Miles To Mind

Proposing an augmented reality based running application for individuals prescribed running to manage symptoms of mild-moderate depression.

By

Abhinav Paul

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1. Abstract

This thesis proposes an Augmented reality (AR) application designed to assist people experiencing mild-moderate Major Depressive Disorder (MDD). I am building on an existing solution space of distance running which has been shown to be an effective tool of managing symptoms of MDD based on multiple recent studies in the field of neuroscience and exercise science. These studies have prompted doctors to prescribe exercise treatment plans to mitigate symptoms. However, MDD often makes it difficult for people to continue these routines due to symptoms of fatigue associated with MDD. My proposed application design aims to address the challenging obstacles that people face **after** they begin their exercise treatment plans, specifically running.

During my recovery from moderate MDD, I understood that running just for the sake of running was another barrier that I had to overcome. Based on some methods I used to keep myself continue a run like chasing an imaginary animal or setting a small mental objective of 10–20 m, I realized that the activity of running could be made more engaging and be based on a purpose other than covering a certain distance, with the help of mixed reality mediums such as Augmented Reality (AR). This thesis lies within a speculative framework assuming by the end of the decade, mixed reality interaction is simplified enough for eyewear without requiring bulky headsets.

Through the proposition of an Augmented Reality (AR) based running application, I explore the idea of using AR to (1) use running as a play centered activity to chase using visual cues, instead of a competitive activity to cover a certain amount of distance, and (2) explore the role of companionship during the run in the form of a virtual companion.

The proposed model could be described as an overlap between an AR based game called Pokémon GO and existing running services like Strava.

KEYWORDS

Depression, running, augmented reality, virtual companion, chasing, gamification.

2. List of Acronyms

AR- Augmented Reality

BDI- Beck Depression Inventory

DG- Dentate Gyrus

EE- Energy Expenditure

HR- Heart Rate

MDD- Major Depressive Disorder

VAA- Virtually Assisted Activity

VR- Virtual Reality

3. Introduction

The thesis is informed by a combination of existing literature in the field of neuroscience and exercise science, on running and its effect on the symptoms of MDD along with insights from my personal process of recovering, through medical assistance, from moderate depression over the span of five years, from 2016 to 2021. It is important to clarify that this thesis focuses on individuals with mild-moderate MDD who have been already prescribed physical activity to manage the symptoms for depression and have certain minimum capacity to begin the process. I would also like to address the ableist aspects that come into picture when researching primarily through the lens of exercise sciences. I acknowledge that depression is a complicated illness with many sociocultural factors that need to be taken into account when addressing the issue. Hence this thesis does not approach depression with an intention to fix the entire problem, rather explore one of multiple solutions like aerobic activity that are recommended to the individuals affected by depression.

Existing research studies in the field of exercise science show that running like other forms of aerobic activities have effects similar to medication and therapy when treating MDD (Déry et al., 2013). However, even though I was aware of this idea, running just for the sake of running felt less intuitive and was also challenging since depression is characterized by a severe drop in motivation to move. Hence the methods I relied upon frequently like visualising chasing an imaginary animal/object, imagining scenarios like “if I don’t reach that bench before that car I would have to start over again” or even picturing dribbling a football, offered great psychological assistance. Based on the combination of this habit of visualising, and research in neuroscience that suggested that people with higher depression scores [measured through Beck Depression Inventory (BDI)] showed a decline in semantic coherence tasks but displayed above average performance in visual coherence tasks (Remmers et al., 2016), prompted me to consider proposing augmented reality (AR) as a possible tool of assistance.

Hence in an attempt to generate any instinctive response from the user to move, the proposition is to design a mixed reality application using Augmented Reality (AR) to incorporate visual incentives into the real world that the user can see and react towards. The vision is to have a moving avatar**,** like a virtual creatures/avatar, in an AR environment that the user is compelled to find and capture using cues such as virtual footprints. The avatar once caught can become a virtual companion for the next run who assists you in finding a new, more challenging companions and explore different running routes.

This thesis also addresses the possible importance of having a virtual companion that not only offers directions during the run but also acts as a companion to interact with in the AR environment. There are psychological studies that show “animal-assisted interventions have the potential to significantly reduce depressive symptom”. (Beetz et al., 2012, p.7)

4. Context and Background

4.1 What is the objective?

The purpose of this body of work is to envision an Augmented Reality running service meant for people prescribed aerobic activity to manage symptoms of mild-moderate MDD. I specify the range being mild-moderate since in the literature I researched, it was specified that they were only addressing individuals with mild-moderate MDD, and that extremely severe cases might require a specific medical intervention (Dunn et al., 2005, p.2). In other words, many severe cases of MDD in people have additional socio-cultural complications that need to be addressed parallel to medical and exercise treatment through various forms of therapy[1].

4.2 Research direction

When dealing with any problem space as a design learner, many traditional design approaches try to divert away from personal experiences on which the solution is built. However, I chose to incorporate my own experiences of recovery from moderate depression over the past five years into my framework for two main reasons (1) Depression has variability, meaning many combinations of events can trigger or treat depression in an individual. I believe it is important to have these experiences shared in some space, which can then be treated like a blueprint for anyone trying to overcome the problem themselves in the future. (2) Research is a crucial aspect of design and in order to cultivate a precise sense of gathering research insights from others, I think a starting point could be to research myself, the one person I know best.

Including existing research in parallel to personal experience is important. Researching literature dealing with clinical depression along with existing services for runners was another key aspect since many current services such as Strava, a popular mobile application used by runners and cyclists to explore routes and record activity data, offer aspects to the user which can be incorporated as additional frameworks.

<u>Phase 1; March 2021 – May 2021 (Analysing running infrastructure in Vancouver)</u>
Noticing the **existing infrastructure** to make a city "runner friendly" was the first thing I took into consideration. Even though I still ran occasionally in my hometown in India, Vancouver felt instinctively more inviting for running after I arrived here in April 2021. A key reason that is immediately evident is the existence of pedestrian sidewalks throughout the city which was not common in my hometown. This makes road running feel safer and someone doesn't need to go to a dedicated space to run like stadiums or open grounds, which is where I used to run when I was back home. Consequently, a safer running infrastructure allows more people to run and watching more people run gave me some psychological push to go out and run as well. Secondly, the presence of running trails in Vancouver city offer a change in environment and terrain for runners which also helps in keeping the activity non-monotonous. These insights

[1] Therapy is however not just useful in more severe cases and is advised for MDD treatment of even mild severity.

allowed me to have an initial image of the environment I want to use as a foundation for the following work.

Phase 2; May 2021 – October 2021 (Literature research/ testing research)

The key source of information through literature study about running and depression was from studies done in the field of Neuroscience and Exercise Science[2]. One specific research offered a **measurable** component in terms of running and its effect of depression i.e., (approximately **17.5 kcal / kg / week** over a period of **12 weeks** is an effective treatment of MDD of mild – moderate severity (Dunn et al., 2005). For me (75 kg) it meant having an output of ~187 kcal / day which was around 2km / day of activity at an aerobic heart rate (HR) (136-154 bpm). This was difficult initially because my HR was very high (anaerobic zone) (155-173bpm) in the initial runs since I was coming from a rather sedentary lifestyle but became steady after around 3 weeks. The output was still irregular for me but there was an average consistency of around 3 runs / week along with having ~5000 steps of walking every day. At around three and half month mark, there was a noticeable change in the general motivation to do things and I was able to cut off medication (under medical supervision) for the first time in a span of three years.

Apart from the measurable aspect, books related to the importance of running in people of certain cultures (e.g., Tarahumara runners mentioned in the book *Born to Run*) (McDougall, C. 2011) prompted the question of why humans ran in the past compared to why we run in the modern era. This directed me to information on the evolutionary perspective of running in humans. Research suggested that two of the original purposes of running may have been to follow wounded prey while hunting (Bramble and Lieberman, 2004) and to escape from predators.

[2] I acknowledge that this topic does raise questions about the ableist assumptions of running, however the scope of this thesis is such that it focuses on 'one of the solutions' offered in treatment instead of proposing a one size fits all solution for depression

4.3 What are the research findings?

The fundamental aspect of depression to consider was that a key symptom of the illness was a prolonged drop in motivation, also commonly described as loss of interest in any activity. But aerobic exercises like distance running can ameliorate the effects of depression in some cases (Shulkin., 2016, p.8). This creates a deadlocked situation, where movement can generate motivation, but you require motivation to generate movement. So even if the person suffering gathers the effort to act towards recovery, the process offers extreme friction that they must drive through.

A study suggested that individuals with higher depression scores on BDI (Beck Depression Inventory) show an unusual response to instinctive stimuli. People with higher levels of depression levels showed a decrease in semantic coherence compared to people with normal BDI scores but, displayed not only normal, rather "enhanced" performance in visual coherence (Remmers et al., 2016). This indicates to some extent that even though motivation is hampered in people with MDD, certain instinctive responses can still be responsive enough. This provides us with an inclination to use as visual stimuli as a key factor driving the run, that could work effectively for someone with MDD.

Considering humans have been hunter gatherers for much of our ancestral past (approximately 1.6 million years), the key purpose of running has been catching, scavenging or escaping. Since we no longer have a need to run for scavenging or hunting in the modern lifestyle, running just for the sake of running might feel less intuitive for some people. Looking at this from another perspective, I believe distance and pace can be viewed as **outcomes of the objective, and not the objective itself**.

Another crucial insight that seemed to work as mentioned before was through research which measured the **dose response of the physical work** needed to experience any noticeable improvements in people with mild – moderate MDD. Specifically, aerobic exercise at a dose consistent with public health recommendations (approximately **17.5 kcal / kg / week**) over a period of **12 weeks** is an effective treatment of MDD of mild – moderate severity (Dunn et al., 2005). Also, an output of around 7.0 kcal / kg / week was considered as a 'low dose'. This gives us 2 key points to work around,
(1) a long-term requirement of 12 weeks ("12 weeks of exercise lead to increased DG (Dentate Gyrus) blood volume in both mice and humans, and in mice the DG (blood) volume increase was further shown to correlate with increased neurogenesis"). (Déry et al., 2013 p.2).
(2) a short-term requirement of 7-17.5 kcal / kg / week.

In my situation considering the depression was diagnosed to be of moderate severity, the EE (energy expenditure) at aerobic HR at which I began to observe noticeable progress in my health was between 4-9.3kcal/kg/week over a duration of four months which is 3-7 runs of 1 km per week. This was considerably lower than what I had estimated. Considering that the study I referred to by A.L. Dunn in 2005 measured the prescribed range in an indoor environment, and I always ran outdoors, I would not rule out the possibility of the potential benefit of aerobic activity prescription in combination with open natural environments in my process of recovery.

This literature review provided important metrics that could be measured. The research on running, depression, and the relation between two provided with a general design framework of running to chase. The measurable data like minimum energy expenditure (EE) and duration of runs offered the foundation for the objectives that could be incorporated in the envisioned design proposition.

4.4 Existing models

Current services based on running predominantly rely on distance and pace as the key motivators for runner and these can be categorized primarily into post run metrics. Services like C25K (Couch to 5k) use 'audio' instructions to manage pace during a run for beginners who want to achieve their first five km milestone. However, for individuals with MDD, verbal instructions may interfere with the benefits of exposure to natural environments and also might not be the most effective method since they are shown to have a decline in their ability at semantic coherence tasks (Remmers et al., 2016).

Other popular running applications like Strava or Samsung health collect running data that the user can see after the run to gain insights about their pace, distance, route covered, cadence etc. They work much better with wearables like smart watches that allow you to record heart rate (HR) and VO2 max which is the maximum rate of oxygen consumption measured during incremental exercise; that is, exercise of increasing intensity. All these data visualisations offer useful information in tracking progress however the primary aspect I would highlight in my proposed application would be the heart rate zone instead of distance covered, since running at an aerobic HR zone has been shown to offer the most noticeable results in treating mild/moderate MDD. Also, a visualization of total energy expenditure so the user can see if they are on track with the 7 - 17.5kcal / kg / week range is helpful instead of showing it in the form of complex numerical data on the application interface.

Pokémon GO, is a similar platform that made people be 'outside' and interact with real world. It is a mobile based game that uses AR where the user has to navigate their real surrounding environment to catch various types of virtual avatars (Pokémons). Together with physical activity and motor skills, the game encourages players to explore their local communities and, in the process, introduces them to new spaces. (Marquet et al., 2017). Also, mediums such as AR offer the appropriate amount of visual stimulation without blocking the awareness to surrounding environment. But in the case of designing towards mental health, the usability is oriented towards personal experience instead of focusing on a social experience (e.g., not having a social comparative aspect like in Strava).

5. Criteria of Investigation

The proposition of an AR based running application is focused on a small fraction of individuals who experience symptoms of clinical depression. The inclusion criteria for the design framework mostly includes,

- MDD symptoms ranging from mild to moderate
- Individuals who are taking therapy or medication to treat mild/moderate MDD
- Individuals who have been prescribed aerobic activity to manage symptoms of MDD
- Individuals who are in a physical capacity to begin the process of running[3]
- Individuals who have access to surroundings with a safe running infrastructure[4]

[3] Exercise programs are encouraged to be tailored to individual needs, taking into consideration age, pre-existing health conditions and presence of any stressors in their surrounding environment.

[4] I am considering the difference in running infrastructure between my hometown, Jalandhar in India, and Vancouver

6. Thesis Design Direction

6.1 What is the purpose of running in this application?

Running for distance implies running towards a fixed point instead of one which is moving, which would be the case in chasing. Running for distance and pace are however powerful motivators in many cases and recording these metrics in fact offer valuable insights to track progress. However, through this application instead of having the distance covered as a reward for the run, the reward is what the runner gathered because of running that certain amount of distance which is catching new and gradually challenging avatars and gaining incentives in the form of virtual companions, like Pokémons. I am therefore proposing that while making a running application for individuals with MDD, running should preferably be incorporated as an outcome of an activity and not the activity itself.

6.2 Effect of virtual companions in AR

Animal-assisted therapies involve interaction between patients and an animal with the aim to improve mental wellbeing in individuals. Research on dog assisted intervention in hospitalised people with MDD concluded that animal-assisted therapy causes highly significant reductions of state anxiety. Presence of dogs may offer an additional therapeutic benefit that might decrease anxiety and enhance psychotherapeutic strategies and motivation of patients and therapists. (Hoffmann, et al., 2009). However, there are difficulties that may arise in handling pet animals during running affecting the safety of the runner or the pet. This is addressed in a recent study that observes any psychological benefits of virtual pet assisted activities in VR on mental wellbeing. (Nakajima, et al., 2020). The study concluded that there are benefits observed through virtual assisted activity (VAA) but these benefits were better in open scenery virtual environments than closed scenery environments.

Based in this particular insight, I lay greater importance on AR environments compared to VR since AR can be set in real-world environments taking greater advantage of interaction with the virtual companion and are much better suited for running related activities.

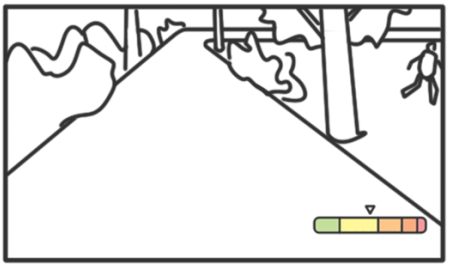
6.3 Use cases

As a beginner, for someone using the running platform for managing their symptoms of MDD, the use cases can be divided into two key sections. (1) New users (2) Using for 2-3 weeks.

The progression is very gradual, and it is important that the user begins by simply exploring the environment and understanding the visual elements without the need to begin the running. The user gets rewarded with a companion after completing the first one km of exploration. This companion can now act as a navigational partner to begin the initial runs. Every companion has a range. A companion with a 50 m range will catch the avatar for you once you are within 50 m of the avatar you are chasing.

USE CASE 1 (New user, currently not a runner)

1

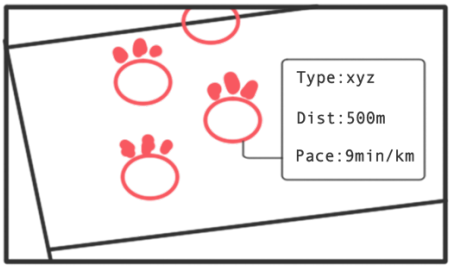


User begins exploring the AR environment

2

Sees paw prints while exploring

3

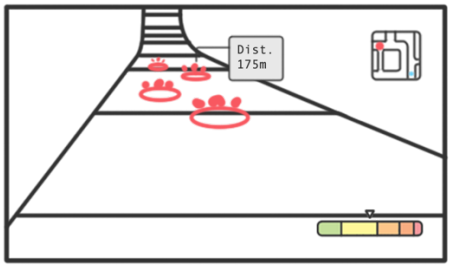


Sees the details of the run and avatar

4

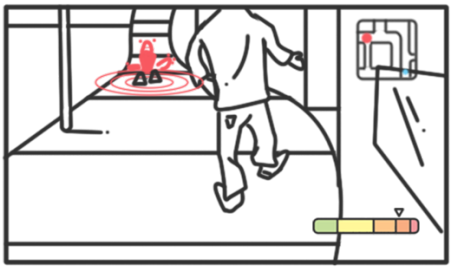
Double tap on the print to start the run

5



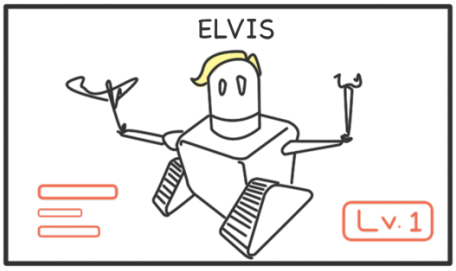
1st run, no minimum pace needed, follow the prints

6



Approach the avatar to capture it

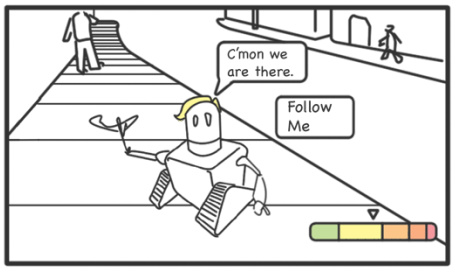
7



Congratulations! You unlocked your 1st companion

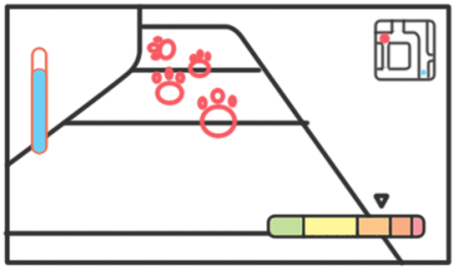
USE CASE 2 (Using for 2-3 weeks, running with a companion)

1



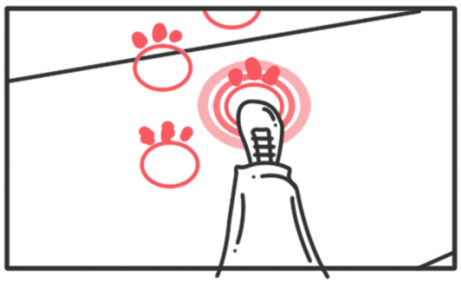
Start the run with the companion

2



Or use a map to navigate without the companion

3

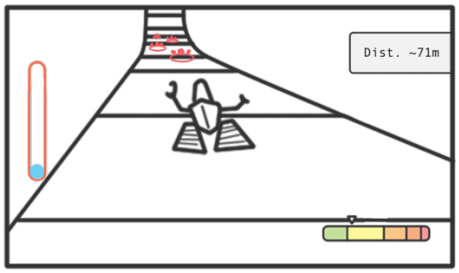


Faster and more distant avatars appear over time

4

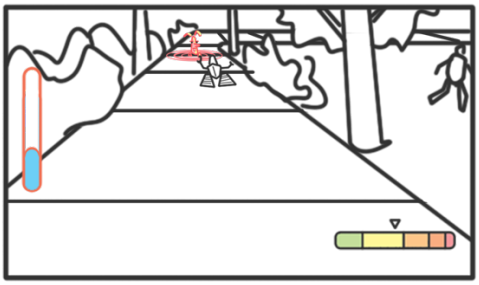
The companion leads you to the next avatar

5



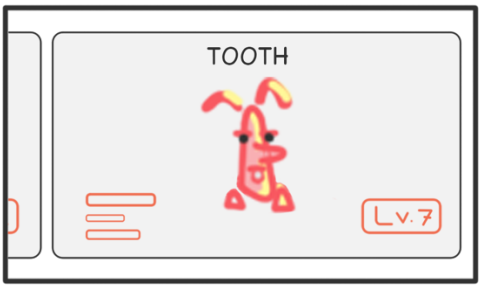
Companion approaches closer to avatar

6



Companion catches the avatar for you

7



New companion added

6.4 Design Specifications

Environments

Since the objective is to replicate a scenario of chasing a moving avatar along with a requirement for the user to be in an open environment, VR is not proposed to be the best possible option. Additionally, VR (Virtual reality) would also restrict the movement aspect of the running platform. AR (Augmented reality) on the other hand allows us to incorporate minor visual elements into an existing environment without making it excessively information heavy for the user. The speculation here is that the eyewear necessary for interacting with AR is accessible and in an ergonomically manageable form like glasses. Glasses are potentially not a hinderance in running experience since people already run with sunglasses in many instances.

Elements in the environment

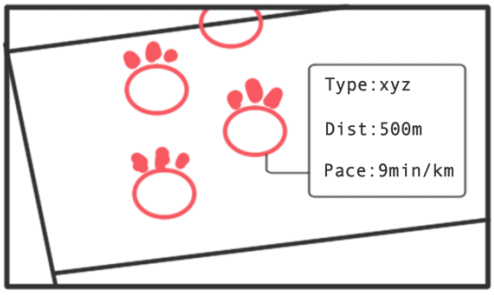
The primary intention while proposing the design of these elements in the AR interface is to make sure they are visually simple to avoid any interference with the real-world environment. The visual elements are there to assist during the activity and make running more intuitive and the intention is to allow the user to appreciate the real environment and not the visual interface. Hence over time as one progresses in using this AR application, they can choose to disable certain features like heart rate (HR) if they feel they have developed an intuitive sense for knowing the current HR and a visual for that is no longer necessary. The intention is to have visually conveyed information and not visually appealing aesthetics, so the user doesn't end up relying on these visuals every time they need to run. The visuals are preferred to be simple and straightforward.

The user goes through a tutorial when they sign into the AR service explaining the role of each visual element in the interface.

Additionally, the changes in visual elements that the user has to monitor during the run must be visible in their peripheral vision so the user doesn't have to focus extensively towards these visuals allowing them to pay more attention to the surrounding environment.

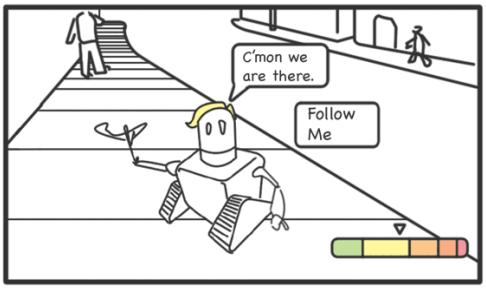
i) Virtual avatar to chase

Like Pokémon GO, where users use AR through their smartphone cameras to physically navigate their real-world environments and catch different avatars in various locations, the user in the AR environment in my proposed application has avatars that are available to catch but not through smartphones, instead through an eyewear-based AR device that allows them to see this virtual environment. However, the locations of different avatars don't appear in the AR interface for the user until they start exploring the virtual AR environment. As the user progresses in difficulty, more challenging avatars start to appear on the map. The pace at which the avatar moves away from the user is inversely related to the user's pace or duration of run.



ii) Running companion

The avatar that the user catches can be used as a running companion for the next run. The companion can serve a purpose like navigating the run towards catching another avatar, act as a pacer or simply be a companion to run with. Companions have attributes like range and pace. A companion with range of 50 m will catch the avatar for the user once they are within 50 m of the avatar they are chasing.

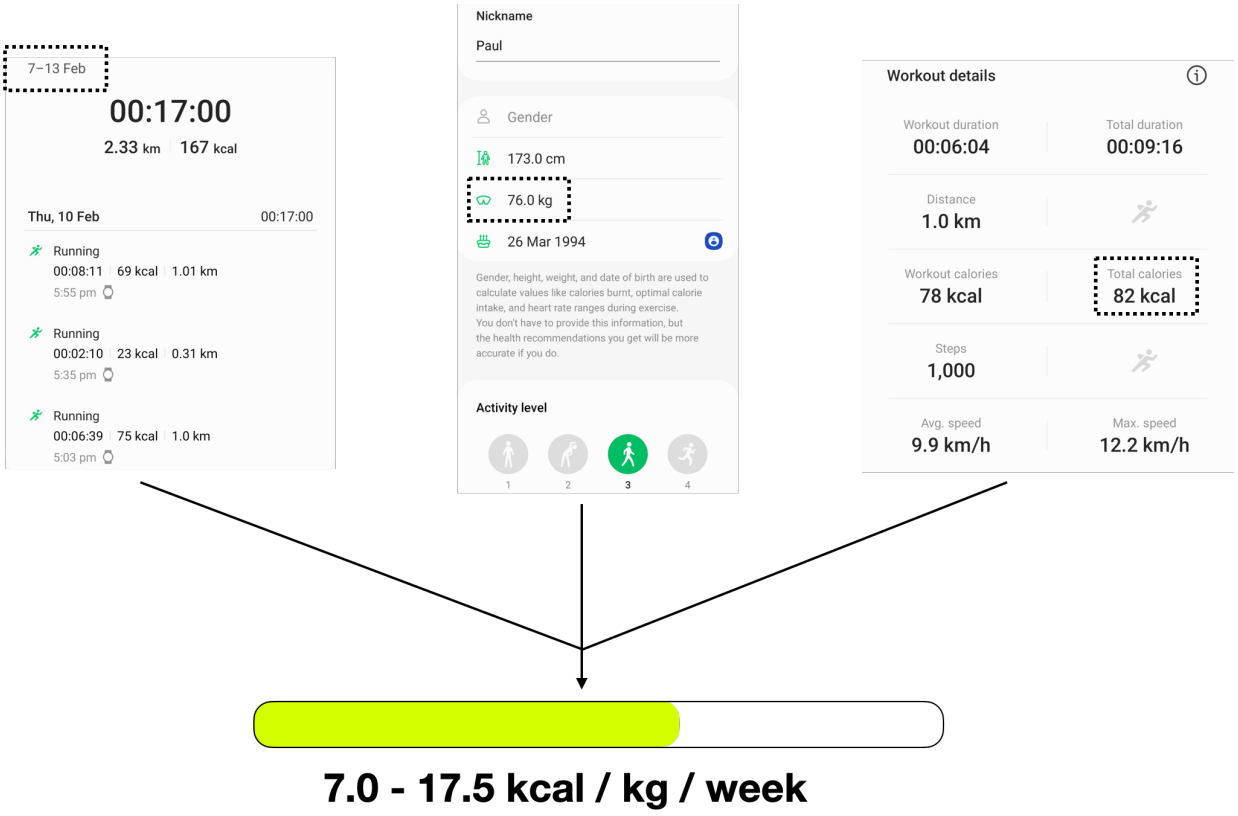


iii) Visualising the metrics

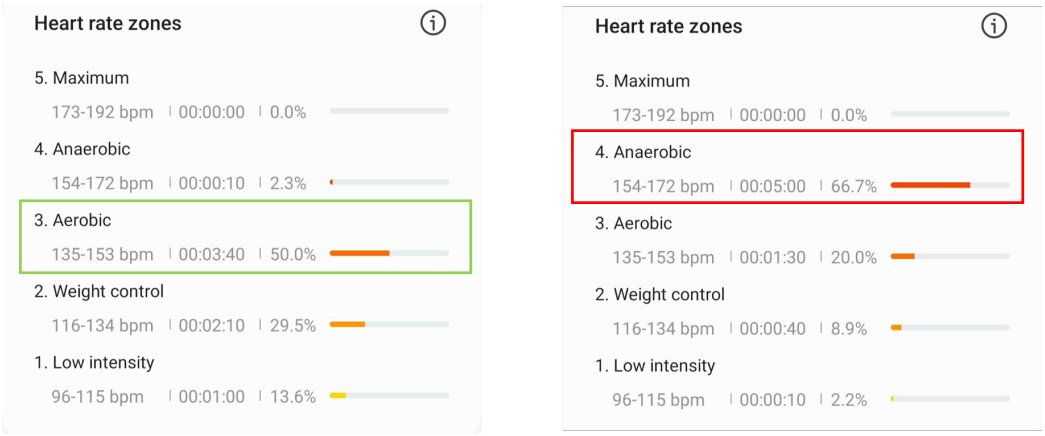
A progress bar in this AR interface is the key indicative of the user's movement in the real world. New routes and corresponding avatars become visible only after the bar is filled. The rate at which the bar fills is synchronous to how close the user's output is to the 17.5 kcal / kg / week requirement. However, this EE (energy expenditure) requirement can still be high for someone who is just beginning the exercise process. So, the bar can be predefined to fill about four times before the EE requirement is met. If the user is expected to have a 400 kcal EE, the bar can fill after expenditure of every 100kcal.

To measure this EE output of a person, the information to be monitored is ;
(1) approx. calorie usage (2) body weight (3) weekly running data.

If we take an example of an existing running service like Samsung health, these three aspects are already being recorded but not used together to generate any specific cohesive data. Hence when designing for someone running to manage symptoms of MDD, these can be used to visualise the EE range that the person is recommended to follow to see progress in recovery from MDD.



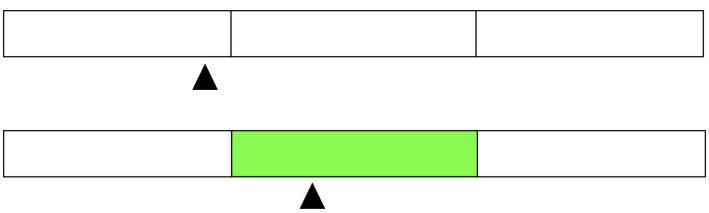
Another key piece of visual information is displaying the heart rate (HR) of the runner. Since the existing research suggests that a steady state exercise in the aerobic HR zone indicates the maximum amount of benefit in terms of reducing symptoms of MDD (Shulkin J., 2016). Hence the users must preferably try to stay in the aerobic HR zone (136 – 154 bpm).



Recommended to run in aerobic HR zone

One method to visualise the HR for the user in the AR interface while they are running is to have the zones illustrated in the form of a bar with a pointer indicating the user's current HR while they are running, instead of displaying the HR numerically. The user is encouraged to keep the pointer in the center of the bar indicating that they are running in the aerobic HR zone (135-153 bpm).

Since for the purpose of using this application in AR, the user essentially has to know 'if' they are in the right HR zone, more than which HR zone they are in, we can eliminate the extra columns representing different HR zone and have just three columns representing the aerobic zone and anything above or below the aerobic HR zone. The middle column represents the recommended HR zone which turns green when the pointer is in that zone.

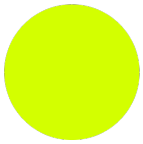


However, we are still dealing with two elements in the HR visualisation which is the bar and the pointer. Also, a bar might indicate progress, where reaching to one end is a sign of success but here the user is trying to stay in the middle. Additionally, we are visualising the EE in the form of a progress bar that fills up. The presence of two similar looking elements that work in different ways would cause interference in the user's mind.

Hence, an alternative visualisation would be to indicate the HR using icons telling the user to increase, decrease or stay in the current HR.

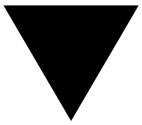
Increase pace;

HR is below aerobic zone



Stay at the current pace;

HR is in aerobic zone



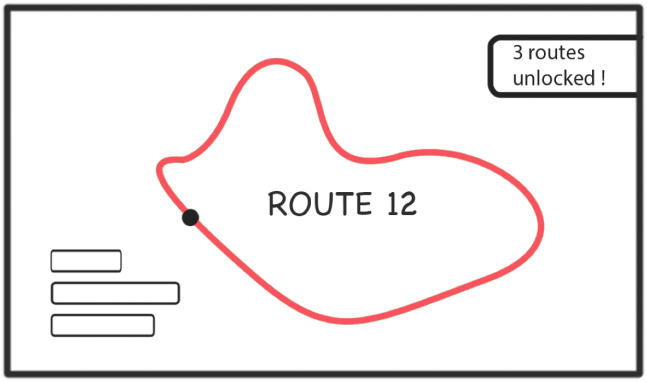
Decrease pace;

HR is above aerobic zone

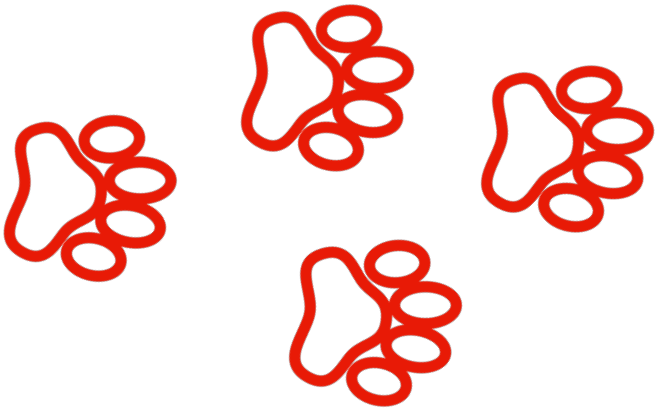
The three icons are not visible simultaneously in the AR interface but instead appear depending upon the user's current HR during the run.

iv) Navigation

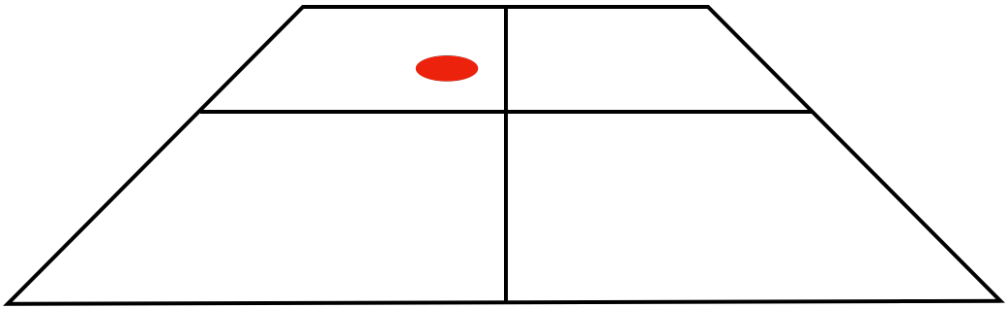
Each avatar to catch would have their respective running routes that the user is encouraged to follow. Once the progress bar fills up, any available routes within 1 km radius to the user's current location are unlocked. The routes are predefined within a city. Each route has varied levels of difficulty depending upon terrain, elevation and distance. Routes with higher difficulty lead to avatars that are comparatively rare to find.



Navigation on these routes is done with the assistance of virtual directional cues in the form of footprints. I decided to have footprints instead of arrows to guide the user since footprints offer a greater sense that the person is trying to chase an avatar that lives in this virtual AR world. A minor detail to make chasing more intuitive instead of it feeling like a task. The footprints appear on the route that one is running on and also to indicate any available route in the city.



A compass is present in the AR interface which along with the footprints, offers a general idea of the location of the avatar with respect to the user's current position. I choose to have a compass instead of a map since a compass encourages the user to explore the surrounding and be engaged with the activity since the user is not exactly aware of the avatar's location. Whereas while using a map, nothing is stopping the user to simply take a bus to reach the location. The goal is exploration and not just reaching a specific spot.



In this instance, the avatar is roughly north-west to the user's current position and the direction they are facing. The point of intersection is the where the user is currently situated.

An initial inclination was to keep the compass circular but that ends up looking like a bullseye in the interface and therefore can cause some confusion to the user.

Interface as seen through an eyewear based AR device (Visualisation - 1)

Exploring a trail route within the city

Initial runs; companion isn't present since no avatars caught yet.

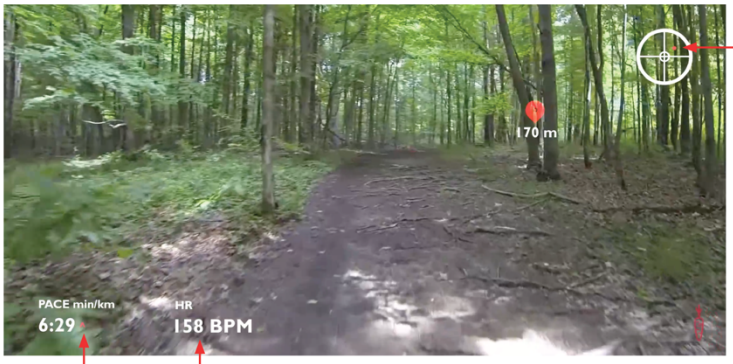
The red dot shows the location of the avatar the user is chasing

The navigation method is similar to a compass instead of a map. The user is encouraged to explore the surroundings and not just reach a particular location

Footprints instead of arrows.

Footprints convey a more anthopomorphic impression of the avatar that the user is chasing.

Conveying a feeling of searching for something that "lives" in this virtual environment.



Here the avatar is 170m away towards the north east direction of the 'user's orientation'.

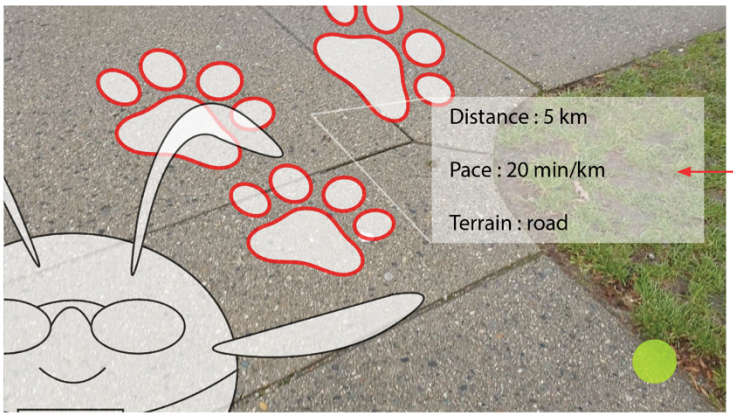
Primary goal - User encouraged to stay in the aerobic heart rate zone (136-154 bpm).

Secondary goal - Increase or decrease in pace is suggested based on the user's HR and distance covered.

Video - Treadmill TV

Interface as seen through an eyewear based AR device (Visualisation - 2)

Exploring a city route.



The avatar has a pace at which it is moving away.

Difficulty depends upon the pace of the avatar and the distance to be covered to reach the avatar.

Avatar characteristics highlighted once the user approaches the footprints on a route

The bar fills as the user continues a run.

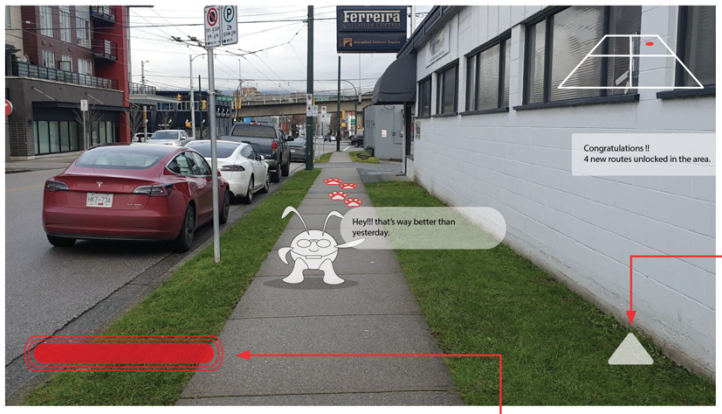
Once filled, the user can walk and the avatar gets closer.

New routes and avatars are unlocked every time the bar fillls.

Heart rate (HR) depicted visually to make it easier to see the current HR.

Currently the user is in the recommended aerobic HR zone

Visually represented information about heart rate and work output



Unlocked routes are saved to user's profile which they can choose to access in the following runs.

User is recommended to increase pace.

HR is below aerobic zone.

Bar filled; as an incentive, user can pause and the avatar to catch gets closer.

Routes unlock with new avatars to search.

Progress bar filled unlocking any routes within a 1km radius to the user's current location.

AR interface with companion chasing an avatar

6.5 Design Outcomes

Considering the ongoing development of AR technology in the next few years, an integral component of the application yet to be explored extensively in my thesis is the user experience of mixed reality. Understanding how the new user adapt to a new visual and spatial experience on top of their existing knowledge. E.g., When I first experimented with Gravity Sketch which is a VR based sketching tool that allows you to draw in 3-dimensional space, there was interreference with my existing knowledge about sketching since I have never drawn in 3D space ever. So, I knew how to draw a 3D object on a 2D paper, but it was harder for me to draw the same 3D object in a 3D environment.

Similarly shifting from AR in smartphones to AR in eyewear alters the experience in aspects like change in visual orientation from portrait in smartphones, to landscape in any speculated eyewear.

User safety while running[5] is another a major aspect to be taken into account.

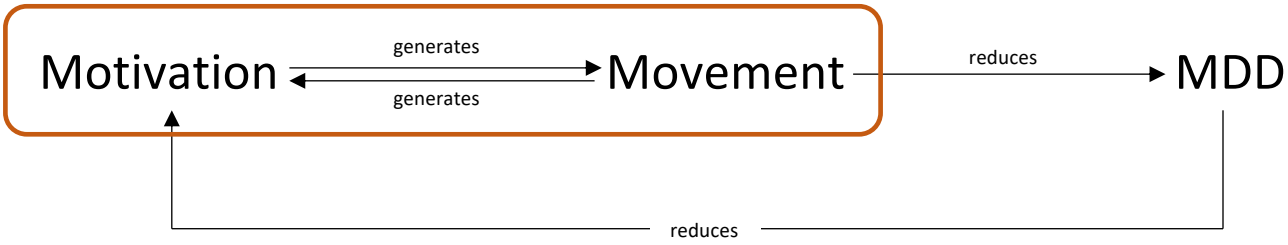
[5] Road safety at pedestrian 'crossings' is another safety concern that this thesis proposal raises. I believe that understanding city rules regarding road safety and merging them with AR design in future running applications is another topic to be researched entirely, which the scope of this thesis doesn't fully address.

6.6 Implication for designers

This thesis primarily offers insight based on personal experiences and existing research on depression in the field of neuroscience that can be kept into consideration while designing AR based assistance tools for individuals with mild-moderate MDD prescribed exercise treatments.

The problem space can be visualised[6] based on the findings that,

i. MDD leads to drop in motivation to generate physical movement in the affected individuals.
ii. Movement in the form of aerobic training can alleviate symptoms of depression.



Based on my understanding of MDD and running through working on this thesis, I see movement and motivation as codependent factors when viewing depression from the orientation of exercise treatments. Implying that the absence of motivation in some cases can be compensated by generating movement. Therefore, when designing for individuals with MDD in an AR environment, generating movement will be the fundamental aspect around which the application is designed.

Another key factor for the proposition of an AR based application is the responsiveness that individuals with MDD have been researched to show towards visual coherence tasks according to the research by C. Remmers in 2016. This prompted me to use visual cues as a primary mode of communication in AR over text-based or audible information. But I would highlight that my proposition encourages **focus on visuals and not visual appeal**.

The reason being that aesthetic visual experiences might not stimulate individuals with MDD as they would with someone not affected with MDD, since a key characteristic of MDD in many cases is presence of Anhedonia, which is the inability of an individual to experience pleasure (Gorwood., 2008). I won't deny the possible presence of any positive effects of having an aesthetically pleasing visual over a rather dull one, however, I would prioritise having visually conveyed information, like displaying numerical data visually, over aesthetical visual interfaces and animations.

[6] Visualisation based solely on the exercise treatment aspect of MDD. The diagram does not include the socio-cultural, genetic and environmental factors.

Also from a visual design perspective, it would be my preference to avoid hyper realistic virtual components since they can create visual interference with real world components. E.g., a real squirrel and a virtual squirrel.

6.7 Scope and Limitations

The end goal of the research is to cultivate a habit of running in individuals working towards treating mild-moderate MDD. The visual cues that guide the user into the earlier explorations into the AR medium are a method of generating the initial push for someone working to manage symptoms of mild/moderate MDD. Since one of the key motivators for someone to continue an activity is the feedback from doing that activity. The process gains some momentum after around 12 weeks of running which is the approximate time for the formation of new neurons in adult humans (Déry et al., 2013).

Additionally, viewing running through a lens of play instead of competition generates some level of curiosity towards understanding the reason behind the presence of this movement pattern and sheds light on various cultures like the Tarahumara tribe of Copper Canyons in Mexico, that have had running as an integral part of their lives for many generations.

One of the key limitations of this proposition is that it demands the presence of a certain level of infrastructure to make running in an AR environment a safe option. I can envision attempts to implement this platform in a runner friendly city like Vancouver, however, the requirements would be entirely different if I have to consider my hometown (Jalandhar) in India. Apart from the reasons discussed earlier like safe infrastructure for runners and presence of different terrains that makes running in Vancouver less monotonous, Jalandhar has a higher average summer temperature (~32°C) compared to Vancouver (~23°C) which also impacts people's desire to run especially during summer.

Another limitation is the accessibility of technology necessary for the AR interaction and for it to be an ergonomically comfortable option.

Hence even though through this body of work I am trying to address a broad issue of clinical depression, I am addressing a thin fraction of individuals in the entire spectrum of people with different levels of severity and levels of accessibility to existing services and infrastructures.

7. Analysis and Discussion

In the process of designing for a complicated social and psychological subject like clinical depression that has research in multiple domains of knowledge, having my personal experience as a guiding factor allowed me to target specific research subjects, like role of visualisation of scenarios during running and potential benefit of companionship as a psychological support. Additionally, I could gain some crucial insights through my own running practice. E.g., when running with a group, I was always able run much further without needing to stop often, however, running alone was much more effective in reliving symptoms of depression even though I was covering lesser distance.

This offered a valuable insight that even though running was effective in managing my symptoms, the benefits of **how I run** (alone) triumphed the benefits **how much I run**. Hence having a socially connected model which in my own experience allowed me to run greater distances, was not my preference when designing for individuals with diagnosed moderate MDD.[7] I am not sure if this would be considered as an appropriate research method but as a learning experience it orients me towards researching the importance of designers' own experiences in the complete process of design. Consequently, it also explains the importance of existing design methods like interviews and empathy mapping in allowing designers to not design purely on the basis of 'observed' numerical data like having excessive focus on distance covered instead of quality of the run.

Lastly, my fundamental intention of writing this thesis is the thought that back in 2017 when I was working on my own recovery from moderate MDD, if I had stumbled upon this piece of writing, it would have offered me valuable assistance and possibly reduced my recovery time to almost half. I kept this thesis very factual and to-the-point from the beginning because I knew that my 2017 self would have appreciated a more direct approach towards giving a solution space. A motivational narrative[8] would have pushed me then if I had the ability to feel motivated in the first place.

[7] On the contrary, a socially connected model like Strava might prove to be more successful with people not diagnosed with MDD.

[8] However, knowing or reading about someone's own journey through the issue did offere a sense that the problem is fixable, and I highly respect and acknowledge the work people put when recovering from the state of depression.

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