Physical activity in nature: an ecological dynamics perspective

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Reference: Yeh, H.P., Araújo, D., Brymer, E. & Davids, K. (2021). Physical Activity in Nature: An Ecological Dynamics Perspective. In E. Brymer, M. Rogerson & J. Barton (Eds), Nature and Health: Physical in Nature, pp.112-126. London: Routledge.

1. Introduction - the complex and co-influenced relationship between humans, nature and physical activity

Recalling your last visit to nature, whether it was walking, mountain biking, climbing, horse riding, sailing, kayaking or other activity undertaken in the mountains or woodlands, sea or reservoir, you likely observed and detected differences or changes that existed in the environment. These noted differences might have encouraged you to change the way you behaved or felt. Such differences were likely associated with the weather, temperature, sunlight, natural views, ground situations or other organisms. It is also likely personal factors such as physical fatigue, mood, expectations, or purposes, impacted on your physical activity. If you were with companions it is also possible that they would contribute to the way you behaved. The physical activity itself (intensity, duration and type) can also influence the experience or outcome of the visit. For these reasons and more exploring the impacts of physical activity in nature is complex and requires a comprehensive underpinning theoretical framework to analyse and explain the processes and outcomes. The ecological dynamics framework is a robust and comprehensive approach to explore physical activity in nature (Araújo, Brymer, Brito, Withagen, & Davids, 2019; Brymer & Davids, 2013; Brymer et al., 2014; Davids, Araújo, & Brymer, 2016; Yeh et al., 2015). The ecological dynamics framework integrates ecological psychology and dynamical systems theory, with three features of significance for understanding human behaviour: emergence of behaviours from multiple subsystems, interacting constraints, and affordances. This approach emphasises the interplay among the interaction of ***individual, environment, task*** categories of constraints, when perceiving and realising ***affordances*** (i.e., possibilities for action) offered by the natural environments to exercisers.

This chapter aims to elucidate salient points from the ecological dynamics framework for understanding the impact of physical activity in nature and offer research or intervention suggestions. A particular emphasis is placed on the role of affordances in nature, and how consequently the perception-action couplings they offer can be captured and influenced.

2. Affordances - the offerings from the physical environment

Gibson defined affordance as”

> The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill. The verb to *afford* is found in the dictionary, but the

> noun *affordances* is not. I have made it up. I mean by it something that refers to both the environment and the animal in a way that no existing term does. It implies the complementarity of the animal and the environment. (Gibson 1979, p127).

The notion of affordances suggests that the relationship between the individual and the environment invites behaviours. For example, a flat, extended and rigid grass surface invites various activities, such as walking, running or lying. But if a flat, extended and rigid surface is made of ice, the affordances might change depending on the organism. Humans might be too heavy for the surface to support but for light bodyweight animals, such as rats or cats, this ice surface is still walk-on-able, run-over-able or lying-down-able. In this example, humans can still detect the function of support from this ice surface but would refuse to use because of safety concern. This example shows that affordances abundantly exist in an environment for individuals with different capacities to perceive or utilised them. The existence of objects in the environment might or might not offer affordances, i.e., *meaningful* interactions for a certain function. The ice surface previously noted might not be functional for humans to perform physical activity, but the scenery of an ice surface might reflect the clear blue sky and clouds which provides a chance for humans to see a natural beauty. Gibson (1979) mentioned that affordances cannot be measured in the same way we might attempt to measure phenomenon in physics as environments might offer more than one affordance for organisms to detect and utilise. For example, a chair can be used as a seat, a table when putting paper on it for writing, a temporary ladder when need to reach high, a weapon to attack people when needed and a tool to perform a dance or stretch your body. The utilisation of affordances would vary between organisms even for the same individual at different times. Similarly, the same environment can be used differently and used for different purposes. In the study conducted by Duzenli, Bayramoglu, and Ozbilen, (2010), affordances provided for adolescents by different urban environments for the psycho-social needs of adolescents were analysed. The youths used the city centre for shopping, recreation and being with friends and schools offer the functions of trying new activities, obtaining new information and hanging out. This shows the various function of affordances offered by the same space to the adolescents.

Any objects or properties in the environment provide affordances related to the animal's capabilities when using them. When we learn to perceive a given affordance, we learn to perceive the *information* about the world conveyed by ambient light, sound, and odour as ambient patterns of energy (Gibson, 1986). We learn to detect what is offered by the

environment which confers *meaning on information* that is detected and related to what can be affected (Gibson & Pick, 2000). Here, instead of simply detecting the object by its physical features, such as colour, shape, size or quality, we are actually detecting the offerings from this object as a whole from various variables. For example, a stick can be grasped or wielded. A building block can be grasped or thrown. In Figure 1, you can see how a public seat offers additional action possibilities when it is detected for different meanings or functions. Children detected the functions for playing, climbing, sliding and walking rather than simply sitting.

Figure 1. A public seat used by children for playing rather than sitting.

Humans learn to perceive and realise affordances from an early age and continue to develop skills in perceiving and acting upon affordances throughout the lifespan (Gibson & Pick, 2000). Infants can only perform limited physical activity and communication, but they actively perceive their surroundings and act on it when possible. Considering perception and action is closely intertwined, infants start to perform exploratory movements to gain knowledge of environmental possibilities, affordances and capabilities. They also learn to pick up distinctive features to differentiate various types of information via exploratory activity (Gibson & Pick, 2000). During the perceptual learning, human learn how to perceive a selection of affordances, such as how far we can reach, how heavy we can carry or how high we can step over, etc. These body-scaled affordances have been studied for various actions, such as reachability (Huang, Ellis, Wagenaar, & Fetters, 2013; Ishak, Adolph, & Lin, 2008), barrier crossing ability

(Snapp-Childs & Bingham, 2009), ability to walk under barrier (Wagman & Malek, 2008) or the ability to jump and reach (Ramenzoni, Davis, Riley, & Shockley, 2010).

As we develop, we continuously gain an understanding of our capabilities and experience of various physical activities and become sensitive to some new affordances. We become experts in perceiving and acting upon certain sets of affordances which we are familiar with. These sets of affordances could be understood as our niche of affordances. Gibson (1986) explained a niche referred to *how* an animal lived its life from daily activities to various events. For example, people with different sports backgrounds would be sensitive to different affordances which are closely associated with their lives. For example, basketball and football players displayed higher accuracy on perceiving sport-related affordances than nonplayers (Weast, Walton, Chandler, Shockley, & Riley, 2014). When a landscape of affordances is available, many of them can be perceived by most humans but not for all. The skill level of particular physical activity would play a role in perceiving and utilising affordances which consequently result in different exercise experience. For example, expert climbers and beginners were tested on their inter-limb coordination patterns when perceiving icefall properties as affordances during performances. Results showed that beginners were less sensitive and lacked of perceptual attunement to environmental properties with lower levels of functional intra-individual variability while the experts displayed a wide range of upper and lower limb coordination patterns and fewer exploratory movements, suggesting they were more sensitive and effective in using affordances to regulate performance (Seifert et al., 2014). The experience and skill of an individual actor underpins the capacity to attune to some affordances and not to others. In this sense, an "affordance" is perceived according to the particular skills of the one who exercises in nature. Therefore affordances refer to the fit between individuals' capabilities and the environmental opportunities that make possible a given activity (Gibson & Pick, 2000). This unique fit between the organism and environment requires that both adapt to each other when performing behaviours, humans more quickly and the environment perhaps more slowly, after accommodating successive interactions with exercisers. For example, walking on a forest trail requires humans to be mobile with the essential ability of posture control, muscle strength and balance while the trail is flat, solid and extended to afford the possibility of walking on it. During the interactive process for the person to walk on the trail, any changing components either from the individual or environment might lead to different behaviours. If it started to rain, the walker might decide to run or do speed walking if she/he didn't want to slip and fall. During the journey, if a rabbit suddenly showed up on the side of the road, the walker might

stop and look or if being frightened by its unexpected appearance, the individual might jump and shout. Any changes (the rabbit or the rain) during the process of perceiving or realising nature affordances might lead to different outcomes (walking, stop walking, jump or running) but it is worth noting affordances remained available without being used (the trail can still be used for walking). This indicated that affordances are dynamic, in the individual-environment interplay, constantly changing the perception-action reciprocity.

Although affordances always exist in the environment whether being perceived or realised, certain sets of affordances invite specific behaviours. For example, the sound of the morning alarm encourages people to quickly react; the dark and cloudy sky prompts people to bring umbrellas with them. In sport, the posture of a defender would make influences on the direction of an attacker's drive (Esteves, De Oliveira, & Araújo, 2011). The information offers their (functional) meanings to the perceivers for corresponding behaviours. On the same note, the objects and layout of the environment encourage or discourage human to emerge behaviours accordingly. Withagen and Caljouw (2016) have conducted an empirical study aiming to stop sitting in a designed office environment with no tables and chairs. Hence, there is **no** offering sit-on-able for human in this given environment. Results showed 83 % of participants worked in different non-sitting postures at different locations, giving rise to locomotion with the same level of concentration and satisfaction with the produced work. When designing environments for particular purposes, it is vital to thoroughly think of all the presented information in the environment which might offer positive and negative invitations for behaviours.

3. The rich landscape of affordances in nature

Physical environments play a vital role in shaping human behaviours. The co-influenced relation between human behaviours and environments in terms of affordances perceptions and realisations and the unique individual-owned niche of affordances. A growing body of research also suggests that natural environments make positive contribution to health promotion (Chawla, Keena, Pevec, & Stanley, 2014; Gilchrist, 2009; Gladwell, Brown, Wood, Sandercock, & Barton, 2013; MacKerron & Mourato, 2013; McCormick, 2017; Twohig-Bennett & Jones, 2018; Van den Berg et al., 2016; van den Bosch & Ode Sang, 2017; L. Wood, Hooper, Foster, & Bull, 2017). Natural environments offer affordances which are more likely to be positive and meaningful to the perceivers and encourage health-enhanced behaviours to emerge. For example, bird sounds were considered to be vital in perception and experience of restoration, and the contributions of their acoustic, aesthetic and semantic properties to such

perceptions (Ratcliffe, 2015). The woodland area and tress offered positive effects on stress reduction (Gilchrist, 2009). Walking in forest allow people exposing to phytoncides (wood essential oils) which offered the chance to enhance human natural killer cell activity and levels of intracellular anti-cancer proteins (Li et al., 2008, 2006). Even bringing nature (plants) indoors created the environment to promote health because of healthier air, feelings of comfort, calm and pleasant (Lohr, 2010).

In nature, there are many diverse sets of olfactory, visual, haptic and acoustic information offered for individuals to perceive and utilise which consequently provides a rich landscape of affordances for humans and suggests a greater perceptual and action availability for individual to draw upon to stay physically, psychologically or emotionally attune to information in nature (Araújo et al., 2019). There is value in "engaging" with nature with or without performing physical activities. The engagement with nature has been presented in previous chapters with robust evidence and developing body of research, advocating the abundant benefits when engaging with nature in different formats (the three levels of *green exercise* which was based on the level of engagement with nature; viewing nature indoors, passively and actively interacting with nature) (Pretty, 2004; Pretty, Peacock, Sellens, & Griffin, 2005).

4. Three interactive constraints - individual, environmental and task

From an ecological dynamics perspective, the previous sections presented the benefits of "bird sounds", "trees", "forest" and "plants" for humans but they might offer no function or be meaningless for the different perceiver if perception did not happen or any changing status of constraints occurred. For example, bird sounds might not be perceived by people with hearing impairment; trees and forests might be offering no extra meaning for people with low-stress level. An indoor plant that looks like it is dying might induce negative feelings. These examples indicate that different constraints impact on behaviours. The rich landscape of affordances in nature would function differently while satisfying different constraints. Engagement with nature (perceiving and utilising affordances from nature) would not be a fixed process or lead to same behaviours but might differ when it occurs in different nature environments (environmental constraint) via different physical activities (task constraint) with different people (individual constraint). Engagement is a dynamic process of ongoing perception-action cycles under different constraints which suggests the need to consider the whole (individual, environmental and task constraints).

In this section, the individual, environment and task constraints are presented with selected research to demonstrate the diversity of each constraint in the context of nature engagement and health promotion.

- Individual constraint:

Individuals are different in all aspects, such as physical capabilities, mental states, age, preferences, experience and thoughts on the environments, etc. These individual differences are classified as individual constraints which are important to consider when designing specific programmes for different target groups. For example, the generation difference might lead to inconsistent results between adults, adolescents and children when measuring engagement with nature (Duncan et al., 2014; C. Wood, Caroline, Jules, Gavin, & Jo, 2013). This age difference was suggested to be linked to an individual's nature connectedness (Duncan et al., 2014) but more work is needed to further our understanding. Even within the same age group, personal differences were noted. Barton, Sandercock, Pretty, and Wood (2014) examined the physical activity level in the playground and nature-based interventions among rural and urban children and found a positive relationship between fitness and time spent in physical activity for the playground intervention while no correlation between fitness and the time spent in physical activity during the nature-based intervention. This study indicated one of the individual differences (fitness level) leads to different outcomes even in the same age group. The study also supported that nature-based activity offered higher availability for a wider ability range which supported the aforementioned point. Certain organismic discrepancies developed over time and revealed its impact on later times. Experience of engaging with nature at childhood was related to fewer symptoms of depression in adulthood and the potential of contact with nature to act as a learned coping mechanism that may improve mental health in adulthood (Snell et al., 2017). The contact with nature or engagement with nature brings out multifarious benefits and promotes children's healthy development, well-being and positive environmental attitudes and value (Adams & Savahl, 2017; Tim, 2014). Connectedness with nature has seen as a personal disposition which might be an indicator to wellbeing, particularly meaningfulness (opposed to depression, referring to a human's need of being in the world and experiencing a sense of purpose in life)(Cervinka, Roderer, & Hefler, 2012).

- Environment constraint:

Environmental constraints are global, physical variables in nature, such as ambient light, temperature, or altitude (Davids, Button, & Bennett, 2008). In nature, the layout of surfaces, the objects or substance, weather, wind or animals, etc. all fall into environmental constraints which provide possibilities or put on limitations for people when performing physical activity. Considering the richness level of information offered in the environment, for example, the surfaces conditions for running, the perceiver might have different levels of engagement with the environment. Running in an urban park or a forest trail, the runner is likely to pay more attention to the forest trail surface than the park path in order to avoid injuring or falling over. The uneven and irregular forest trail surface offered more haptic information for the runner or invite the runner to respond to it for safety concern. The urban park runner would still receive haptic information from each step making contact with the park path surface but lower diversity of uneven and irregular running surfaces requiring no extra engagement with the environment. This richness level of affordances of environment might link to the biodiversity of the environments (Marselle, Irvine, Lorenzo-Arribas, & Warber, 2015). Take birds sounds as an example, in Ratcliffe's doctoral project of research (2015), four studies have been conducted and indicated the important value of various bird sounds associating to perceptions and experiences of restoration for mental wellbeing. If we think of the multiple affordances, the abundant levels of information in nature would largely increase the availability to wider range users (Araújo et al., 2019). For example, increasing the level of greenness of nearby environment to home improve children's cognition functions (Wells, 2000) and increased neighbourhood greenness was related to lower risks of poor mental health and cardiovascular diseases at the individual level (Richardson, Pearce, Mitchell, & Kingham, 2013). Gascon and colleagues (2018) suggested a potential protective role of long-term exposure to green spaces on mental health (depression and anxiety) in adults.

Individuals might have their habitual ways to interact with the environment or even choose their preferred environments. In the previous section, it was mentioned that Gibson used the concept "niche" to describe an animal and the way of its life and a niche is a set of affordances for a particular animal to live their lives (Gibson, 1986). Therefore, different people would tend to perceive and utilise their own set of affordances for physical activity which might be strongly associated with their experience. Evidence in the literature indicates that children learned to perceive these nature-based affordances from a young age with positive effects which might consequently develop a tight connection with nature and benefit from this connection (Montgomery, 2015). However, it is unclear what would this connection change over time?

Would this building connection associate with individual differences to a greater extent? Further investigations would be required to expand our understanding of this connection.

- Task constraint:

Task constraints are usually more specific to performance contexts including task goals, specific rules associated with an activity, activity-related tools, ground areas or equipment (Davids et al., 2008). The duration, intensity and type of physical activity are all counted as task constraints. All these task-related factors would play a role in exercise performances. For example, performing a normal 5 miles field run would be different from doing a 20 miles field run for the same runner on the levels of energy expenditure, and exertion, time or running strategy, etc. Certain exercises require essential equipment adjustment/setting when performing in different types of environment, for example, cycling. The styles and width of tires using on mountain bikes and on road bikes are different because each requires different types of tires to make contact with surfaces. Different models of footwear and footwear characteristics would make an impact on running economy (Fuller, Bellenger, Thewlis, Tsiros, & Buckley, 2015).

The three categories of constraints were explained separately along with examples in order to make readers understand their influential roles and impacts. The three categories of constraints are inseparable and intertwined. None of them can be ignored or neglected. It is vital to consider the three categories of constraints equally important when designing exercise programmes or carefully manipulating one of the constraints to meet research purposes when design studies.

5. Suggestions for future research

Examining how people perform physical activities (tasks) in a natural environment as a whole, facilitates the analysis of the process of how people are engaged with nature and the outcomes of the engagement. The engagement with nature is the process showing how individuals perceive and realise affordances from nature channelled by individual, task and environmental constraints. The outcomes of the engagement can be the behaviours or performances we observe. Some tasks required more engagement than others. For example, outdoor climbing would require the climber developing strong engagement with the surroundings when using the whole body making contact with the rock, more haptic information is offered from any contact points of the body and the rock, as well as relevant visual information is needed to

allow decision-making on climbing routes. In comparison, walking in a woodland demands lower engagement with the environment. Certain tasks might require a high level of particular sensory sources than others. For instance, birdwatching might require the birdwatchers being more aware of any acoustic and visual information for identifying, locating and watching birds. Even undertaking the same type of physical activity (task), the variety of intensity or duration of physical activity would allow people to form distinct engagements with nature. When requiring exercisers to complete different tasks such as a five-kilometre field run within 20 minutes and over 30 minutes, exercisers might focus on the run including their pace, breathing, running surfaces or other environmental obstacles to achieve the under 20 minutes requirement while more non-task related perception and action would possibly occur between exercisers and the environment during the over 30 minutes run, such as the views or others organisms or objects in the given environment. The discrepancy between each type of physical activity should take into considerations with the potential distinct engagements with nature and exercise experience. This is, however, what currently is lacking in the literature and using mixed methods or collecting more qualitative data may be useful.

If we link back to previous sections talking about the features of affordances and each constraint, we can understand that the engagement with nature is a complex and dynamic process about how affordances have been realised and how the three categories of constraints interact with each other. In Duvall's (2011) study, the group who was walking outdoors while using different methods to raise their awareness of environment, experienced significant improvements in multiple dimensions of psychological well-being. Moreover, they were more likely to obtain psychological benefits when walking at low to moderate levels. This method aims to encourage human actively putting themselves into the environment by using various awareness plans. On the same notion, creating a type of tight engagement with the environment by using virtual reality technology might be a way to examine this further. Giving the nature of virtual reality, people are more likely fully immersive in the environment; hence, the engagement with nature can be investigated by manipulating the setting or designs of the presented environment which require more studies offering related information. Seeing the increasing popularity of using virtual reality in healthcare, it is expectant the use of virtual reality with nature-based programmes for patients could be a good tool for health promotion, especially the patients who can get access to outdoors nature due to physical or medical limitations or safety concerns. This idea requires more studies to examine its feasibility and effects when put in practice.

When designing a nature-based exercise programme for health promotion, 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 exercises such as the presentation of essential information, available physical activities, exercise intensity, duration, and the target group (Yeh, 2017). Here, the presentation of essential information is not only suggesting the display of key information for the participants to perceive but also removing the distracting stimulus for participants. When planning the task, group differences and individual differences are equivalently important to consider; hence, the flexibility of developing individual-specific exercise behaviours should be considered. This flexibility within the programme can have crucial influences on the effects of designed programme which should be investigated further. This point is also important when designing interventions, especially for people with special needs.

6. Conclusion

Overall, this chapter discussed main principles of an ecological dynamics perspective including the three interactive categories of constraints (individual, environment and task) and the reciprocal individual-environment interplay. Further discussions on each type of constraint and potential research questions were offered. Regarding the further research or interventions designs, the designers or researchers need to think thoroughly the research questions or intervention purposes alongside the interactive constraints and the mutual person-environment system to highlight the benefits when undertaking physical activity in nature.

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