ 5 males)	6 (3 females /3 males)
Age (years)	23.8 ± 2.6	27.2 ± 3.3
Stature (cm)	170.7 ± 11.5	173.2 ± 10.6
Mass (kg)	68.3 ± 13.9	70.1 ± 13.0
BMI ($kg \cdot m^{-2}$)	23.3 ± 3.2	23.2 ± 2.8

6.3.2 Study design

The physical task was conducted in an indoor laboratory and all participants were asked to perform a self-paced twenty-minute treadmill run at a personal comfortable level throughout the session. Participants were required to complete two sessions per week

for six consecutive weeks (12 sessions in total). Individual interviews with participants from the two exercise groups were conducted by the researcher within seven days of their last trial. Participants were informed of their right to change the running speed at any point during each session as long as they considered the running was at personal comfortable level. These two exercise groups performed the same physical task in the same experimental setting with same procedure, but with different information presented during the running. Participants in both groups were advised of their freedom to change the information (within the same type) at any point during any session. Participants in the music group were entitled to choose any type of music to listen to during their run and were able to change their own music and adjust the volume at any point. In order to offer the participants in the nature video group the same freedom as the music group, there were twenty-four different nature-based videos with corresponding sound for participants to choose or change during the run. Aiming to create a similar running experience of the nature group compared to the music group regarding changing the presented information, a wireless headphone (MDR-ZX770BN, Sony, Japan) and a touch screen laptop (Envy 13-ab008na, HP, USA) were used to offer a quick selection and changing of the video. During the 12 sessions, two questionnaires were used to evaluate emotional and psychological effects in selected sessions (details please see Figure 6. 2).

The Nature group involved participants running on a treadmill while viewing one or more presented dynamic images out of twenty-four nature clips with corresponding sounds. The options of nature videos included beach scenes with wave sounds, sheep wandering in a field, birds jumping between branches and twittering, geese swimming in a lake with bird and geese sounds, a running waterfall with water sounds and thunderstorm and rain sounds, running streams and forest scenes with birds twittering. The single frame of each video is displayed in Figure 6. 1. The selections of nature video in the current study attempted to offer diverse types of nature environments which would provide nature-based information but would not be linked to the required physical task and caused confusion for participants. This decision was based on the finding in Chapter 5. The collection of the videos was also limited by the accessibility of nature videos and the list of chosen videos can be found in Appendix 6.

The Music group involved participants running with their own music choices. No restrictions on music options were made, but participants were only allowed to be

exposed to audio-only information. All participants chose to run with headphones, either wired or wireless.

6.3.3 Procedure

Participants in this study followed the same procedure for data collection (see Chapter 3 for details) but the exact schedule for questionnaires was shown in Figure 6. 2.

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Figure 6. 1. The single frame and brief description of 24 presented nature videos (The list of video can be found in Appendix 6).

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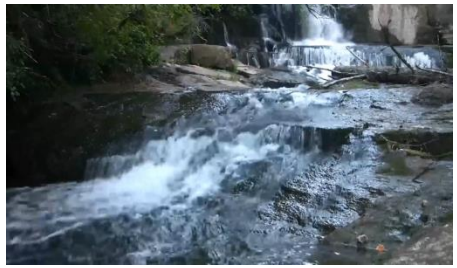

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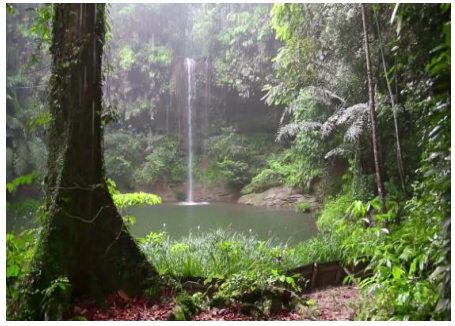

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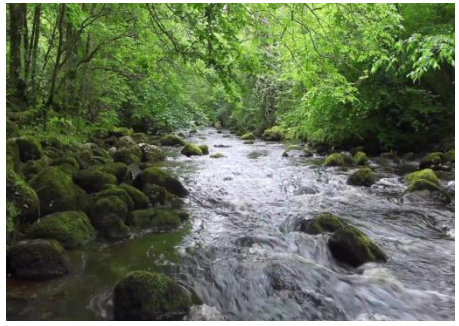

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Figure 6.1. -continued

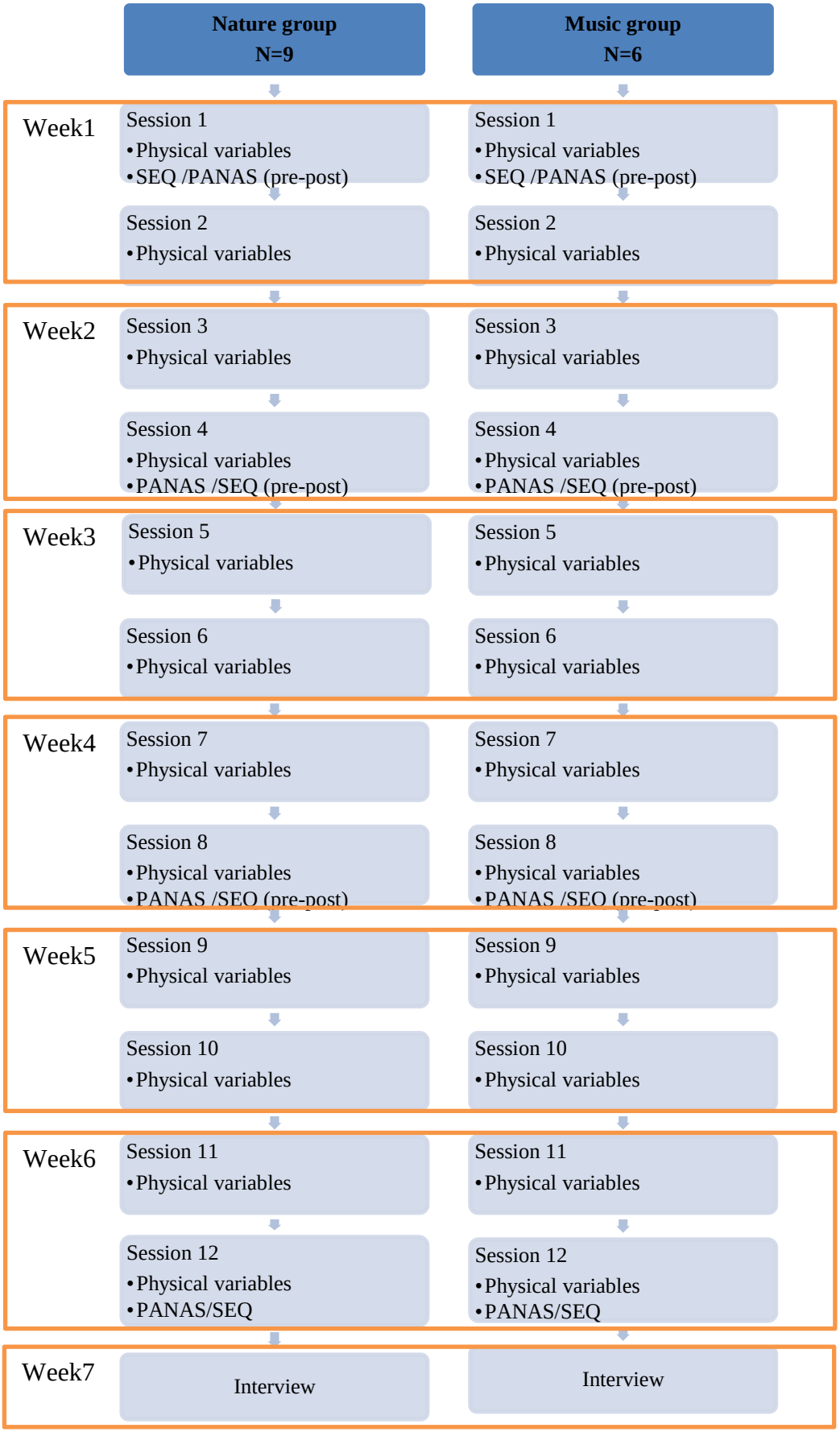

Figure 6. 2. Details of the variables collection schedule for 12 sessions and follow-up interview.

6.3.4 Measurements and apparatus

The physical variables collected in this study were distance, speed, heart rate, perceived exertion, and energy expenditure. PANAS and SEQ were used to assess mental effects. The same experimental setting and equipment were used in this study as previous chapters (details please see chapter 3, Figure 3.1 and Table 3.3).

6.3.5 Interview guide

The same semi-structured interview guide (Appendix 8) was used in this study (see Chapter 3) with modifications made according to the two groups. Modifications were made regarding to music choices (e.g., "What was your focus when running with this music choice?"), video choices (e.g.," What were you looking at this selected video?) and time effects (e.g., "Did you feel any changes from session to session?"). Additional questions were created to explore the reasons for and feelings about video and music selections, including "Why did you change your video choice/ music choice?" or "What type of feelings did you have when running with the selected video/ music?"

6.3.6 Data processing and analysis

Heart rate data were excluded from this data analysis because of a limited number of successful data (two out of 15 participants), which was ascribed to technical problems. Distance, speed and perceived exertion were recorded by the researcher during data collection. The questionnaires were printed and completed by each participant before and immediately after the trial (see Figure 6.2). The scores of each participant of each questionnaire were calculated with Microsoft Excel 2010. Energy expenditure output was created with its commercial software (Actilife, Actigraph, USA). Four separate mixed two-way ANOVA tests were used to examine the difference for energy expenditure, speed, running distance and perceived exertion level of the 20^{th} minute of the run between groups. A two-way mixed ANOVA test (group × time) was used to examine the difference between two groups in five minutes intervals of the run (the 1st minute, the 5th, the 10th minute, the 15th and the 20th minute) on speed. For PANAS and SEQ, data were analysed separately by group because of the violation of the homogeneity of variance assumption. Although the normality assumption was not met in all measurement of PANAS and SEQ, *F*-ratio (ANOVA) was believed to be a robust test to be unaffected by the violation of normality and when the design is equal-sized

and repeated design study (Field, 2009; Rogerson, 2016). Five, separate two-way repeated measure ANOVAs (time × sessions) were used to examine the difference on the positive and negative affect scale of the PANAS; anxiety, excitement, and happiness of the SEQ. The dejection and anger scale of the SEQ were excluded for statistical analysis because the scores seriously violated normality and homogeneity of variance.

After obtaining informed consent, each participant engaged in a semi-structured face-to-face audio-recorded interview in a quiet place. Data processing and analysis followed the same procedure presented in Chapter 3. Interviews for the whole nature group took six hours one minutes and 40 seconds and two hours and 56 minutes and 13 seconds for the whole music group. Two extra interviews were conducted with two participants from the nature group because further clarification was needed. For transcription accuracy, one participant did not reply and fourteen participants confirmed the accuracy with no changes required. To ensure the quality and rigor of this study, a research team worked closely together throughout the whole research process and several steps were taken, including member checking for transcripts accuracy and investigators triangulations (please see chapter 3 for details).

6.4 ***RESULTS***

6.4.1 Choices of nature videos and self-selected music

For the nature group, the sum of viewing duration of each video of 96 trials can be seen in Figure 6. 3. The longest viewing duration was video "17" (a waterfall running to a beach) for 4 hours 22 minutes and 45 seconds, followed by the video "12" (a running water next to trees and mountain) for 2 hours 59 minutes and 15 seconds and then was the video "24" (A running water view with trees and rocks) for 2 hours 16 minutes and 10 seconds. Others were all below 2 hours viewing duration. The variety of types of self-selected music was reported and can be found in Figure 6. 4 which showed the percentages of presence out of 72 trials. The most frequent chosen music type was Rock music, followed by Pop music and Hip-hop music.

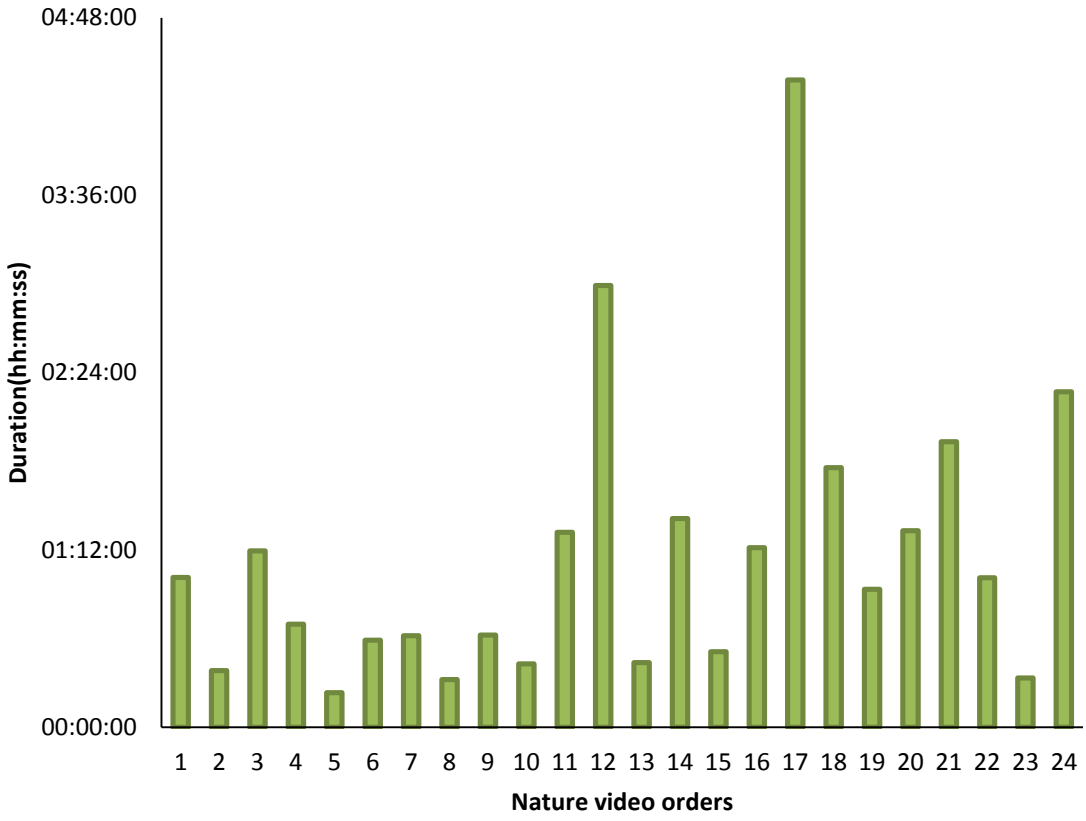

Figure 6. 3. Accumulated viewing duration of each nature video of the nature group out of 96 trials.

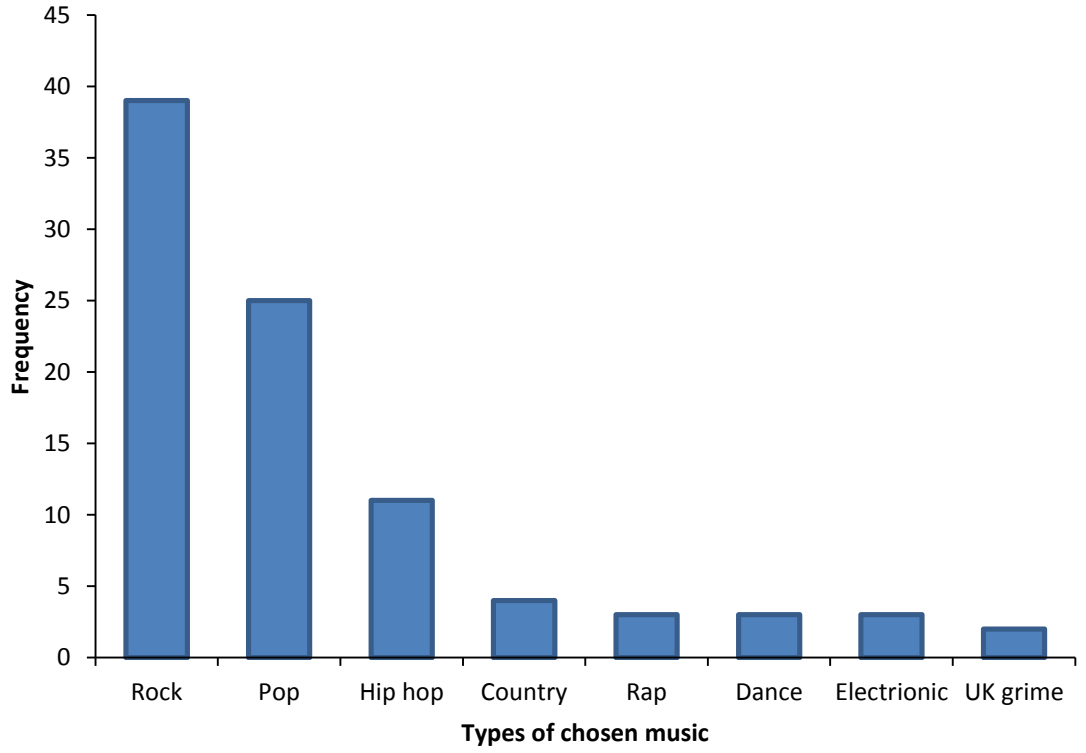

Figure 6. 4. Percentages of different types of self-selected music chosen by the music group of 72 trials.

6.4.2 Physical measurements

The descriptive data of speed, distance, energy expenditure and perceived exertion of the five different times during the run in each condition over 12 sessions can be found in Table 6.2.

Table 6. 2. Descriptive data of speed, running distance, energy expenditure and perceived exertion in two groups of 12 sessions (mean ± SD).

Variables/Groups	Nature	Music
Distance (m)	3187.9 ± 487.6	3150.3 ± 748.4
Speed (km/h)	9.8 ± 1.5	9.6 ± 2.3
Energy Expenditure (kcal)	234.3 ± 32.7	251.4 ± 36.9
Perceived exertion 0^{th} Minute (start)	6.8 ± 1.4	6.1 ± 0.4
Perceived exertion 5^{th} Minute	8.8 ± 1.8	11.0 ± 1.7
Perceived exertion 10^{th} Minute	9.9 ± 1.8	12.3 ± 1.3
Perceived exertion 15^{th} Minute	11.2 ± 1.9	13.3 ± 1.0
Perceived exertion 20^{th} Minute	12.4 ± 2.3	14.1 ± 1.3

6.4.2.1 *Energy expenditure*

There was no difference for energy expenditure between the two groups, F (1, 10) = 0.236, $p > 0.05$, $p\eta^2 = 0.023$. Session had no effects on distance between two groups, F (11, 110) = 1.033, $p > 0.05$, $p\eta^2 = 0.094$. No interaction was observed, F (11, 110) = 0.790, $p > 0.05$, $p\eta^2 = 0.073$.

6.4.2.2 *Running distance*

There were no differences for distance between two groups, F (1, 11) = 0.012, $p > 0.05$, $p\eta^2 = 0.001$. Session had no effects on distance between two groups, F (4.373, 48.100) = 0.686, $p > 0.05$, $p\eta^2 = 0.059$. The average distances of two exercise groups in each session over 12 sessions (3187.9 ± 487.6 m for the nature group and 3150.3 ± 748.4 for the music group) were showed in Figure 6.5. No interaction was observed, F (4.373, 48.100) = 1.698, $p > 0.05$, $p\eta^2 = 0.134$.

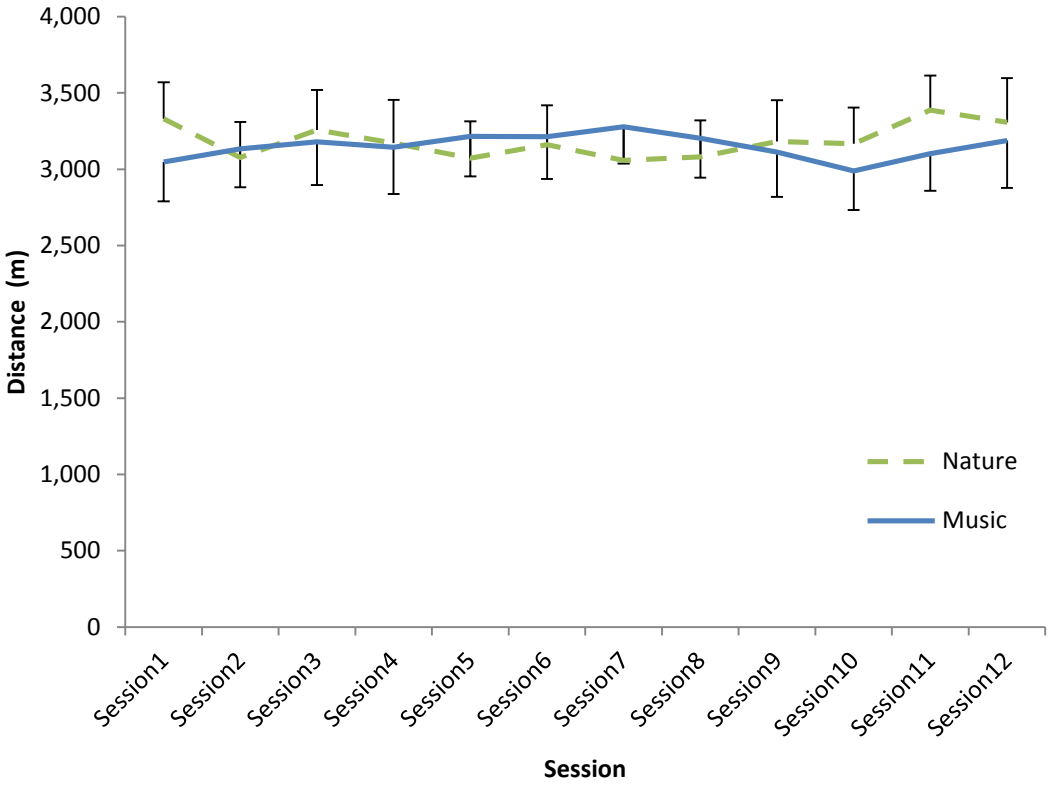

Figure 6. 5. Mean distance ran of two groups in each session (mean ± SE.) For clarity, the positive error bar was used to show the standard error of the nature group whereas the negative error bar was used to show the standard error of the music group.

6.4.2.3 *Speed*

Two types of speed data are presented in this section in order to show the running speed profiles and outcomes. The mean speed across session was 9.8 ± 1.5 km/h for the nature group and 9.6 ± 2.3 km/h for the music group. However, the minute-by-minute speed over 12 sessions exhibited two distinct running strategies in terms of when to increase or decrease running speed over 20 minutes (Figure 6. 6). The mean speed of the nature group started at 8.5 km/h and steadily increased to 10.6 km/h whereas the mean speed of the music group started at 9.3 km/h and remained similar pace throughout the twenty minutes and finished at 9.7km/h.

A two-way mixed ANOVA test (group × minute) was used to examine the differences between PA condition over time for speed. There was no difference in speed between two groups, F (1, 11) = 0.021, $p > 0.05$, $p\eta^2 = 0.002$. Session had no effects on speed

between two groups, F (4.501, 49.511) = 0.690, $p > 0.05$, $p\eta^2 = 0.059$. No interaction was observed, F (4.501, 49.511) = 1.703, $p > 0.05$, $p\eta^2 = 0.134$.

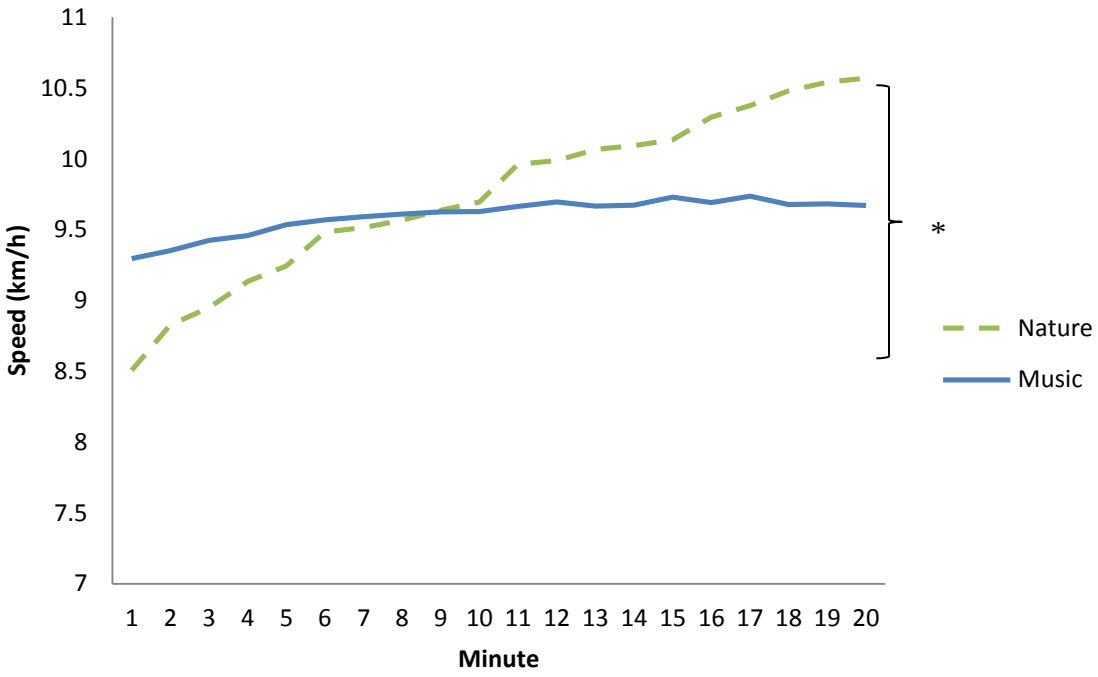

Figure 6. 6. Running profiles: the average minute-by-minute speed of each group over 12 sessions throughout 20 minutes; * indicates running speed was significantly different between the 1st and 20th minutes for the Nature group ($p < 0.05$).

Another two-way mixed ANOVA test (group × minute) was used to examine the difference between two groups for five different timings (1st, 5th, 10th, 15th and 20th minute). The degrees of freedom were corrected using Greenhouse-Geisser corrected estimates of sphericity (ε = 0.507 for the main effect of time). Time had a main effect on speed, F (2.029, 22.320) = 15.752, $p < 0.05$, $p\eta^2 = 0.589$. Group had no main effect on speed, F (1, 11) = 0.056, $p > 0.05$, $p\eta^2 = 0.000$. An interaction was found between time and group, F (2.029, 22.320) = 7.173, $p < 0.05$, $p\eta^2 = 0.395$ and post hoc analyses indicated the nature group ran at a significantly higher speed at the 20th minute compared to the 1st minute whereas the music group run at a similar pace over the 20 minutes (Figure 6. 6). Figure 6. 7 and Figure 6. 8 present the 20-minute running profiles over 4 selected sessions over time (the average minute-by-minute speed of Session 1, Session 4, Session 8, and Session 12). These two figures were demonstrate that these two exercise groups seemed to have different running strategies during the twenty-minute run and the differences were shown to change over time in the nature group but not in the music group.

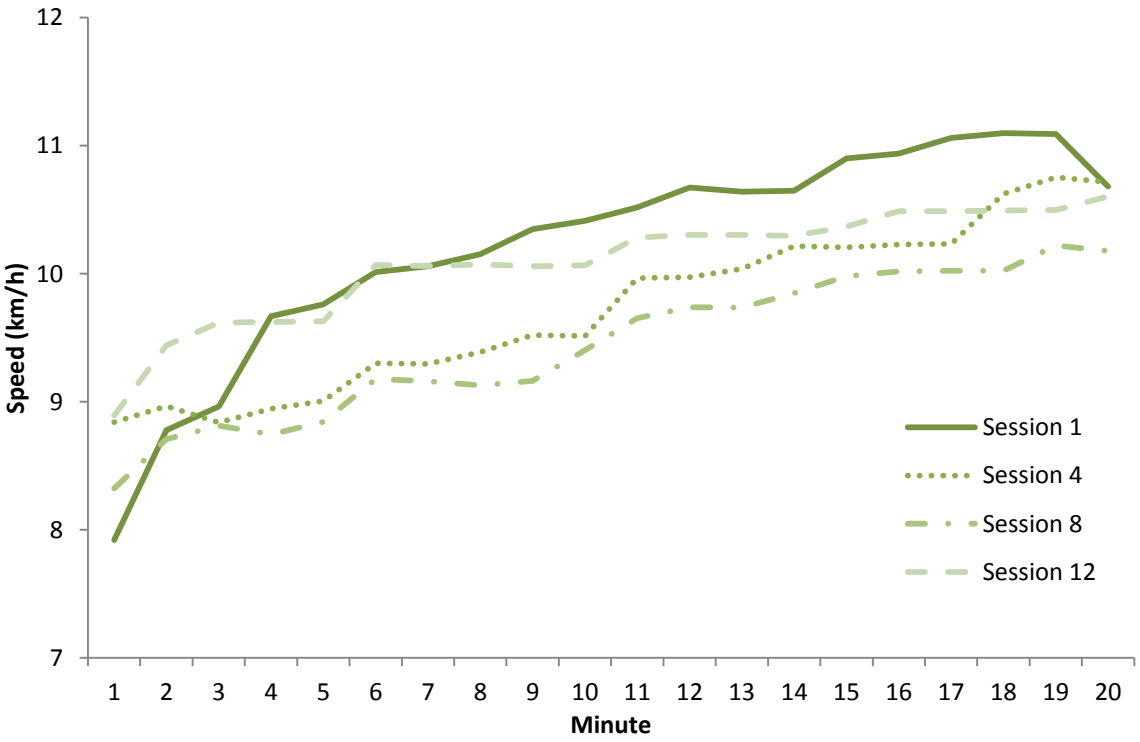

Figure 6. 7. Minute-by-minute mean speed of four selected sessions of the nature group over a 20-minute run.

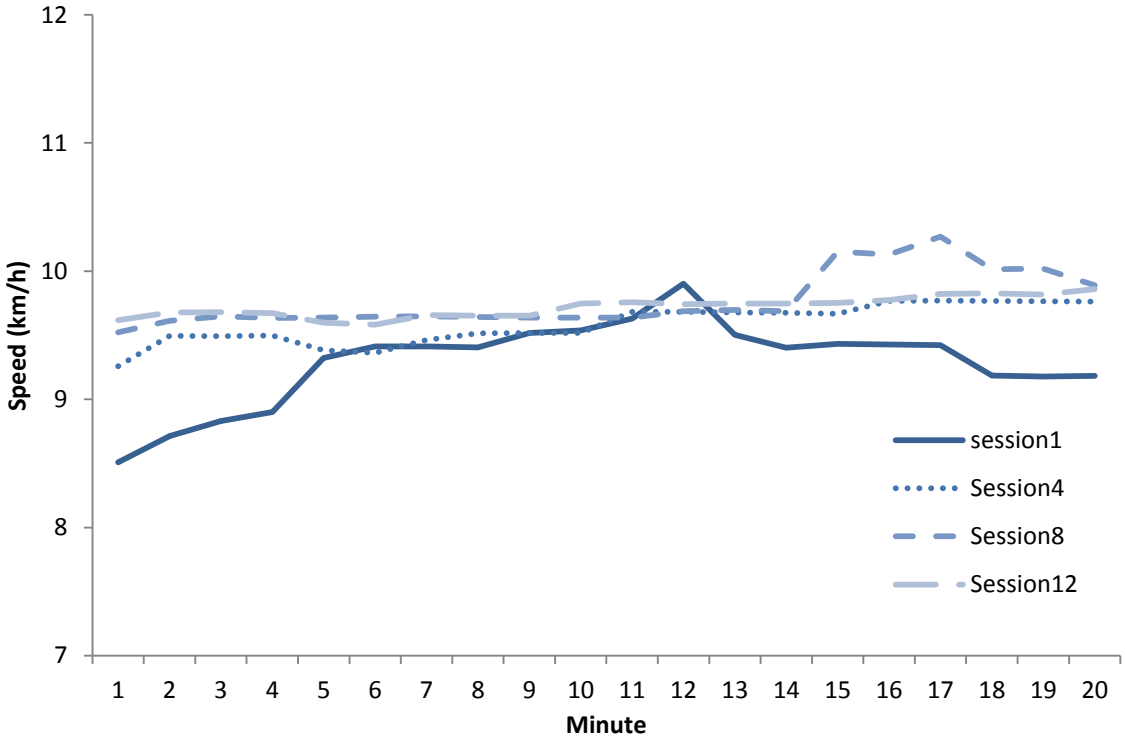

Figure 6. 8. Minute-by-minute mean speed of four selected sessions of the music group over a 20-minute run

6.4.2.4 *Perceived exertion*

Group had a main effect for exertion, F (1, 13) = 5.939, $p < 0.05$, $\eta p^2 = 0.314$. Figure 6. 9. shows that the music group had higher exertion level than the nature group over time. Session had no effect on exertion, F (11, 143) =1.496, $p > 0.05$, $\eta p^2 = 0.103$. No interaction was found, F (11, 143) = 0.387, $p > 0.05$, $\eta p^2 = 0.029$.

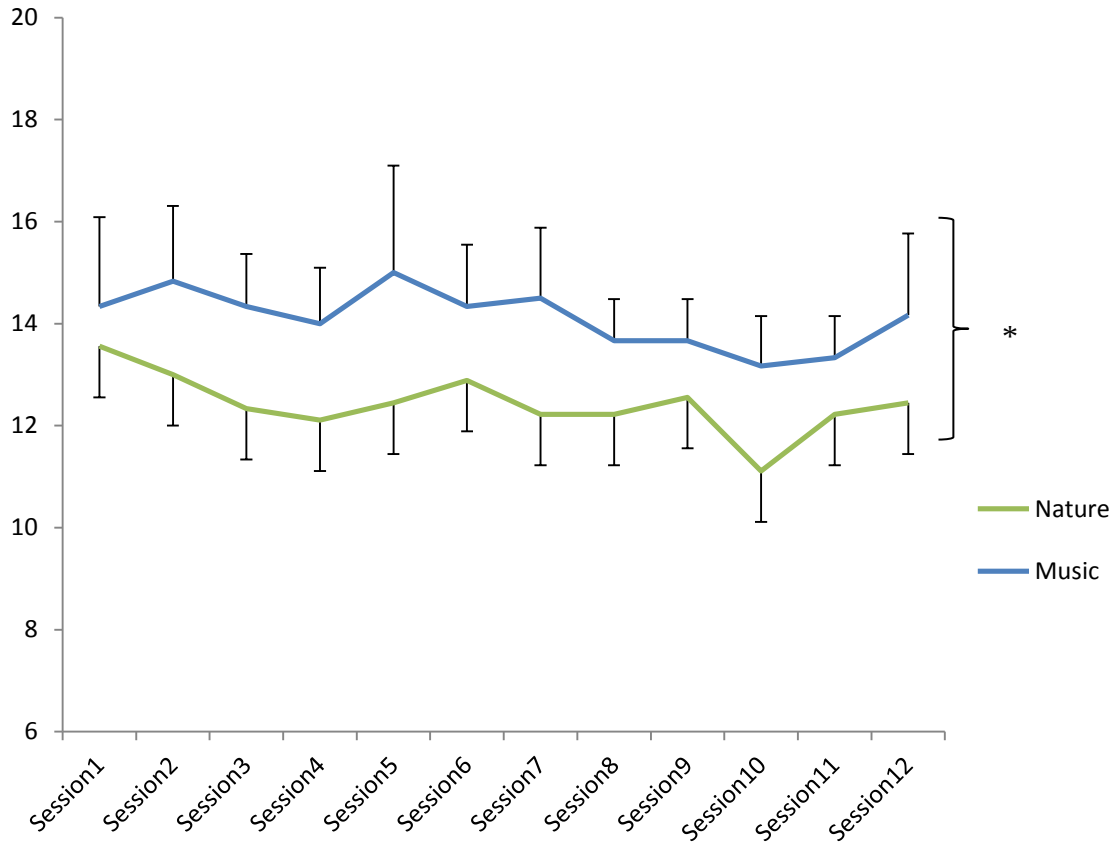

Figure 6. 9. Exertion level of the 20th minute over 12 sessions between two groups (mean ± SE); * indicates significant difference between group in each session, $p < 0.05$. For clarity, the error bar of the music group was shown with the positive error bar whereas the nature group was shown with the negative error bar.

6.4.3 Psychological measurements

Descriptive data of two groups in four selected sessions of the positive and negative affect scores is shown in Table 6. 3. Both groups rated higher positive affect scores in Session 1compared to other sessions.

Table 6. 3. Pre-and-post positive and negative affect scores of two groups in four selected sessions (Mean ± SD).

Variables	Nature group		Music group	
Positive affect scores	Pre-test	Post-test	Pre-test	Post-test
Session 1	29.9 ± 9.6	35.2 ± 10.8	24.0 ± 3.3	20.5 ± 4.2
Session 4	24.4 ± 9.7	30.7 ± 9.7	22.7 ± 5.6	23.1 ± 3.9
Session 8	20.4 ± 6.2	27.8 ± 6.2	22.5 ± 4.8	22.3 ± 3.9
Session 12	20.8 ± 6.5	28.5 ± 6.5	25.0 ± 3.3	25.8 ± 3.3
Negative affect scores	Pre-test	Post-test	Pre-test	Post-test
Session 1	10.9 ± 1.7	9.4 ± 3.7	14.8 ± 6.3	11.5 ± 2.8
Session 4	10.4 ± 1.6	10.8 ± 1.1	12.1 ± 2.4	11.0 ± 2.0
Session 8	11.2 ± 3.2	10.7 ± 1.1	13.2 ± 3.5	10.8 ± 2.0
Session 12	11.2 ± 3.9	10.7 ± 0.9	11.7 ± 2.9	10.8 ± 1.6

6.4.3.1 *Positive affect scores*

For the nature group, time had a main effect for positive affect scores, F (1, 8) = 9.816, $p < 0.05$, $\eta p^2 = 0.551$, indicating that the positive affect scores of the post-test (30.6 ± 2.8) were higher than the pre-test (23.9 ± 2.4) in each selected session. Session had a main effect on positive affect scores, F (3, 24) =6.809, $p < 0.05$, $\eta p^2 = 0.460$. Bonferroni correction revealed that that the positive affects scores of Session 1(32.6 ± 3.4) were significantly greater than Session 12 (21.7 ± 2.3). No interaction was found, F (3, 24) = 0.477, $p > 0.05$, $\eta p^2 = 0.056$ (Figure 6. 10).

For the music group, time had no main effect for positive affect scores, F (1, 5) = 0.141, $p > 0.05$, $\eta p^2 = 0.027$ and session had no main effect on positive affect scores, F (3, 15) =2.315, $p > 0.05$, $\eta p^2 = 0.316$. No interaction was found, F (3, 15) =2.024, $p > 0.05$, $\eta p^2 = 0.288$ (Figure 6. 11).

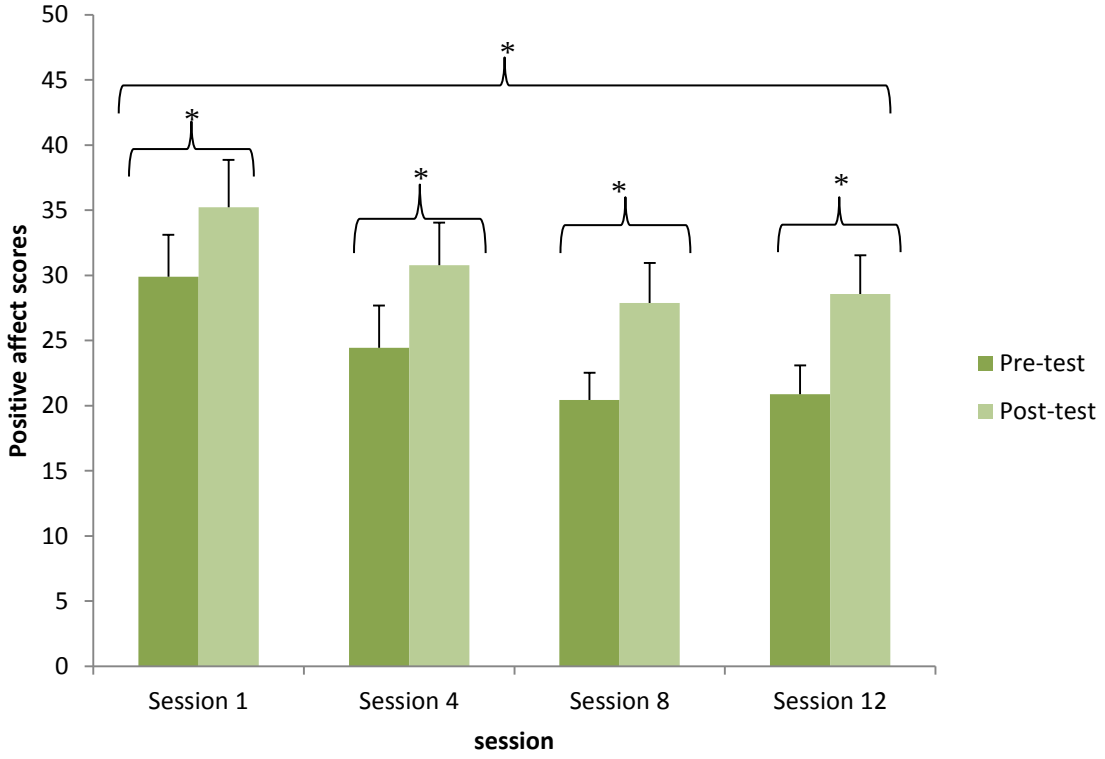

Figure 6. 10. Pre-post positive affect scores of the nature group in four selected sessions (mean ± SE); * indicates that $p < 0.05$

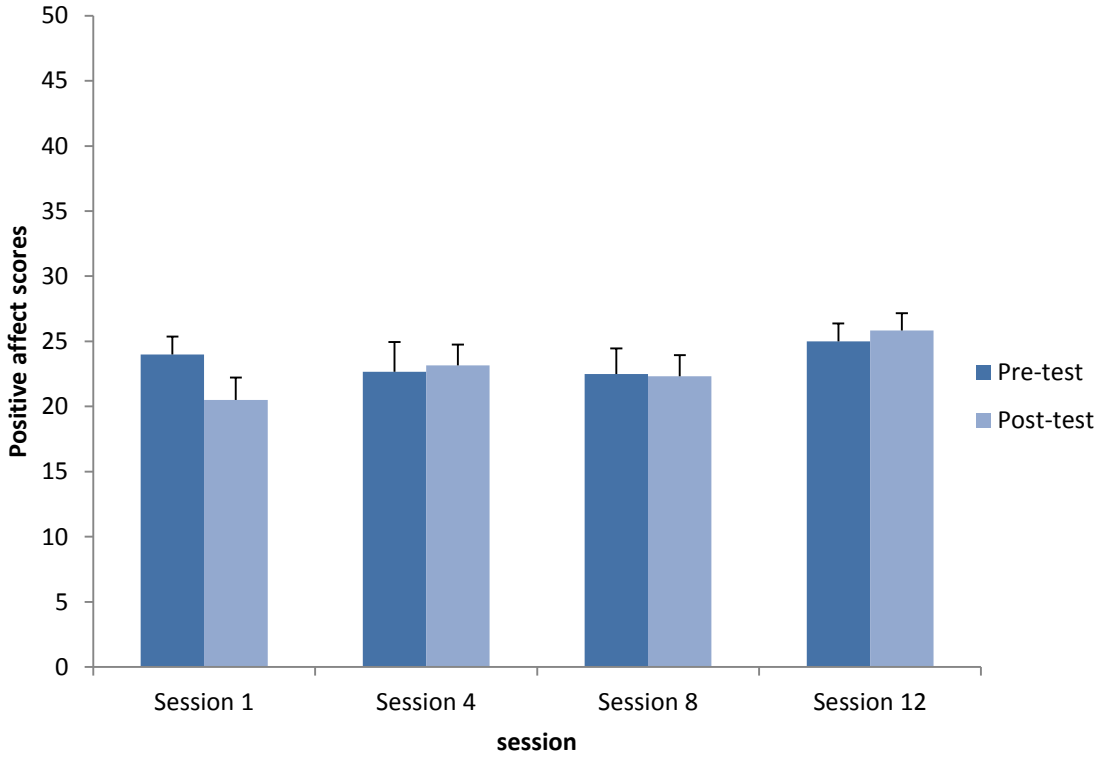

Figure 6. 11. Pre-post positive affect scores of the music group in four selected sessions (mean ± SE).

6.4.3.2 *Negative affect scores*

For the nature group, no main effect was found from time or session for negative affects scores, F (1, 7) = 0.043, $p > 0.05$, $\eta p^2 = .006$; F (3, 21) = 0.496, $p > 0.05$, $\eta p^2 = 0.066$, respectively. No interaction was found F (3, 21) = 0.813, $p > 0.05$, $\eta p^2 = .104$.

For the music group, the degrees of freedom were corrected using Greenhouse-Geisser corrected estimates of sphericity ($\varepsilon = 0.36$ for the main effects of time and 0.37 for the main effect of interaction). Time had no effect on negative affects scores, F (1, 5) = 2.304, $p > 0.05$, $\eta p^2 = 0.315$; F (3, 15) = 2.148, $p > 0.05$, $\eta p^2 = 0.300$, respectively. No interaction was found F (3, 15) = 1.022, $p > 0.05$, $\eta p^2 = 0.170$.

6.4.4 Emotional measurements

The descriptive data of the five different emotion scores of two groups in the four selected sessions are shown in Table 6. 4.

6.4.4.3 *Anxiety*

For the nature group, no main effect was found from time or session for the reported feelings of anxiety, F (1, 8) = 2.139, $p > 0.05$, $\eta p^2 = 0.211$; F (3, 24) = 0.733, $p > 0.05$, $\eta p^2 = 0.084$, respectively. An interaction was found, F (3, 24) = 3.629, $p < 0.05$, $\eta p^2 = 0.312$ but post hoc analyses failed to reveal the differences (Figure 6. 12).

For the music group, time had a main effect for the reported feelings of anxiety, F (1, 5) = 7.507, $p < 0.05$, $\eta p^2 = 0.600$, showing that the pre-test anxiety scores (0.8 ± 0.3) were higher than the post-test anxiety (0.09 ± 0.06). Session showed no main effect, F (3, 15) = 2.754, $p > 0.05$, $\eta p^2 = 0.355$. There was an interaction found, F (3, 15) = 3.881, $p < 0.05$, $\eta p^2 = 0.437$. Post hoc analyses indicated that participants reported feeling less anxious than pre-running in session 1, 4 and 8 but not in session 12 (Figure 6. 13).

Table 6. 4. Descriptive data of the pre-and-post scores of five emotions of the nature and music groups in 4 selected sessions (Mean ± SD).

Emotions	Nature group		Music group	
Anxiety	Pre-test	Post-test	Pre-test	Post-test
Session 1	0.31 ± 0.35	0.17 ± 0.16	1.13 ± 1.07	0.03 ± 0.08
Session 4	0.26 ± 0.24	0.38 ± 0.32	0.50 ± 0.45	0.03 ± 0.08
Session 8	0.55 ± 0.35	0.22 ± 0.31	0.80 ± 0.72	0.07 ± 0.16
Session 12	0.47 ± 0.53	0.16 ± 0.17	0.57 ± 0.51	0.23 ± 0.41
Dejection	Pre-test	Post-test	Pre-test	Post-test
Session 1	0 ± 0	0.03 ± 0.08	0.16 ± 0.32	0.16 ± 0.32
Session 4	0.04 ± 0.13	0 ± 0	0.26 ± 0.65	0.13 ± 0.32
Session 8	0.26 ± 0.61	0.08 ± 0.17	0.03 ± 0.08	0.03 ± 0.08
Session 12	0.11 ± 0.33	0.05 ± 0.11	0.10 ± 0.24	0.03 ± 0.08
Excitement	Pre-test	Post-test	Pre-test	Post-test
Session 1	2.25 ± 1.28	2.28 ± 1.33	1.12 ± 0.54	1.79 ± 0.60
Session 4	1.56 ± 1.19	1.69 ± 1.00	1.13 ± 0.68	2.12 ± 0.59
Session 8	1.13 ± 0.70	1.28 ± 0.89	1.13 ± 0.54	2.13 ± 0.88
Session 12	1.25 ± 0.74	1.33 ± 0.99	1.63 ± 0.41	2.50 ± 0.69
Anger	Pre-test	Post-test	Pre-test	Post-test
Session 1	0.03 ± 0.08	0.08 ± 0.25	0.08 ± 0.20	0.42 ± 1.02
Session 4	0.03 ± 0.08	0.06 ± 0.11	0.04 ± 0.10	0.13 ± 0.31
Session 8	0.25 ± 0.35	0.08 ± 0.18	0.25 ± 0.32	0.17 ± 0.41
Session 12	0.41 ± 0.73	0.08 ± 0.18	0.04 ± 0.10	0.13 ± 0.31
Happiness	Pre-test	Post-test	Pre-test	Post-test
Session 1	2.03 ± 0.99	2.28 ± 1.18	1.41 ± 0.30	1.79 ± 0.62
Session 4	1.67 ± 1.13	2.31 ± 1.07	1.41 ± 0.56	2.13 ± 0.74
Session 8	1.36 ± 0.76	2.03 ± 1.06	1.38 ± 0.54	2.00 ± 0.77
Session 12	1.39 ± 0.63	1.92 ± 1.13	1.54 ± 0.58	2.46 ± 0.71

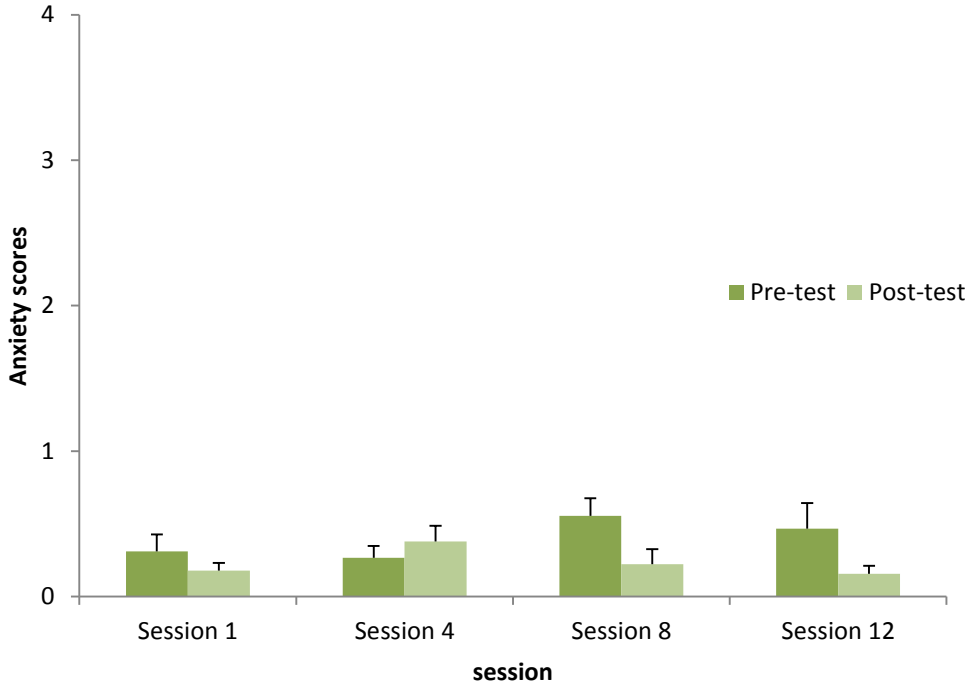

Figure 6. 12. Pre-post anxiety scores of the nature group in four selected sessions (mean ± SE).

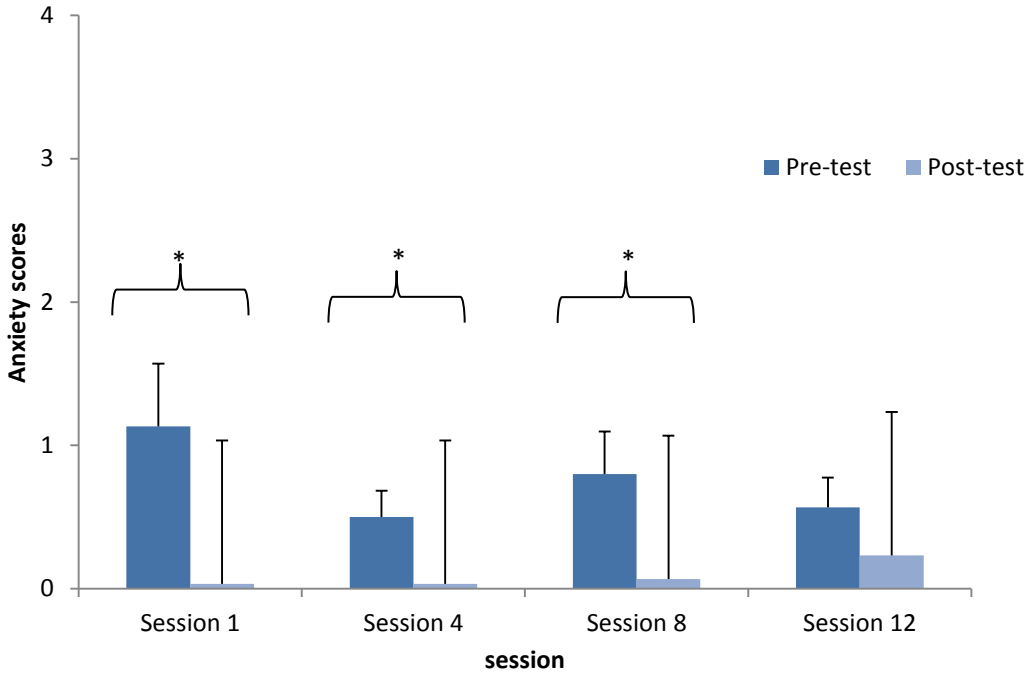

Figure 6. 13. Figure 8.13. Pre-post anxiety scores of the music group in four selected sessions (mean ± SE); * indicates that $p < 0.05$.

6.4.4.4 *Excitement*

For the nature group, no main effect was found from time for the reported feelings of excitement, F (1, 8) = 0.276, $p > 0.05$, $\eta p^2 = 0.033$. Session showed a main effect for the reported feelings of excitement, F (3, 24) = 8.813, $p < 0.05$, $\eta p^2 = 0.524$ and the post hoc analysis indicated that excitement scores of session 8 (1.2 ± 0.2) were rated lower than session 1 (2.3 ± 0.4). No interaction was found, F (3, 24) = 3.629, $p < 0.05$, $\eta p^2 = 0.312$ (Figure 6. 14).

For the music group, time was found to have a main effect on the reported feelings of excitement, F (1, 5) = 18.199, $p < 0.05$, $\eta p^2 = 0.784$; the post-test excitement (2.1 ± 0.3) was higher than the pre-test excitement (1.3 ± 0.2). Session was also found to have a main effect on the reported feelings of excitement, F (1, 5) = 5.422, $p < 0.05$, $\eta p^2 = 0.520$, showing that the excitement scores of session 12 was higher than session 1 (1.5 ± 0.2). No interaction was found, F (3, 15) = 1.477, $p > 0.05$, $\eta p^2 = 0.228$ (Figure 6. 15).

6.4.4.5 *Happiness*

Time was found to have no main effect on the reported feelings of happiness for the nature group, F (1, 8) = 4.433, $p > 0.05$, $\eta p^2 = 0.357$. Session was showed no main effect on the reported feelings of happiness, F (3, 24) = 2.937, $p < 0.05$, $\eta p^2 = 0.269$ and no interaction was found, F (3, 24) = 1.190, $p < 0.05$, $\eta p^2 = 0.130$ (Figure 6. 16).

For the music group, time was found to have a main effect on the reported feelings of happiness, F (1, 5) = 6.702, $p < 0.05$, $\eta p^2 = 0.573$. The post-test happiness (2.1 ± 0.3) was higher than the pre-test happiness (1.4 ± 0.1). Session was found no main effect on the reported feelings of happiness, F (1, 5) = 2.582, $p > 0.05$, $\eta p^2 = 0.341$. No interaction was found, F (3, 15) = 2.427, $p > 0.05$, $\eta p^2 = 0.327$ (Figure 6. 17).

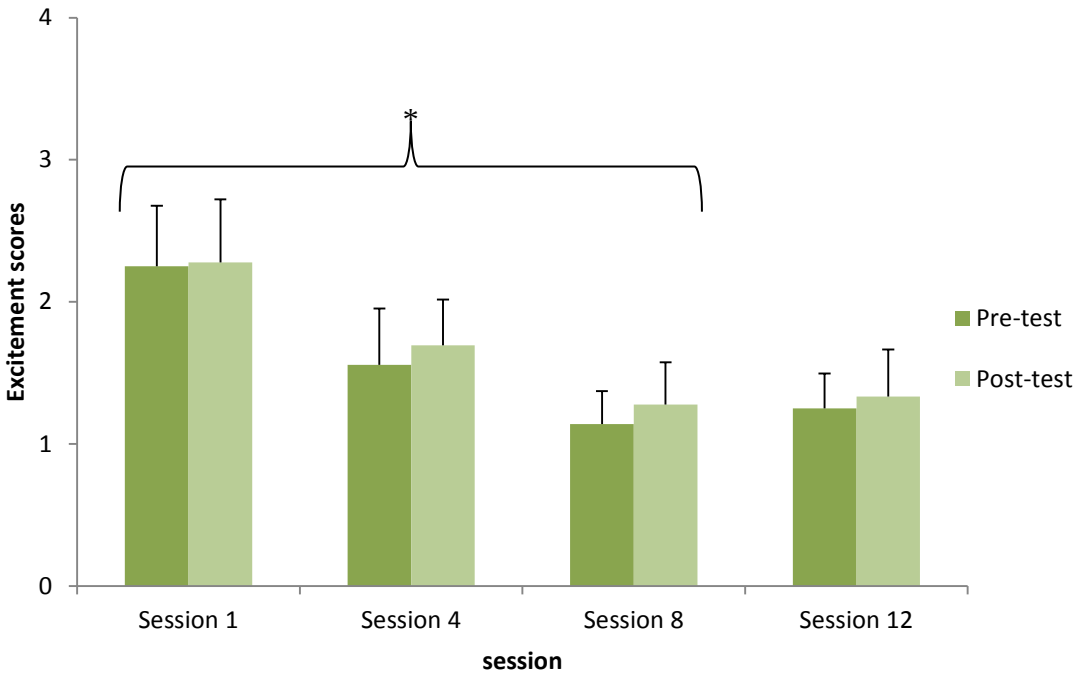

Figure 6. 14. Pre-post excitement scores of the nature group in four selected sessions; * indicates that $p < 0.05$.

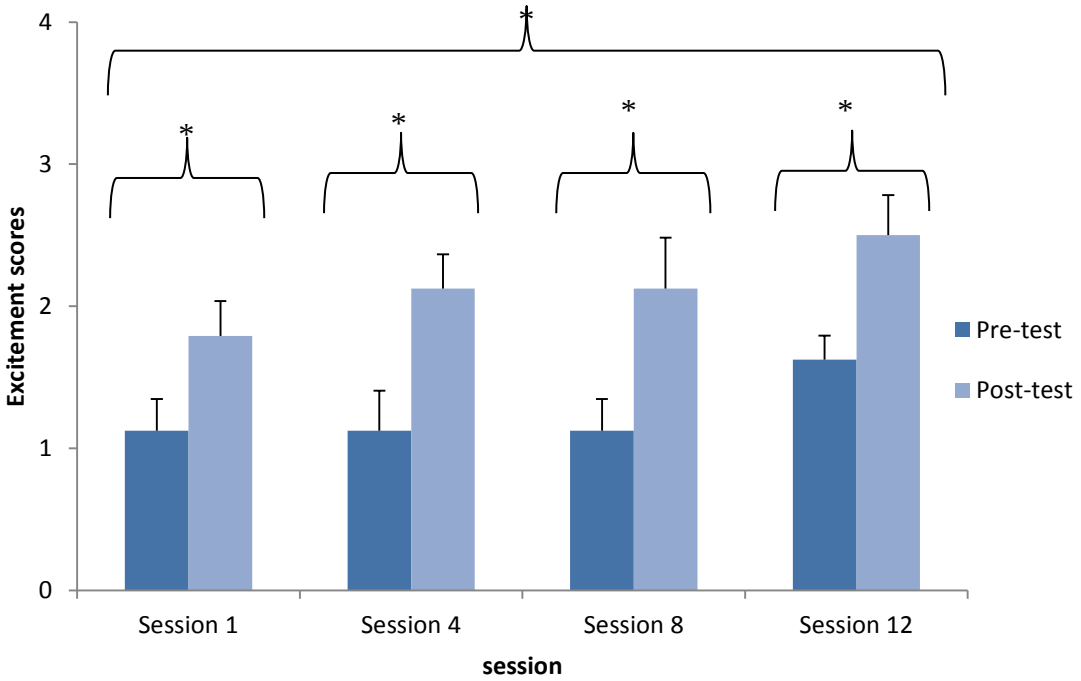

Figure 6. 15. Pre-post excitement scores of the music group in four selected sessions; * indicates that $p < 0.05$.

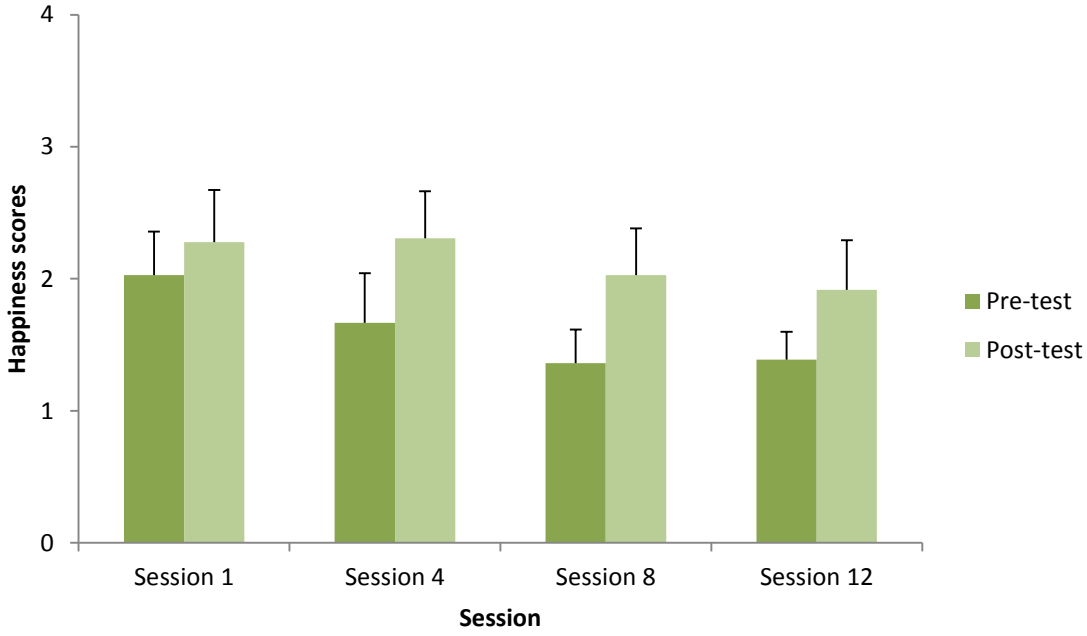

Figure 6. 16. Pre-post happiness scores of the nature group in four selected sessions.

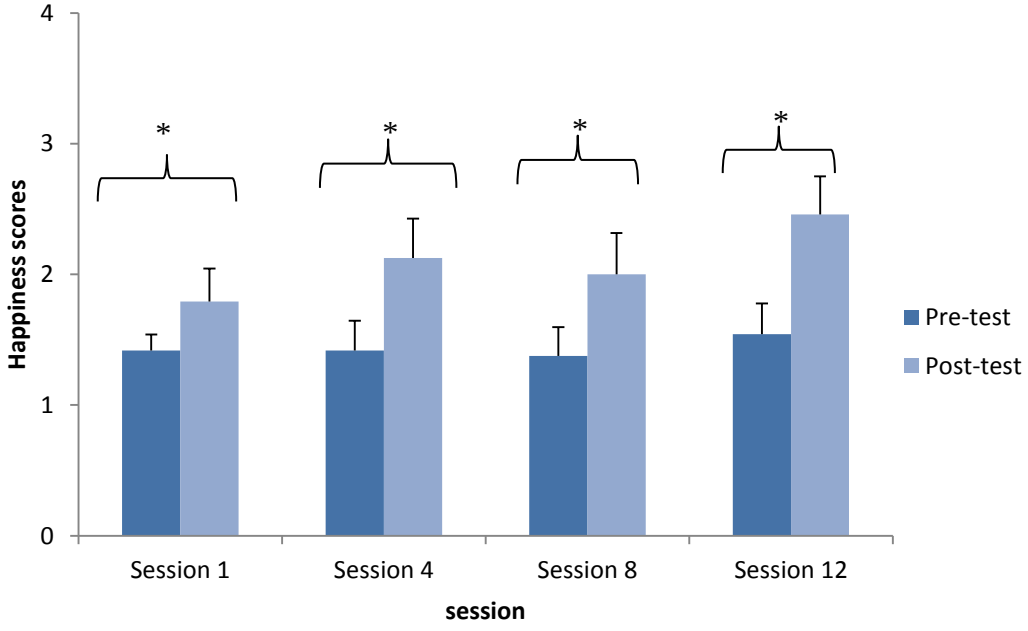

Figure 6. 17. Pre-post happiness scores of the music group in four selected sessions;* indicates that $p < 0.05$.

6.4.5 The nature group

For the nature group, a total of 352 raw data codes were extracted from the transcripts in Stage 2 (initial coding, please see Chapter 3 for analysis procedure), which were extracted into 18 higher-order themes and 42 lower-order themes in four general dimensions. Table 6. 5 displays the outline of the generated themes and a selection of quotes were shown for examples. For quotes, participants in the nature group were identified by numbers, such as Participant 1 to Participant 9.

6.4.5.1 *Focus*

Focus was to exhibit participants' engagement. The engagement was discussed from various viewpoints, including participants' visual and acoustic attention on the environment, presented information and personal physical conditions during the run. Specifically this included the information of the physical setting, the nature videos and their personal physical condition which lead into their utilisation of this information. Furthermore, the engagement also included their thoughts during the run. This dimension consisted of three higher-order themes: perceiving the richness of videos, awareness of physical states, and wandering mind.

Firstly, the detailed description of the presented nature video was given by the participants stating information available from the presented videos as perceptually rich. Participants outlined a variety of visual or acoustic information they noted and they also actively engaged with certain features, such as identifying the diverse sounds of bird calls and the wind, multiple colours of the leaves, mountains, sky, bright settings of the video, and dynamic motions of animals, water or waves and small details of the video. For example, Participant 3 recognised the multiple sounds from the video and stated "*there would be different sounds, maybe different birds. Maybe a big stroke of wind coming to the tree and I picked that up."* On occasion, the exact information would come from the video in a manner that would trigger an instant augmentation of happiness; Participant 3 also mentioned *"that kind of mix of bright colours just caught my attention straight away and kind of instantly felt happier."* Participants further expressed that they either studied the video as a whole picture or particularly searched for details at different sessions if they chose to watch the same video. Participant 7 described actively changing his perspective by searching the scene for sheep to count. For example, he said "*on the sheep [video] when I kept counting how many sheep there*

were". This process of counting aspects within the video provided an opportunity to engage in the scene rather than just as a means for distraction.

Secondly, participants advised that they habitually self-monitored their physical states, including checking breathing, legs, and foot placement during the twenty-minute running with no specific time at which this occurred reported. For example, Participant 8 stated "*when I'm running I'm thinking about my running, my pacing, and things like that. But that is just nature because I've ran a lot before."* However, the self-monitoring on physical information became the dominant focus when participants desired to pursue a better exercise outcome, such as, Participant 7, who said " *when I run, when I start to push myself, I control my breathing so, I breathe in, over two steps, and then I then concentrate on that, so that then takes my mind off everything else.".*

Lastly, participants' minds "wandered" between different things due to numerous individual purposes, such as Participant 9, who pointed out" *while you were running the more engagement was about how to plan your day"* or with the attention to improve personal performance, she also thought "*a lot about hockey or training and what I could be doing better."* Participant 7 shared his shifting attentions because of personal habit " *when I'm running I like to think about different things in my life and try to figure them out more, 'cause I think like when you're running you can focus on both your running and other things"* or external factors "*if I had an assignment I would think about it whilst running".*

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Table 6. 5. The generated themes of the PA experiences of the nature group.

Lower-order themes	Higher-order themes	General dimensions
Colours, changes, different foci/ Birds, wind	Perceiving the richness of videos	Focus
Breathing, legs, foot placement	Being aware of physical states	
Daily plans or personal task (hockey, assignment, mapping the day	Wandering mind	
Dynamic content, encouragement (bright setting, colourful)	The functional visual content of videos	Feedback
Still scenery (nothing happening)		
Blank between videos		
White noise	The encouraging video sounds	
Positive incentives		
Personal conditions (mood/physical state)	Purposely chosen video	
Link to past experience		
Personal preference (being in that place/ dislike video)		
Expected to get encouragement		
Negative feelings of video (boring/annoying)		
Keep variety		
First 5 minute :slow	Attuned to nature video	
Middle stage: get in the rhythm		
Last: refocus or push		
enhancing physical output	Immersion	
Mental benefits		
Clear mind or release	Relief effects of running	
Gauge time and reflect physical condition for increase or decrease speed	Reminder of physical check - perceived exertion board	
Help to focus and enhance self-awareness	The low distraction setting	
Different from normal gym	Different treadmill	
Warmth, other items, and people	Distracting lab	
Annoying / frustrating (video/covered panel)	Diverse feelings	Feelings
Being away		
Calm		
Dull		
Enjoyment		
Happy(bright colour, past memory, sounds)		
Boring(discouragement, repetitive)	Positive in-task feelings	
Looking forward to it		
Motivated		
Relaxing (beach, water or woodland)		
More energetic	Positive post-task feelings	
Stronger		
Sense of completion	Post-study accomplishment	
Learn how to run in this study	Benefits of participation	Time effect
Physical improvement (performance/physical awareness)		
Video-less attractive		
Desire to run more		

6.4.5.2 *Feedback*

Feedback was named to illustrate participants' responses and comments with or without related causality across different elements of this study including the presented information (videos with sound), the experimental setting and the physical task. Participants proposed the functional visual content of videos, the encouraging video sounds, purposely chosen video, attuned to nature video, relief effects of running, immersion, physical reminder, the lower distraction setting and the distracting laboratory setting.

When advocating the functional contents of the video, participants pointed out the dynamic changing video effectively retained their interests. For example, Participant 8 enjoyed watching birds and stated "*the birds always moving and jumping around and there was one coming in and one going out. There was always something new to put your attention on.*" The video was also seen as a visual stimulus to encouraged physical performances, as Participant 1 said "*the movement of the water and how fast it was going. It like, is kind of a stimulus*."

The brightness and colourful setting of the video was also supported by the participants with the physical and mental benefits, such as Participant 3 stated, "*It made me feel a bit happier when I saw all the different colours and the noises and different movements, like stream and wind blew going on. So, I had that to motivate me throughout the session. I felt happier and happier. I felt like I can do more*."

Conversely, some videos reduced participants' interests in the video because the scenes were relatively still with only minor changes observed in the video. For example, Participant 1 said that "*the video with the sheep, it was very stagnant. The sheep were just eating, nothing was happening*" or the video presented from the same angle as filming over time contributing to boredom, "*it was very simplistic. Nothing really happens on the beach apart from the water coming and going out*." (Participant7). Two participants (3 and 5) opposed the short gap when switching between videos because the immersion with video was interrupted and they were consequently distracted by other things. For example, Participant 3 said that "*when I was switching between them, there was a 10 or 15 seconds delay between them and so I can see other people in the background, walking behind. I was sort of thinking like who were they or what was going on a little bit"* and Participant 5 said that he "*when something popped up on the screen, I got distracted quite easily. When I did get distracted it was quite frustrating."*

The sounds of nature videos were suggested as white noises by 4 participants as a constant, smooth, not overwhelming sound which can just stay in the background and cause no negative effects. Nature sounds also offered reinforcements for running and functioned as distractions and led to increased feelings of happiness, motivation and alertness. For example, "*the bird sounds, it was just the pitch. Because it was really chirpy, so it was kind of matching the bright colours going on, so, it left like really light-hearted, really happy and quite motivated in a way.*" (Participant 3).

Videos were purposely chosen by participants for a variety of personal reasons, including matching their personal conditions (physical tiredness or mood) like Participant 3 who stated that he would watch the video with the bright setting to pick him up because he felt invigorated that day. To some participants, the personal link to past experiences was expressed including memory or activities related to family experiences, for example, "*it reminds me of the times that I used to run in my grandparents' house on holiday. And do that and relax and be away from everything. It was really nice"* (Participant 4) or habitual PA experiences, like Participant 5" *I think it's related to stuff I would do normally outside. It's like the same in forests and I went out camping quite a bit. It reminds me of that yeah*."

Personal preferences played an influential role in video choices; especially some participants would try to picture themselves in the same environments as shown in the videos. For example, "*The sun was coming through the trees, it's what you would imagine running through, it's the sort of environment that I would be likely to run in if I was to run outside*" (Participant 7). Some would want to avoid being in the same environments because of some disliked elements, for example, "*I don't really like the birds. Like pigeons, I don't like at all, they scare me. So I chose not the birds.*" (Participant 9).

In the hope of receiving certain positive encouragements, such as motivation, distraction and relaxation, participants would deliberately select specific videos. For example, Participant 1 switched video to see sunshine or a bit more activities in the video because "*it gave me like visual stimulation to push myself.*" or Participant 3 decided to run with water videos due to "*it was really slow and something was really repetitive. So, I knew that sound was coming and it would calm me down.*" Unpleasant emotions, such boredom or annoyances would trigger the action of changing videos. Two participants (7 and 8) pointed out they attempted to keep a variety of video choices every time to

avoid boredom. Participants received mental and physical benefits from immersing themselves mentally into the video. When participants were immersed in the video, they would be less focused on running and less sensitive to the increased speed or breathing heavily and were therefore able to sustain the task for longer and lose track of time as a consequence.

Throughout the twenty-minutes numerous running stages were identified because participants stated that different engagements with the PA occurred as they attuned to the video differently over time. During the first stage, participants appeared to perform a slower paced run with placing dominant attention on videos and they also expected the physical movement to get into a rhythm. In the second stage, participants were more likely to be immersed in the video or distracted by other thoughts; in this stage, the running became automatically performed without extra efforts, as Participant 1 said" *it's kind of check-out, I just run, I don't think.*" The last stage of running varied from individuals in terms of their engagement. For example, Participant 8 would "*just leave it [speed] the same if I'm feeling quite tired"* but other participants would chose to end up at a higher speed. Participant 1 "*would start focussing back on the video toward the end*" in the last stage of her run.

Positive physical and mental benefits were accrued via the immersion in the video. For example, Participant 3 stated that "I was *in my own little bubble and I didn't realise how high I had increased the speed and felt a little bit easier as well.*" and he also said that he "*got distracted and stop worrying, not care less about them but worry less about it [an assignment]*." Increased happiness, ignorance of running and a sense of being "in nature" were proposed by participants when they actively immersed in the video. Participant 8 shared that she felt "*I was actually running through the woods or whatever, even though I wasn't. It took my mind off what I was doing and felt extra relaxed.*" When undertaking the physical task, four of the participants identified that one result of the run was that they felt a relief from feelings of stress they may have been experiencing and left them feeling calm and more able to plan their life.

Several environmental factors were actively mentioned by participants, especially the perceived exertion board, the covered panel of the treadmill and two partitions. The perceived exertion board in this study functioned as a reminder to check physical states. With the frequency of every 5 minutes checking exertion level by the researcher, participants used it to gauge time and reflect their physical conditions for increasing or

decreasing speed. Participants said the created environment helped them to avoid distractions, focus on the videos because "*if there wasn't that sort of thing closing, I would get distracted quite easily. There wasn't much to look at so I was almost forced to look forward at the video.*" (Participants 6) and enhance self-awareness of physical states, for example, "*I didn't care [distance and speed]. I just pressed when I wanted more.*" (Participant 4).

There were few responses about the differences between the laboratory and gym treadmills and the distracting laboratory environment, including the warmth of the laboratory, the comfortableness of headphones and other equipment and people in the laboratory.

6.4.5.3 *Feelings*

Within feelings, this theme captured participants' mental states, including various emotions with or without specific reasons and how these experienced emotions appeared at different times during the study. Before running, some participants said that they looked forward to the task when the trial was arranged. Participants felt frustrated or annoyed because of the concealed information of the treadmill when they first started running in the early stages of the study.

During the run, participants had various emotions from videos with specific features, participants felt calmness, happiness, enjoyment and had a sense of "being away" by the videos of running water, beach and woodland which can make people feel calm and relaxed. Additionally the bright colours and sounds of videos made them feel happy. However, different participants might respond to the same video differently which was evidenced in the videos of the sheep or forest scenery which were considered to be dull or boring to some participants. This boredom led to discouragement for some participants but others felt motivated by the sheep video for personal reasons, for example, Participant 9 used to run outside through farmers' fields, therefore, he felt "*definitely happy, enthusiastic and it made me motivated about running when saw the sheep*."

Participants also experienced annoyance from some of the videos because the birds kept jumping around or the constant sounds of the running stream were thought of as noise. After undertaking the run, participants felt stronger, more energetic and had a sense of completion.

6.4.5.4 *Time effects*

After completing 12 bouts of running over 6 weeks, the nature group recommended the participation because of numerous benefits, including a sense of improvement on performance and physical awareness. For example, Participant 3 thought he "*learned to know myself and my body a bit better and I thought that improved with each session in each week as well.*"

An individual-specific way of completing the physical task and also satisfying personal need and preferences was developed over time. Participants learned to perform the running with the removed information (distance, speed and heart rate) in this study and sharpened their sensitivity about noticing physical states, recognising a better treadmill running position and personal best running video for their run. Such as,

"*So getting used to the study and how it worked, so I think the first two maybe three sessions that I did I was like changing videos and just trying to figure out what worked best for me, trying to figure out like the rhythm and stuff.*" (Participant 2)

Some participants also expressed their desire to run more either after a session or in the future but for two participants, the attraction of videos decreased in the later stages.

6.4.6 The music group

For the music group, a total of 151 raw data codes were inductively extracted from the transcripts in Stage 2 (initial coding, please chapter 3 for analysis procedure), which were falling into 33 lower-order themes and nine higher-order themes in four different dimensions (Table 6. 6). For quotes, participants in the music group were identified by letter, such as Participant A to Participant F.

6.4.6.1 *Focus*

Focus aimed to record participants' engagement in this study, including their attention allocations and thoughts during the running. In this theme, shifting attentions were indicated by participants in five areas: reflections in the television, music, physical states, personal tasks and running.

Table 6. 6. The generated themes of the PA experiences of the music group.

Lower-order theme	Higher-order theme	General dimensions
Reflection of the television	Shifting attention	Focus
Music		
Change of physical states		
Personal task		
Running		
Expectation from music	Purposely chosen music	Feedback
Fast tempo		
Habitual music type		
Provide escape	Functional music	
Gauge time		
Enhance physical performances		
Influences on running cadence		
Gauge time	Rated Perceived Exertion board as reminder	
Increase running speed		
Constraint physical performances	Two-sided effects of study setting	
Enjoy run and music		
Encourage physical awareness		
Require adjustment		
Understanding of physical capability and states	Decisive factors for speed	
Motivated by music	Positive feelings	Feelings
Happy		
Energetic		
Interesting		
Sense of completion		
Enjoyment		
Attentive		
Others(determined/relief/relaxing/ looking forward to exercise)		
Annoying/frustrating/tiring(difficult)	Negative feelings vary from participants	
Stuffy, warm, mundane(physical setting)		
Easier and fitter	Changing difficulty	Time effects
Higher exertion		

First, all participants instinctively picked up the reflection in the television (the screen was switched off) with two levels of engagements. Some participants were simply "*looking at how I was running and posture* "(Participant A) or "*watching how my legs were moving for the 20 minutes* "(Participant B) while other participants not only checked their running form but further used this visual feedback as an augmentation to correct or adjust their running posture. For example, Participants C said that "*it's a nice, like feedback, I can see my form and how I'm running I was like adjusting once in a while if I was looking funny.*"

During the running, music occupied participants' attention in different ways. For example, with familiar music, participants were able to "*sang in my head or on occasion sang a little along to the music. I was kind of focusing more on the lyrics*" (Participant D) or to "*picture music video of the songs at the same time or visualise the song as you know what words are coming up.*" (Participant B). However, music was not considered worth attention on occasion when "*the song was just playing and I knew the song exactly, so it became noise because I listened to it 1000 times before, I probably focused on the reflection more.*" (Participant B). In other words, the familiarity of music seemed to be both advantageous and disadvantageous. Participants can sing along to the music in their head or be able to reproduce the music-video context in their own mind as benefits. But the familiarity of music can also lose its benefits with low attraction or when considered to be the wrong choice. Another consideration may be that the type of music might be influential. For example, Participant B had picked a specific music genre, UK grime, which required extra attention because "*the lyrics are quite hard to hear, so you have to kind of listen to understand what they're saying.*"

Participants also paid attention to their physical states and changes (breathing, foot placement and sweat), such as Participant D *"tried and breathed a little bit more through my nose* "and "*check my feet a little bit"* as well as Participant B "*was picking up on the sweat as it was really kind of raining down on me.*"

With the purpose of improving their running technique, participants engaged with the physical task (the twenty-minute run), for example, Participant B "*have been trying to promote more of a forefoot strike so was focusing on it throughout the whole time.*" or with the thought to complete the run, like Participant D " *was thinking was please God, make me make the whole 20 minutes.*"

Participants thought about personal tasks, such as Participant A "*thought about what I have to do, what's going on and used it as a time to calm down, figured everything out*", Participant D was thinking "*what trip am I gonna do this weekend*" or past memory triggered by music, like Participant B said "*it (the music) kind of brought back memories when I was in Arizona.*"

In terms of focus, participants visually engaged with the television reflection and used it for checking or correcting running posture and allocated their attention between the physical task (the run), music (tempo or lyrics) and physical conditions (legs or breathing) while thinking about personal tasks (daily schedule or weekend trip).

6.4.6.2 *Feedback*

Feedback presented participants' responses across the purposely chosen music, functional music, perceived exertion board as a reminder, the two-sided effects of study setting and decisive factors for speed. Most participants purposely chose to run with habitual music for various reasons, such as personal preferences, fast tempo and loudness, the level of upbeat, familiarity and the expectation from music.

Participants intended to run with habitual music because it satisfied their personal preferences and the familiarity of the habitual music could maintain their attention. When listening to the purposely chosen music, participants were expecting to be motivated and excited to retain focus on running. The main choice was fast tempo music because this type of music was upbeat and motivating to participants to keep them moving or perform running at a faster speed. Here, Participant B demonstrated why he deliberately chose the music for a higher intensity exercise for motivation "*because I wanted to work hard, I would choose harder music. And similar with the southpaw [movie] and its soundtrack, I would put that on if I wanted to do something that was quite hard."*

Participants indicated that music had various functions. For example, Participant E used music to gauge time because one song normally lasted for 4 minutes which indicated the whole run was around 5 or 6 songs. Music also provided space in my mind to focus on the task and escape from thinking other random thoughts, for example, Participant C said "*it [the music] makes me focus on what I'm doing and I'm not thinking about other stuff going on."* Music also enhanced physical performances and influenced running cadence, such as Participant F who stated *"think if it's a quite upbeat song and it's a song you really enjoy listening to you probably run further, or you'd be able to sustain it for longer."*

Different offered environmental elements led to various utilisations by the exercisers. The perceived exertion board was used by participants to gauge running time and remind them to increase speed in the last 5 minutes for some of the participants. For example, *"in the last 5 minutes on some of them I did increase the speed cause I knew I'd be finished soon, I wanted to get my last little bit in."* (Participant F).

The covered control panel contributed to a two-sided effect for different participants. Participant A required time to get used to running in the designed PA environment

while Participant B did not care and focus more on personal physical conditions since the information of running was not available. Participant F reported the restricted physical performances because of the hidden information by the covered control panel. Participants C and D received encouragement to actively concentrate on the running because of the immersion in the music and the unavailable information (distance, speed and heart rate).

Participants revealed there was a link between the running speed and the personal understanding of physical capability. For example, Participant A decided the running speed by judging *"what I was feeling within the first minute. How fast I felt I could keep it up, how tired I was what I had done, before if I got enough sleep"*. Participant F changed the speed "*if I was not sweating that much, I would try to run a little bit quicker"*. Another reason was that participants would increase speed due to individual states physically and mentally, for example, Participant B would increase the speed because *"sometimes you just want to do something for a while. You're not that worried about doing it particularly hard whereas sometimes just kind of push myself and that would be the day when I put it up a bit"*

Within feedback, participants ran with their habitual music which was based on personal preferences, tempo, levels of upbeat, familiarity and expected encouragement of the music. During running, music was reported to enhance physical performance and running cadence as well as to offer a break from the daily task by the participants. The perceived exertion board was used by the participants to gauge time and give the notice to increase speed. The covered control panel not only led to positive responses i.e. improve physical awareness and encouraging the enjoyment of running and music, but also negative replies including adjustment of the time required.

6.4.6.3 *Feelings*

Various positive feelings were expressed by participants including; motivation from the music; feelings of happiness; higher levels of energy; longer retention of interests, a sense of completion and enjoyment and attentiveness. For example, Participant E stated *"Rocky [movie], obviously that's gonna be motivating, but some songs within the music are motivating and you can relate to the film where he's training"* or Participant C said "*just happier, I felt like I had more energy after, accomplishing a run.*" Some participants experienced different negative feelings in this study, such as annoyed

(Participant A), frustrated and difficult (Participant E) by the covered control panel and felt stuffy (Participant B) and mundane (Participant F) from the physical setting.

6.4.6.4 *Time effects*

There was changing difficulty of the physical task in this study pointed out by the participants over 12 sessions. Most participants reflected a sense of physical improvement, such as Participant C reported that *"I feel like the first one I was very dead at the end and by the end ones I felt like I could maybe still run a bit more after that"* and felt the session was getting easier.

For example, *"from the earlier sessions, I found it more difficult and I needed something a bit more motivating that would keep me going whereas towards the end it was something that I could actually enjoy and actually enjoyed the music as well as running."* (Participant E).

But Participant F expressed that the exertion level of the physical task increased with time because "I just, I push myself to the point where I wouldn't be able to sustain that for another six run and the outside factors, if I've not slept properly or if I was hungry, that I wouldn't necessarily run as hard or as far then I did the first few.".

6.5 ***DISCUSSION***

This study aimed to investigate the physical, psychological and emotional effects and experience of nature-based affordances for treadmill running compared with the music-based affordances running condition over 6 weeks. These two types of information offered individual different affordances in emerging behaviours. Quantitative results indicated that physically, there were no differences between these two groups for distance, speed and energy expenditure in any of the 12 sessions. However, a higher 20^{th} minute exertion level of the run across 12 sessions was found in the music group compared to the nature group. Psychologically, for the nature group, a greater post-run positive affect state was found in all of the four selected sessions and the pre-and-post difference was significant between session 1 and 12 which implies that these positive effects remain as strong for 4 weeks. No increased or decreased negative affect states were observed in the pre-or-post run. Different results were found in the music group. There were no differences in either the positive or negative affect scores of the music group from pre-to-post run. For specific sport-related emotions, none of the pre-and-

post difference was observed within the nature group over the 4 selected sessions but the rated excitement scores of session 8 were significantly lower than session 1. The music group was found to decrease the anxiety of session 1, 4 and 8 as opposed to session 12. The people who ran with music were found to feel more excited after the run and the effect lasted over all trials with the significant higher excitement in the session 12 as opposed to session 1. The music group was found to have higher post-run happiness in all of the four selected sessions. When discussing results of PANAS and SEQ, it is important to be aware that the direct comparisons between groups were not made on these two mental questionnaires because of the violation of the homogeneity assumption in the data. The examinations of the pre-and-post differences between sessions were performed within the same group over time. Therefore, it would require extra caution when interpreted the mental benefits between groups considering the limitations of this study. From qualitative data, the nature group exhibited a well-engaged experience with the videos. The engagement included the observations of the video information, making a personal link to video and immersing in the video to accrue physical and mental benefits. Participants attuned to the video which affected their running speed. Multiple positive emotions were accrued because of the videos, including happiness, enjoyment, calmness, motivation, relaxation, higher energy levels and increased strength as well as few negative feelings of boredom and annoyance reported due to the stillness or repetition of videos. This unique knowledge obtained in this study was that participants showed how they adapted to run in a created environment without information of running distance, speed, heart rate and time and developed their way to cope with these challenges as well as utilising the available information offered by the study over time. This was important information for green PA in order to reduce the risk of the "novelty effect", but in the later stage of the experiments, the attraction of the videos seemed to reduce for two of the participants which might suggest the diversity of videos would be needed to be taken into consideration with the time constraint. For the music group, music occupied the participants' attention for different reasons and resulted in different engagements. Participants purposely chose to run with their habitual music which was often upbeat and fast tempo music, because they expected to be motivated or to feel excited about the run. The overall experience seemed centred on the run, suggesting associative focus when running which might explain why the music group was found to have higher exertion level compared to the nature group. Positive and negative feelings were both expressed by the interviewees and suggested lower exertion level as more sessions were

completed except Participant F. From ecological dynamics perspective, these two groups demonstrated how different information would accrue different behaviours over time; especially the nature group developed individual-favoured PA behaviour through self-organised mechanism.

The physical benefits of both groups, except exertion level, were in line with the findings in Chapter 4 and 5 which showed that no differences were found on physical effects between nature-based affordances for treadmill running and self-selected entertainment PA environment. The difference between the results for exertion level shown in the current study and those in Chapters 4 and 5, where no differences for exertion level between PA condition was found, might be due to the increased richness of nature-based affordances in the current study (24 nature videos with sounds) compared with relatively limited richness of nature-based affordances in Chapter 4 (a static and dynamic nature image) and Chapter 5 (a collection of ten short nature videos with and without sounds). With no observed changes in physical performance over time between groups, but lower perceived exertion in the nature group compared to the music group, exercising with nature could be viewed as a better alternative PA condition for treadmill running. There is scant research investigating the effects of exercising with music and green PA in the same experimental design. Jones and colleagues (2014) conducted a similar study examining the effects of four PA conditions, music-only, music-nature video (cycled through a parkland), video-only and no-music-video at two exercise intensities. In that study, no physical effects were examined, but results showed that two PA conditions (music-only and music-nature video condition) were beneficial on valence affect and exercise enjoyment which was aligned to the current study. Inconsistent results were shown when compared to the literature in a wider scale regarding the effects of music on perceived exertion. Some research proposed that exercise with music would lower perceived exertion level (Fritz et al., 2013; Silva et al., 2016) or enhance physical performance (Barwood et al., 2009), while others studies found no differences in perceived exertion when exercising with music (Barwood et al., 2009; Tenenbaum et al., 2004). However, these five aforementioned music-related studies were conducted with high intensity exercise which would lead to different results when compared with the current study. When increasing the intensity of exercise, exercisers would experience attention shifts between external and internal stimulus, this shifting would have influences on exercise outcomes (Johnson & Siegel, 1992). Furthermore, the comparisons were mainly made between various music-related

PA conditions including exercising with music, exercising with music-video or exercising with no entertainments. Therefore, it would not be appropriate to make direct comparison with the current study because the above studies did not include any nature-based information for exercise as a comparison PA condition.

When looking at the running profiles of the two groups over 12 sessions (Figure 6.6), two distinct trends were identified. The nature group started at a slower speed but gradually increased speed throughout the whole twenty minutes, whereas the magnitude of the speed changes of the music group was small. Statistically, the initial speed (the 1st minute of the run) was significantly different from the finishing speed (the 20th minute of the run) among the nature group while the music group was running at a similar speed throughout the 20 minutes. In Figure 6.7 and Figure 6.8, the changes in the twenty-minute running profiles between sessions of the music group were indistinct whereas a distinguishable change in the twenty-minute running profile between sessions of the nature group was found. The session-to-session changes might reflect the two running groups had different running experiences because the nature groups performed different running speed over sessions whereas a similar running profile of the music group was showed over time. This highest speed performance might suggest that running with nature videos showed novelty effect because it was new experience. However, there were no time effects showed on physical performances and mental effects in the nature group. Potentially, the variety of nature video might act as one factor which offered rich affordances for participants to utilise until the last session. In contrast, the music group showed a habitual way to perform treadmill run which might be the results of exposure to similar music. This was supported by the interview data. Throughout the twenty minutes, participants engaged with their run at different stages over time: warm up, get in rhythm/ mind wandering, last push or remain steady, based on how they attuned to the videos. In line with the previous statement, participants ran at a slower pace in the early stage of the run then gradually increased speed until the end of twenty minutes. There was no such finding in the Chapter 5 which presented the similar type of nature-based affordances. This might reflect the time effects. Participants in this Chapter had 12 sessions to establish a personally-favoured PA pattern while participants in Chapter 5 were only required to perform the run once. In Chapter 4, participants mentioned they tried to keep the same pace with the presented video while they ran on the treadmill. This was a different type of attunement because the information offered in Chapter 4 was related to the physical task (i.e. participants ran on

a treadmill while looking at a video camera moving along the path in a park). Another possible reason for this attunement to the nature video might be due to time considerations. To the researcher's best knowledge, this study was the first study conducted over longer periods, therefore, participants have more time to "learn" to adjust and adapt to the study based on their own need and ability while satisfying the experimental requirements. From session to session, participants found their ways to perform the experimental task on different aspects, such as a more suitable twenty-minute pace without knowing speed and distance, a more sensitive physical self-perception, a better recognition of video choices and a better position on the treadmill. Over time, the nature group also felt physically improved and desired to run more in the future while the music group was reported the feeling of improvement with exception of Participant F.

These distinct running profiles suggest these two groups performed their twenty-minute run differently which may suggest different engagement come from the offered information for affordances. The offered information, the nature video with corresponding sounds and music was not only distinct on the content of the information but also required runner to activate different sensory receptors. To be more specific, the nature groups were exposed both visual and acoustic information at the same time and the perceived information was likely to be new and dynamic to the runners throughout the whole twenty minutes. This new or unfamiliar information might act as a constraint requiring a longer coordination period to perform the physical task because people would pay more attention to the video while running; hence, the slower starting speed was revealed in the running profile of the nature group. In terms of functionality of information, the rich and new information shown in the nature video might initially encourage a slower speed. However, the presented video information was dynamic and constantly changing which was more likely to retain participants' interest in the videos and allow a prolonged utilisation of video information until the last minute of their run. The running profile of the nature group also showed that the speed kept increasing until the end of the run. Qualitative results showed more detailed information to explain why the nature group showed distinct running profiles. The nature group identified diverse information from the videos visually and audibly and took notice of the variety of video settings. For example, a range of bright colours and different environmental sounds from animals, water or the wind, changing contents and details of videos. These videos were watched by participants as a whole picture or studied in detail, like counting

sheep/ trees at different sessions. Secondly, the nature group utilised the information in various ways. One example was when participants immersed them in the videos to get positive effects mentally, such as being more relaxed, increasing motivation or feeling happier. There were also physical benefits which included a distraction from the exertion of the task and questioning the sustainability of their efforts. The functionality of nature videos was partly from the visual information because of the bright setting, various colours, constant and dynamic changes of video contents which encouraged participants. The sounds of the videos were considered beneficial as white noise to offer a constant and steady background sound as well as provide a positive stimulus for motivation, alertness, and distraction. Participants mentioned the short gap between the video switching led to negative effects because it interrupted the immersion or concentration. These 24 videos also showed diverse functionalities for individuals, such as building a link to past experiences, identifying personal preferences and dislikes of videos, offering encouragement for a good physical outcome or inviting positive emotions or simply providing a variety of options. The strong engagement with nature videos in the current study was aligned with Chapter 4 and 5. Participants expressed their desire to turn a corner or avoid colliding with pedestrians when they run along a path in the park in Chapter 4 whereas, in Chapter 5, participants recalled past memory or pictured themselves in the similar environments when they watched the nature videos with the similar environments. This strong engagement might suggest that the design of the PA environment was efficient in building a link between exercisers and the environment. Furthermore, this finding also indicated that a well-designed PA environment needs no extra instruction to encourage participants immersed in the video as was found in the literature (Pretty et al., 2005; Rogerson & Barton, 2015).

In contrast, the music runners were mainly exposed to acoustic information which was more likely to be familiar to the music exercisers and required less time to coordinate; hence, the music group would be able to perform the run consistently from the beginning while listening to the music. Furthermore, the music might be familiar to participants which would become functionless information for the music runner for offering distractions or encouragements. As such, the running speed of the music group showed a steady speed throughout the whole run. In line with interview data, the whole music group perceived the reflections in the television and used them for running posture correction except Participant D who was looking at other people in the laboratory. This external information worked as feedback for participants to pay

attention to their running. Participants also paid attention to different running related information, such as keeping running and completing the run, running pace, breathing, sweat and foot placements. Although during the run, participants also thought about personal tasks or their daily schedule, the main attention was placed on music and running. In this study, no further information was offered by participants stating the effects of the constant visual feedback from reflections. However, participants listened to the music to lead their running cadence and received motivation to run while watching the reflection to correct their running form. For example, "*I could feel myself getting a lot pumped up on some of the songs so I felt like those ones may have quickened my step a little bit.* (Participant D)" In the statement, the functionality of music was found not only to offer mental benefits but also enhance physical performance. These two types of benefit (motivation from music and faster cadences) were aligned to the asynchronous use of music (Karageorghis & Priest, 2012a). This concept framework indicated that the individual makes no conscious effort to synchronise their movements to its rhythm and the motivational quality of music benefits people via listening to it and as a consequence improves their mood as well as reducing their perceptions of exertion. Supporting Karageorghis and colleagues' work, several positive feelings were expressed in the interview including motivation, happiness, feeling more energetic and enjoyment which matched the improved post-run emotions found in this study and previous work (Edworthy & Waring, 2006; Jones et al., 2014). The use of music to reduce perceived exertion was supported in literature (Fritz et al., 2013; Silva et al., 2016) but not this study which might because the exertion was compared at different levels. First, the comparison was made between different PA conditions on post-run in each trial and this study failed to offer this information as none of the interviewees mentioned it. Nevertheless, when examining the 12 sessions as a whole time series, reduced exertion was found as most participants reported the session was getting easier and they physically felt fitter except Participant F who thought the exertion was increasing as the session went on because of external factors, such as assignments.

The different engagements of two groups could also indicate different attention allocation while running explained by William Morgan's work regarding Association and Dissociation (Brick et al., 2014; Maters & Ogles, 1998). Associative focus monitored physical sensory inputs, pace, pain whereas dissociative focus captures all other information except body and internal sensations, such as work, scenery, other non-

exercise-related tasks (LaCaille et al., 2004). In contrast, when the attention is focused on anything other than the body and internal sensations, the focus is external (i.e. dissociation or distraction). Focusing on internal stimuli may increase effort perception while focusing on external stimuli may decrease effort perception (Johnson & Siegel, 1992). As mentioned previously, from the running profiles, these two groups had higher likelihood of experiencing different engagements. The nature group might pay more attention to the video and sound (i.e. external attention) rather than the physical task or themselves (i.e. internal attention) because of the rich affordances from the nature video. In the interviews, participants mentioned abundant information of videos (colours, setting, sounds and details), immersion and attuned to the video and various cognitive activities (past memory, daily schedules or weekend trips) with less information of the run. However, this attention allocation shifted when running became the dominant part of the experiences (switching from external to internal information). As the physical awareness was becoming dominant when participants tried to pursuit physical performance which recalled the dissociative focus mentioned above. For example, Participants 8 stated that *"when I run, when I start to push myself, I control my breathing. I breathe in, over two steps, and then, I then concentrate on that, so that then takes my mind off everything else."*. During the run, participants' attention occasionally wandered between personal tasks or daily schedule and their physical states occasionally. Several environmental elements provided numerous functions, such as the exertion board for gauging time and reflecting physical states and the experimental setting to maintain focus and improve self-perception. The differences between the laboratory and gym treadmill were noticed as well as the warmth, other equipment and people in the experimental environment. The hidden information of the treadmill, i.e. distance and speed, frustrated and annoyed participants especially in the early stage of the study but turned into a beneficial setting because participants adapted the constraint and found their ways to cope with restrictions (improved self-perception or selected a personal preferences video). For the music group, the lower variety or the familiarity of the music of the participants might reduce the richness of the affordances for the music group which were more likely to highlight the run and the related physical exertion (i.e. internal attention) rather than the music (i.e. external attention). The music group was more likely to experience associative focus rather than dissociative focus during the physical task which might explain why people in the music group showed higher perceived exertion than the nature group. However, the actual attention shifts during

exercise might require different methods to promote further understanding in future research.

From session to session, the experimental setting remained the same on constraining information of distance and speed but participants overcome this limitation by improving self-perception for running or using the exertion board to gauge time. With the same available 24 nature videos from trial 1 to trial 12, participants learned to recognise their preferences and dislikes and selected the video appropriate to their need (want to run faster with motivation or feel relaxed) to improve or change their PA experiences. This "found their ways" indicated that on the way to complete the experimental task, participants self-organised every subsystem (e.g. the physical states, emotions, cognitive activities) while satisfying different constraints (e.g. hidden information of distance or limited nature videos). This was in line with the ecological dynamics perspective. This coordination process was occurred and improved over time and was an important example to reflect to the main concepts (affordance and interacting constraints) of an ecological dynamics perspective. This might be useful information when designing a long period exercise programme to include pre-session research of personal preferences to increase the likelihood of positive PA experience.

With the significant greater positive affect scores and no different emotions observed in the nature group in all sessions, running with 24 different nature videos and sound was found to create a more pleasurable engagement of the PA experiences rather than create chances for participants to encounter the five measured sport emotions in SEQ. However, the interview data were proposed more emotional benefits, such as happiness, enjoyment and calmness resulting in relaxation which was in line with findings in Chapter 5 when people ran with the collection of ten short nature videos. For example, *"all the stresses seem went down and I started to enjoy more as I got more into it [videos] because my mood was improving."* (Participant 3 in Study 3); "*about half way through, I definitely into a zone and forgot I was running and felt really comfortable and I really enjoyed. I kind of lost track of time and just got into a rhythm* ." (Participant 7 in Study 2*).* These positive emotions were also found in previous research either by the visual or audio nature information (Benfield et al., 2014; Horiuchi et al., 2014; Pretty et al., 2005) and can be supported by Ulrich's SRT that a non-threating nature environment offered people opportunity for "being away" and able to relax (Ulrich et al., 1991). The nature group showed a significant increase in pre-and-post positive affect scores over 6 weeks but no differences ratings were observed in the SEQ. This

might be that running with 24 nature videos created broad pleasing PA experiences because nature environments were considered as a space to relax or to release stress; hence participants tended to focus on external information from the environments. Supporting by interview data in this study, the nature group emphasised the details of the videos (colours or sounds), personal tasks (assignment or daily schedule) and environment (treadmill or other people) rather on the running (breathing or sweat).

In contrast, the music group showed differences on specific sport-related emotions but not in the positive or negative affect scales which suggest that running with music was more likely to lower anxiety, increase excitement and happiness after run. This might indicate that running with music was more likely to invite exercisers to undergo particular emotions rather than create a more general positive experience. These findings were partially consistent to the data from the Chapter 4 and 5 regarding the positive and negative affect scores. However, there were different emotions observed in the music group, but not in the nature group which was not consistent to the Chapter 4 and 5. Although this finding is unexpected, it might due to the different examined nature-based information (static and dynamic image, with and without sounds, the available choices of nature video) and experiment duration (3 trials and 12 trials) which contribute to different PA experiences because the different affordances. This piece of information might be important for exerciser designers to take into account and consider the expected effects of the presented information when designing PA environment or programmes.

Collectively, the PA experiences of these two groups showed some similar and different effects. Both types of environment encouraged physical performance by increasing motivation by the presented information, which was in line with the finding in this chapter and Chapter 4 (no differences for distance and speed). Similar positive emotions were accrued from the nature videos and music environments, including motivation, happiness, and enjoyment but other feelings were reported only in the nature group including calmness, relaxation and boredom. Although the nature group mainly focused on the videos and the music group paid attention to running, both groups reported shifting attention between personal tasks or daily schedules sometimes during the run. Different engagements, in terms of information perception and utilisation, were seen in the interviews. Rich and diverse information offered from the videos and participants who ran with nature videos were able to pick up both visual and audio information, noticing and searching for details, building a connection to past experiences or

immersing themselves in the virtual environment which suggested the nature group engaged well with the video. The two types of presented information (videos and music) for exercise led to two forms of attention states because the functionalities of information were different for affordances. The music group chose to run with their familiar music (audio information) while concentrating on the running reflections (visual information) which indicated a greater attention placed on the running rather than the music. Therefore, the main perceived information was focusing on running which encouraged concentration on the running in an associative state. The nature group perceived information from videos and utilised it various way, including immersion and building links to past experiences which invited a dissociative state. These distinct attention states might explain why the nature group showed greater post-run scores on PANAS while the music group revealed improvements on SEQ. The two types of information perception and utilisations showed different affordances in two PA environments. From session to session, the nature group showed a learning progress and found their ways to perform the experimental task but the music group did not display this development. This might be because the music lost its functionality with the high familiarity and the reflections became the main information to encourage concentration on running. Regarding the created experimental setting, same responses were made by both groups as the covered control panel annoyed participants but encouraged self-perception improvement. The perceived exertion board was used to gauge time and as a decisive factor for running speed in both groups as the session progressed.

There were some limitations to this study. Firstly, the small sample aimed to act as a preliminary study which provided an initial exploration of green PA. A bigger sample size will be needed for the future research in this field to advance the findings. In addition, this experimental period (6 weeks) of this study might be considered not long enough to be valid for any behaviour change implications (normal intervention duration $\geq$ 12 weeks) which should be further investigated (Samdal, Eide, Barth, Williams, & Meland, 2017). The benefits observed in this study proposed a future research direction for related PA programme designer or sport psychologist when designing intervention. The 24 nature videos offered in this study were not of equal amounts in each category as there were more water related videos and fewer animals or mountains videos because of the limited video resources. The reflection of running in the music group was an unexpected influence because it offered extra visual information for exercisers in this study which can be improved in future studies. However, this might reflect the

representative design in this condition because people normally see reflections from the window or mirror in the gym (Araújo et al., 2007). Future research can aim to offer an equal number of each category to avoid bias and examine the effect of specific scenery of videos. An alternative could be to offer the personally preferred type of nature video for exercise since participants in this study chose to run with their preferred video after few sessions. If possible, a collection of personally-selected videos can be produced before any physical task to increase the likelihood of a positive PA experience and outcome. The exercise intensity was self-paced which might contribute to different effects when the intensity was higher which can be further examined in the future. This study failed to collect enough heart rate data which can be improved in future research. Finally, this study compared the mental effects within group and not between groups owing to violation of homogeneity assumption which would not allow a strong conclusion to be drawn regarding the differences between PA environments.

For application, the use of nature information for treadmill running were found to be more positive than music on reducing exertion when undertaking PA for 6 weeks. This is particular useful to attract the population perceiving exertion as a barrier for PA participation and the effectiveness of the nature environment had lasted for 6 weeks in this study which showed promising use for PA level promotion. The study also advocated the flexibility of PA environments or programmes to allow participants adjusting or developing individual-specific behaviours to improve PA maintenance, especially over time. The lower exertion and sense of user-centred were all influential on PA engagement and maintenance (Allen & Morey, 2010; Scott, 2014)

6.6 *CONCLUSION*

This study created two PA environments with different affordances which resulted in different PA experiences and outcomes between groups. The two designed PA environments encouraged runners to achieve similar physical performance but there was lower perceived exertion in the nature PA condition throughout 12 sessions. From the running profiles, these two groups engaged with their run differently. These two PA environments also encourage runner to accrue mental benefits but in distinct aspects. The nature group reported a greater positive affect state after running across 12 sessions whereas the music group demonstrated specific emotional changes over 12 sessions. The nature group described well-engaged PA experiences with the presented videos in dissociative attention state whereas the music group concentrated on running in

associative attention state. More importantly, only the nature group developed individual-specific exercise behaviours over time which emphasised the important value of the flexibility when designing PA environment or programme via offering rich and diverse presented information, especially for longer period research.

CHAPTER.7

EPILOGUE

With the effective promotion of physical health and mental wellbeing for urban residents in mind, this programme of research focused on indoor environment design for the first level of green PA (viewing nature indoors). Three dominant theories (the biophilia hypothesis, stress reduction theory and attention restoration theory), explaining the beneficial relationship between nature and human, were discussed alongside two popular PA theories (social cognitive theory and the ranstheoretical model). All address the initiation and maintenance of health through PA focusing on the individual and a behavioural epidemiology framework to guide research on human health behaviours (please see 2.3). Concerns were raised because these theories have failed to consider the importance of the interaction between nature, PA and the individual. With an emphasis on the individual-environmental relationship, taking into consideration the role of environment, individual and task when understanding human behaviours, the ecological dynamics perspective was proposed in this thesis to underpin the effects of experiences with green PA. Three studies were developed with the aim of investigating physical, psychological and emotional effects and experience of different affordance-based designs for green PA. A mixed method approach was applied in each of the three experimental studies (Chapters 4-6). The final chapter of this thesis acts as a discussion to highlight how the empirical studies within this programme of work have added to current literature and existing knowledge. In reflecting upon this programme of work and the insights gained, some limitations are identified, and areas of future research are proposed.

7.1 *ADDRESSING THE RESEARCH AIM*

In order to meet the research aim of this thesis, a series of objectives were devised during different phases of this programme of research. In this section, commentaries are given to demonstrate how each objective was achieved within the completed work.

7.1.7 Objective 1: Create an indoor treadmill running environment which allows examination of different nature-based affordances (Chapter 2 and 3)

To achieve this objective, the benefits of exposure to nature from empirical research and theories were first outlined, followed by more detailed discussion in relation to differences in current research of green PA on experimental designs. These included various types of nature-based information, durations, modes of PA, populations and the identified gaps in the literature. The theoretical framework of an ecological dynamics

perspective was proposed to underpin this thesis with its unique concept of "affordances" which emphasises the individual-environment relationship. This theoretical framework was proposed to offer a more inclusive consideration of the role of the environment, individual and PA, with a particular focus on individual differences when understanding human behaviours (Brymer & Davids, 2013). Key concepts in ecological dynamics suggest how human behaviours are shaped by how individuals perceive and utilise information from the environment (affordances) when undertaking PA while satisfying individual, environmental and task constraints (Yeh et al., 2015, 2017). Different information sources available in the environment for PA contribute to different affordances and consequently lead to different effects and experience of PA (Heft, 2003). Building on this idea, the selection of presented information within a PA environment is important when assessing effects as individuals interact with a PA environment. Applying this framework, an experimental setting was created to present essential information (nature images or videos) while removing other confounding information (data displays on running distance and speed). This design allowed investigation of the effects of various types of nature-based information on physical, emotional and psychological effects and experience in the three experimental studies. This experimental design created PA environments that were assumed to encourage participants to engage with the manipulated information. Although this experimental setting built on underpinning theory and previous studies (Plante et al., 2006; Pretty et al., 2005), the novel value of this setting was that no verbal instructions were provided for participants to increase their engagement with nature information. The physical activity task was designed to consider the personal differences when examining affordances to increase the likelihood of positive PA experiences for participants. Mixed methods were applied in this thesis, not only for collecting rich information to address research questions, but also for providing novel qualitative data lacking in the literature (McSweeney et al., 2015). In addition, a more representative PA environment was used as a control condition compared to previous research requiring participants to view a blank wall when undertaking PA (Pretty et al., 2005). Self-selected entertainment was used to represent typical gym behaviours instead of asking participants to undertake PA in front of a blank wall which is uncommon in typical gym-based PA environments.

7.1.8 Objective 2: Examine physical, emotional and psychological effects and experiences of two types of nature-based affordances (i.e. a single static and dynamic nature image) for treadmill running (Study 1).

In order to achieve Objective 2, the effects of and experiences in two nature-based PA environments (running with visual-only static or dynamic image) were examined and compared to a self-selected entertainment condition. In these conditions, data on running distance, speed, heart rate and perceived exertion, and two questionnaires (PANAS and SEQ) for assessing mental benefits were collected with follow-up semi-structured interviews. Thirty participants completed three bouts of twenty-minute self-paced treadmill running in three PA environments and sixteen participants from the same pool of participants agreed to take part in a face-to-face audio-recorded semi-structured interview within ten days of the last trial. The comparison of these three PA designs in the same physical setting was believed to advance knowledge on green PA because previous studies mainly investigated differences between urban or nature scenes or indoors and outdoors (Benfield et al., 2013; Plante et al., 2006; Pretty et al., 2005). In addition, the display using dynamic or static information was shown to contribute to different behavioural outcomes (Heft & Nasar, 2000). From an ecological dynamics perspective, the three environments present different information sources for participants to engage with, leading them to accrue different effects and experiences. To be clearer, different information sources formed different affordances and different affordances were expected to lead to the emergence of different behaviours. Running with the self-selected entertainment was the most beneficial environment in this study with extra physical benefits observed alongside the same emotional benefits, such as lower reported levels of anxiety, dejection, anger, and higher levels of excitement and happiness. Participants revealed a good connection developed with their own chosen media in the self-selected entertainment environment. For participants who chose music, the tempo of the music played a major role in leading cadence or providing motivation to run. This interpretation was supported by the asynchronous use of music (Karageorghis & Priest, 2012a) and was aligned with previous research (Barwood et al., 2009; Bharani et al., 2004; Dyrlund & Wininger, 2008; Jones et al., 2014). The rich information sources participants received in the self-selected entertainment condition suggested how a greater functionality of information for affordances can be utilised to accrue PA benefits. Conversely, the static image environment was the least influential condition to enhance physical performance, compared to the other two designed

environments (participants ran the shortest distances and at the slowest speed). This was supported by the interview data because participants experienced shifting attention between external and internal information, especially after the first 5 minutes of the run because they lost interest in the image which was in line with data from a previous study (Brown et al., 2013). Affordances are dynamic and change over time; for example, the first 5 minutes of viewing a static image were more likely to retain participants' attention than the remaining 15 minutes of exercise when the information was no longer useful for participants. When losing interest, different coping methods were reported by participants in the static image environment including self-motivation or increasing speed that can exemplify how individual satisfied task constraints when undertaking PA. Similar emotional and physical benefits were found in the dynamic video condition compared to the other two PA designs. The least compelling psychological effects were found in the dynamic video environment which contradicted an ecological dynamics explanation, because of the richer information sources offered in the dynamic image setting. Interview data suggested that strong engagement with the video was the reason which contributed most to observations of positive and negative effects. For example, the video was considered to offer encouragement for participants to keep running but participants also felt annoyed by the video due to perception-action incongruity. This result advanced knowledge by proposing the use of a dynamic display for immersive experiences, suggesting the need to consider the suitability of presented information in an indoor PA environment. For applications, when designing PA environments, dynamic displays of nature could be more immersive which is advantageous to accruing benefits. Experience of receiving benefits is vital for PA engagement (Scott, 2014). It is important to select presented information to enable retention of the exercisers' interest over time. This would reduce the perception of exertion and increased the probability of positive PA experiences to enhance their future intentions for PA participation (Huberty et al., 2008). Considering that affordances for PA do change over time, PA designers are also recommended to constantly re-assess exercisers' experiences and outcomes in a PA programme or environment, especially with regard to the functionality of designed affordances for participants. This regular re-assessment process would avoid potential production of negative experiences to hamper PA maintenance (Williams, 2008).

7.1.9 Objective 3: Examine physical, emotional and psychological effects and experiences of a range of nature-based affordances (i.e. a collection of ten different nature videos with and without corresponding sounds) for treadmill running based on the findings of objective 2 (Study 2).

Building on the findings of Study 1 and previous literature, the appropriateness of presented nature information needed to be investigated. Particularly, the promising benefits of acoustic information from nature sounds found in previous research with short exposure times, required further investigation (Annerstedt et al., 2013; Wooller et al., 2015). Hence, two different types of nature-based information for indoor treadmill running were created by manipulating the sources of sensory inputs of presented media (the video-sound condition and the video-no sound condition). These two environments were compared to a self-selected audio-only entertainment condition. The reoccurring measurements were taken across physical, psychological and emotional aspects. 24 participants completed all the data collection. Participants were asked to complete three bouts of self-paced twenty-minute treadmill runs under three conditions at a personal comfortable level with one week between conditions. Eight participants from the original pool of participants agreed to participate in a face-to-face audio-recorded semi-structured interview within ten days of the last trial. When explaining findings from an ecological dynamic perspective, the richness level and diversity of information were considered to act as a constraint to guide behaviour and to reveal individual differences (Yeh et al., 2015). With the rich and diverse information in the video-sound condition, participants not only perceived and used visual information but also acoustic information; the presented video seemed to come alive with visual and acoustic information and consequently augmented participant engagement with nature. The well-engaged experience with the nature video not only encouraged physical performance but also accrued mental benefits which suggested the video-sound condition was the most beneficial treadmill environment of the three designed PA environments over short exposure. Participants especially endorsed the positive experiences that emerged when running with a personally-preferred nature video clip. This personally-favoured nature clip was considered to build a strong connection between the video and the participant which was beneficial for creating positive experiences. The diverse presented information was also beneficial, revealing individual differences and avoiding negative effects that occurred during PA. In either visual or acoustic information in the self-selected audio environment or in a video-no sound environment, participants reported a

variety of attention allocation strategies to attend to the physical task, physical states, the presented information and the experimental setting. More negative feelings and opinions were expressed in these two environments compared to the video-sound environment (Brick et al., 2014). The above findings were in line with previous research supporting the relevant use of nature information during PA (Akers et al., 2012; Franco, Shanahan, & Fuller, 2017; Jahncke et al., 2015; Olafsdottir et al., 2017; Pretty et al., 2005). The findings offered advanced information by advocating a greater diversity of information in the PA environment for satisfying a wider population when designing PA environments. The findings suggested that the effectiveness of exercise quality and outcomes could be enhanced when involving multiple information sources with richer information context (nature videos with corresponding sounds) when designing PA environments. In terms of application to PA environment or programme designs, this study proposed to present rich nature information from more than one information source to enhance the PA outcomes and quality of experiences. Personal preference was also noted as a critical factor to enhance PA performance and experience which can be improved by undertaking pre-session discussions or by preparing diverse information options for presentation to satisfy a wider population. This person-centred approach is significant when employing a PA programme or intervention design to promote PA maintenance (Scott, 2014).

7.1.10 Objective 4: Examine physical, emotional and psychological effects and experiences of the new nature-based affordances (i.e. a list of 24 nature videos with corresponding sounds) for treadmill running based on the findings of objective 3 over time (Study 3).

Based in Chapter 4 and 5 and previous literature, further investigation was needed to examine the effect and experience of running with video-sound nature information over longer experimental period. Two PA environments were designed in this study with different presented information including 24 nature videos with sound and self-selected music, to examine the physical, psychological and emotional effects over time. Reoccurring measurements were taken in this study across physical, psychological and emotional aspects. 9 participants were allocated to the nature group and 6 participants were in the self-selected music group. These two groups were asked to perform 12 bouts of twenty-minute self-paced treadmill runs over 6 weeks (2 sessions a week). All participants agreed to take part in follow-up interviews within one week after the last

trial. When discussing findings from an ecological dynamics perspective, the most noticeable finding was the development of a "personalised approach" by participants in this study. This can be viewed as an example showing how human behaviours self-organise in satisfying task, environment and individual constraints. The nature group found "their own ways" to perform the physical task by recognising personally-preferred videos and developing different running stages. This individual-specific behaviour was developed over time and reported in the nature group only. This piece of information is unique and novel in the field of green PA which showed promising benefits for application to elicit behaviour change in PA programme design. These two groups showed similar physical outcomes with distinct running profiles over the twenty minute running periods and different mental benefits which suggested distinct PA experiences. The similar physical performances (running distance, speed and energy expenditure) were achieved between the two exercise groups with higher exertion level reported in the music group over time. The nature group achieved greater post-run psychological benefits throughout 12 sessions whereas the music group reported significant post-run emotional benefits on anxiety (until session 8), excitement (throughout 12 sessions) and happiness (throughout 12 sessions). Such findings also indicated how different information for affordances could accrue different outcomes (the nature group received psychological benefits with lower exertion levels, whereas music group received emotional benefits with higher exertion levels). The different utilisation of information (for affordances) also created distinct experiences. The nature group immersed themselves in the nature video and picked up features and details from the video which led to lower exertion and greater psychological benefits. The music group used their television reflection and music for correcting running form and leading cadences which led to emotional benefits and higher exertion. This study added novel knowledge relevant to the field of green PA about related effects and experiences over a longer period. When translating findings into practice, the use of nature information for treadmill running was found to more greatly reduce levels of perceived exertion than the use of self-selected music. This finding can be used to provide a more beneficial experience for populations who perceive exertion as a barrier during PA. The study also advocated the flexibility of PA environments or programmes to allow participants to adjust or develop individual-specific behaviours to improve PA maintenance, especially over time.

7.2 *ADVANCING KNOWLEDGE OF GREEN PA*

As the aforementioned section summarised how different objectives were achieved to satisfy the research aim, novel knowledge of green PA was found in this thesis. Theoretically, the proposal of an ecological dynamics perspective for examining PA seems to offer a more inclusive consideration of the interactions of the environment, PA and individual. Other contemporary theories tend to emphasise or neglect these aspects (e.g., see the biophilia hypothesis, stress reduction theory, attention restoration theory, social cognitive theory, the transtheoretical model and behavioural epidemiology framework).The ecological dynamics framework not only allows rigorous examinations of numerous types of nature-based information for indoor green PA but also offers the principles to formulate the experimental setting including the selection of presented and removed information and explanations for observed effects. Methodically, the created physical setting in this thesis was a vital step to illustrate the powerful influence of the physical environment to the shaping of human behaviour. The improvement of the control PA condition was considered to be more representative for typical indoors PA condition compared to the control condition used in the literature (Plante et al., 2006; Pretty et al., 2005). The employment of mixed methods also provided richer information for the research question. Each study contributed to knowledge by offering novel information for suggestions. In Study 1 (Chapter 4), the suitability of the presented nature-based information for green PA was found to be critical and the use of dynamic display of nature information was suggested to be more likely to enhance participants' engagement with nature for future research. This study showed how information influences behaviours and indicated that the type of display format and the content of presented information required careful consideration. In Study 2 (Chapter 5), the use of multiple video with sounds as the most beneficial PA environment was endorsed by participants. This observation advanced our understanding of the influential value of rich and diverse nature information when designing PA environment. In addition, the important role of personal preference of presented information for PA was also identified for future research. Such statements were supported by the information utilised for affordances which was rich and based on individual differences. The effects and experiences of a preliminary examination with extended time lengths of green PA participation were presented in Study 3 (Chapter 6) suggesting the development of personally-favoured PA behaviour over time. This finding evidenced how human behaviour emerged from three interacting constraints, including individual differences,

from an ecological dynamics perspective. The prolonged experimental period designed in Study 3 was needed to reduce the risk of novelty effects of green PA in the literature. The development of personally-favoured PA behaviour was novel information which can be used to improve PA programme design in the future. Overall, this programme of research improved understanding of the experience and effects of careful and systematic examinations of different richness of nature-based information for green PA over different time lengths. The findings of this thesis advanced knowledge applied to PA programmes or environment designs with a higher possibility of creating positive experiences using green PA for PA initiation and maintenance. Such information was believed to contribute to the development of efficient methods to tackle physical inactivity and mental disorders for city residents in highly urbanised society

7.3 *PRACTICAL IMPLICATION*

There are practical implications from the findings of this thesis, which would help to inform green PA programme design. Firstly, the results of this thesis proposed the critical role of personal preference of the presented information to create positive and pleasant PA experiences. This positive experience can be influential for PA maintenance (Allen & Morey, 2010). Personal preferences were also found to be useful in creating positive experiences. Therefore, for PA programme designers, it might not be practical to create a set of individual-specific nature-based information for different people because the workload and material preparations might not be affordable or too time-consuming. However, it is possible to increase the diversity and richness of the presented nature-based information for different exercisers to raise the likelihood of satisfying personal needs. It might be feasible to prepare a list of nature videos for exercisers to select before the PA to achieve the same purpose. Secondly, the finding indicated that removed running related information, such as distance, speed and heart rate may cause negative effects initially but conversely participants were able to engross themselves in the presented nature-based information which negated the physical tiredness. This manipulation of removed non-essential information might shift participants' attention to external information and is more likely to create pleasant PA experiences. This might be a crucial step for sport psychologist or PA intervention designers to apply when planning or undertaking exercise programmes, especially for inactive or overweight people who might oppose any type of exercise or have a higher tendency to drop out. Finally, for gymnasium or exercise facility designers, the

inclusion of a variety of nature-based information showing on the exercise facilities, such as treadmill, stationary bike or elliptical cross trainers should be taken into consideration for further action.

Although it was not the purpose of this programme of research to advocate undertaking PA indoors, this thesis supported the use of indoor environments designed for green PA to promote physical health and mental wellbeing. This is believed to be useful for people who have limited accessibility to outdoor environments in nature or those with safety concerns in visiting outdoor green spaces, such as the elderly, disabled people or people with medical conditions. It also seems beneficial for people with time constraints to create a similar PA environmental at home to maintain or improve PA and wellbeing with improved accessibility. The designed PA environment in this thesis is easy to recreate at home with a limited requirement to have access to the Internet for nature information. With the positive effects and experiences observed from 5 types of green PA in this thesis, people can choose the appropriate mode of green PA, depending on their own situation. Furthermore, the lower exertion effect of green PA found in this thesis might be particularly favourable for people perceiving PA as barrier and an experience lacking enjoyment (Costello, Kafchinski, Joellen, & Sullivan, 2011).

7.4 *FUTURE RESEARCH*

The studies conducted in this programme of research have advanced the understanding of green PA. However, there are a number of potential future studies outlined in this section that could be undertaken to further advance this knowledge.

Firstly, regarding exercise duration and time length of the experimental period, as the three studies conducted in this research have exposed exercisers for short duration (twenty minutes) in the frequency of once a week or twice a week (forty minutes), these two exercise durations were not long enough to meet the 150 minute moderate intensity of PA per week (World Health Organization, 2010a). Therefore, longer exercise duration of green PA can be a direction for future research to advance the understanding of the efficient time length of nature-based information. Because of time constraints, participants were recruited to perform the green PA over 6 weeks in Chapter 6 which might not be sufficient time length to apply green PA for behaviour change intervention. Hence, further examinations of green PA over a longer experimental period such as more than 12 weeks would be needed to affirm the effects of green PA

for behaviour change. Unfortunately, there has been no follow-up phase to track effects of green PA over a longer timeframe involving in the three conducted studies in this thesis which would be an important direction for research to offer this valuable information to construct a more comprehensive understanding of green PA

Regardless the endeavour to examine the effects of green PA over time, low numbers of participants were recruited in Chapter 6 which would require further investigation with larger sample to confirm the effects of green PA over time. With the consideration of practical implications for general population, participants recruited in the programme of research were mixed with various physical abilities. Furthermore, different age groups might react to nature-based information differently, especially the young generation in the modern society spending more time on screen-based activities while more elderly people enjoyed spending time on gardening or allotments. Different age groups also have different effectivities in perceiving and utilising affordances and result in different PA experiences and outcomes even in the same PA environment.

Studies in this thesis have examined two different sensory inputs (visual-only and visual-audio) to offer nature-based information for green PA which leave the understanding of the effects of other sensory components, for example, olfactory or haptic information for green PA unclear. Nature-based olfactory information can be a critical sensory component for relaxation or calmness, especially the popularity of the oil massage. Furthermore, there are no empirical studies which have systematically examined the effects of different combinations of each type of nature-based information for green PA, including visual-audio, visual-olfactory, audio-olfactory or visual mixed with audio-olfactory information.

For the ultimate goal to promote PA and mental health, it is recommended conducting a field study, such as a local gymnasium or fitness centre with a large sample size for numerous time frames.

7.5 *RESEARCH LIMITATIONS*

Throughout the whole thesis, limitations were discussed. The criteria for participants' recruitment in each empirical study remained the same because of the desire to generalise the findings to the general population. However, the different populations, such as trained or untrained exercisers, active or inactive participants might react or perform differently in the same PA environment in terms of PA experiences or

outcomes. Other factors, such as the intensity level and duration of PA may have also contributed to different PA outcomes and experiences observed in this thesis. The nature information used in this thesis was limited to visual or visual-acoustic sources in nature videos which can be explored further with the inclusion of scents and fragrances of nature in future research. With the mixture of participant backgrounds (university students and other occupations), participants might have been influenced by external factors (such as assignments or exams) during data collection. This is especially true of data collection in Chapters 6, which was conducted from February to April. In order to increase the merit of application of this thesis, the presented information (nature videos) were downloaded from YouTube which placed limitations on the available videos choices. Longer experimental periods for green PA is needed in future studies, for example, over 12 weeks or 6 months, to strengthen understanding of green PA applied to health behaviour interventions (Samdal et al., 2017).

7.6 *THESIS CONCLUSION*

Seeking to advance the development of effective promotion methods for physical health and mental wellbeing in urban residents, this thesis aimed to examine the physical, emotional and psychological effects and experiences of different nature-based affordances using indoor treadmill running with a mixed-methods research design. An ecological dynamics perspective was proposed to guide experimental designs for presenting essential information and removing confounding information based on the concept of affordances and interacting task, environmental and personal constraints. Theoretical explanations were offered by discussing how information would be perceived and utilised to form affordances and regulate behaviours, with individual differences, under the three interactive constraints. With the improvement of study design, especially the more representative control condition, these findings of this thesis endorsed the efficiency of a well-designed indoor PA environment to accrue physical, psychological and emotional benefits of green PA for treadmill running over short or moderate periods of time. The use of mixed methods was also providing rich information which was lacking in the existing literature. Findings in the thesis suggested the essential considerations of the appropriateness and diversity of presented information with the inclusion of dynamic presentation and nature sounds as well as personal preferences for full immersion when designing green PA programme. The flexibility of developing individual-specific exercise behaviours during green PA were

also an important consideration when designing PA environments or programmes, especially over time. These particular suggestions are noteworthy when designing PA environments or programmes, and are more likely to enhance performance and create positive experiences contributing to PA maintenance and adherence. The low cost and ease of duplication of the designed setting in this thesis is also considered as a practical benefit to overcome barriers to PA, such as accessibility, time constraints and safety concerns.

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Appendix 1. Information sheet

Sheffield Hallam University | Centre for Sports Engineering Research

Participant Information Sheet: Physical, psychological and emotional benefits of indoor treadmill running

Thank you for expressing your interest in taking part in this study. This study aims to examine the effects of indoor running on a treadmill while viewing different media on physical, emotional, and psychological variables. You will be asked to complete several questionnaires. We are aiming to recruit healthy adults with no current injuries affecting running capacity, aged 18 years and above.

The task will be conducted in the biomechanics laboratory, Collegiate Campus, Sheffield Hallam University during summer 2015. You will be asked to perform three different sessions of twenty minutes each running on a treadmill at your comfortable speed in the laboratory. The three conditions will be running on treadmill while viewing: 1) a static image projected on to a wall in front of the treadmill, 2) a natural video projected on the same wall, and 3), self-selected entertainment of your choice, such as listening to music, watching a TV programme or a movie or looking at a blank wall. There will be three trials for participants to perform (one trial for each condition) presented in a random order.

Once you arrive at the laboratory, you will be given a full explanation about the study before any tests start. The researcher will answer any questions you may have related to the study. Your consent form and relevant background information will be collected. The researcher will explain the whole experiment procedure and put on a heart rate monitor and you will need to complete three pre-test questionnaires. There will time for you to familiarise yourself on the treadmill running and warm up. After testing, you will have time to cool down and fill in post-test questionnaires. Each trial will approximately take one hour to complete. Therefore, the total time required from you will be 3 hours and an extra 2 to 4 hours to conduct interviews on later days. You will be asked about your willingness for the interviews but the researcher will contact you again if interviews are needed.

All digital and non-digital data will be protected and placed in a locked cabinet and only used for academic purposes. The data will be kept confidentiality for ten years after publication and anonymised, so no individual will be identifiable from it. No one will get access to the data without getting approval from you and the member of the research team. All data will be analysed and written up for conference presentations, journal articles and a dissertation. If you are keen to receive further information and results, the researcher will provide the following academic output and information. You are free to withdraw from this study at any time for any reasons and you are not required to give a reason.

Thank you very much for your interest, Tam

If you have any questions, please contact the researcher.

Hsiaopu Yeh (Tam) PhD student in Centre for Sport Engineering Research

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Appendix 2. Participant consent form

PHYSCIAL, PSYCHOLOGICAL AND EMOTIONAL EFFECTS OF DIFFERENT AFFORDACNES IN INDOOR RUNNING.

	YES	NO
1. I have read the Information Sheet for this study and have had details of the study explained to me.	☐	☐
2. My questions about the study have been answered to my satisfaction and I understand that I may ask further questions at any point.	☐	☐
3. I understand that I am free to withdraw from the study within the time limits outlined in the Information Sheet, without giving a reason for my withdrawal or to decline to answer any particular questions in the study without any consequences to my future treatment by the researcher.	☐	☐
4. I agree to provide information to the researchers under the conditions of confidentiality set out in the Information Sheet.	☐	☐
5. I wish to participate in the study under the conditions set out in the Information Sheet.	☐	☐
6. I consent to the information collected for the purposes of this research study, once anonymised (so that I cannot be identified), to be used for any other research purposes.	☐	☐
7. If you meet our criteria for following interviews, would you agree to take part?	☐	☐

Participant's Signature: _____ Date: _____

Participant's Name (Printed): _____

Contact details:

_____

_____

Researcher's Name: HSAIOPU YEH

Researcher's Signature: _____

Researcher's contact details:
Hsiaopu Yeh. The Centre for Sport Engineering Research
Sheffield Hallam University/ Faculty of Health & Wellbeing/Room S001/Chestnut court/Collegiate Crescent/ Sheffield S10 2BP
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Please keep your copy of the consent form and the information sheet together.

Appendix 3. Physical activity readiness questionnaire

Sheffield Hallam University | Active

Physical Activity Readiness Questionnaire (Par-Q)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

First Name		Sex	Male / Female
Surname		Date of birth	

Common sense is your best guide when answering these questions. Please read the questions carefully and answer each one honestly by ticking the appropriate box:

1.	Has a doctor ever stated that you have a heart condition and that you should only do physical activity recommended by a doctor?	Yes ☐	No ☐
2.	Do you feel pain in your chest when you do physical activity?	Yes ☐	No ☐
3.	In the past month, have you had chest pain when you were not engaged in physical activity?	Yes ☐	No ☐
4.	Do you lose your balance due to dizziness or do you ever lose consciousness?	Yes ☐	No ☐
5.	Do you have a bone or joint problem which could be made worse by a change in your physical activity?	Yes ☐	No ☐
6.	Are you presently taking any medication for blood pressure or heart condition?	Yes ☐	No ☐
7.	Do you know of any other reason why you should not do physical activity?	Yes ☐	No ☐

If you answered YES to one or more of the above questions, talk with your doctor BEFORE you start becoming more physically active. Tell your doctor about the PAR-Q and which questions you answered YES.

If you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better. If you are or may be pregnant – talk to your doctor before you start becoming more active. If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

SAFETY AGREEMENT

I acknowledge that there are risks and dangers inherent in physical exercise and declare that I know of no reason why I should not take part in moderate exercise. I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction.

I understand that any exercise taken is at my own risk and I agree to waive any legal recourse (other than for negligence) for any damages to myself arising from my participation. I also agree to follow any verbal instructions given by the fitness staff and to observe any written notices regarding safety whilst visiting the facilities at SHU.

Signed		Date	

Appendix 4. Sport emotion questionnaire

Below you will find a list of words that describe a range of feelings that sport performers may experience. Please read each one carefully and indicate on the scale next to each item how you feel right now, at this moment, in relation to the completed competition. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best describes your feelings right now in relation to the completed competition.

	Not at all	A little	Moderately	Quite a bit	Extremely
Uneasy	0	1	2	3	4
Upset	0	1	2	3	4
Exhilarated	0	1	2	3	4
Irritated	0	1	2	3	4
Please	0	1	2	3	4
Tense	0	1	2	3	4
Sad	0	1	2	3	4
Excited	0	1	2	3	4
Furious	0	1	2	3	4
Joyful	0	1	2	3	4
Nervous	0	1	2	3	4
Unhappy	0	1	2	3	4
Enthusiastic	0	1	2	3	4
Annoyed	0	1	2	3	4
Cheerful	0	1	2	3	4
Apprehensive	0	1	2	3	4
Disappointed	0	1	2	3	4
Energetic	0	1	2	3	4
Angry	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4
Dejected	0	1	2	3	4

Appendix 5. Positive and negative affect scale

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. **Indicate to what extent you feel this way right now, that is, at the present moment (circle the instructions you followed when taking this measure)**

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

_____ 1. Interested
_____ 2. Distressed
_____ 3. Excited
_____ 4. Upset
_____ 5. Strong
_____ 6. Guilty
_____ 7. Scared
_____ 8. Hostile
_____ 9. Enthusiastic
_____ 10. Proud
_____ 11. Irritable
_____ 12. Alert
_____ 13. Ashamed
_____ 14. Inspired
_____ 15. Nervous
_____ 16. Determined
_____ 17. Attentive
_____ 18. Jittery
_____ 19. Active
_____ 20. Afraid

Appendix 6. List of nature videos

Study 2

I. Relaxing 3 Hour Video of Tropical Beach with Blue Sky White Sand and Palm Tree

https://www.youtube.com/watch?v=KUgrBTNbSe4

II. Sounds of life - Sheep Grazing in the Field - Germany - HD

https://www.youtube.com/watch?v=YTls8LsBWBg

III. 8 Hours Nature Sounds Relaxation-Bluebell Woods Birdsong Relaxing Meditation Forest Sounds

https://www.youtube.com/watch?v=v9P7kIH3a3E

IV. Sounds for Cats to Listen To and Sleep - Birds Being Awesome : Longest Bird Video on Youtube

https://www.youtube.com/watch?v=z_17VlRYjrE

V. Relaxing Sounds of Water Stream 60mins (The Sounds of Nature)

https://www.youtube.com/watch?v=zVXnoIoWu88

VI. Bird Songs Relaxing - 2 Hours - Sound of Nature

https://www.youtube.com/watch?v=Ue9DyRhtXMA

VII. Rain Sound and Rainforest Animals Sound - Relaxing Sleep

https://www.youtube.com/watch?v=8myYyMg1fFE

VIII. 1 Hour Relaxing Sound of Water-Nature Sounds Meditation Relaxation W/O Birdsong-Relax-Calming

https://www.youtube.com/watch?v=RwZ75skpcLI

IX. "Wave Sounds" 60min Sunrise at "The Beach"

https://www.youtube.com/watch?v=ers6wBc_SwQ

X. 8 Hours Relaxing Nature Sounds for Studying-Birdsong Relaxation-Bird Singing

https://www.youtube.com/watch?v=1HQZKjlxcts

Study 3

1. The Ultimate Videos of Birds for Cats To Watch

https://www.youtube.com/watch?v=fBCAOjAS9d4

2. The Ultimate Videos of Birds for Cats To Watch

https://www.youtube.com/watch?v=fBCAOjAS9d4

3. Bird Songs Relaxing - 2 Hours - Sound of Nature

https://www.youtube.com/watch?v=Ue9DyRhtXMA

4. Sounds of life - Sheep Grazing in the Field - Germany - HD

https://www.youtube.com/watch?v=YTls8LsBWBg

5. 1 Hour - Nature Sounds - White Noise - Birds - Forest - Relaxing - Ambience - Ambient

https://www.youtube.com/watch?v=NZQqPU07Tm0

6. Relaxing Nature Sounds Birds Singing In The Morning Forest for Deep Sleep Relaxation Meditation

https://www.youtube.com/watch?v=KwF03xd_IXo

7. Walking in forest - One hour of relaxing forest sounds(Real Background Video)

https://www.youtube.com/watch?v=V8QS-OwFIYo

8. In the Heart of Nature - 1 hour Relax Sound, Forest Sound FULL HD

https://ww.youtube.com/watch?v=5FQjuoOBObA

9. 8 Hours Nature Sounds Relaxation-Bluebell Woods Birdsong Relaxing Meditation Forest Sounds

https://www.youtube.com/watch?v=v9P7kIH3a3E

10. 8 Hours Relaxing Nature Sounds for Studying-Birdsong Relaxation-Bird Singing

https://www.youtube.com/watch?v=1HQZKjlxcts

11. Endless Tranquility - 22min 4K Nature sounds and Landscape

https://www.youtube.com/watch?v=sQ0tTMYLyko

12. 4 Hours Mountain Stream - Relaxing Nature Sounds

https://www.youtube.com/watch?v=Zsqep7_9_mw

13. Nature Sounds: High Mountain Footage (Relaxing/ASMR-ish)

https://www.youtube.com/watch?v=X7DYMmlYuT4

14. 1 Hour of Relaxing Ocean Waves at Sunset (HD)

https://www.youtube.com/watch?v=_ziUhNerFMI

15. Relaxing 3 Hour Video of a Mountain Stream

https://www.youtube.com/watch?v=KEAwbnMs8ts

16. Very Relaxing 3 Hour Video of SMALL Waterfall

https://www.youtube.com/watch?v=RlLSVBBAeag

17. Relaxing 3 Hour Video of a Waterfall on an Ocean Beach at Sunset

https://www.youtube.com/watch?v=fIlJyZEbrzo

18. Relaxing 3 Hour Video of A Tropical Beach with Blue Sky White Sand and Palm Tree

https://www.youtube.com/watch?v=qREKP9oijWI

19.Relaxing Videos & Nature Sounds For Stress Relief, Studying & Sleep - Beautiful Beach Relaxation

https://www.youtube.com/watch?v=LvRRTqpseIg

20. video 2 relax – breathtaking lonesome Indian Ocean Beach: Relaxing video with nature sound

https://www.youtube.com/watch?v=nPZZJdBFFDI

21. Rain Sound and Rainforest Animals Sound - Relaxing Sleep

https://www.youtube.com/watch?v=8myYyMg1fFE

22. Relaxing Sounds of Water Stream 60mins (The Sounds of Nature)

https://www.youtube.com/watch?v=zVXnoIoWu88

23. 8 Hours Relaxing Sounds of Nature-Bird Sounds-Water Sounds-Waterfall-Birds singing

https://www.youtube.com/watch?v=-Ej1B3U4lBI

24. 1 Hour Relaxing Sound of Water-Nature Sounds Meditation Relaxation W/O Birdsong-Relax-Calming

https://www.youtube.com/watch?v=RwZ75skpcLI

Appendix 7. Data collection sheet

Experiment record sheet

Date		Time			
Participant					
weight		Height		DB	

Instruction (experiment) ☐ Consent ☐

Resting HR (Polar) ☐ _____ Background Information ☐

Questionnaires

PANAS ☐ set-up information ☐

Sport emotion ☐

Running (30 minutes)

Video running ☐ Polar ☐

Warm up ☐

Cold down ☐

Distance _____ Start time _____

Speed

0:0	1:	2:	3:	4:	5:
6:	7:	8:	9:	10:	11:
12:	13:	14:	15:	16:	17:
18:	19:	20:			

Perceived exertion (during run)

0		5		10		15		20	

Questionnaires-post

PANAS ☐

Sport emotion ☐ Interview wiliness ☐

Appendix 8. Interview guide

1. Could you please briefly share with me your experience regarding the participation of this study?
2. What was your focus while running with the three different conditions?

   Follow-up questions:

   - Did you notice any differences of the run from session to session
   - What were you looking at when running with music/ nature video
   - What were you thinking when running on the treadmill with video/ image/ music
   - Which video/ music did you choose, Why
   - What did you pay attention to the video/ music, does it change
   - Did you recall anything from past experience
   - Please tell me more about how you think this came about.
3. How did you run with music/ video?

   Follow-up questions:

   - What did you find out in each condition
   - Did you notice anything physically or mentally
   - Did you think you perform similar in three conditions
   - Did you experience any changes in your body during physical activity
   - How did you get over this twenty-minute run
   - How did you interact with the environment
4. How about your feelings or emotions across three conditions?

   Follow-up questions:

   - When you experience the feeling/thought that you mentioned before
   - Could you please tell me more about it
   - Why did you feel the emotions this way
   - How did you feel in the beginning and after the run
   - What was it about the environment that facilitated the feelings
   - What did you think these two conditions (with and without music)
5. What did you think about the physical environment?

   Follow-up questions:

   - About the indoor space

- About the viewing mediums
- About the task
- How would you say the differences between different clips of the nature video
- Could you please tell me more about it

6. Why did you choose this type of self-selected entertainment?
7. Did participate in this study have any influence for your daily exercise pattern? Why?
8. Was there anything you would like to share with me that has not been asked before?

Appendix 9. Ethic approval for Study 1

Research Ethics Checklist (SHUREC1) (Ref No HWB-S&E-35)

Wallace, Sue on behalf of Wallace, Sue

Follow up. Start by 03 August 2017. Due by 03 August 2017.

Sent: Tue 11/08/2015 12:35
To: Yeh, Hsiaopu
Cc: Davids, Keith

Dear Hsiaopu

I acknowledge receipt of your Research Ethics Checklist (SHUREC1) for the following proposed research:

Physical, psychological and emotional benefits of indoor treadmill running.

I will register the details with the Faculty of Health & Wellbeing Research Ethics Sub-Committee.

Kind regards
Sue
Faculty of Health & Wellbeing Research Ethics Sub-Committee Administrator

Sue Wallace
Senior Administrator

Sheffield Hallam University
A017, Collegiate Hall,
Collegiate Crescent,
Sheffield S10 2BP

Telephone +44 (0)114 225 5628
email: s.wallace@shu.ac.uk

Appendix 10. Ethic approval for Study 2

Research Ethics Checklist (SHUREC1) (Ref No HWB-S&E-65)

Wallace, Sue on behalf of Wallace, Sue

Follow up. Start by 11 May 2016. Due by 11 May 2016.
You replied to this message on 29/04/2016 09:07.

Sent: Thu 28/04/2016 15:41
To: Yeh, Hsiaopu
Cc: Davids, Keith

Dear Tam

I acknowledge receipt of your Research Ethics Checklist (SHUREC1) for the following proposed research:

Comparison of affordance-based designs for indoor treadmill running.

I will register the details with the Faculty of Health & Wellbeing Research Ethics Sub-Committee.

Kind regards
Sue

Sue Wallace
Faculty of Health & Wellbeing Research Ethics Sub-Committee Administrator

Health and Wellbeing Research Institute

Sheffield Hallam University
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Telephone +44 (0)114 225 5628
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Appendix 11. Transcription example

Interview Transcription 17th

Question 1: Can you briefly share these three different experiences?

A: The first condition was the video-only condition. I quite enjoyed that one. It was kind of the environment that I run usually but having the laboratory sound was a bit jarring. You got a video cue but the audio cue doesn't match. So, it was more jarring than without the video. The next one was listening to my pod cast and I found that was a bit difficult because I usually run without any headphone on or without any sounds. So, I can hear my feet steps and what's going on around me. So, that was the one I enjoyed least and I found it most difficult as well. I consciously think of time. Is it over yet? Whereas the third one, the video and sound one, which match the video. That one, I really enjoyed it and I am kind of forgetting that I was running as such on the treadmill. Obviously you know you are on a treadmill but the distraction was enough and I didn't feel as tired compared to the other two. I was happy and I can have got on much longer on that one. But on the audio-only condition, I was really feeling tired because I was not interesting in it. That's what I felt of the three.

Q: When you listened to the pod cast, were they only people talking?

A: I was listening to Brain Cox and they were talking about the Frankenstein. So, they had like a panel: him, two other scientists and comedian in front of the audience. They just chatted to each other, so, it was kind of like talking. There is no like cadences to run to it. Which is a bit…, I don't enjoy that so much. Maybe that wasn't the right choice to listen to.

Q: why you chose this type of audio information?

A: Probably that's because it was I listened to in the lab. That's what I normally listened to when I work. I don't really listen to any sound or music when I am running.

Q: What do you mean by enjoy in the first condition?

A: It is just kind of nice to watch something of nature. It is like the environment I run. I felt more relaxed in that one.

Q: if we compare the three, you mention that you enjoyed the last one as well?

A: yeah, the last one with the corresponding sound, the nature sound and the nature video, that's the one I enjoy most, then the visual-only and then the sound-only at the bottom.

Q: If we talked about the first one, what were you thinking in that condition?

A: I just kind of like looking around and watching the video. I noticed that I was running on the treadmill more than the final condition but less than the second condition. It is kind of just looking different parts of the video. Looking around and I was realising that I was on the treadmill and noticing that you were kind of being pull back by the treadmill. I was noticing that more.

Q: When the clips change, did you feel differently?

A: Some of them are more than others, I guessed. I can't remember which one specifically. It was kind of motivation tour all the way. Because you know that clips were only two minutes long. When it changed and you know that another section, so, you can kind of gauge how were you doing in that. Obviously I don't know the different time steps for each clip but it was kind of motivational thing.

Q: do you have different preference of different clips?

A: yeah, I can't remember which on specifically now. I remember there is one by a gorge or some kind of river thing and the rain, I quite enjoy and some forest ones. I remember the sheep that was quite.(Laughed).

Q: Did you change the speed or run differently when the different clips come on?

A: I think the speed remain constant in the first one (visual-only). I think I just set it to where I felt was a comfortable pace and ran at that pace for twenty minutes.

Q: when different clips come up, did you recall anything past experiences?

A: Nothing specific, maybe the one where there is a kind of stream and where I used to run near a reservoir. There is a really small footpath. It was like a stream filling into the reservoir on the side. It was kind of like that.

Q: In the first condition, do you aware about running or thinking about run?

A: I can't recall but I think I probably did actually. Because I can see and notice my reflection in the TV and I tried to correct my form (physical environment-the lab). I can see myself from the top of the TV which is black.

Q: Even you were watching images, a part of you still try to correct your form?

A: yes, I think that I did it while running anyway. So, it was not intrinsic to while I was watching the TV. It was like when you looked at the TV and you can kind of seeing your reflection but it was very faint and it was kind of just to jog your memory - pun intended.

Q: if we said the visual area, where were you looking at?

A: I was kind of centre mostly. The sheep one was the most distinctive cos I kept remembering if there is one walking the other side and you were kind of noticing it and then I just back to the centre.

Appendix 12. Ethic approval for Study 3

Research Ethics Checklist (SHUREC1) (Ref No HWB-2016-17-S&E-11)

Wallace, Sue on behalf of Wallace, Sue

Follow up. Completed on 03 August 2017.

Sent: Tue 13/12/2016 15:40
To: Yeh, Hsiaopu
Cc: Davids, Keith

Dear Hsiaopu

I acknowledge receipt of your Research Ethics Checklist (SHUREC1) for the following proposed research:

The effects of nature-based affordances environment of indoor treadmill running over time.

I will register the details with the Faculty of Health & Wellbeing Research Ethics Sub-Committee.

Kind regards
Sue

Sue Wallace
Faculty of Health & Wellbeing Research Ethics Sub-Committee Senior Administrator

Health and Wellbeing Research Institute

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