RUNNING WITH MUSIC: ANALYSING EXPERIENCES AND INTERACTIONS OF RUNNERS WITH DIGITAL AND TANGIBLE INTERFACES

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submitted by **AÇELYA KÜÇÜKKURT** in partial fulfillment of the requirements for the degree of **Master of Science** in **Industrial Design, Middle East Technical University** by,

Prof. Dr. Halil Kalıpçılar

Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Gülay Hasdoğan

Head of the Department, **Industrial Design**

Prof. Dr. Bahar Şener-Pedgley

Supervisor, **Industrial Design, METU**

Examining Committee Members:

Prof. Dr. Yiğit Yazıcıoğlu

Dept. of Mechanical Engineering, METU

Prof. Dr. Bahar Şener-Pedgley

Dept. of Industrial Design, METU

Assist. Prof. Dr. Sevi Merter

Dept. of Industrial Design, Yaşar University

Date: 11.09.2023

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name Last name : Açelya Küçükkurt

Signature :

ABSTRACT

RUNNING WITH MUSIC: ANALYSING EXPERIENCES AND INTERACTIONS OF RUNNERS WITH DIGITAL AND TANGIBLE INTERFACES

Küçükkurt, Açelya
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Running is an activity that many people prefer to do in order to feel more physically and mentally healthy. Listening to music, on the other hand, is more like a passive activity compared to running, but it usually affects the mood that we are in and helps us to focus. Doing these two activities together reveals advantages in terms of running performance, but may also bring some disadvantages. Runners prefer to run light, but this duo of activities requires the use of different devices and interfaces, such as a smartphone, headphones, and a music streaming platform. This research aimed to understand runners' experiences during their interactions with music listening equipment while running, which music control command is the easiest and which is the most difficult, the positive and negative effects on the running experience by considering the devices they carry such as electronic devices, headphones, etc. and to make design development suggestions that are more suitable for their needs. Since all music listening equipment have different interfaces and interactions when listening to music, it is assumed that the interactions between them may be complicated and difficult to manage. Relevant data was collected from ten runners through a running activity that included eye-tracking technology. In addition to that, one-on-one interviews also revealed the problems and benefits that they had and helped to dig into their routines more deeply. The results of the research give

researchers and designers some ideas for how to design the interfaces and the interactions, as well as some suggestions for further study.

Keywords: User experience, interface design, digital interactions, physical activity

ÖZ

MÜZİKLE KOŞMAK: KOŞUCULARIN DİJİTAL VE SOMUT ARAYÜZLERLE DENEYİMLERİNİN VE ETKİLEŞİMLERİNİN ANALİZİ

Küçükkurt, Açelya
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Koşmak, birçok insanın fiziksel ve zihinsel olarak daha sağlıklı hissetmek için yapmayı tercih ettiği bir aktivitedir. Müzik dinlemek ise koşuya kıyasla daha pasif bir aktivite gibi görünse de genellikle içinde bulunduğumuz ruh halini etkiler ve odaklanmamıza yardımcı olur. Bu iki aktiviteyi bir arada yapmak koşu performansı açısından avantajlar ortaya koysa da bazı dezavantajları da beraberinde getirebilir. Koşucular hafif koşmayı tercih eder ancak bu ikili aktivite akıllı telefon, kulaklık ve müzik akış platformu gibi farklı cihaz ve arayüzlerin kullanılmasını gerektirir. Bu araştırma, koşucuların koşarken müzik dinleme ekipmanlarıyla etkileşimleri sırasındaki deneyimlerini, hangi müzik kontrol komutunun en kolay hangisinin en zor olduğunu, taşıdıkları elektronik cihaz, kulaklık vb. cihazları göz önünde bulundurarak koşu deneyimine olumlu ve olumsuz etkilerini anlamayı ve ihtiyaçlarına daha uygun tasarım geliştirme önerilerinde bulunmayı amaçlamıştır. Müzik dinlerken tüm müzik dinleme ekipmanlarının farklı arayüzlere ve etkileşimlere sahip olması nedeniyle aralarındaki etkileşimlerin karmaşık ve yönetilmesi zor olabileceği varsayılmıştır. İlgili veriler, göz izleme teknolojisini içeren bir koşu etkinliği aracılığıyla on koşucudan toplanmıştır. Buna ek olarak, bire bir mülakatlar da yaşadıkları sorunları ve faydaları ortaya çıkarmış ve rutinlerini daha derinlemesine incelemeye yardımcı olmuştur. Araştırmanın sonuçları, araştırmacılara ve tasarımcılara arayüzlerin ve etkileşimlerin nasıl tasarlanacağına dair bazı fikirlerin yanı sıra konuyla ilgili daha fazla çalışma yürütebilmek için bazı öneriler de sunmaktadır.

Anahtar Kelimeler: Kullanıcı deneyimi, arayüz tasarımı, dijital etkileşim, fiziksel aktivite

To my beloved family and friends

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CHAPTER 1

INTRODUCTION

Running is one of the most popular and most practiced sports worldwide (Chan et al., 2022). People prefer jogging or running for a variety of reasons, including weight loss, fitness, and meditation. It may be part of a social activity such as group runs, or it may be part of a mental treatment that can be suggested for depression, anxiety, etc (Helsen et al., 2022). It does not require much equipment when compared to other kinds of sports, and this makes running more preferable. And in most cases, it becomes a regular activity in people's lives and a part of their daily or weekly routine.

Music listening is another activity that takes more of our time than we expected. Global Music Report (2023) indicates that an average person listens to 961 hours and 10 minutes of music per year and hears roughly 1.3 million songs in their lifetime. Music listening is usually an accompaniment activity rather than something done all by itself. For instance, when taking a bus or subway, people tend to put on their headphones and listen to music during the ride in order to keep themselves busy and have some fun. This kind of situation increases the time that we are exposed to music.

Experiencing these two activities together is a whole other experience for both runners and music listeners. As mentioned before, running can be seen as a feasible sport since it does not require any equipment; however, running with music makes this advantage disappear. Different types of wearables and carried devices become involved in the experience. First of all, runners need a source of music, such as a mobile phone or music player. This source needs to be equipped with a channel such as a headphone or earphone, in order to make the experience more personal and more focused. Most of the time, the source and the channel communicate through an application and an interface. The application provides controls, such as pausing or resuming songs, changing songs, increasing or decreasing the volume, and changing the playlist. These elements enhance the running experience all at once when the runner decides to run with music. This intervention creates the issue of carrying extra equipment from the very start.

For runners, the experience of controlling music while on the go can be challenging. When running, physical movement and external factors, such as wind and traffic can disrupt the experience, making it difficult to access the music control features easily. Moreover, the extra weight and bulk of the devices can be bothersome and uncomfortable during long runs. Finding a balance between controlling the music and focusing on the running task at hand can be a tricky task for many runners. Despite these challenges, many runners still choose to incorporate music into their running routine and find ways to make the experience more seamless and enjoyable.

Current mobile music streaming platforms and headphones are already offering different features to the users to make their experience with music more and more effective. However, looking through it from the runner's perspective, this experience can be very shaky and blurry. Many studies in the literature try to dig in about the running performance and focus related issues; however, there is not much about the devices and their interfaces that they use in the frame of this duality of actions. So, the focus of this study will be both on the overall experience and the specialized interactions between the user and the tangible and digital interfaces.

1.1 Motivation for the Research

The inspiration for this study comes from a previous research endeavour that investigated the impact of interface alterations on driver safety in the context of Spotify (see Figure 1.1). First, drivers were instructed to execute the music playing controls in the default playing now mode and interface of the Spotify from the car screen, while they were wearing eye-tracking glasses. In the second part, the same instructions were given in the car view mode of the Spotify. Their gaze and fixation points recorded and then analysed. Drivers' gaze behaviours and the response time to the instructions revealed that the car view of the Spotify is more effective and safer to use when it is compared to the normal view. Eventually, this study demonstrated that simple modifications, such as adjusting icon sizes and removing unnecessary information, significantly improved drivers' ability to focus on the road rather than being distracted by the interface (see Figure 1.1).

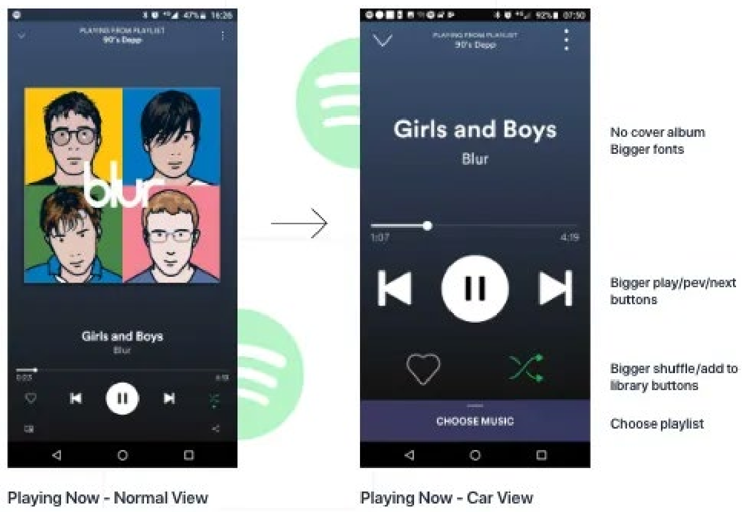


Figure 1.1 Spotify 'Playing Now' normal view and 'Playing Now' car view (taken from https://medium.com/@ainatlandau/a-journey-to-an-ultimate-driving-experience-e310f7d49760)

This finding prompted the researcher to explore whether similar alterations could be beneficial for runners. While running, individuals often rely on music as a source of motivation and entertainment. However, the existing interfaces of music control applications are primarily designed for general use, lacking considerations specific to runners' needs. Consequently, runners may face difficulties navigating and controlling their music while maintaining their focus on the path ahead, potentially compromising their safety and overall running experience.

By extending the principles of interface alterations from the driver safety study to the realm of running, this research seeks to address these challenges and enhance the running experience for individuals, who enjoy music during their workouts. The ultimate goal is to empower runners to seamlessly control their music without distractions, allowing them to maintain their concentration and rhythm while staying connected to their chosen playlists.

The researcher believes that by adapting music control interfaces for running activities, it is possible to optimize the user experience and create a safer and more enjoyable environment for runners. Drawing inspiration from previous successful applications of interface alterations, the researcher aims to apply similar design principles and adapt them to the specific context of running.

Through this study, the researcher hopes to bridge the gap between technology and recreational activities, aligning them in a way that enhances rather than hinders the runner's experience. The motivation to explore and innovate in the field of music control interfaces for runners is driven by the belief that advancements in interface design can significantly contribute to optimizing performance, safety, and overall satisfaction during running sessions.

In conclusion, the motivation and inspiration behind this study lie in the researcher's commitment to improving the running experience by examining the experiences and interactions that the runners have with the tangible and digital interfaces they interact with. The success of previous interface alterations in the context of driver safety serves as a catalyst for exploring the potential benefits of similar modifications tailored specifically for runners. By addressing the unique challenges faced by runners when interacting with music control interfaces, the researcher aspires to create a safer, more engaging, and ultimately more rewarding running experience.

1.2 Aim and Objectives of the Study

The main aim of the study is to understand the experience of running with music while observing the runners' interaction with the digital and tangible interfaces that they use in order to achieve simple controls. In addition to that, the study tries to present design recommendations according to the needs and expectations of the runners to make their experience more user-friendly.

To accomplish the aims of the research, the study established three objectives. The first objective is to comprehend the impact of existing digital music streaming platforms and headphones on the experience of running with music. The second objective is to uncover the genuine requirements and anticipations of runners regarding running with music. Finally, the third objective is to provide design suggestions to improve and advance the overall experience of runners while listening to music during their runs.

1.3 Research Questions

According to the mentioned aim and the objectives of the study, some research questions emerged. These questions and sub-questions are listed below.

- What devices and streaming platforms do runners use to listen to music?
    - What effects do interfaces of the devices and digital music streaming platforms have on the experience of running with music?
- What are the most challenging music control commands for runners who prefer to listen to music while running?
- What design recommendations can be made to enhance the running experience while listening to music through both digital and physical interfaces?
- Can eye-tracking technology be effectively used to study the experience of running while listening to music?

1.4 Scope of the Study

This study mainly focuses on the runner's routines and behaviors when they decide to listen to music while running. The running activity (fieldwork) involves amateur runners from Ankara, Turkey, who run regularly and prefer to run with music. The fieldwork was carried out in a stadium that belongs to the university (ODTÜ Devrim Stadium) in order to create consistency about the environmental features and the running distance. The runner's running performance is not measured or compared; only the experience that they have with the interfaces that they use is tried to quantitatively and qualitatively analyze.

1.5 Audience of the Study

The results of the study provide insights for designers and researchers to improve the interfaces and interactions for runners, who listen to music while running and suggest further areas of study. So, future researchers and designers can be pointed out as the audience of this study.

1.6 Structure of the Thesis

The thesis structure includes five chapters, as presented below.

Chapter 1 gives a short summary of the study's background, its purpose and goals, its research questions, and how it is organized.

Chapter 2 discusses related literature. This chapter starts with some previous studies related to running with music and the motivations for running with music. And it continues with the examination of music streaming platforms and the usability of their features, followed by a similar examination of headphones and their features. Finally, the eye-tracking technology was briefly explained and presented in relation to the study.

Chapter 3 describes the structure of the research methodology. The chapter provides an overview of the three phases of the fieldwork (pre-running-interviews, the running activity ‘Devrim Running’, post-running-interviews), data collection tools and methods, and data analysis phases.

Chapter 4 offers the results and analysis of the fieldwork, along with the researcher's design ideas and recommendations.

Chapter 5 is the conclusion of the study. After reviewing the research topics, the researcher's views, the research's limitations, and ideas for further research are offered.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

The impact of music on various aspects of human life has been a subject of interest and research across different domains. In the context of physical exercise and performance, running with music has gained considerable attention. This chapter aims to provide a review of literature surrounding the topic of running with music, exploring its effects, technologies that facilitate running with music, including wearables and mobile applications, as well as relevant design considerations. To achieve this, the chapter starts with the examination of running as a physical activity, focusing on the effects of music on running that include performance, psychology, and design-related studies. After discussing the various research methodologies used to investigate this phenomenon, the chapter explores the technological landscape in the next section. Then, the chapter investigates the evolution of headphone and earphone designs by covering design considerations. In the final section, the chapter ends with a conclusion. It is expected to examine the multifaceted relationship between running and music.

2.2 Running with Music

Running and music have unique places in the lives of many people individually. Music is a universal source of inspiration, rhythm, and enjoyment, whereas running represents physical exercise, health, and social ties. When these two interests come together, the result can significantly enhance the overall running experience.

There are many issues that need to be analysed in order to understand running with music. First of all, these two experiences need to be evaluated and analysed separately. The exercise of running alone and the activity of listening to music have different requirements. When these two experiences come together, there is a lot to consider. Therefore, before analysing the experience of listening to music while running in detail, a general review of their place in the literature should be made separately.

2.2.1 Running as an Activity

Running is a popular physical activity that engages individuals across various age groups and fitness levels. This section introduces the topic of the running experience and emphasises the importance of understanding its multidimensional nature.

The physical sensations and bodily responses associated with running contribute to the overall experience. Research suggests that running involves physiological changes, such as alterations in heart rate, breathing patterns, and energy expenditure (Berger et al., 2006; Foster et al., 2019). These physiological changes are essential for meeting the increased demands placed on the cardiovascular and respiratory systems. Additionally, some studies have examined the effects of running on muscle activation, joint forces, and biomechanics (Boyer et al., 2019; Milner et al., 2015). Understanding these aspects provides insights into the physical demands and benefits of running.

The psychological experience of running is notable for its positive effects on mental well-being. Research has shown that running can induce a "runner's high", a state of euphoria and well-being, often attributed to the release of endorphins (Boecker et al., 2008; Dietrich and McDaniel, 2004). Moreover, running has been linked to mood regulation and stress reduction. Regular running has been associated with reduced symptoms of depression and anxiety, improved self-esteem, and enhanced cognitive functioning, including attention and memory (Hassmen et al., 2000; Stults-Kolehmainen and Bartholomew, 2012).

Running also has the power to evoke a wide range of emotions. Many runners report experiencing joy, a sense of accomplishment, and empowerment during and after their runs (Lane and Wilson, 2011; Yeadon et al., 2008). The emotional benefits of running extend beyond the immediate experience, contributing to overall emotional well-being. Research has indicated positive associations between running and emotional well-being, self-esteem, and body image (Sabiston and McDonough, 2009; Tiggemann and Zaccardo, 2018). Running can provide a sense of control, mastery, and positivity in one's relationship with their body.

Running can be both a solitary and a social activity. Many individuals find motivation and support through participation in running groups, virtual communities, and organised races (Eime et al., 2013; Stragier et al., 2015). The social aspects create a sense of belonging and camaraderie among runners. The shared experiences, encouragement, and friendly competition within the running community contribute to the social dimension of the running experience (Toering et al., 2009). Social support from fellow runners can also enhance motivation, accountability, and overall enjoyment of the activity.

Running presents both challenges and rewards. Common challenges include the risk of injuries, which can arise from factors such as improper training techniques, inadequate recovery, or biomechanical issues (Krabak et al., 2011; Niven et al., 2020). Fatigue and fluctuations in motivation can also pose challenges to runners. However, the rewards of running are significant and often outweigh the challenges. Running provides a sense of accomplishment and achievement, particularly when goals are met or personal records are broken. It offers a means of improving fitness, maintaining a healthy weight, and promoting overall physical well-being. Additionally, running can lead to personal growth, increased self-confidence, and a sense of empowerment (Moore et al., 2020; Trujillo et al., 2019).

Therefore, the experience of running encompasses physical, psychological, emotional, and social dimensions, offering a holistic perspective on its impact on individuals. By considering these dimensions, individuals can gain a deeper understanding of the holistic impact that running can have on their physical health, mental well-being, and social connections.

2.2.2 Music as a Motivational Tool

Music has long been recognized as a powerful motivational tool, particularly in the context of exercise and physical activities. Numerous studies have investigated the impact of music on psychological state and performance, highlighting its ability to enhance affect, reduce ratings of perceived exertion, improve energy efficiency, and increase work output (Karageorghis and Priest, 2012). When carefully selected according to its motivational qualities, music has been shown to have a magnified positive impact on both psychological state and performance (Karageorghis and Priest, 2012).

Motivational music tends to have a fast tempo (>120 bpm) and a strong rhythm, which is proposed to enhance energy and induce bodily action (Franěk et al., 2014). The beat and tempo of music can synchronize with the body's movements, leading to improved performance and endurance (Bood et al., 2013). Listening to motivational music has been found to stimulate physical activity, improve mood, reduce perceptions of exertion, and induce changes in arousal (Franěk et al., 2014). It can serve as a distraction from feelings of pain and fatigue, allowing individuals to push through challenging moments during exercise (Bood et al., 2013).

The effects of music on motivation and performance are not limited to physical exertion alone. Music has the ability to evoke emotions and create a positive affective state, even in the presence of negative psychological circumstances (Tol and Edwards, 2011). Listening to pleasant music has been shown to raise dopamine levels and activate brain regions associated with pleasure, reward, and emotional response (Tol and Edwards, 2011). This suggests that music has important psychological effects, even when individuals are not consciously aware of them.

In conclusion, music serves as a powerful motivational tool in the context of exercise and physical activities. It has the ability to improve mood, reduce perceptions of exertion, and create a positive affective state. By understanding the motivational qualities of music and selecting appropriate tracks, individuals can harness the power of music to enhance their motivation, performance, and overall exercise experience.

2.2.3 The Intersection of Running and Music

The combination of running and music creates a unique synergy that enhances the overall running experience. The rhythmic nature of running aligns well with the rhythmic qualities of music, creating a harmonious and immersive experience. Music can serve as a powerful motivator, providing a steady beat that helps runners maintain their cadence and pace. It can also evoke emotions, uplift spirits, and distract from physical discomfort, allowing runners to push through challenging moments. The integration of music into running routines has become increasingly popular, as runners recognize the positive impact it can have on their performance, enjoyment, and overall well-being. By looking through the related literature the studies that involves the combination of running and music mostly focused on the performance and psychological state of the runners.

The impact of music on running performance has been explored in different contexts. For example, a study investigated the effects of musical stimuli on university students' performance in a deep-water running protocol and found no significant differences in heart rate and perceived exertion with and without music (Cabral et al., 2022). However, it is found that different levels of music information had an effect on running performance, and that participants tended to run a greater distance when there was more music information, particularly in synchronous conditions (Ramji et al., 2016).

Another aspect of the intersection between running and music is auditory-motor synchronization. The beat and tempo of music can synchronize with the body's movements, leading to improved performance and endurance (Bood et al., 2013). Research has shown that synchronizing movement tempo to acoustic stimuli, such as music or metronomes, can enhance running performance. This synchronization creates a rhythmic and energizing backdrop that helps runners maintain a steady pace and optimize their running efficiency (Bood et al., 2013).

The intersection of music and running also offers psychological benefits through distraction and dissociation. Bood et al. (2013) discuss how motivational music can divert attention from running-induced feelings of fatigue and discomfort, allowing runners to push through challenging moments. Focusing on motivational music as a distraction technique can help runners dissociate from physiological signals and enhance performance.

Music has a profound impact on psychological state during running. It can influence mood, arousal, and attentional focus. Karageorghis and Priest (2012) emphasize the motivational qualities of music, which can stimulate physical activity, improve mood, and reduce perceptions of exertion. The motivational impact of music can enhance runners' focus, determination, and overall enjoyment of the running experience.

Moreover, the motivational qualities of music play a crucial role in the intersection of running and music. Motivational music with its fast tempo and strong rhythm can stimulate physical activity, improve mood, and reduce perceptions of exertion (Bood et al., 2013). It serves as a powerful motivator, providing a source of inspiration and distraction from feelings of pain and fatigue during running. The motivational impact of music can enhance runners' focus, determination, and overall enjoyment of the running experience (Terry et al., 2012).

Several studies have investigated the both psychological and performance impact of music on running performance. Karageorghis and Priest (2012) highlight the positive effects of music on psychological state and performance, emphasizing its ability to enhance affect, reduce perceived exertion, and improve energy efficiency. They suggest that carefully selected music can promote ergogenic and psychological benefits during running.

Running with music offers a dynamic and engaging experience that combines the physical benefits of running with the emotional and motivational power of music. The rhythmic nature of running and the ability of music to evoke emotions and enhance motivation create a synergistic effect that enhances the overall running experience. By understanding the impact of music on running and harnessing its potential, individuals can optimize their running routines and achieve their fitness goals.

While many studies support the positive effects of music on running performance and psychology, some studies also present contradictory findings. Atan (2013) found that music and its rhythm did not enhance anaerobic performance or change the physiological response to exercise. These contradictory findings suggest that the effects of music on running may vary depending on factors, such as exercise intensity and individual preferences.

In addition to the performance and psychology studies that is focused on the experience of running with music one last literature can be examined too, which is the user experience literature. Several studies have explored the relationship between running with music and design-related aspects. One study focused on designing a music-controlled running application (Bauer and Kratschmar, 2015). The goal of this work was to synthesize findings and translate them into design requirements for new applications. The study highlighted the phenomenon of people instinctively syncing their pace with the music's tempo, which can be leveraged in the design of music-controlled running applications.

However, it has been found that the literature examining the experience of listening to music while running from a user experience perspective is lacking in many aspects. Another aim of this study is to try to contribute to filling this gap by analysing the music listening experience of runners through the interfaces and device interactions they use.

Overall, running with music has been shown to have significant effects on both performance and psychological state. Music can enhance running performance through auditory-motor synchronization, motivational qualities, and distraction techniques. It can also influence mood, arousal, and attentional focus, contributing to an overall positive running experience. However, there are also contradictory findings that provokes the opposite opinion about the performance and motivation boost feature of the music while exercising. Further research is needed to explore the specific mechanisms underlying the effects of music on running and to understand the individual differences in response to music.

2.2.4 Motivation towards Running with Music

Numerous runners use music as more than just an accompaniment; they use it as a support system to help them stay focused, maintain a steady pace, and push through challenging situations. Running can feel less effortless when the music's beat matches each step (Barbosa et al., 2010) because it creates a rhythmic flow. According to Tenenbaum et al. (2004), while listening to music while doing high-intensity running may be beneficial, it may not help them maintain their effort for longer than they could without it. It indicates the necessity to pursue this line of investigation further by doing more research that considers individual preferences for musical style and rhythm.

Research shows that the combination of running and music not only improves performance but also fosters a deeper psychological connection. According to a study published in the Journal of Sport and Exercise Psychology (2015), listening to music while running can lead to improved endurance and increased feelings of pleasure and enjoyment. The tempo of the music can also influence the pace of running, as faster-paced songs often promote faster running speeds (Terry et al., 2012).

It is significant to highlight that each runner has different musical preferences, which reflects the variety of ways they incorporate music into their routines. Some runners thrive on the rush of fast-paced, high-energy music. These tracks can assist in balancing their intensity, motivating players to tackle challenging exercises or races with passion. For example, a sprinter getting ready for a brief, strong burst of speed can discover that bouncy rock or electronic music creates the ideal tempo to match with their rapid strides. On the other hand, some people benefit from running to cultivate awareness and a meditative state. The music preference for these runners shifts to relaxing and soothing sounds. They can lose themselves in the rhythm of their breath and the tranquillity of nature with the help of these songs, which act as a calming backdrop.

In addition, the selection of music can align with the specific goals of the run. Long-distance runners might create playlists that progressively get louder as they advance through their endurance practice. Such playlists might begin with gentle tunes as a warm-up and gradually switch to more energising music for the main part of the run. his progressive change in music tempo can help runners maintain a steady and controlled pace by serving as a psychological and physical cue.

A number of techniques can be used to maximise the effects of music on a runner's physical and psychological performance while using music to improve performance while running. This includes synchronising one's steps with the beat of the music to control pacing and cadence, choosing uplifting and motivating songs to increase mental endurance, using music as a distraction from discomfort and fatigue, improving concentration with instrumental or rhythm-focused music, elevating mood to maintain a positive mindset, and invoking successful mental images. Other essential elements include personalised feedback mechanisms, timed intervals, and customised playlists. The effectiveness of music in enhancing running performance ultimately depends on the individual's objectives, tastes, and the particular requirements of their training or race, making it a very individualised tool for runners looking for an advantage.

2.3 Electronic Devices, Platforms and Accessories Used while Running with Music

Running is more than just a physical activity; it is a blend of fitness and personal enjoyment. For many runners, music adds another layer to this experience. That is why the tools and technology that make this combination possible should be explored.

Modern electronic gadgets like smartphones and smartwatches have become essential companions for runners. They are offering all sorts of features that enhance the running experience. Together with these devices there should be another component to complete the overall experience while providing the transmission of the music which is headphones and earphones. Alongside these devices, a variety of digital music platforms that provide the music are also provided for the runners. There is also a range of accessories designed specifically for running with music, such as armbands. These accessories make runners' music listening experience more comfortable.

By breaking down these electronic devices, platforms, and accessories, this chapter aims to shed light on how technology and music influence the act of running. Uncovering how these tools shape the runner's experience will help to better understand how music and running come together.

2.3.1 Electronic Devices

Runners carry various electronic devices to listen to music while running. These devices include smartphones, music players such as iPods or MP3 players, wireless or wired headphones/earphones, and wearable devices, such as smartwatches or fitness trackers with music playback capabilities (Janssen et al., 2017). The choice of device depends on personal preferences, convenience, and desired features that enhance the running experience.

Smartphones are a popular choice among runners as they provide access to music streaming apps, personal music libraries, and customizable playlists. Music players offer a dedicated device for portable music playback, often with long battery life and compact design. Wireless headphones/earphones have gained popularity due to their convenience and freedom from tangled wires, while some runners still prefer traditional wired options (Janssen et al., 2017).

Wearable devices, such as smartwatches or fitness trackers, often have built-in music playback features that allow runners to listen to music without carrying a separate device. These devices can connect to wireless headphones/earphones or have built-in speakers for audio output (Pobiruchin et al., 2017).

Runners today have a plenty of options for electronic devices for enhancing their music-infused running experiences. These devices range from versatile smartphones with music streaming capabilities to dedicated music players offering reliability and extended battery life. Wireless headphones and earphones have become a favored choice due to their freedom from cumbersome wires, while some runners still appreciate the simplicity of wired options. Additionally, wearable devices like smartwatches and fitness trackers have seamlessly integrated music playback features, eliminating the need for a separate music player. This variety of electronic companions underscores the significance of individual preferences and convenience in the world of running with music.

2.3.2 Headphones and Earphones

Choosing the right headphones or earphones for running is a crucial decision for athletes and fitness enthusiasts. The design of these audio devices for running goes beyond just providing sound; it encompasses integrated technologies, specific design features, and considerations for user preferences. In this part, the various aspects of headphone and earphone design tailored for running will be mentioned. We will delve into the integrated technologies like noise-cancelling, bone conduction, and sound isolation, as well as the design features such as comfort, stability, durability, and sweat resistance. Additionally, the user preferences and practices that runners consider when selecting their ideal audio companion for their workouts will also be examined. By understanding these factors, runners can make informed decisions and find the perfect headphones or earphones that complement their running routines.

2.3.2.1 Specialized Features and Integrated Technologies

Headphone and earphone design for running incorporates a range of integrated technologies to enhance the user experience, comfort, and performance

(Loewenstein et al., 2001). These technologies play a crucial role in factors such as sound quality, fit, durability, and functionality, ensuring that runners can enjoy their music or audio content while engaging in physical activity.

One important aspect of headphone and earphone design is the consideration of acoustic transfer functions of the external ears (Deng and Yang, 2015). Deng and Yang (2015), discusses the modelling and estimation of these transfer functions, which affect the perceived sound features. The study develops a method for estimating the frequency responses of external-ear transfer functions based on an acoustic signal model. This allows for individualised data and realistic simulations, enabling designers to optimise sound reproduction and tailor the audio experience to the individual runner.

Integrated technologies also include virtual reality (VR) systems (Chan et al., 2020). Chan (2020), highlights the components of VR systems, such as audio systems (earphones or headphones), visual systems (head-mounted displays), and motion tracking systems. These technologies provide an immersive experience and presence in virtual worlds, with applications in various fields, including healthcare and entertainment. While VR systems may not be directly designed for running, they showcase the potential for integrating audio and visual technologies to create engaging and interactive experiences for runners (Wang et al., 2022).

Wireless connectivity is another important feature in headphone and earphone design for running. Bluetooth technology enables wireless connection to devices, providing freedom of movement during running. This eliminates the hassle of tangled wires and enhances convenience for runners, allowing them to focus on their performance without being restricted by cables. Wireless connectivity also enables seamless integration with smartphones or other devices, allowing runners to control their music or audio content effortlessly.

Battery life is another important consideration. Long-lasting battery performance ensures that runners can enjoy their music or audio content without interruption during extended workouts. Charging cases or quick charging capabilities are additional features that enhance the usability of these accessories.

Sound reproduction and quality are crucial considerations in headphone and earphone design (Chapman, 2001). Chapman (2001), discusses the techniques used by DJs, where cross-faders and scratching are employed to manipulate sound elements. These techniques rely on the design and functionality of headphones to achieve the desired effects. Similarly, in running accessories, the design should prioritise accurate sound reproduction, balanced frequency response, and noise isolation to deliver an immersive and high-quality audio experience for runners.

It is worth noting that while headphone and earphone design for running offers numerous benefits, there are also considerations related to safety and awareness. It is important for runners to remain aware of their surroundings, especially when running outdoors. Some designs incorporate features like transparency modes or quick ambient sound activation to allow external sounds to be heard while still enjoying music.

Furthermore, some headphone and earphone designs for running integrate biometric sensors to provide additional functionality. These sensors can monitor heart rate, distance, pace, and other fitness metrics, providing real-time feedback to runners. This integration eliminates the need for separate fitness tracking devices and offers a streamlined experience.

2.3.2.2 Design Considerations

When designing earphones for the specific context of running, several key considerations come into play to ensure an effective combination of audio enjoyment and safety. Firstly, the form factor should prioritize a secure and comfortable fit, as runners' movements are dynamic and rigorous. In-ear or over-ear designs with ergonomic shapes and adjustable features tend to provide a secure and snug fit that minimizes the risk of earphones dislodging during physical activity.

Secondly, earphones should consider the runner's need for situational awareness. Open-ear or bone-conduction designs that allow ambient sounds like traffic or conversations to be heard alongside music can be safer options, especially when running in urban environments. Alternatively, noise-canceling and sound-isolating features can be essential for those seeking an immersive musical experience while running in quieter or more controlled settings.

Durability and resistance to moisture are also paramount. Earphones designed for running should be sweat-resistant or even waterproof to withstand the rigors of outdoor workouts or intense training sessions. Additionally, tangle-free and lightweight cables can contribute to a hassle-free running experience.

Lastly, control interfaces should be intuitive and accessible, allowing runners to adjust volume, change tracks, or answer calls with minimal disruption to their stride. Whether through tactile buttons, voice commands, or touch-sensitive surfaces, user-friendly controls enhance the overall usability of earphones in a running context. In essence, earphone design tailored to the unique demands of running plays a pivotal role in ensuring a safe, enjoyable, and musically enriched exercise experience.

Ear anthropometry plays a crucial role in earphone design. Fu and Luximon (2020) highlight the importance of considering the concha dimensions and curvatures of the ear root for earphone-head design. Understanding the variations in ear size and shape helps designers create earphone designs that provide a secure and comfortable fit for different individuals.

Material selection is another important aspect of design. Thi et al. (2021) discuss the application of membrane technology in face mask products and the development of protection mechanisms. Similarly, in earphone design, the selection of moisture-resistant materials is crucial to ensuring sweat and water resistance. This helps protect the internal components of the earphones and prolong their lifespan.

Ergonomic considerations are essential for designing earphones that are comfortable to wear during running. Song et al. (2020) emphasize the importance of measuring relevant anthropometric parameters and designing products accordingly. This includes factors such as ear dimensions, product attributes, and wearing comfort. By considering ergonomic principles, designers can create earphone designs that minimise discomfort and fatigue during prolonged use.

User preferences and usability are also important design considerations (Kiehl et al.; 2005, Sakoglu et al., 2010), and Sheth et al. (2022) discuss the use of earphones and headphones in various experimental settings. These studies highlight the importance of ensuring that earphones are worn as instructed and that they provide a satisfactory sound experience. User feedback and usability testing can help designers refine their designs and address any issues related to fit, sound quality, and ease of use.

2.3.3 Mainstream Music Streaming Platforms/Services

Mainstream mobile music streaming platforms, also known as music streaming services, have become a popular means of accessing and listening to music. These platforms offer on-demand access to a large database of audio or audio-visual content centred on music (Hesmondhalgh, 2021). They have transformed the social dynamics of music consumption and provided users with the ability to access millions of music tracks at any time and from any location using mobile devices (Sakurai et al., 2022).

Music streaming platforms have gained significant traction, with a large number of users worldwide. A survey of online users in 21 countries found that 89% of respondents used music streaming services (Hesmondhalgh, 2021). Platforms, such as Spotify, Apple Music, QQ Music (China), and NetEase Music (China), have become prominent players in the music streaming industry (Chang et al., 2021).

The rise of music streaming platforms has brought about changes in music curation and consumption. Traditional gatekeepers in the music industry, such as radio programmers and journalists, have been replaced by platform gatekeepers, who combine proprietary algorithms and human curators (Bonini and Gandini, 2019). These platform gatekeepers have the power to set the "listening agendas" of global music consumers, utilising algorithms and big data to enhance their editorial power (Bonini and Gandini, 2019).

The shift from ownership models to access models has been a significant development in music streaming services. Unlike traditional digital music services that offered ownership of music, streaming services provide users with access to a comprehensive music library without legal ownership (Danckwerts and Kenning, 2019). This shift has contributed to the growth of music streaming revenue, with a sharp increase in ad-supported and paid streaming services (Danckwerts and Kenning, 2019).

The design and features of music streaming platforms have also evolved to enhance user experiences. Mobile apps have become a key component of these platforms, providing users with convenient access to music libraries and establishing relationships between users and the platforms (Stocchi et al., 2019). The brandification of apps has further expanded the reach of music streaming services, making them commercially popular and extending the presence of offline brands into the digital realm (Stocchi et al., 2019).

While music streaming platforms have become mainstream, there are ongoing discussions and research on various aspects of these platforms. Studies have explored the effects of streaming on music culture, the role of psychological ownership in streaming consumption, and the environmental impact of streaming (Beuscart et al., 2022; Danckwerts and Kenning, 2019; Hesmondhalgh, 2021).

In summary, mainstream mobile music streaming platforms have revolutionised the way people access and consume music. These platforms offer on-demand access to vast music catalogues, combining algorithms and human curators to shape the listening experiences of global music consumers. The shift from ownership models to access models has transformed the music industry, and mobile apps have played a significant role in establishing user-platform relationships. Ongoing research continues to explore the impact and dynamics of music streaming platforms on music culture, user behaviours, and playlist generation.

2.3.3.1 YouTube Music

YouTube Music is a music streaming platform and app developed by YouTube. It offers a wide range of music content, including official music videos, live performances, remixes, covers, and user-generated content (see Figure 2.1). YouTube Music provides users with access to a vast library of songs and albums from various genres, artists, and labels.

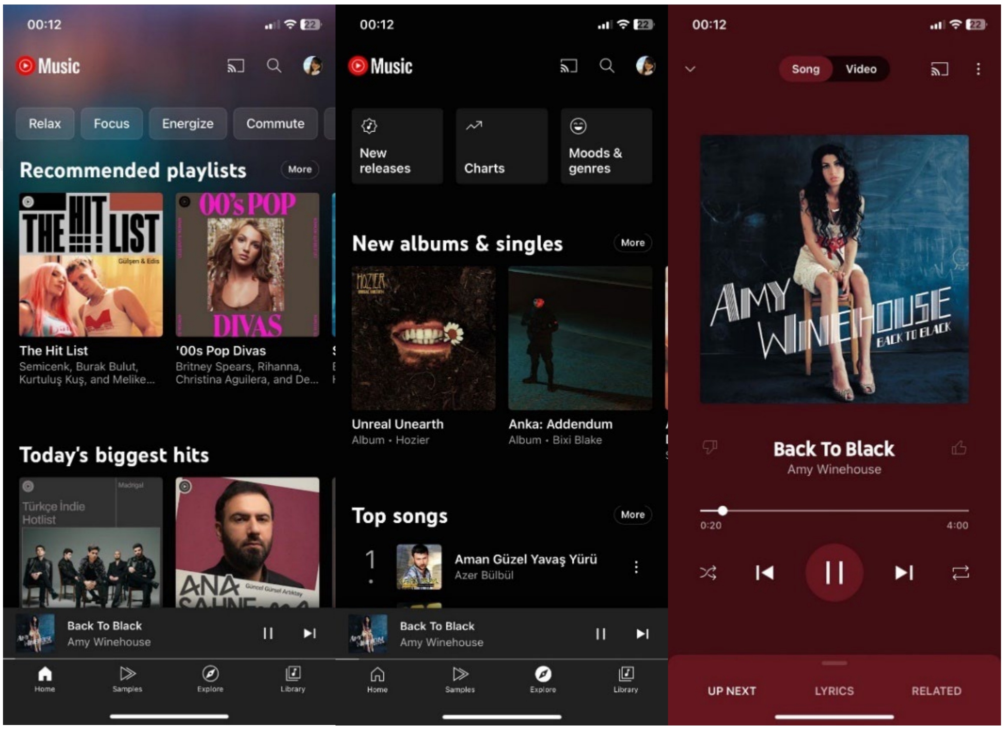


Figure 2.1 Example screenshots from the YouTube Music mobile platform

One of the key features of YouTube Music is its personalised recommendations and discovery algorithms. The platform utilises machine learning and user data to suggest music based on individual preferences, listening history, and user interactions. This helps users discover new artists, songs, and playlists tailored to their tastes.

YouTube Music also offers various playlists curated by music experts and popular artists. These playlists cover different moods, genres, and themes, providing users with a diverse selection of music for different occasions or preferences. Users can also create their own playlists and share them with others.

In addition to the audio content, YouTube Music incorporates music videos into its platform. Users can watch official music videos, live performances, and other visual content related to the songs they are listening to. This integration of music videos enhances the overall music streaming experience and allows users to enjoy a more immersive and visual music experience.

YouTube Music is available as a standalone app for mobile devices and can also be accessed through the YouTube website. It offers both free and premium subscription options. The premium subscription, known as YouTube Music Premium, provides ad-free listening, background playback, offline downloads, and access to YouTube Originals content.

Overall, YouTube Music provides a comprehensive music streaming experience, combining audio tracks, music videos, personalised recommendations, and user-generated content. It has become a popular platform for music discovery, sharing, and consumption, offering a vast and diverse collection of music content to users worldwide.

2.3.3.2 Spotify

Spotify is a popular digital music streaming platform that provides users with access to a vast library of music from various genres, artists, and labels (Siles et al., 2020). It offers both free and premium subscription options, allowing users to listen to music on-demand, create playlists, discover new artists, and share music with others (Hracs and Webster, 2020).

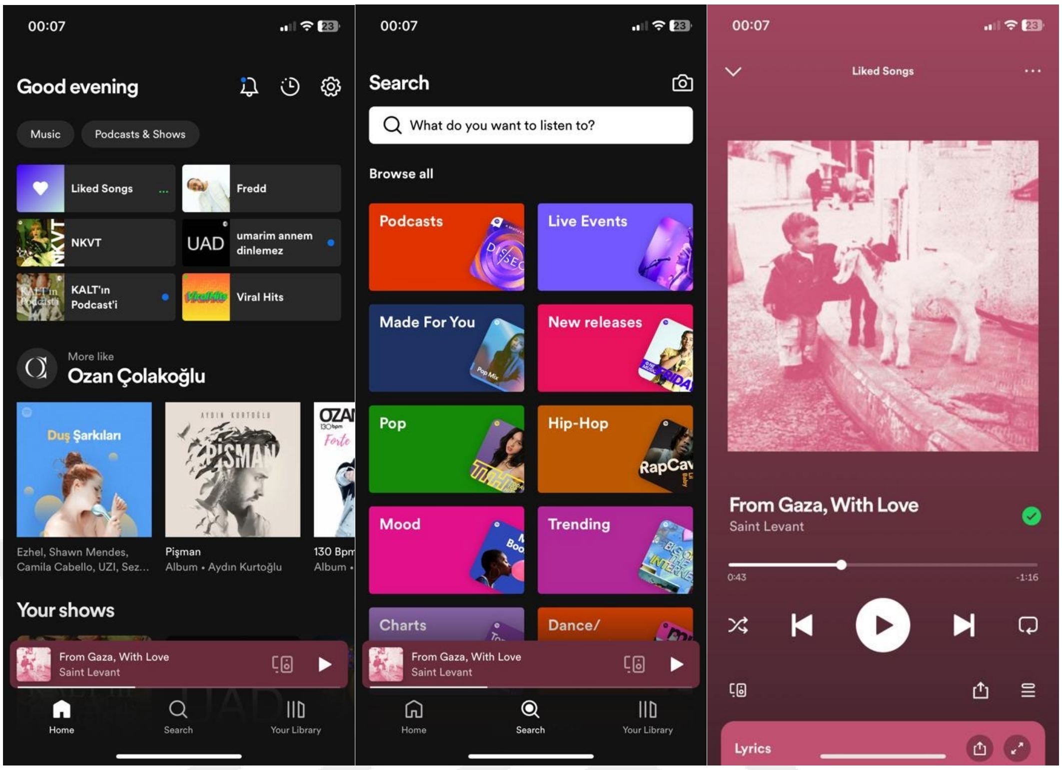


Figure 2.2 Example screenshots from the Spotify mobile application

One of the key features of Spotify is its extensive music catalogue, which includes millions of songs from around the world (Pizzolitto, 2023). Users can search for specific tracks, albums, or artists, or explore curated playlists and personalised recommendations based on their listening history and preferences (Siles et al., 2020). Spotify's recommendation algorithms utilise machine learning and user data to suggest music tailored to individual tastes, helping users discover new music (Siles et al., 2020).

Spotify also offers social features that allow users to follow friends, artists, and influencers. Users can share their favourite songs, playlists, and albums with others, collaborate on playlists, and see what their friends are listening to (Siles et al., 2020). This social aspect enhances the music discovery experience and facilitates music sharing within the Spotify community.

The platform is available on various devices, including smartphones, tablets, computers, smart speakers, and other connected devices (Siles et al., 2020). Users can download the Spotify app or access the platform through a web browser, providing flexibility and convenience for listening to music anytime, anywhere (Siles et al., 2020).

In addition to its music streaming services, Spotify has expanded its offerings to include podcasts and other spoken-word content. The platform has become a leading destination for podcast listening, featuring a wide range of podcast genres and exclusive content (Siles et al., 2020).

Spotify has also been a significant player in the music industry, influencing the way music is consumed and distributed. It has provided new opportunities for artists to reach a global audience, and its data-driven approach has influenced music marketing and promotion strategies (Bello and Garcia, 2020). The platform has also been involved in licensing agreements with major record labels and independent artists, contributing to the monetization of music streaming (Pizzolitto, 2023).

Overall, Spotify has transformed the way people listen to and discover music. With its extensive music catalogue, personalised recommendations, social features, and availability across multiple devices, Spotify has become one of the leading music streaming platforms globally (Siles et al., 2020).

2.3.3.3 Apple Music

Apple Music is a music streaming platform developed by Apple Inc. that offers a vast library of songs, albums, and playlists (Lai, 2022). It provides users with access to a wide range of music genres and artists, allowing them to discover new music and create personalised playlists.

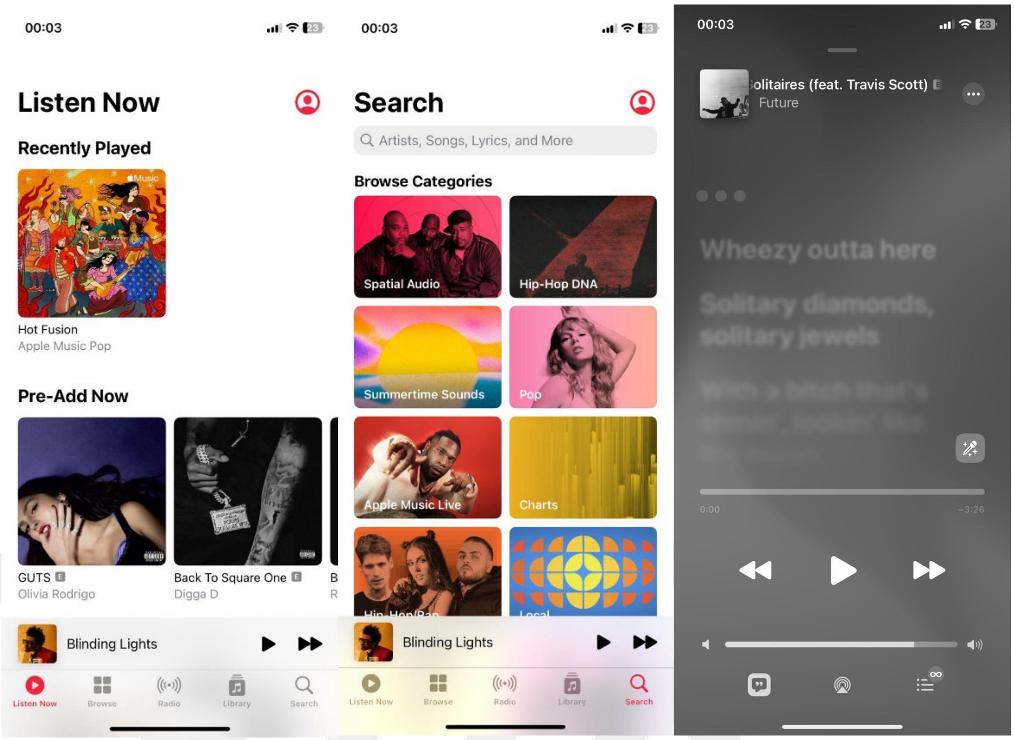


Figure 2.3 Example screenshots from the Apple Music mobile application

One of the notable features of Apple Music is its integration with the Apple ecosystem. It is seamlessly integrated with Apple devices, such as iPhones, iPads, Macs, and Apple Watches, providing a cohesive and synchronised music experience across multiple devices (Hu, 2018). Users can access their music library, playlists, and recommendations on various Apple devices, making it convenient for Apple users.

Apple Music offers personalised recommendations based on users' listening habits and preferences. The platform utilises algorithms and machine learning to analyse user behaviour and suggest music that aligns with their tastes (Barata and Coelho, 2021). It also provides curated playlists and radio stations, including Beats 1, a global radio station featuring live shows and exclusive interviews with artists (Barata and Coelho, 2021).

In addition to music streaming, Apple Music offers exclusive content, such as live performances, music videos, and documentaries, providing users with a comprehensive music experience (Barata and Coelho, 2021). It also supports offline listening, allowing users to download songs and playlists for offline playback (Barata and Coelho, 2021).

Apple Music offers a subscription-based model, with options for individual, family, and student plans. Subscribers gain access to ad-free music streaming, high-quality audio, and additional features like lyrics display and music video playback (Barata and Coelho, 2021).

Apple Music has been influential in the music industry, with its large user base and integration with Apple devices. It has played a significant role in the shift from physical music formats to digital streaming, contributing to the growth of the music streaming market (Hracs and Webster, 2020). The platform has also collaborated with artists and labels to release exclusive content and promote new releases (Meier and Manzerolle, 2018).

Overall, Apple Music provides a comprehensive music streaming experience with a vast music library, personalised recommendations, exclusive content, and seamless integration with Apple devices. It has become a prominent player in the music streaming industry, offering a wide range of features and services to music enthusiasts.

2.3.4 Wearable Accessories

The design of wearable running accessories that provides stability for the electronic devices is important for several reasons. These accessories provide a secure and stable platform for carrying devices, such as smartphones, music players, or GPS trackers during running activities.

Figure 2.4 Wearable running accessories examples

Giraldo-Pedroza et al. (2020) discuss the importance of stabilising running accessories to prevent device movement and potential damage during physical activity. The study highlights the need for secure attachment mechanisms, such as adjustable straps or armbands, to ensure that the devices remain in place and do not interfere with the runner's movements.

Furthermore, the design of these accessories should prioritise comfort and ergonomic considerations, such as the importance of adjustable and breathable materials to enhance comfort during running. The design should also consider factors such as weight distribution and impact resistance to minimise discomfort and potential injuries.

In addition to stability and comfort, the design of wearable running accessories should also consider accessibility and ease of use. Giraldo-Pedroza et al. (2020) discuss the importance of intuitive and user-friendly designs that allow runners to access their devices and interact with them easily. Features, such as touch-sensitive screens, transparent windows, or headphone cord management systems can enhance the usability of these accessories.

Durability is another crucial aspect of design. Giraldo-Pedroza et al. (2020) highlight the need for robust and water-resistant materials to protect the devices from sweat, rain, or other environmental factors, encountered during running. The design should also consider factors such as shock absorption and impact resistance to protect the devices from accidental drops or impacts.

Overall, the design of wearable running accessories that stabilise the devices runners carry is important to ensure device security, comfort, accessibility, and durability during physical activity. By considering these design factors, designers can create accessories that enhance the running experience and provide a reliable platform for carrying devices while maintaining the runner's focus and performance.

2.4 Conclusions

This literature review has provided a comprehensive exploration of the various aspects surrounding the phenomenon of running with music. It began by dissecting running as an activity, understanding the motivations and psychological underpinnings of individuals who choose to incorporate music into their running routines. This review delved into the performance-related, psychological, and user experience-related studies that shed light on the impact of music on runners.

Furthermore, the devices, mobile applications, and accessories examined that runners employ to enhance their music-enhanced running experiences. Electronic devices, such as smartphones and dedicated music players, have evolved to become indispensable companions for runners. The choice of headphones/earphones, with their specialized features and design considerations, plays a crucial role in ensuring both comfort and safety while running with music.

Additionally, mainstream music streaming platforms like YouTube, Spotify, and Apple Music have emerged as central hubs for curating running playlists and accessing a vast library of tracks. These platforms have redefined how runners engage with music during their workouts, offering convenience and personalization.

Lastly, wearable accessories, provides more comfortable experience with the electronic devices while carrying them.

This comprehensive literature review sets the stage for a deeper investigation into the impact of music on running, the preferences and challenges faced by runners, and the potential design enhancements that can elevate the running experience. It lays the groundwork for the subsequent chapters, where empirical research findings and insights will be discussed in further detail.

CHAPTER 3

METHODOLOGY

In this chapter, the methodology of the research is introduced. Fieldwork setup, data collection tools and methods, and participant selection are also covered in detail, along with an overview of the fieldwork.

3.1 Overview and Aim of the Fieldwork

The aim of this study is to provide predictions on how music platforms and their communication/interaction between headphones/earphones can be better designed to improve the music listening experience of amateur runners while running outdoors while exploring their user experience with the interfaces that they use. The fieldwork consists of the following three parts.

Part 1 (Pre-running-interviews) is planned as an interview section where participants will be asked about their running habits, running with music routines, devices, and platforms that they interact with. They also provided with more detailed information about the implementation of the study just before the fieldwork.

Part 2 (Running Activity on a Track: "Devrim Running") is a fieldwork procedure that consists of 10-15 minutes of running activity around the Devrim Stadium with a wearable eye tracker. Participants had their headphones/earphones and technological devices with them in order to listen to music while running. Participants were given instructions about controlling the music during the running activity, and the sequences of performing them were recorded through an eye-tracking device. The aim of this activity was to understand participants' experiences with tactile and digital interfaces and reveal the challenges that participants may have related to them.

Part 3 (Post-running-interviews) is again an interview section that is conducted right after the running activity. The aim of this interview was to gather feedback on the activity and the instructions that were given to participants. The conveniences and challenges that the participants have with the devices and interfaces are questioned, and their advice on these design products is obtained. In addition, their thoughts on the experience with the wearable eye tracker were also gathered. The visualization of the four parts of fieldwork can be seen in Figure 3.1.

Figure 3.1 Fieldwork overview diagram

3.2 Data Collection Tools

The main tool used in the study to collect data was a wearable eye-tracking device. Eye-tracking technology is a method that involves tracking and recording the movement and activity of a person's eyes. It provides valuable insights into where and for how long a person is looking at specific objects or areas of interest (Lahey and Oxley, 2016). Eye-tracking technology can be applied in various fields, such as economics, reading behaviour, medicine, education, cybersecurity, and usability, since it is a valuable tool for studying human behaviour and interactions.

Eye-tracking technology has also been widely used in sports research to gain insights into the perceptual-cognitive skills of athletes. By tracking the eye movements and gaze patterns of athletes, researchers can analyse their visual search behaviours, decision-making processes, and attentional focus during sports performance (Williams et al., 2007). Almost all of the sports research conducted with eye-tracking has been aimed at examining athletes' performance or performance-related outcomes. The specificity of this research is that, although it includes running exercise, it is not about the performance of the runners but rather to better understand their interaction with devices and interfaces

In order to justify the use of eye-tracking technology in this study and in field studies, the areas of usability and user experience should also be addressed as another area of study. Eye-tracking technology is a valuable tool for usability evaluation of interfaces, as it provides insights into human behaviour, decision-making processes, and visual attention (Hareide and Ostnes, 2017). By tracking and analysing eye movements and gaze patterns, researchers can assess how users interact with interfaces and identify areas that may cause difficulties or confusion. To reconnect with the purpose of this study, the main consideration in examining the runner's music listening experiences was the availability of eye-tracking technology in the area of usability research.

The eye-tracking system that was used in the study is called: Pupil Invisible. Pupil Invisible is a deep learning powered eye-tracking system. It can be put on like a normal pair of glasses, and starts to get gaze data. The system has three integral parts: eye-tracking glasses, a companion device, and a cloud. Pupil Invisible Glasses are packed with sensors: two eye cameras, a scene camera, a microphone, and an IMU (Inertial Measurement Unit). The glasses connect to an Android companion device that runs the Pupil Invisible Companion App for real-time gaze estimation, recording, streaming, and more. Recordings get uploaded to Pupil Cloud for data storage, visualization, and analysis (see Figure 3.2).

Figure 3.2 Pupil Invisible System

3.3 Data Collection Methods

The main data collection method that is conducted was the structured observation. Structured observation methodology is a systematic and controlled approach chosen for the study to collect behavioural data within a specified running environment. While commonly employed in research involving infants and young children, structured observation can be effectively adapted to study adult behaviours, such as those exhibited by runners during their music control activities (Rezende et al., 2014).

In the context of this study, structured observation involves the selection of specific behaviours relevant to participants' interaction with the music control interface and their running performance. These behaviours may encompass actions, such as volume adjustments, track changes, or pausing/resuming the music. The characteristics of each behaviour are clearly defined, ensuring consensus among observers regarding their classification and measurement.

The implementation of structured observation entails documenting the occurrence and frequency of the targeted behaviours during the running activity. Observers systematically record data at predetermined intervals or in response to specific events or actions. This approach enables a comprehensive and detailed examination of participants' engagement with the music control interface, offering valuable insights into their interactions and decision-making processes (Guhn et al., 2020).

Structured observation focuses on specific behaviours and aims to gather qualitative and quantitative data. By focusing on a limited set of behaviours, it was possible to quantify and analyse the behaviours of interest rather than capture the entirety of the participants' experiences (Jhangiani et al., 2019). These limited sets of behaviours can be identified as the music control actions that the runners may be using while running with music. Defining these behaviours was useful to analyse how long they took for the participants and provide a better comparison between their levels of difficulty.

One advantage of employing structured observation in this study is the generation of quantitative data. By selecting specific behaviours and quantifying their occurrence and frequency, researchers obtain numerical measurements that provide an objective understanding of participants' actions and interactions. These quantitative data can be subjected to statistical analysis, enabling the identification of patterns, trends, and associations among variables.

The utilization of structured observation in this study allows for a systematic and controlled approach to gathering quantitative data concerning specific behaviours exhibited by runners during their music control activities. This methodological choice facilitates a comprehensive understanding of how interfaces influence participants' engagement and performance. By employing structured observation, valuable insights can be derived to contribute to the development of user-centred design principles for music control interfaces tailored specifically to the needs of runners.

In addition to the structured observation, there were pre and post semi structured interviews that were conducted with the participants. Semi-structured interviews are a qualitative research method that allows for open-ended questioning while still providing some structure to the conversation (Kallio et al., 2016). In the context of the study, pre-running-interviews were conducted before the running activity and post-running-interviews after the activity. These interviews aimed to explore the participants' subjective experiences, perceptions, and emotions related to listening to music while running.

The pre-running-interviews were designed to gather information about the participants' expectations, preferences, and previous experiences with music and running. This helped establish a baseline understanding of participants' attitudes and their expectations for the study. In addition, learning their current routine of running with music provided some foresight about what kind of challenges they might have even before the running activity. The reason that the interviews were semi-structured was to gain deeper insights into the conveniences and challenges they encountered indirectly, in addition to learning about the experiences of listening to music while running directly. Also, some comments on the interactions that they had required more reflection on the devices and interfaces that they used.

Following the structured observation of the running activity with music and the completion of the interviews, post-running-interviews have been conducted to capture the participants' reflections and reactions. These interviews aimed to explore their immediate thoughts, feelings, and perceptions after engaging in the running activity with music. The post-running-interviews allowed for an in-depth exploration of their experiences and provided an opportunity for participants to express any changes or insights they gained during the activity.

By combining structured observation with pre and post semi-structured interviews, the study sought to achieve a more comprehensive understanding of the participants' experiences of listening to music while running. While structured observation provided quantitative data on specific behaviours, the interviews provided a qualitative perspective, delving into the participants' thoughts, emotions, and personal interpretations of their experiences. This combined approach allowed to capture both the observable behaviours and the subjective dimensions of the participants' experiences, providing a more nuanced and holistic understanding of the phenomenon under study.

3.4 Participant Selection

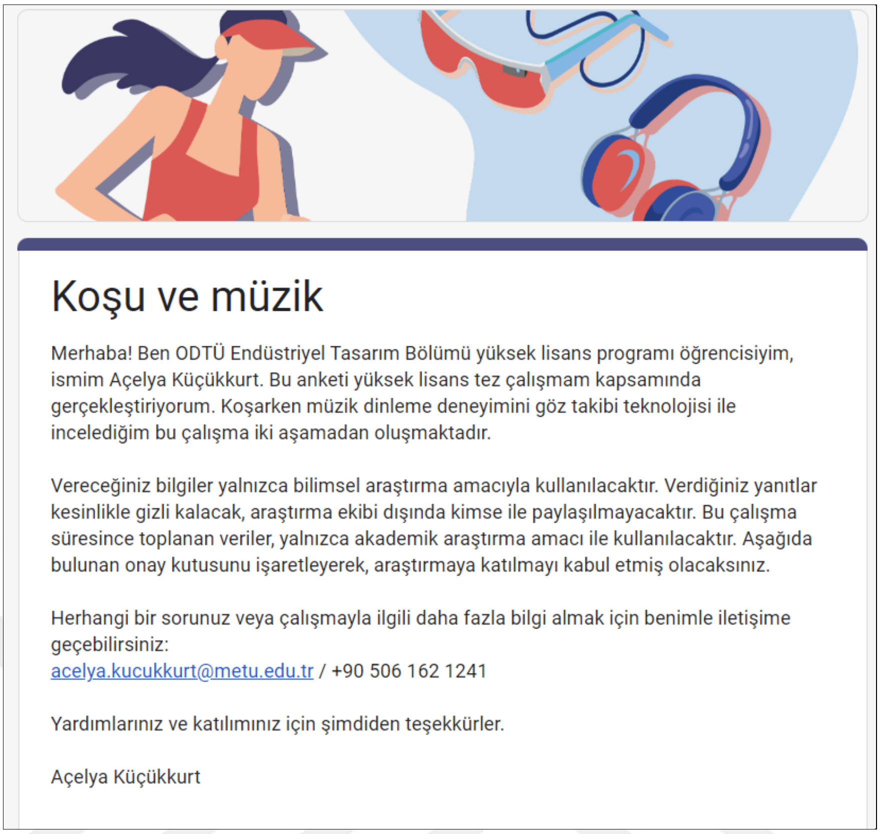
To be able to participate in the fieldwork activity of the study, the requirements were to listen to music while running regularly and be 18 years of age or older. In order to reach participants, an announcement poster was prepared (see Figure 3.3) and shared through social media platforms, including Instagram and Facebook. The call for the study was also distributed across some Ankara-based running communities' WhatsApp groups through personal contacts. The aim was to reach at least ten amateur runners that were eligible to participate in the running activity.

The runners, who were willing to participate, were communicated with via WhatsApp and phone calls. The face-to-face meeting was prepared according to their convenience after these calls.

Figure 3.3 The invitation poster shared through social media platforms

Online Survey among Runners

In order to check the candidates' suitability for the study, an online survey was prepared on Google Forms, and the link was shared with the invitation poster (see Figure 3.4), the full set of questions can be seen in Appendix B. The survey briefly introduced the researcher and the aim of the study. In the first part of the survey, the candidates were informed about the confidentiality and their consents were requested.



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Açelya Küçükkurt

Figure 3.4 A screenshot from the online survey prepared on Google Forms

After obtaining consent to participate in the survey, the second part of the survey, which contains the requirements for participation, has been forwarded. The requirements for participation in the planned running activity were asked in the form of Yes/No questions. Running regularly and having the habit of listening to music while running were established as the main requirements.

As the fieldwork required the recording of the data with the eye-tracking technology, (i.e., a pair of eye tracker glasses that comes with an Android smartphone), which had an effect on the participant selection. In order to avoid compromising their vision and the data flow of the eye tracker glasses, the participants were chosen from those who did not need glasses with a prescription. They were also instructed not to wear sunglasses. Otherwise, wearing glasses on top of each other would have made it difficult to maintain the stability of the eye tracker. To ensure the effective use of eye-tracking technology, the participants were also asked whether they used prescribed glasses or not. The candidates who answered one of these questions as

“No” were not provided access to the second part of the survey, and the invitation to study was not forwarded. Instead, they were thanked for participating in this part of the survey.

The second part of the survey aimed to learn about the participants’ running habits, including the devices they used to listen to music, the kinds of headphones they used, and the digital music listening platforms they used. The last part of the survey asked the candidates’ names and preferred contact information (e.g., email address, and telephone number) if they wished to participate in the study.

The eligible amateur runners were reached through their preferred method of communication, and the appropriate dates and times for their participation in the field work were asked. They were informed about their transportation to the ODTÜ Devrim Stadium, where the fieldwork would take place at the specified date and time. Prior to meeting with the participants, they were asked to bring along their own music-playing devices and headphones. They were asked to have at least two playlists that they would be listening to while they were running. They were given the opportunity to select their preferred music genres or playlists to enhance their engagement and motivation during the run. The fieldwork is carried out with each participant individually.

3.5 The Procedure of the Fieldwork

The procedure of the fieldwork involves three parts which are the pre-running-interviews, the running activity and post-running-interviews. These parts of the fieldwork procedure will be detailed in following sections.

3.5.1 Part 1: Pre-Running-Interviews

Ten amateur runners are targeted and recruited for both interviews and the running activity after the participant selection phase. Pre-running-interviews were conducted face-to-face right before the running activity at ODTÜ Devrim Stadium, which is the same venue for the running activity and the post-running-interviews. Interview sessions were recorded with a smartphone in order to be stored for analysis. Before starting the interview, all participants were informed of the overall purpose of the study and the running activity and were asked to sign the printed consent form (see Appendix C). In the consent form, participants were informed that all answers would be used anonymously and for research purposes only.

The participants were also explained that the study did not measure their running speed, running style, or any other running metrics but rather concentrated on how they interacted with their music-playing devices, digital music platforms, and accessories, whether they had difficulties interacting with these while moving, their frustrations, and their expectations so that better or improved music-playing devices and platforms could be designed.

The pre-running-interviews were prepared and conducted to provide preliminary information about the study, warm up the running activity, and gather general information about participants' running and listening to music habits. Pre-interview questions can be sorted into three parts: the running habits and routines of the participants, their motivations for listening to music when running, and the devices they used to listen to music while running.

- Firstly, as a warm-up, participants were asked questions about their running habits and preferences. These were questions that could directly and indirectly influence participants' preferences for listening to music while running, such as what types of runs they prefer and which time intervals they prefer for running.
- The second part of the questions was about the participants' motivations to listen to music while they were running, the factors affecting whether or not they listened to music, and the advantages and disadvantages of listening to music as they ran.

- Lastly, participants were asked what kinds of devices and interfaces they were carrying while they were running, and which ones they had with them, especially for the purpose of listening to music.

The pre-interview included twelve questions (see Appendix D). At the end of the questions, participants were thanked for their contributions and escorted to the running activity.

3.5.2 Part 2: The Running Activity 'Devrim Running'

The running activity, called 'Devrim Running', was designed to collect a sample of the recorded experience of listening to music while running. Together with the interviews, the aim was to gather quantitative and qualitative information about participants' music listening experiences while they were running. The choice of the fieldwork venue and data collection tools used for this running activity was planned according to the purpose of the study.

3.5.2.1 Fieldwork Venue

The fieldwork was planned to be carried out with suitable participants presenting themselves through an online survey. At this point, it was crucial that running activity take place in a controlled and safe environment, where the runners could be observed, avoid putting them in danger (e.g., traffic, difficulties with the running terrain, etc.), and give each runner a similar running experience that might have varied in a different running field. Therefore, this part of the fieldwork, named "Devrim Running", was planned to take place at the Devrim Stadium, on campus running track facility within the Middle East Technical University. Although no special permission was needed to use the facility, participants from outside the university had to register for their visit at the gates using METUpass, a system that automates and manages pedestrian and vehicle crossings on campus.

Devrim Stadium is 400 meters long and is a natural grass field (See Figure 3.5). There is also a sandy runway surrounding the stadium, where the running activity is conducted. The construction of the stadium allowed the written instructions to be shown to the participants while they were running without constantly seeing the researcher or being followed by.

Figure 3.5 A photo of the ODTÜ Devrim Stadium

3.5.2.2 Fieldwork Equipment

Fieldwork equipment consists of the eye-tracking system (Pupil Invisible Glasses), a white portable board, a board marker, a board eraser, and a smartphone. Eye-tracking system has an Android smartphone that needs to be connected to the eye-tracking glasses, as mentioned before.

Recording the eye-tracking data of the participants was required to plan the activities during the day before the sun goes down. In order to have better recording quality and capture of the gaze movements, direct light was needed.

A white portable board, a board marker, and a board eraser have been used to deliver the music control related instructions to the participants visually (Figure 3.6). It was not possible to deliver the verbal instructions since the music listening experience should not be interrupted. It was also an option to send notifications or messages via the participants' smartphones, which they carried with them, but it was decided that it would again be a channel of communication that would interrupt the entire experience. As a result, it was decided that the instructions would be given visually by the researcher by writing them on a white board.

Lastly, a smartphone was used as a fieldwork equipment in order to have voice recordings of the participants during interviews and also to take photos during the activity.

Figure 3.6 An example of white portable board, a board marker, and a board eraser

3.5.2.3 Introduction and Familiarization with the Eye Tracker

The participants were greeted and escorted to Devrim Stadium. They were briefed on the study's objectives and given an overview of the fieldwork protocol. They were also introduced eye-tracking technology and its operation. Afterwards, the participants were given comprehensive instructions on how to correctly wear and calibrate the device. A brief practice session was held to make sure the eye tracker was comfortable for the participants to wear and use during running.

3.5.2.4 Running Activity on a Track: "Devrim Running"

Participants were given a period of time to wear eye-tracking glasses, wear headphones, and keep their smartphones connected to digital music listening platforms. When the participants were ready, the running activity was started.

- Participants started to run around Devrim Stadium (the lane length is approximately 410 meters for each round).
- The eight banners that have various instructions about music control were shown to the participants in different parts of the stadium and at different frequencies without interrupting their running. These instructions were supported with the related icons in addition to the written text (see Figure 3.7).
- Figure 3.8 shows a diagrammatic representation of how the commands were displayed on the track. Every participant had different instruction combinations.
- After completing the total of eight instructions, the running activity has ended.
- Participants were given a period of time to rest and remove the equipment they used. Then, they were escorted to the post-running-interviews which is the last part of the fieldwork.

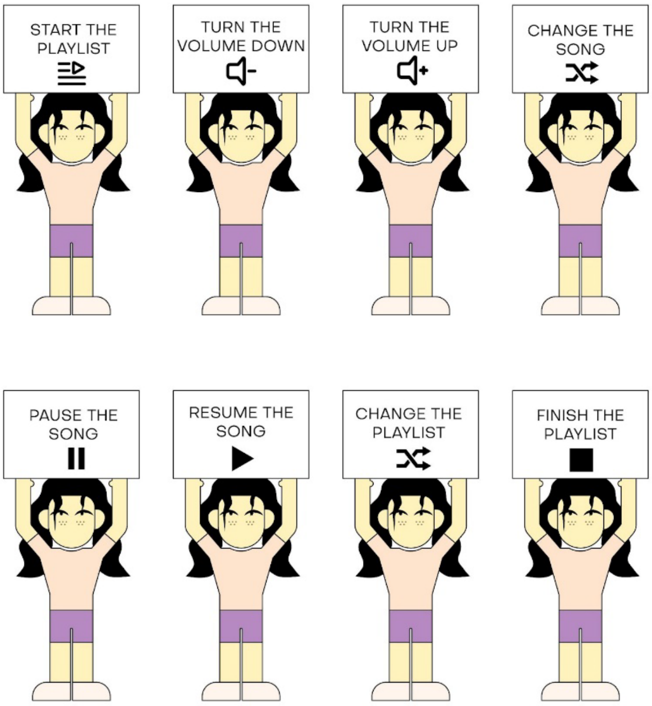


Figure 3.7 A representation of the eight written banners

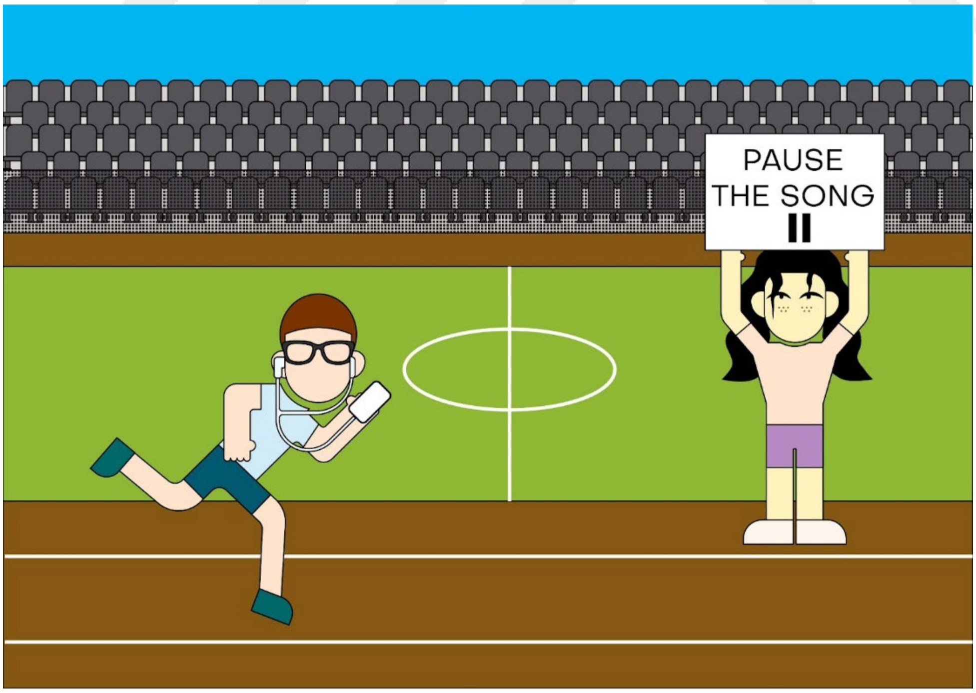


Figure 3.8 A representation of the commands' arrangements as participants displayed on the track

3.5.3 Part 3: Post-Running-Interviews

On completion of the running activity, the participants were offered a short break and refreshments. They were asked if they had any sort of problem with the process of the activity, and made sure that they did not have any physical discomfort. Then, when they felt ready, they were invited to the post-running-interviews.

- Post-running-interviews are conducted face-to-face right after the running activity at ODTÜ Devrim Stadium, which is the same venue for the running activity and the pre-running-interviews. Interview sessions are recorded with a smartphone in order to be stored for analysis.
- The interview questions first focused on the technological equipment, headphones/earphones, and digital music listening platforms that the participants used during running to listen to music.
- The contribution of these devices and interfaces to the music listening experience while running was questioned, and in addition to this, the conveniences and challenges that they caused were also asked.
- The recommendations were made for the devices and interfaces where they can customize their music listening experience while they are running.
- The reflections of the participants on the use of eye-tracking technology were gathered.
- The last part of the interview consisted of 5-point Likert scale-based questions that were about the instructions given to the participants. The full set of thirteen questions can be found in Appendix D.
- At the end of the questions, participants were thanked for their participation and contributions. The same procedure was repeated for all ten participants.

3.6 Pilot Study

Upon selecting the two experiences of running and listening to music for analysis and observation, the first study preparations were undertaken. The examination of these two activities within an enclosed setting, such as fitness facilities, is regarded as the focal point of the research agenda. Nevertheless, this particular choice elevated the prominence of treadmills, as they were the only equipment capable of accommodating this unique combination within the gym setting. Treadmills introduce an additional interface to the study's framework, alongside other devices and interfaces such as smartphones, headphones, and mobile music streaming services.

The pilot study was conducted within a gymnasium setting with a pair of participants who utilized their personal headphones, smartphones, and eye-tracking glasses. The individuals proceeded to engage in a jogging activity on the treadmill, together initiating the act of listening to music. Visual representations of written instructions on music control were presented to the individuals. The participants attempted to execute the given instructions by using their smartphones, headphones, and the interface of the treadmill (Figure 3.9).

Figure 3.9 The eye-tracking recording screenshots from pilot study

Following a brief 10-minute activity, the inclusion of the gym environment and treadmill scenario was excluded from the research design. The primary factor contributing to the ineffectiveness of incorporating the activity idea for the purpose of this study is the inherent difficulty and detrimental impact on data analysis that arise from introducing an additional interface for interaction. The implementation of the researcher's instructions had an impact on the performance of the runners, as they exhibited a tendency to slow down on the treadmill in order to follow the directions provided through their smartphones, while also utilizing the treadmill interface. Furthermore, it was determined that the evaluation of the running experience was hampered due to the treadmill's inability to accurately replicate the true nature of the activity. The decision was made to acknowledge the potential risks associated with utilizing the intermediate side of the running band for the purpose of adjusting running speed, while simultaneously attempting to maintain control over the listening experience of music.

An additional aspect that warrants consideration is the utilization of eye-tracking technology, which necessitates wearing eye-tracking glasses. It is worth noting that maintaining the attachment of these glasses during treadmill running may be a greater challenge compared to the conventional running experience. The presence of vibration and restricted range of motion associated with the treadmill caused challenges in achieving proper fixation of the eye-tracking glasses, thereby leading to discomfort experienced by the participants in the facial region. Furthermore, the shaking and vibration resulted in an imbalance in the calibration of the glasses.

3.7 Data Analysis Overview

This section provides an overview of data analysis techniques as well as suggested tools and approaches. For the quantitative analysis of Part 2 of the fieldwork (Running Activity), a 5-point Likert Scale is used to compare the difficulty scale of the instructions. Additionally, in order to determine whether there was a statistical significance between the execution times for the running activity commands, a one-way ANOVA (Analysis of Variance) test was used.

In Parts 1 and 3 (Pre-Running-Interviews and Post-Running-Interviews), the results will be analysed by theme using a general inductive coding method (Thomas, 2006) to get useful information from the raw data. In order to accomplish that, the recorded statements of participants will be transcribed into keywords and phrases. After that, these phrases were reviewed and grouped together to form thematic clusters. To interpret the most important results from the interviews, themes were revised and improved in the final step.

3.8 Ethical Considerations

The necessary ethical approval for the fieldwork was obtained from the Applied Ethics Research Centre (UEAM: Uygulamalı Etik Araştırma Merkezi) of the Middle East Technical University, with the approval number: 0397-ODTUİAEK-2022 (See Appendix F).

CHAPTER 4

RESULTS, ANALYSIS AND DISCUSSIONS OF FIELDWORK

The fieldwork examined the runner's experience of listening to music while running and users' interactions between tangible and digital interfaces that they interact with during running. The results were analysed using both qualitative and quantitative methods. Accordingly, this chapter presents the results and analysis of the three parts of the fieldwork.

Part 1 (Pre-Running-Interviews) studied the participants' running routines and habits, and the effects of these habits on their music listening experiences. In Part 2 (Running Activity on a Track: 'Devrim Running'), a running activity with participants was performed, the music interfaces that they used while running were monitored through predefined commands shown to the participants. The recordings of this process allowed quantitative analysis of the time intervals of the participants. In Part 3 (Post-Running-Interviews), semi-structured interviews were conducted to gather more information on the interactions between the digital and tangible interfaces of the devices and accessories that participants used to get feedback about their running activity.

4.1 Part 1: Pre-Running-Interviews

The main purpose of the Pre-Running-Interviews was to gather general information about the participants' music listening routines while running. It also allowed the researcher to establish rapport with the participants and warmed them up before moving on to the running activity.

The researcher met each participant on campus at an agreed-upon time and date. To avoid crowds and potential interference, quiet times of day were chosen whenever possible. Following the introduction, they proceeded to the Devrim Stadium, where the fieldwork would take place. Each stage of the fieldwork with each participant was completed one at a time. The researcher then directed interview questions about the participants' running habits. These were more concerned with the different types of runs, where participants ran, and when they ran. It was aimed to find out what changes would occur if the music variable was added to these choices. The next set of questions focused on their choice of music, as well as the technology equipment, headphones, and digital music platforms they used. Participants were also questioned about the types of runs they prefer to listen to music on and reasons for doing so. Finally, they were asked about the advantages and disadvantages of listening to music while running (see Appendix D for full set of questions).

The analysis of the participants' responses to the survey questions revealed their motivations for incorporating technology and music into their running. The music listening technology ecosystem included earphones, headphones, smartphones, smartwatches, and digital music streaming platforms. To summarise, the interview questions explored participants' running routines and habits, types of technological equipment, headphones, and digital platforms they had, motivations for running with music, and the advantages and disadvantages of running with music.

Each pre-running-interview session lasted between 3 to 5 minutes. For the analysis, all audio files recorded during the sessions were entered into Microsoft Word as transcriptions. The analysis was carried out in stages in order to uncover the main points from the transcribed data with the help of the Miro platform (see Figure 4.1). The interview questions consisted of three main categories followed by sub-questions.

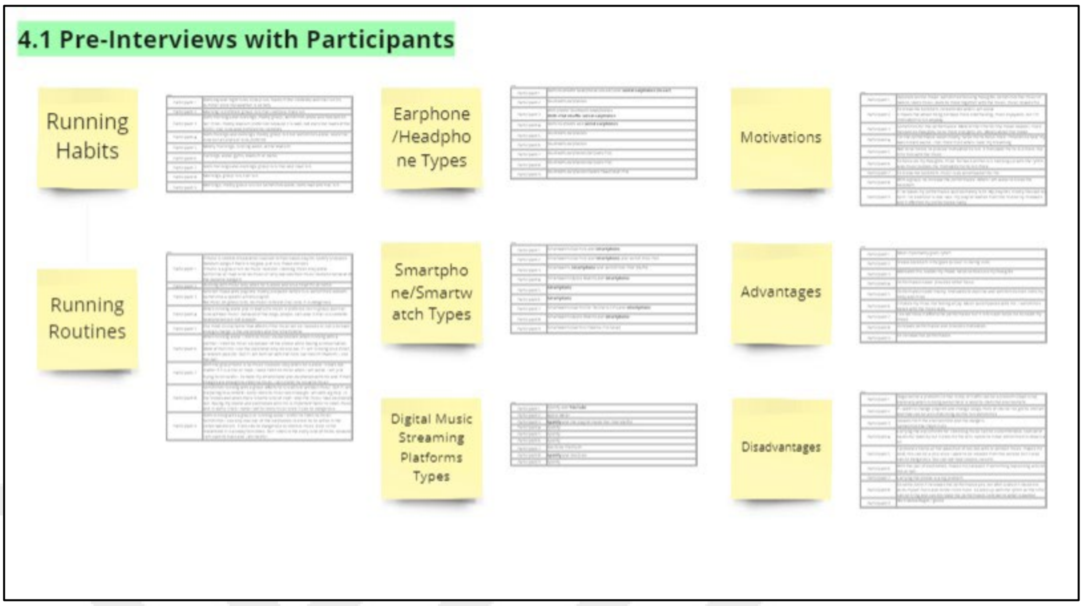


Figure 4.1 A screenshot from the Miro platform shows the transcribed pre-interview data thematic analysis

4.1.1 Running Habits and Routines

The activities of music and running, which may initially appear to be separate endeavours, intersect in a multifaceted manner that impacts the manner in which individuals perceive their experiences while engaging in the act of running. In addition to serving as a simple auditory accompaniment, the association between music and running encompasses other dimensions, including psychological, physiological, and sociological aspects. Participants' answers about their running routines and habits provided some explanations about these dimensions and delved into the complexities of this distinctive alliance.

In the first part of the interview the questions mainly focused on the participants' running habits and routines. These questions provided statistical information on what type of runs they prefer and these choices visualised with the help of pie charts. In the next stages of the interview, the participants explained the reasons for these choices in order to explain their running with music routines. Together with these explanations, the participants' answers to the interview questions about their running habits and routines were categorised under the following headings: i) music preferences and running goals, ii) group runs and music, iii) safety concerns and music, iv) preparation and music, v) device charge and music, vi) adaptation to environment, vii) adherence to regulations, viii) individual comfort.

The participants were not subjected to any demographic classification such as age, gender, occupation etc. The participants were amateur runners residing in Ankara. For the purpose of the study, participants were only asked about their running time, running type and running location preferences. It was hypothesized that these choices might affect their music listening habits and routines while running.

The participants' choice of running time varied between mornings, evenings and both (see Figure 4.2). One participant preferred to run only in the evening made the scenario of using eye-tracking technology as a data collection tool more effective. It was necessary for the eye-tracking glasses to record in a bright environment without direct exposure to light in order to provide the most accurate results.

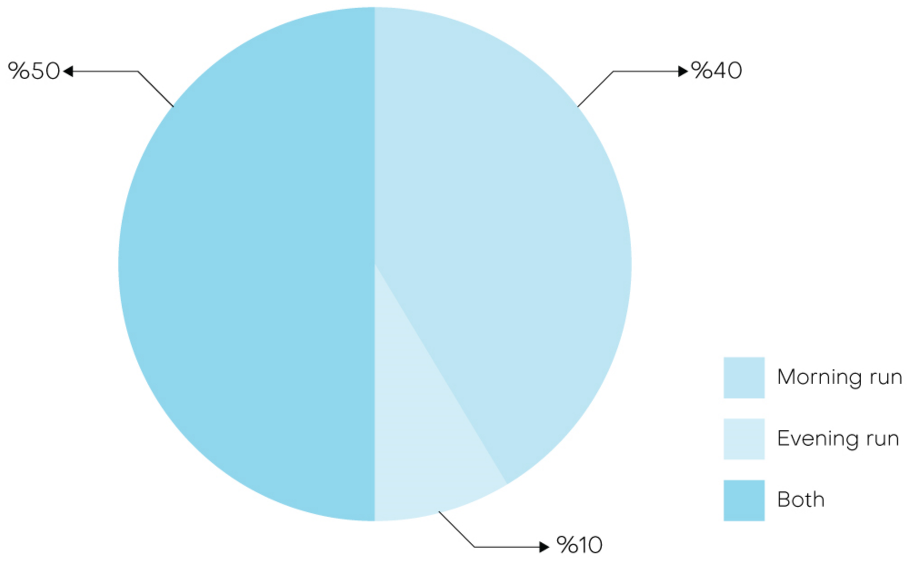


Figure 4.2 Running time preferences of ten participants

Another variation in the participants' running habits was running partner preferences. This was categorized into those who prefer to run with a group or partner, those who prefer to run alone and those who prefer both (see Figure 4.3). The extent to which these choices affected their music listening habits was investigated. What changes the music listening experience requires in the transition from singular to plural was questioned through these preferences of the participants.

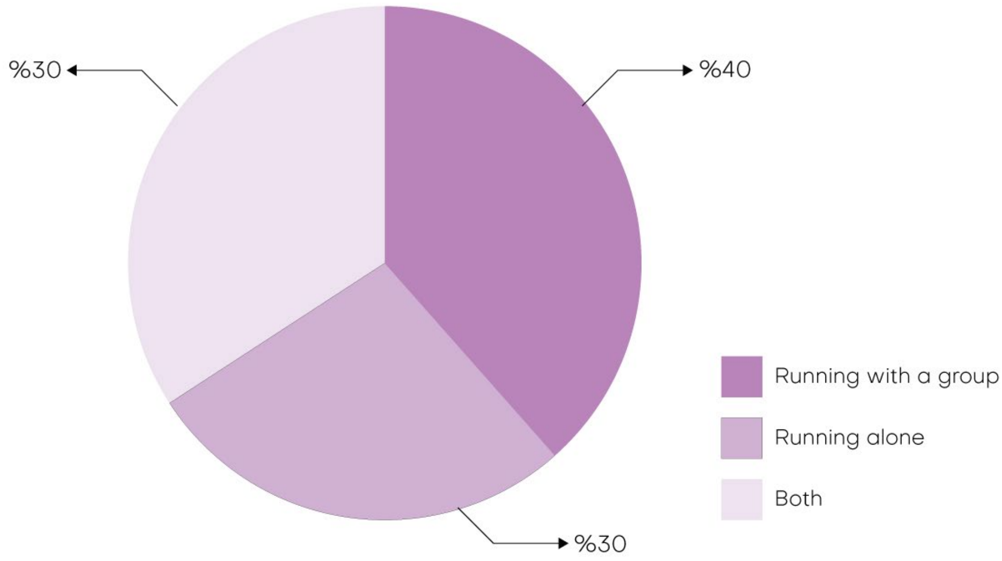


Figure 4.3 Running partner preferences of ten participants

The last part that varied in relation to participants' running habits was where they preferred to run. Since the participants of the study were amateur runners, the areas they preferred as running areas were generally parks, roads, and stadiums where they felt more comfortable. They also added that when they were preparing for a marathon or a race, they also did trail running. These choices did not provide any quantitative data for the study, but they did support the quantitative analysis in the next sections of the chapter.

In the following parts, the various aspects of this symbiotic association are explored, delving further into the perspectives and disclosures expressed by individuals engaged in running.

i) Music Preferences and Running Goals. The participants' responses indicate that music is often used as a tool to align with their running goals and enhance their overall running experience. For instance, tempo-based playlists for marathon preparation underline how music can be tailored to specific running objectives.

"If I am preparing for a marathon, I choose to listen to some Spotify playlists that are available to increase my tempo and make me run more efficiently." (P01)

This suggests that the rhythm of the music might help participants regulate their pace during training and competitions. Additionally, the choice of music might reflect the desired mood or mindset for each run.

"My mood decides what to listen to, and I pick from the playlists that I made earlier." (P03)

ii) Group Runs and Music. The trend of avoiding music during group runs is likely rooted in the importance of communication and coordination within the group. Most participants' cautious approach, listening to music only when alone, showcases a shared concern for group dynamics. It is likely that group runs are viewed as opportunities for social interaction, where conversation and fellowship take precedence over personal entertainment.

"I listen to music only when I am running alone." (P07)

There can also be some scenarios about group runs that involve music. Some running groups and communities prefer to carry a speaker that will provide music to the runners out loud and will accompany them through their runs. This share can promote the feeling of togetherness with the running activity and boost the tempo of the runners at the same time.

"When I am running with someone, I put the music on speaker and run with them while having a talk." (P06)

The last scenario about running with a group and music is continuing to listen to music even though there is a group involved. If the music is crucial for the runners', they push the conditions to keep going with music. The method they use to have both music and conversations at the same time is to have only one of the earphones. And sometimes they only take out the earphones when there is a break.

"I can also listen to music on group runs, at least when wearing one of the earphones. Sometimes I get involved in conversations." (P09)

iii) Safety Concerns and Music. Safety emerges as a critical consideration for many participants, particularly during trail and road runs. The presence of hazards, such as dogs, cars, and uneven landscape, makes it understandable that participants decide to avoid or minimize the use of music. This aligns with safety guidelines that many marathon and trail run organizers enforce to prevent accidents and ensure participants' well-being.

"I do not listen to it on the trails because it's isolating you from the outside. Because you need to be careful where you're standing. Sometimes you get confused by music. It's important to pay attention when you run on the trail to see where you're pushing down. I used to listen more, but I don't listen on the trails anymore." (P03)

iv) Preparation and Music. Music becomes a psychological catalyst for peak performance. Marathon or race preparation entails more than physical readiness; it is about priming the mind. Participants' dedication to listen to music even during group runs before marathons highlights the role of music in mental preparation and focus. Music can serve as a mental pump-up, helping participants get into the right mindset for competitive events. This underscores the psychological aspect of running and the impact that music can have on motivation.

v) Device Charge and Music. The practical consideration of device charge underscores the technological aspect of modern running routines. This suggests that participants rely on their smartphones and earphones to provide the music experience, emphasizing the integration of technology into their running routines. The need for sufficient charge reflects the dependency on these devices for entertainment and motivation during runs.

When participants were asked about the factors that influenced running with music, one of the answers they gave except the types of running they experienced and the field they ran was whether or not the technology equipment they used was charged. Moreover, it is considered one of the most crucial factors to decide whether the music will be involved or not.

"The biggest factor is obviously my headphones and my phone's battery. Sometimes I don't even run if they're not charged." (P05)

vi) Adaptation to Environment. Running is not confined to a single setting—it spans a spectrum of environments, from familiar streets to uncharted trails. The way runners interact with music varies depending on their surroundings. The answers of the participants uncover how runners adapt their music usage based on environmental familiarity, highlighting the nuanced decisions that arise from a runner's relationship with their surroundings.

Participant 6's adaptability to the running environment illustrates how runners make nuanced decisions about music based on their surroundings. The familiarity with a particular running field (such as Devrim Stadium) allows for greater comfort in using both earphones. This adaptability showcases the dynamic relationship between personal preferences, the environment, and safety considerations.

"If I'm going to run in the street, I'll take one earphone out, see if there's anything out there, for control. I mean, I can keep wearing it in a place where I feel comfortable. I need to feel more comfortable, safer. For example, I wear both in the Devrim Stadium. But in any park or on the street, I'm running with a single earphone again." (P06)

vii) Adherence to Regulations. Running, whether in marathons or casual jogs, operates within a framework of rules and regulations. These guidelines extend to the use of music during races. Delving into compliance with such regulations offers insights into the balance between individual preferences and collective adherence, emphasizing the sense of responsibility runners have toward the larger running community.

Participant 9's acknowledgment of regulations against music in marathons and trails highlights the importance of abiding by race rules. This indicates a balance between personal preferences and respecting event guidelines. The fact that participants like them still choose to use music in controlled environments suggests a level of confidence in their ability to manage potential risks.

"Music should not be involved, especially in the trail runs. It's already forbidden to wear headphones at marathons. But I keep listening music in the trails, there are trails that I've run before. I'm trying to be more careful." (P09)

viii) Individual Comfort. Running can be a solitary endeavour or a shared adventure. How runners choose to engage with music during conversations and group runs reveals a lot about their personal comfort zones. This exploration delves into the dynamics of interaction, the fusion of music with human connections, and the delicate equilibrium between self-entertainment and social engagement during runs.

"When I am running with someone, I put the music on speaker and run with them while having a talk." (P06)

"I can also listen to music on group runs, at least when wearing one of the earphones. Sometimes I get involved in conversations." (P09)

The choice to use a single earphone for conversations (Participants 6 and 9) points to the social nature of running for some individuals. The ability to interact with others while enjoying music demonstrates the adaptability of runners to strike a balance between personal enjoyment and shared experiences during runs.

Participants' responses provide a comprehensive view of how music influences their running routines. The use of music aligns with goals, adapts to social dynamics and environments, and balances personal enjoyment with safety considerations. This multifaceted approach showcases the intricate relationship between music and the various aspects of a runner's experience. In conclusion, responses provide a comprehensive view of how music influences participants’ running routines. The use of music aligns with goals, adapts to social dynamics and environments, and balances personal enjoyment with safety considerations. This multifaceted approach showcases the intricate relationship between music and the various aspects of a runner's experience.

4.1.2 Physical Music Playing Devices

Participants' choices in physical music playing devices present a window into their technological ecosystem. As they interact with these devices in their running routines, insights into the way's technology becomes an integral part of their physical pursuits are gathered. By examining their preferences, we uncover the nuanced ways in which devices seamlessly blend into the symphony of running.

In the realm of amateur running, the choices made concerning technological equipment wield significant influence over the auditory backdrop and overall running experience. By examining the preferences of ten amateur runners (see Table 4.1), an exploration into the intricate interplay of technology with this sporting pursuit is embarked upon. In this investigation, emphasis is placed on design and interface considerations, which distinctly meld the runner's experience.

Table 4.1 Music playing device preferences of the participants

Technological Equipment Preferences	
Participants	Type
P_01	Smartwatch and smartphone
P_02	Smartwatch, smartphone and sometimes music player
P_03	Smartwatch, smartphone and sometimes music player
P_04	Smartwatch and smartphone
P_05	Smartphone
P_06	Smartphone
P_07	Smartwatch and smartphone
P_08	Smartwatch and smartphone
P_09	Smartwatch
P_10	Smartphone

A choice often made among amateur runners is the integration of smartwatches and smartphones. This harmonious coexistence represents a comprehensive approach to the running experience, with music playback being skilfully blended with extensive fitness tracking. Smartwatches, known for their user-friendly touchscreens and accessible interfaces, are frequently employed as extensions of smartphones. Moreover, smartphones fulfil the role of central repositories for music libraries and expansive variety of running applications. These design considerations converge to facilitate versatile and multifaceted running equipment.

The other music playing device type that is added to the duo of smartphones and smartwatches and sometimes preferred to be used independently of these two is the music player. The biggest advantage of the music players for the runners was that they had a lighter load to carry instead of their smartphones since and no distracting notifications or calls. Music players can provide the playlists in their storage which is often provided through the phones and the platforms. On the other hand, as participants 2 and 3 pointed out, the fact that most music players are not compatible with wireless headphones but work with wired ones prevents them from being the first choice for listening to music while running.

"The biggest handicap to listening to music with an iPod is that it requires having wired earphones, which is annoying." (P03)

Participants who preferred a more minimalist approach, choosing only a smartphone or a smartwatch, had different motivations. A subset of runners, including Participants 5, 6, and 10, prefer simplicity with the use of a smartphone alone. Smartphones may offer the convenience of an all-in-one device for music playback and fitness tracking. However, the fitness tracking feature may not be as effective as what the fitness watches offer. At this point, it was necessary to examine the motivations behind the choice of Participant 9, who stated that the smartwatch as the only technological equipment for listening to music while running. The smartwatch was chosen to be compatible with listening to music and fitness tracking and market research was conducted on this subject by Participant 9.

"My watch only integrates with Spotify, that's why I chose it. It only plays the playlists I downloaded. So, I don't need an internet connection." (P09)

Another physical device to complete the experience of running with music is headphones. The choice of earphones and headphones emerges as a key facet of participants' technology engagement during running. This subsection delves into the diverse array of preferences when it comes to these auditory companions. Through their insights, an understanding of the considerations that influence their selections—ranging from comfort and sound quality to stability during physical activity—is gathered.

Participants' choice of headphones/earphones for listening to music while running varied, as shown in Table 4.2. As can be seen from the table, most of the headphones used by the participants for listening to music while running were Bluetooth earphones. The reason for this choice will be analysed in more detail in the following sections. However, among the participants, who preferred to use both types of headphones, the Participant 3 had a different motivation. While the other participants said that they preferred to use the wired headphones in scenarios where they had to, such as when the wireless ones did not have a charge, the motivation of the Participant 3 for choosing between wired and wireless headphones was the differentiation of the electronic device providing music.

Table 4.2 Earphones/headphones types of the participants

Headphones/Earphones Preferences	
Participants	Type
P_01	Bluetooth headphone or wired earphones
P_02	Bluetooth earphones
P_03	Bluetooth headphones or wired earphones
P_04	Bluetooth or wired earphones
P_05	Bluetooh earphones
P_06	Bluetooth earphones
P_07	Bluetooth earphones
P_08	Bluetooth earphones
P_09	Bluetooth earphones
P_10	Wired earphones

In summary, the confluence of technology and amateur running encompasses a spectrum of individualized equipment preferences. Within this array, design and interface considerations intrinsic to each device assume pivotal roles in defining the auditory ambience and enhancing the overall running experience. Whether it entails the seamless combination of smartwatches and smartphones, the versatile synergy with music players, the streamlined efficacy of a smartphone-smartwatch tandem, or the minimalist ethos of exclusive smartwatch utilization, each choice exemplifies the runner's purposeful selection of equipment, carefully engineered to elevate their auditory and performance dimensions in the quest for an enriched running journey.

4.1.3 Digital Music Streaming Platforms

Exploring the music streaming preferences of amateur runners provides valuable insights into how they curate their auditory landscapes during their runs. The dynamics that shape their musical engagement and how technology amplifies the auditory experience within the realm of physical activity are uncovered by understanding the motivations behind their selections. The preferences of the digital music streaming platforms that ten amateur runners made can be seen in Table 4.3.

Table 4.3 Digital music streaming platforms preferences of the participants

Digital Music Streaming Platform Preferences	
Participants	**Type**
P_01	Spotify or YouTube
P_02	Apple Music
P_03	Spotify
P_04	Spotify
P_05	Spotify
P_06	Spotify
P_07	YouTube Music Platform
P_08	Spotify or YouTube
P_09	Spotify
P_10	Spotify

The music streaming preferences of amateur runners are diverse, reflecting their individual tastes and priorities. While some runners enjoy the synergy of multiple platforms, others find solace in the exclusivity of their chosen streaming service. Ultimately, these choices underscore the significance of music in enhancing the running experience, as each runner curates their auditory journey to match their preferences and motivations.

4.1.4 Motivations

The fusion of music and running presents an intriguing confluence of sensory experiences, where auditory rhythms intertwine with the cadence of physical exertion. This exploration delves into the multifaceted relationship between music and running, focusing on how music serves as a catalyst for enhanced motivation and performance. Through the perspectives of different participants, diverse ways have been discovered in which music becomes an integral companion during the journey, influencing emotions, altering perspectives of time, breaking the monotony, and fine-tuning the pursuit of optimal performance.

Thematical analysis of the participants statements about their motivations is provided following headings: 6) enhancing mood and focus, ii) breaking boredom and elevating entertainment, iii) performance optimization.

i) Enhancing Mood and Focus. Music transcends mere auditory pleasure for many runners. As the narratives of participants are delved into, it is discovered that music becomes a conduit for emotional transformation. Whether Participant 1's use of music to mirror their emotions or Participant 3's reliance on music for mood elevation and energized focus, this segment unravels the intricate relationship between music and the emotional backdrop of the run. Emotions blend seamlessly with melodies, enhancing mood and fostering a mental state that aligns with the runner's objectives.

"It relaxes me. I like music, I like to move with music, that's why I listen to it. It gives me rhythm." (P01)

"Sometimes it improves my performance. Most of the time, like I said, it's more of a mood thing, so if I'm thinking about something, music is good for me to focus on that thought. I listen to thought-provoking music. If I'm happy If I'm energetic then I listen to more upbeat music. Sometimes, of course, I also listen to music to run faster." (P03)

ii) Breaking Boredom and Elevating Entertainment. In the middle of a rhythmic running pattern, monotony can set in. However, participants like Participant 2 and Participant 7 illustrate how music serves as a captivating antidote. Music does not just accompany; it elevates the entertainment level of the run.

"I listen to music to break the boredom, particularly of a treadmill run." (P02)

"I listen to music to avoid boredom, music is the accompaniment." (P07)

Both Participant 2 and Participant 7 emphasize music's role in breaking the monotony of running. This section explores how music serves as an entertainer, injecting excitement into the run and elevating its entertainment quotient. The engagement with music as a boredom-busting tool highlights its transformative power to turn the run into an enjoyable endeavour.

iii) Performance Optimization. It was mentioned in the Chapter 2 that the relationship between music and performance has been examined in many studies. Music is not just an auditory backdrop—it's a catalyst for heightened performance and focused attention. Also, music's ability to redirect their focus away from their own breath sounds is crucial, offering a psychological edge in maintaining their pace and endurance.

"I usually listen to it to improve my performance." (P08)

"I think it improves performance. It also helps to focus. Anyway, especially moving music I'm listening to it, and it's blocking me from hearing my breath. When I hear my breath, it's more I feel like I'm getting tired." (P04)

Participant 4 and Participant 8 emphasize the performance-enhancing aspect of music. At the same time, it was mentioned that it is also useful for the music to block out some bodily sounds like breathing or stepping sounds that can negatively affect their performance.

In addition to the performance boosting features of music itself, the strategic selection of playlists also takes centre stage through Participant 9's emphasis on beats per minute (BPM). The precision in selecting music tailored to the runner's pace and goals underscores the science behind playlist creation.

"It affects my performance by 20%, so I listen to it to increase my performance. I adjust my playlists accordingly, it's bpm-oriented." (P09)

In essence, the narratives of these participants collectively craft a comprehensive portrait of the dynamic relationship between music and running. Participants' main motivations for listening to music while running were to increase their mood and focus, to break the boredom that running can cause, and to help improve their performance.

4.1.5 Advantages

The advantages of listening to music while running for amateur runners were very similar to the motivations for listening to music while running asked in the previous section. Within the realm of advantages, participants' reflections offer a spectrum of insights into the benefits they perceive from their technology-infused running experiences. This subsection dissects these advantages, ranging from heightened focus and energy to a profound sense of enjoyment. These advantages can be listed as follows:

- performance optimization
- mood elevation and continuous motivation
- boredom buster and time illusion
- mind liberation and enjoyment
- rhythm and pace synchronization

Music while running is like a turbocharger for amateur athletes. It fuels performance elevation by sharpening focus and boosting motivation, enabling runners to push their physical boundaries. Participant 8 acknowledges that it "increases performance to some point," but cautions that excessive pushing can lead to increased fatigue.

Participant 9 succinctly states that the primary reason for listening to music while running is to "increase performance," highlighting the performance-enhancing potential of music during exercise.

"It (listening to music) definitely increases my performance." (P09)

Music serves as the emotional scaffolding of a run, elevating mood and sustaining motivation. Participant 3 identifies all the benefits of listening to music while running as increasing motivation, mood enhancement, and focus. Participant 5 predominantly sees music as a performance booster, but also notes that it "motivates to exercise and sometimes even rests the body and mind." Participant 7 views music as a mood enhancer and a source of enjoyment during runs, underscoring its positive impact on their overall running experience.

Running can be a battle against monotony, and music is the weapon that conquers boredom. Participants 2 and 5 attests to this, emphasizing how music "makes time seem to pass more quickly." Participant 2 notes that the ability to change playlists and songs can sometimes be distracting but acknowledges music's role in alleviating the tedium of long, uneventful runs. Participant 5, while highlighting music's performance-enhancing potential, also notes that it combats boredom effectively.

Music is not just an auditory backdrop; it's a liberator of the mind. Participants 4 and 6 shares how it "clears the mind" and infuses runs with "joy." Participant 4 notes that carrying music-playing equipment can be uncomfortable but recognizes the therapeutic role of music in freeing the mind from daily stressors. Participant 6 takes it a step further, describing how music infuses their runs with joy, even inspiring dance-like movements, transforming exercise into an exuberant celebration of movement.

Running is a dance of strides and breaths, and music becomes the choreographer that synchronizes every move. Participant 1 appreciates how music provides "rhythm and pace synchronization," noting that the beat of the music can align with a runner's strides, enhancing their performance. Participant 5, while emphasizing music's performance-boosting aspect, acknowledges that it serves as a "natural metronome," aiding in maintaining a consistent rhythm and pace.

4.1.6 Disadvantages

Participants spoke about the other side of this double-edged sword of listening to music while running, acknowledging that there are advantages as well as disadvantages to the experience of listening to music while running. This subsection looks at how music affects running, again based on the experiences of ten amateur runners. Music can boost performance and mood, make runs less boring, and change how we perceive time. But it can also make us less aware of our surroundings, disrupt our focus, and isolate us. These advantages that the participants acknowledged can be listed as follows:

- performance limitation
- lack of environmental awareness
- interaction disturbance
- isolation from environment
- equipment discomfort
- paranoia and alertness
- the physical load of the technological equipment

Just as music can optimize performance, it can also impose limitations. Participant 8 notes that while music increases performance to a certain point, it can have a counterproductive effect over time. Maintaining a consistent rhythm, while initially enhancing performance, can lead to overexertion and increased fatigue, ultimately diminishing the desired performance levels.

"I mean, it improves my performance up to a certain point, but after a certain point, it makes me push myself too hard and get too tired. Keeping up with that

rhythm and listening to the music all the time can get tiring. And vice versa, it can cause my performance to drop." (P08)

Music can compromise environmental awareness, particularly during trail or road runs. Participant 1 points out that in such settings, it's crucial to remain attuned to the surroundings, whether it's the presence of dogs on a trail run or traffic on a road run. Participant 5 highlights that earphones, regardless of whether music is playing, can make the runner feel deaf to their environment, posing potential safety risks by obstructing sounds like approaching vehicles or pedestrians.

"For example, sometimes, when I have headphones in my ears, whether music is playing or not, I go deaf. I don't hear any sound around me completely." (P05)

Managing music playlists or songs while on the run can be a challenging task, interrupting the fluidity of the exercise. Participant 2 acknowledges that interacting with music-playing devices during the run can be disturbing, potentially diverting focus and detracting from the overall running experience.

"If I want to change playlists and change songs, then of course I've got to interact and that can be a bit disturbing on the run sometimes." (P02)

While music can elevate mood and motivation, it can also create a bubble that isolates runners from their surroundings. Participant 3 notes that music isolates them from the environment and potential dangers, underlining the trade-off between enhanced mood and a reduced connection with the surroundings.

"One of its disadvantages is its isolation from the external environment and dangers." (P03)

Carrying music-playing equipment, such as smartphones, can be challenging during runs. Participant 4 highlights this issue and mentions the use of wristbands for stability, although they note that these accessories can be uncomfortable and potentially restrict arm movement.

"Oh, and I usually use an armband for the phone. It also bothers my arm. I have to move it like this from time to time." (P04)

Runners who use earphones may become overly vigilant about their surroundings, leading to a constant state of paranoia and alertness, which can be mentally exhausting. Participant 6 mentions that using a pair of earphones makes them paranoid about potential incidents occurring around them.

"That's what happens when I have two earphones plugged in. There's a constant questioning of whether something is going on around you. It is paranoia." (P06)

Carrying a smartphone or music-playing device can be defined as a main issue for most participants. The additional physical load of the smartphone or music player is affecting the runner's performance negatively and causing constant discomfort while carrying them. Participant 7 points out that carrying the phone is a significant problem for them, potentially adding discomfort and logistical challenges to their runs.

"It's just a weight problem of carrying the phone." (P07)

Interestingly, one participant (P09) reports no discernible disadvantages, implying that, in their experience, the benefits of music outweigh any potential drawbacks. This perspective underscores the highly individual and context-dependent nature of the impact of music on running. In addition to this view, this specific participant was a participant who selected and purchased his technological equipment and headphones with a focus on their suitability for listening to music while running.

4.2 Part 2: The Running Activity on a Track: 'Devrim Running'

People can listen to various types of music using a variety of devices and digital platforms. Listening to music while running, on the other hand, may present different challenges for runners in terms of interaction and attention, as everything must be completed 'on the move', ideally without pausing the run. The aim of Part 2: Running Activity of the fieldwork was to examine how participants interact with the interfaces of music playing devices and/or music streaming platforms while running, as well as the challenges they face, in order to draw conclusions about how the design of the interfaces can be improved to better meet the needs of runners. In order to avoid the training effect, the commands order is randomized. However, some commands needed to be placed to some certain order. For example, 'Start the playlist' was always the first and 'End the playlist' was the last command to have the standard sequence of starting and ending the music listening experience. Also 'Pause the song' command came before the 'Resume the song' in order to protect again the structure of music listening experience. So, partial training effect can be one of the limitations of this procedure. In this regard, the following eight music playing commands were identified for the study:

- "Start the playlist."
- "Turn the volume down."
- "Turn the volume up."
- "Change the song."
- "Pause the song."
- "Resume the song."
- "Change the playlist."
- "End the playlist."

In this part of the fieldwork, participants completed a running activity in Devrim stadium track with their own music playing devices. During the run, the scene view, eye movements, and fixation points of the participants were recorded with the help of eye-tracking glasses. Each run session with each runner lasted between 9 and 15 minutes.

The procedure for Part 2 of the fieldwork was as follows.

- First, the participants were reminded that their running performance was not evaluated and that they should follow the instructions with their usual running style. The researcher then described how the music playing commands would be displayed and what was expected of them.

- Participants wore their personal music players, headphones/earphones, and mobile phones, all of which were ready to play music as usual.
- Eye-tracking glasses were worn, and participants were checked to ensure if they were comfortable enough to run with them, as well as if they had any questions about the glasses. Then, the eye-tracking glasses were activated, and the run began.
- Whilst running, the running participants were given instructions written on a whiteboard lifted up by the researcher from a visible location by the track (see Figure 4.4). The running activity was completed when the participant was shown all of the music playing commands and completed the necessary interactions. For each participant, the commands were given in a different order. Only some instructions had to be done in a certain order, which will be explained in the following sections.
- After the running activity was completed, the participants were asked to evaluate the level of difficulty they felt while doing the given instructions with six 5-point Likert scale questions specially prepared for the study (see Appendix D). This was to learn, understand, and compare the difficulty levels of the music controls performed by the runners on the platform and devices they used.

Figure 4.4 An illustration of how the participant was shown the music playing commands

The participants' eye-tracking recordings were used to analyse the running activity's results, along with manual monitoring of those records. In addition to the time required to complete the commands, the phone interface regions and the number of focusing points that participants had used were manually analysed. This was done in order to find out where the participants had trouble finding the command or correctly executing it.

Eye-tracking recordings were provided by the online cloud of the eye-tracking glasses. Video recordings can be played on the interface provided by this online platform. As can be seen in Figure 4.5, there are 4 sections and headings on the analysis screen. The first one is a timeline with preview images. This timeline provides faster access to the regions and time intervals where the participant was in the stadium during the activity. Gaze, on the other hand, shows the points where the participant's eyes are focussed during the run by marking them as a red circle. Fixation is used to show the paths and flow between the points where the participant's eyes are focussed by marking with blue circles and the fixation numbers. These two pieces of information can be switched on and off via the platform. Finally, in the Events section, a certain time interval in the recording can be selected, separated and named.

The use of these features during the analysis of the records was as follows. The Thumbnail section helped analyse the parts that were not interacted with any device or interface during the run faster. The Gaze section showed which areas the participant focused on in the interfaces they interacted with. In the Fixation section, the participant's eye focus mobility was examined and it was possible to analyse the eye movement of the participant from the moment they saw the orientation. However, due to the low accuracy of the eye-tracking glasses used and the movement and vibration caused by running, it was sometimes difficult to provide these two pieces of information. Finally, the Events part was used to measure and determine the duration of the instructions given. The time it took for each instruction to reach the participant and the time it took for the participant to realise it.

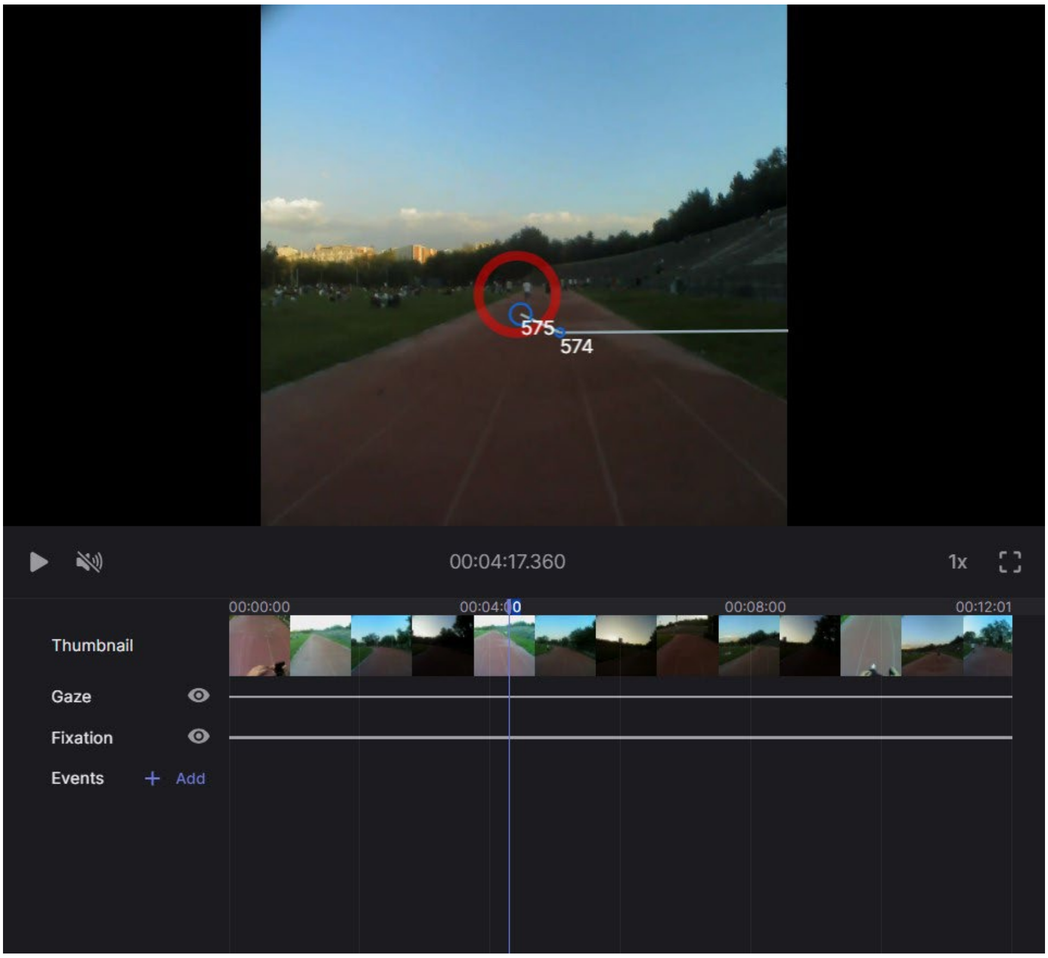


Figure 4.5 Online analysis screen of the eye-tracking glasses

Specific outcomes related to each of the commands are presented in the following sections.

4.2.1 Start and End the Playlist

"Start playlist" and "End playlist" were the first and last commands of the running activity. These were placed at the beginning and end of the study to avoid any confusion about the course of the study. The participants began their run around the stadium track by starting the playlist they had pre-prepared at the start of the study's recording with the eye-tracking glasses.

In Figure 4.6, the digital music platforms' playlist display screens that the participants used to listen to music can be seen in the order of Spotify, YouTube Music, and Apple Music. These screens provide the icons for starting the playlists and shuffling the songs in the playlists. Some participants prefer to use these icons and buttons to start their playlists (see Figure 4.7), while others prefer not to use the buttons provided, but scrolled through the playlist, selected the song they wanted to listen to and started the playlist by starting the songs they choose (see Figure 4.8).

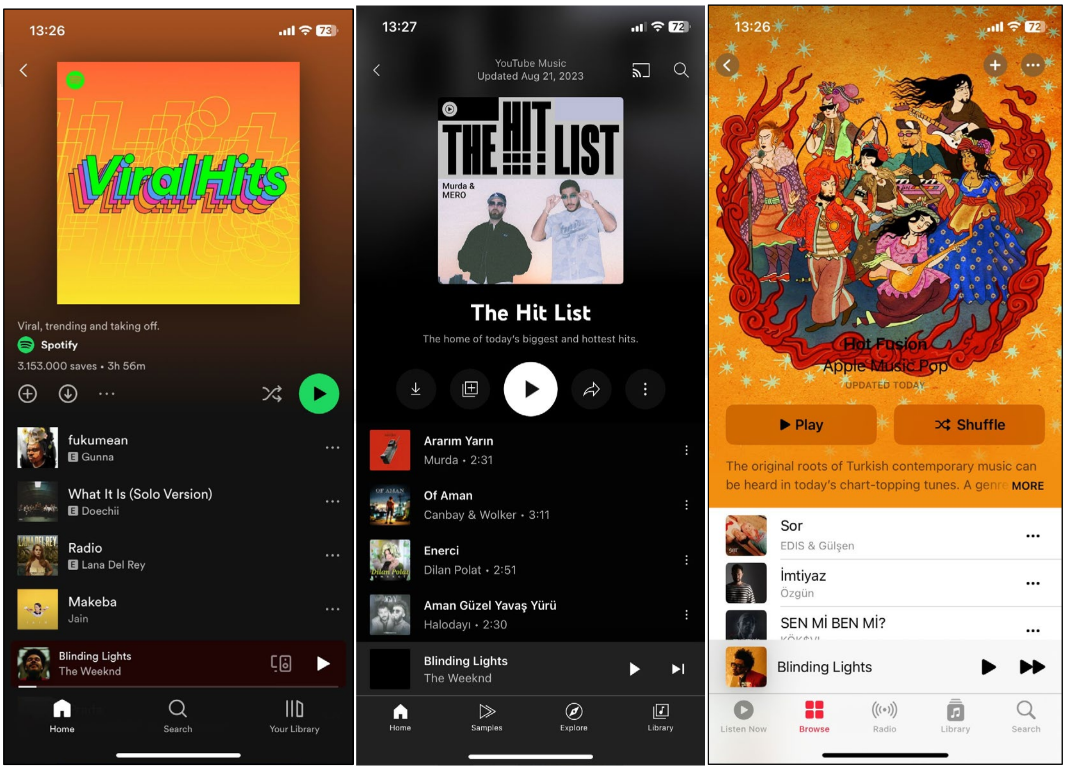


Figure 4.6 Screenshots of the playlist screens from Spotify, YouTube Music and Apple Music

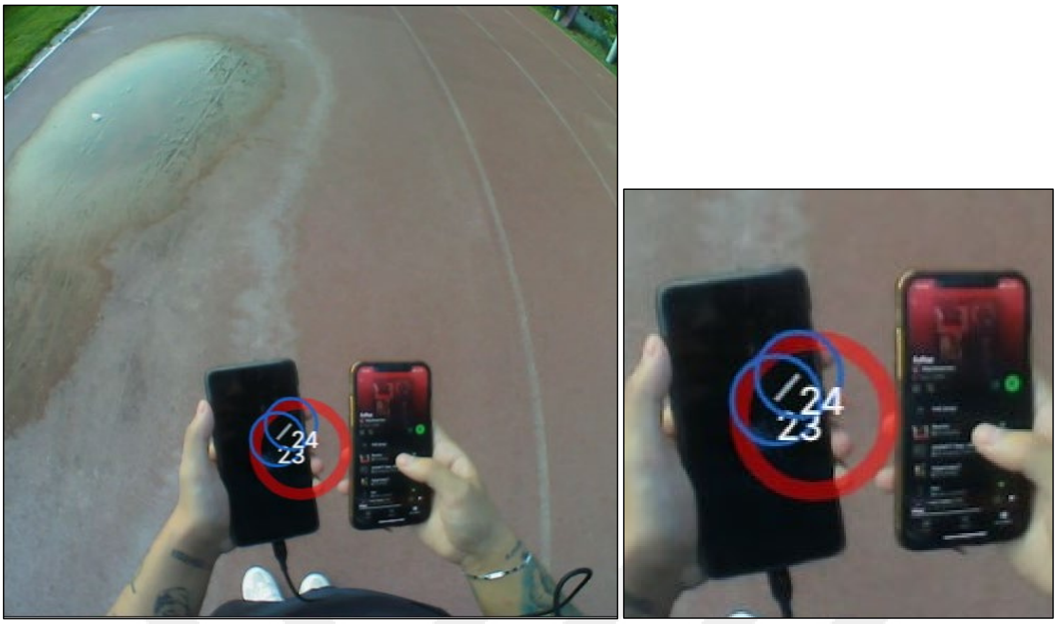


Figure 4.7 Screenshots from the eye-tracking recording of the participant who chooses a song to play from the playlist

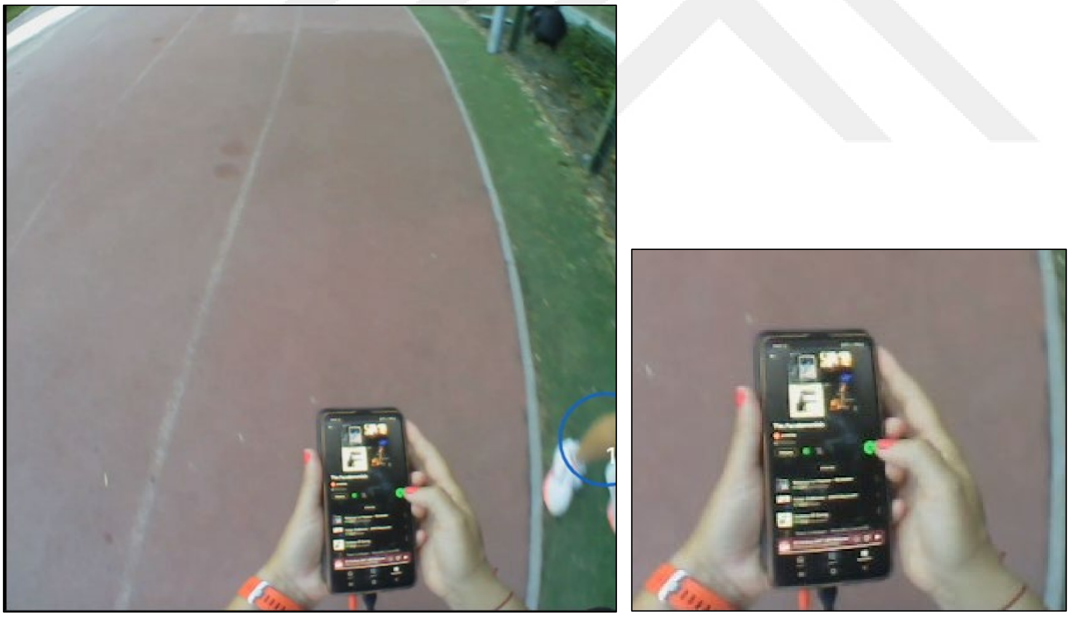


Figure 4.8 Screenshots from the eye-tracking recording of the participant who starts the playlist via play button

Nevertheless, the same participant who used the button to start the playlist decided after a few seconds to go back to the playlist and scroll through the songs to select (Figure 4.9). These actions showed that even if the platform provides the participant with a start icon to start the playlist they have decided on, and even if the playlist can be predetermined to play in shuffled or prepared order, it is possible that the user may want to return to the list they have prepared according to their current mood and start the song they want.

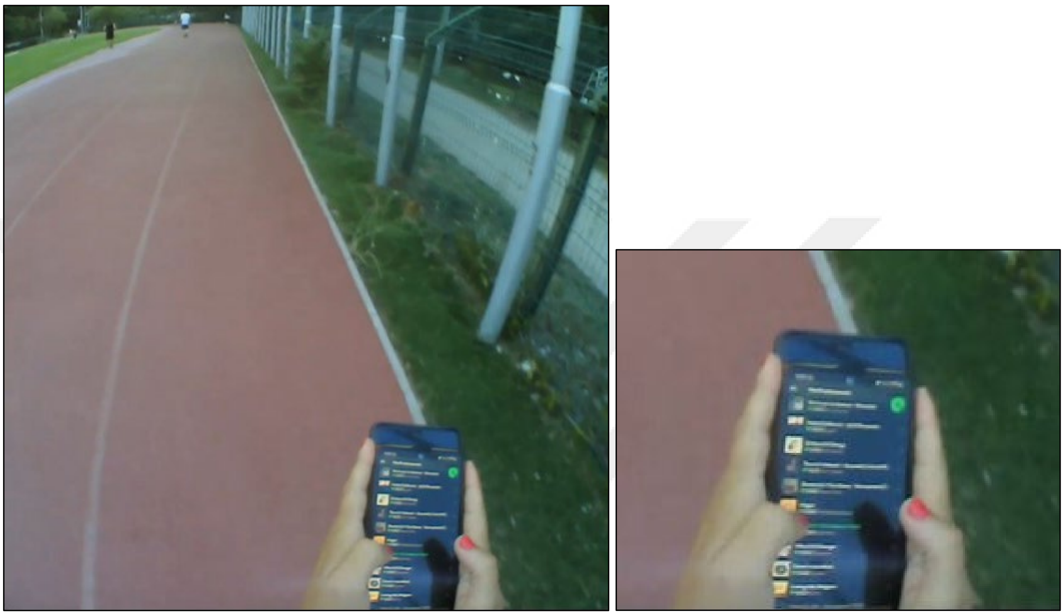


Figure 4.9 The participant is scrolling the playlist to choose a song

The fact that not all participants preferred the same interaction and started their playlists also affected the playlist start time interval data from the eye-tracking recordings. As can be seen in Figure 4.10, there was a notable difference between these time intervals. Participants who used the icon to start the playlist took less than 10 seconds to perform the command, while participants who started the playlist by scrolling through the songs and selecting the desired song instead of using the start button took more than 10 seconds to perform the command.

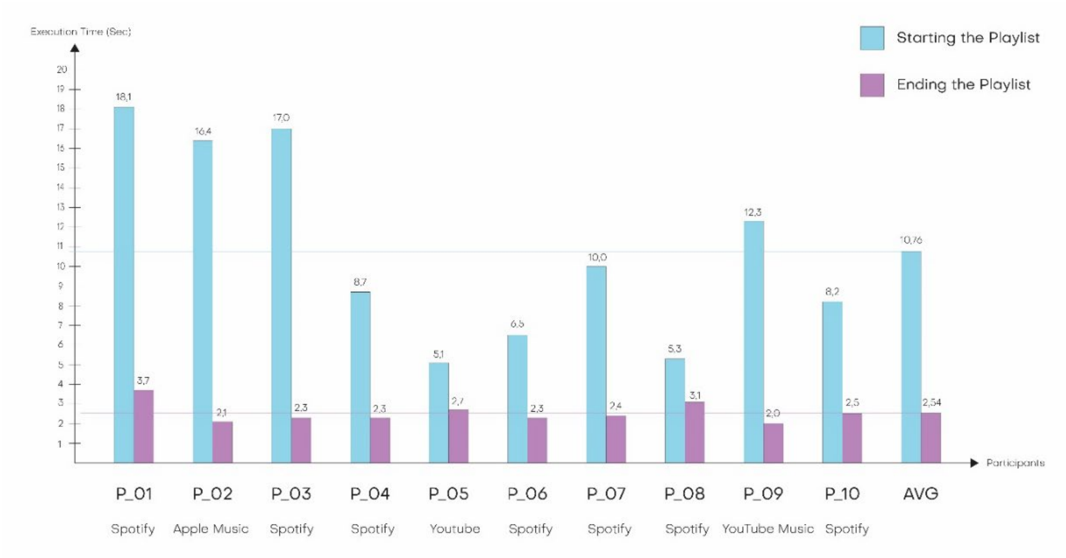


Figure 4.10 ‘Start the playlist’ and ‘End the playlist’ execution time bar chart

Starting the playlist instruction execution times were shorter for the ending playlist instruction, as can be seen again in Figure 4.10. This was because participants were pressing the button to stop the song already playing in the playlist, rather than the stop button that the playlist start button had become. There was a relative size difference between the two buttons, for this reason it was concluded that participants were more inclined to use icons that were both faster to reach and more visible on the screen they used (see Figure 4.11).

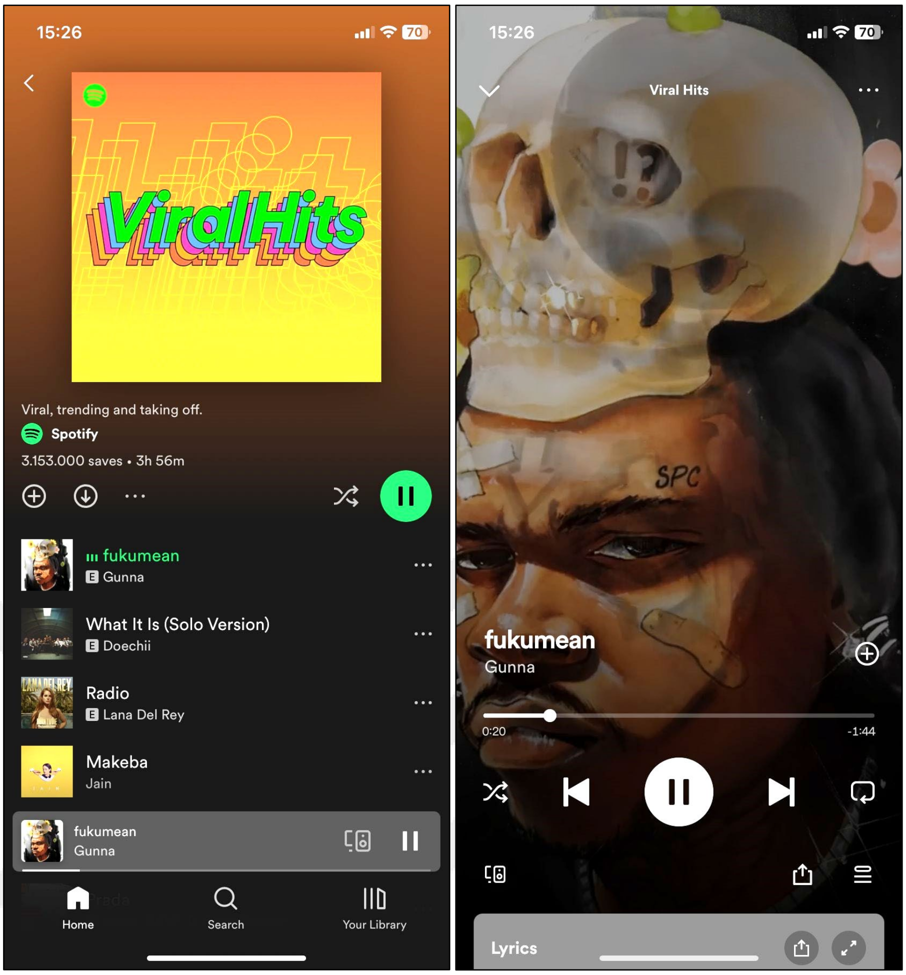


Figure 4.11 Screenshots of the playlist and song playing screens from Spotify

4.2.2 Volume Adjustments: Up and Down

Participants were informed prior to the study that they should only follow the instructions given through the technological equipment and digital platform interfaces they were using. This information critically reduced the expected execution times of the sound increase and decrease instructions (see Figure 4.12). The reason for this was that almost all participants preferred to perform the voice controls via the tangible buttons of their phones instead of the interface of the digital platform they were using (see Figure 4.13).

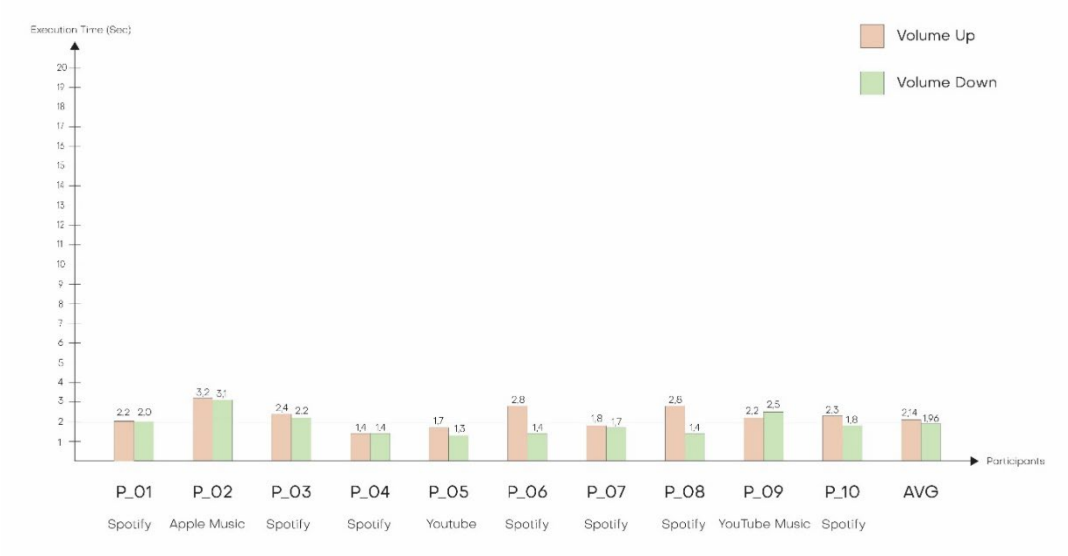


Figure 4.12 ‘Turn the volume up’ and ‘Turn the volume down’ execution time bar chart

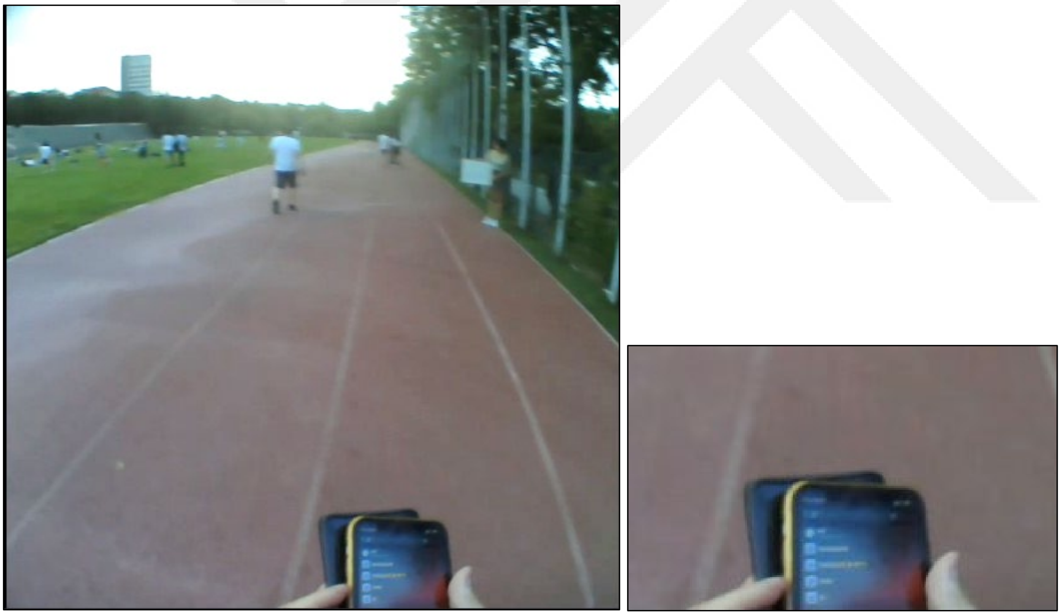


Figure 4.13 Screenshots from the eye-tracking recording of the participant that turns the volume down from the smartphone interface

However, not every participant preferred a tangible interface over a digital one. Some of them used the volume bar on the interface of the digital music platform they were using rather than the volume up and down buttons on their smartphone (see Figure 4.14).

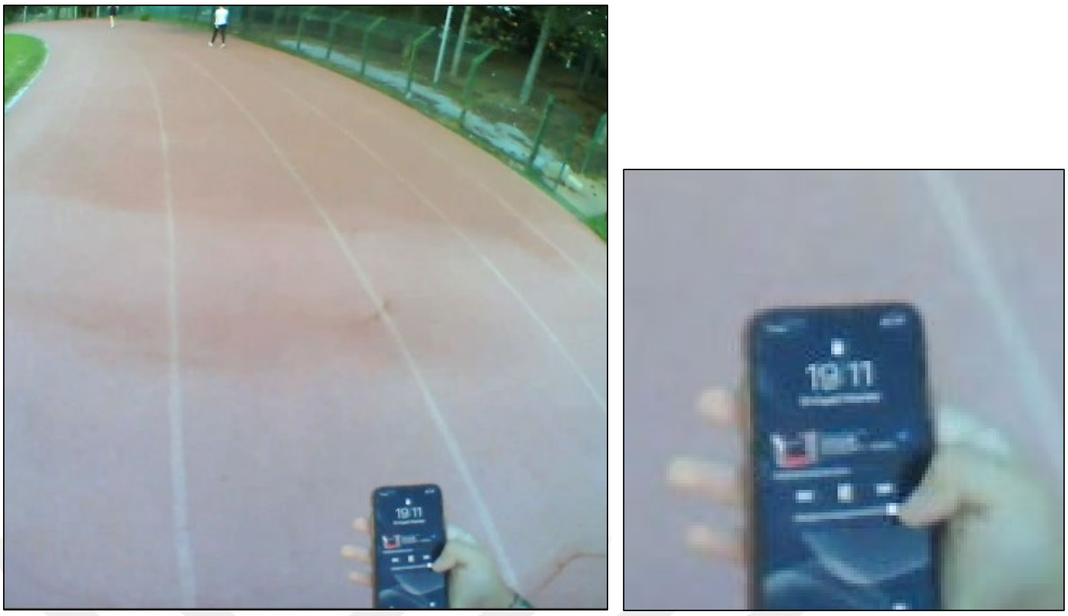


Figure 4.14 Screenshots from the eye-tracking recording of the participant that controls the volume from the platform interface

In addition, according to Participant 1, the volume up/down command was the most difficult command to achieve when attempting to perform the action on the interface of a digital music platform (i.e., Apple Music). The participant complained that the platform's volume control bar was too small and caused accidental clicking on the bottom icons (see Figure 4.15).

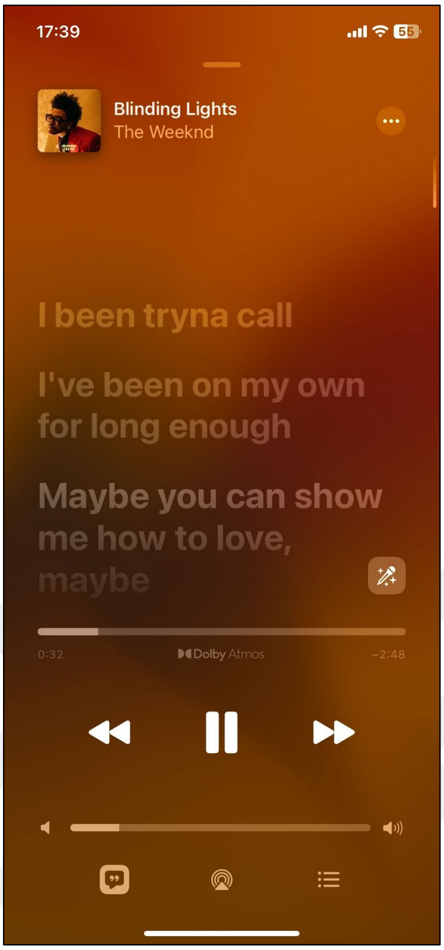


Figure 4.15 An example screenshot of the song playing screen and icons from Apple Music

The participants' smartphones also varied in how the lock screens were displayed on various digital platforms. While an Apple user/participant could see the sound bar in the the lock screen preview, an Android user could not see it and preferred to control the volume with tangible buttons, as shown in Figure 4.16.

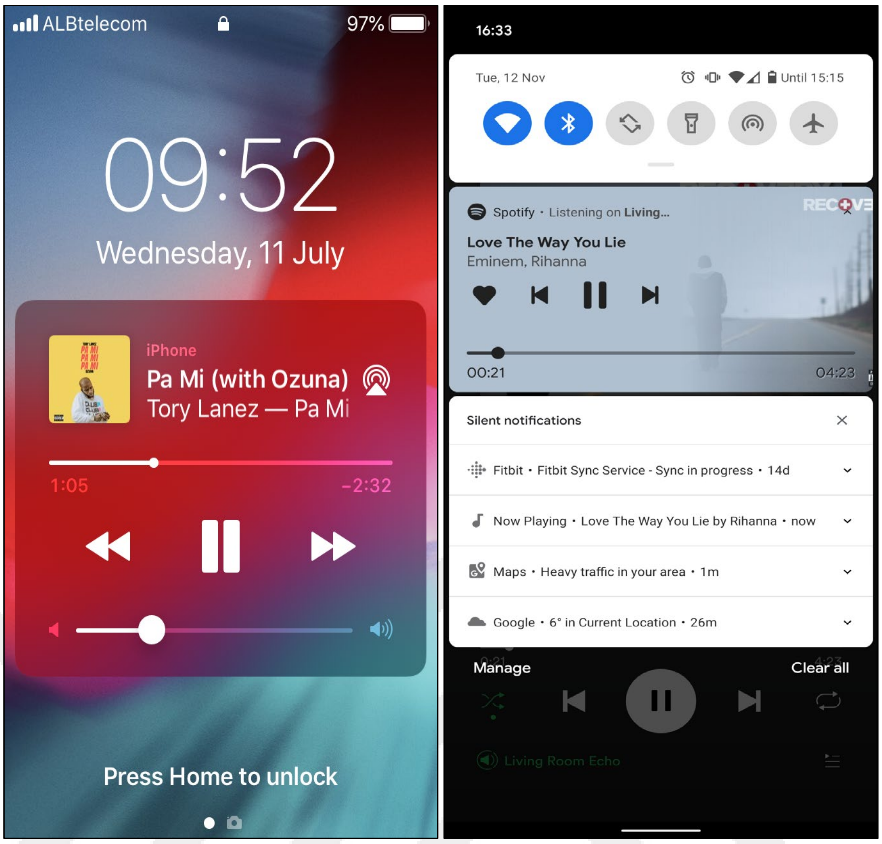


Figure 4.16 Spotify's lock screen widget view examples in Android and iPhone (taken from https://community.spotify.com/)

4.2.3 Pause and Resume the Song

The instructions for pausing and resuming the song were intended to evaluate the effectiveness of the music playing platforms' digital interfaces. All participants, except the one participant who used only smartwatch to control music, were able to see a preview screen on their smartphones (see Figure 4.17) that displayed 'Pause' ( ) and 'Resume' ( ) icons. The icons in the preview ('pause' and 'resume') were provided to avoid the extra step of entering the smartphone's password to access the music playing platform, and the preview made it possible to execute these commands in a single step (Figure 4.18).

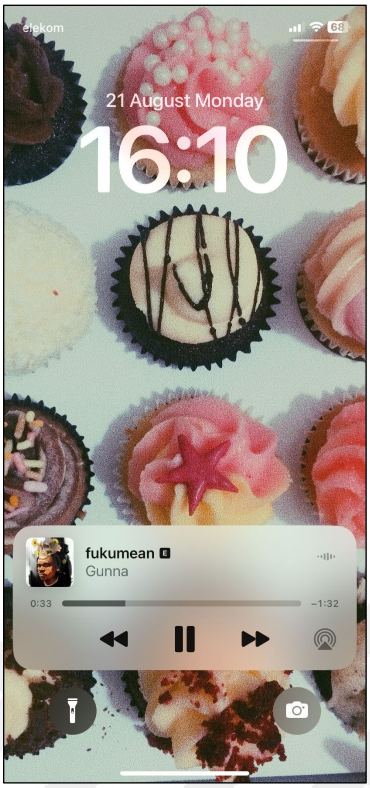


Figure 4.17 A screenshot of Spotify's lock screen preview with icons for song pause/resume

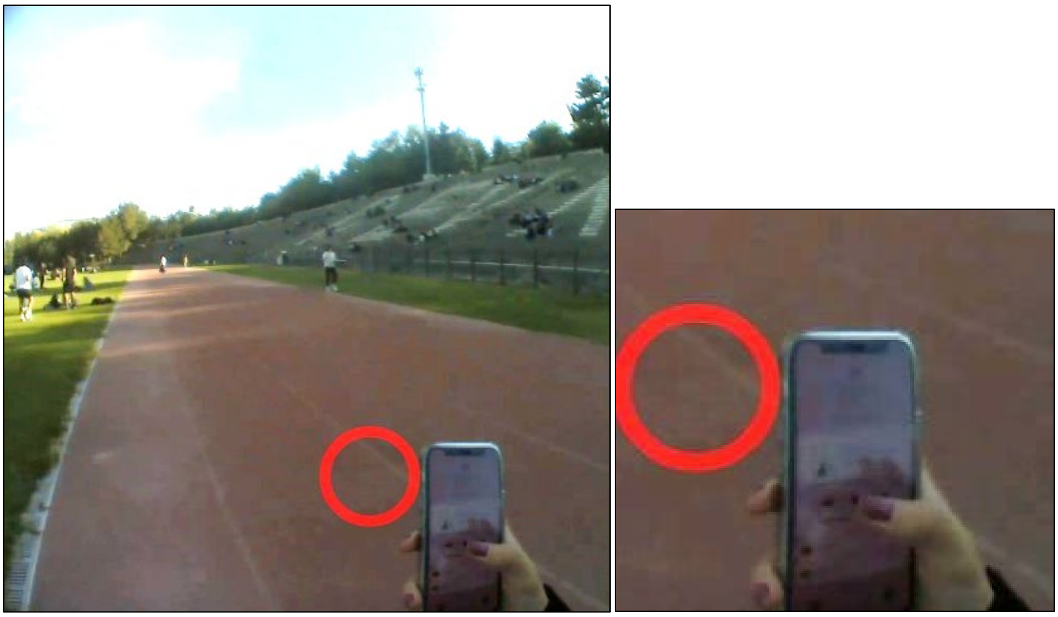


Figure 4.18 Screenshots from the eye-tracking recording of the participant that resumes the song from the preview screen

The analysis of the time intervals for performing these two instructions reveals that the participants took slightly longer time to perform the instruction to ‘pause’ the song than the instruction to ‘resume’ the song (Figure 4.19). Participants said this was due to the feeling of surprise when they saw the command to pause the song. They stated that they did not want to pause the song while running, so it took them longer to realise the instruction. One participant even reported that stopping the song was the most difficult instruction to execute.

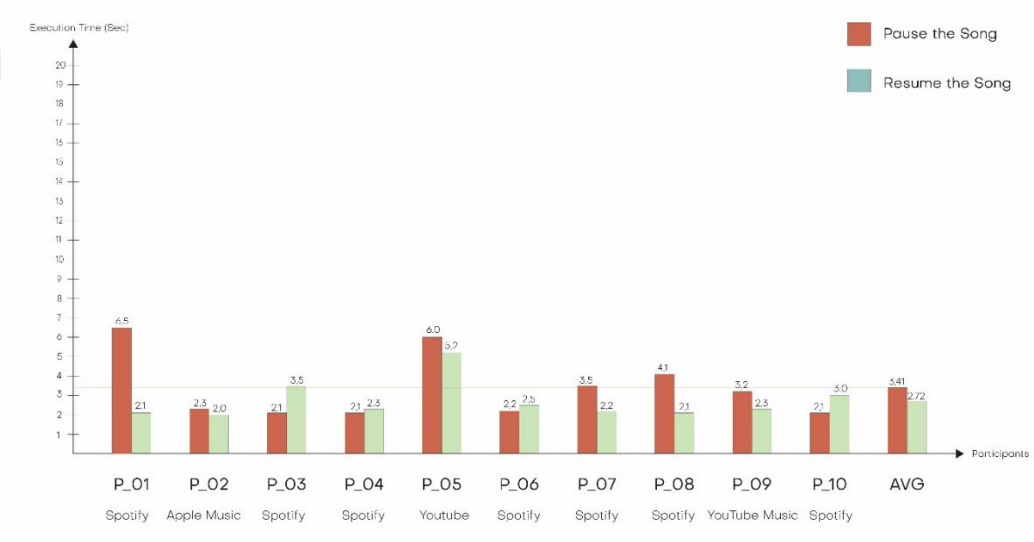


Figure 4.19 Results of the ‘Pause the song’ and ‘Resume the song’ execution time intervals bar chart

4.2.4 Change the Song

When participants were given the command to change the song, it was observed that they were responded to this command in two different ways. First, as detailed in the previous section, was to use the forward button on the preview widget provided by digital music listening platforms on the lock screen of their smart devices. That is, participants completed the command to change the song by moving to the next song in the sequence of their playlists (see Figure 4.20) to execute the same instruction, participants scrolled through their playlists and switched to their preferred song (see Figure 4.21).

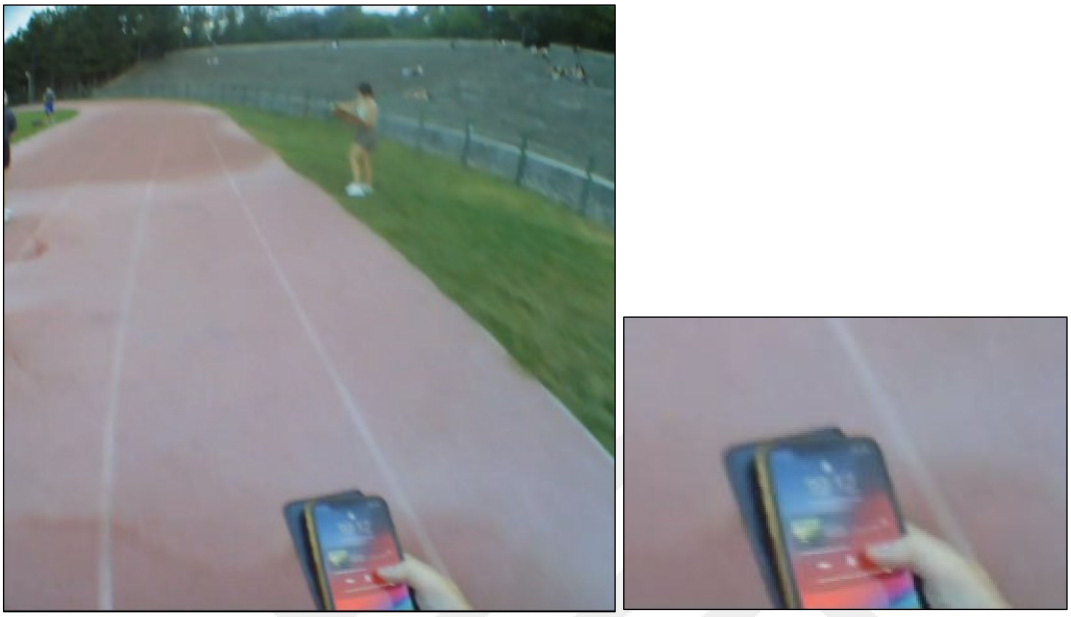


Figure 4.20 Screenshots from the eye-tracking recording of the participant that changes the current song with the forward icon

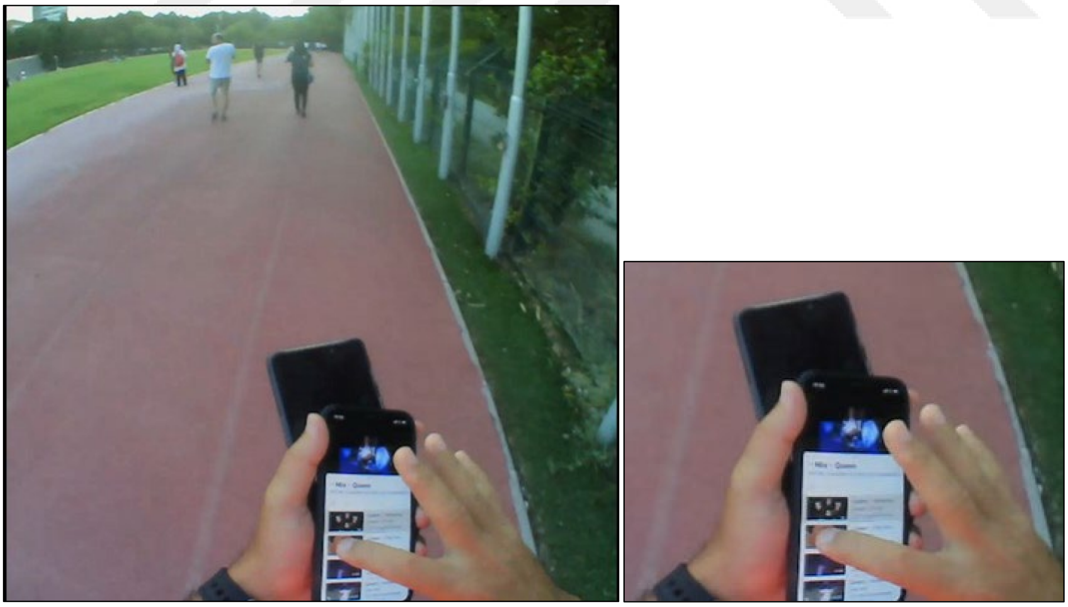


Figure 4.21 Screenshots from the eye-tracking recording of the participant scrolling the playlist to change the song

The Figure 4.22 shows the time intervals for executing the switch the song command. The time value differences between the participants were caused by the use of the two different paths to changing the song as mentioned above.

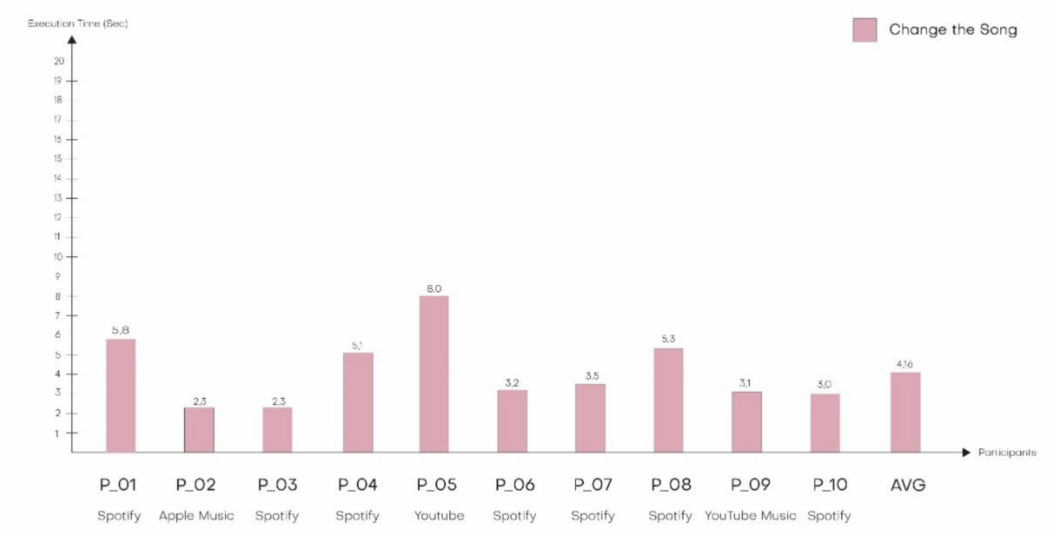


Figure 4.22 ‘Change the song’ execution time intervals bar chart

4.2.5 Change the Playlist

The command to change the playlist was a command that required multiple steps for all participants. As a result, as can be seen in Figure 4.23, the time intervals for performing the instruction were the longest, with an average of 12.82 seconds.

One of the most used sequences for changing the playlist can be seen in Figure 4.24 a.b.c. In these screenshots taken from the Spotify app, the first step is to unlock the phone (a). Then, the intro page for the currently playing song is displayed (b), and on the final screen, if a playlist was previously opened from the playlists section, playlists screen is displayed and a new playlist is selected by browsing the playlist (c).

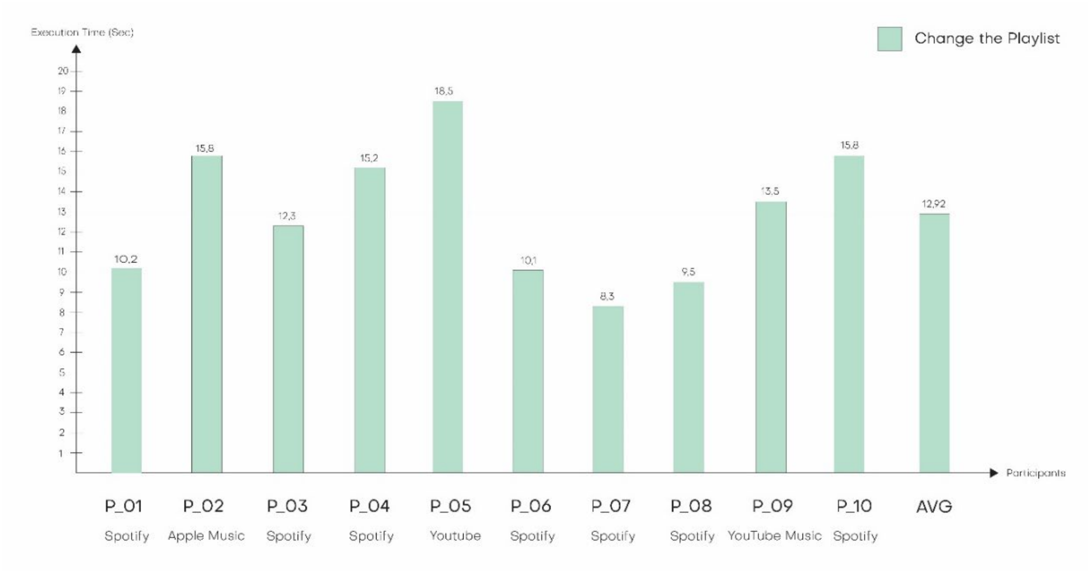


Figure 4.23 'Change the playlist' execution time intervals bar chart

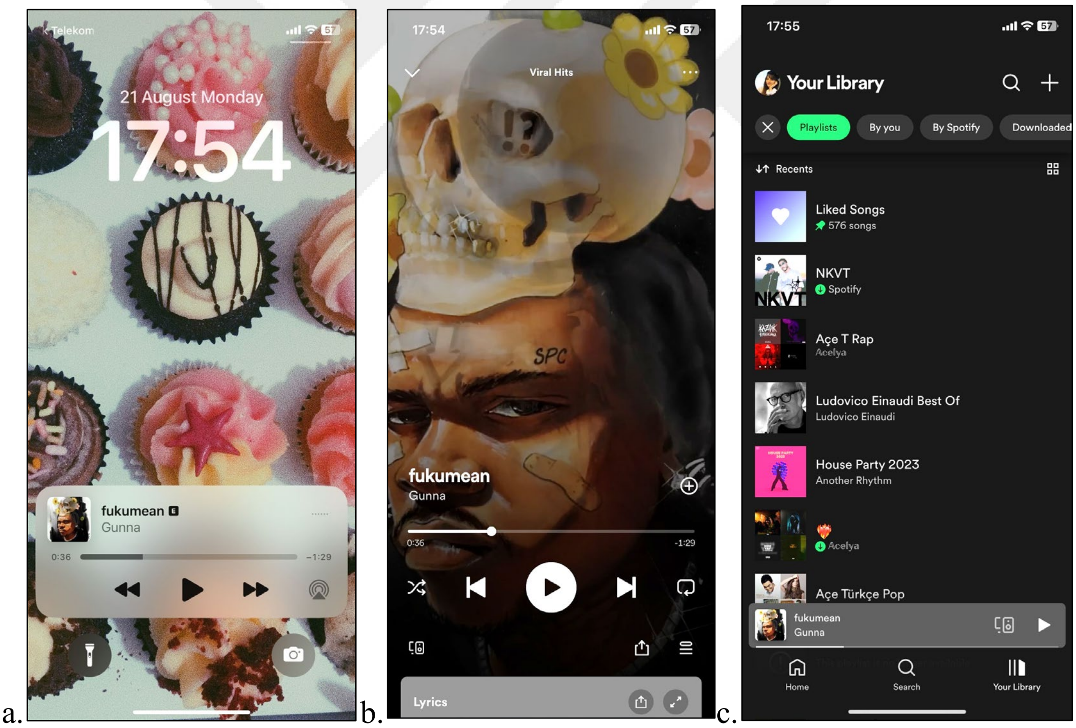


Figure 4.24 Screenshots from the playlist change sequence of Spotify application

Lastly, Table 4.4 shows the list of commands and the average (mean) time to execute them (in seconds) by rank order. As a result, "Change the Playlist" and "Start the Playlist" had the longest time intervals for participants to execute commands, whereas "Volume Down" and "Volume Up" had the shortest.

Table 4.4 List of commands and average (mean) time to execute them (in seconds) by rank order

		TIME INTERVAL (SEC)							
Platform	Participants	Volume Down	Volume Up	Ending the Playlist	Resuming the Song	Pausing the Song	Changing the Song	Starting the Playlist	Changing the Playlist
YouTube	P_01	2.0	2.2	3.7	2.1	6.5	5.8	18.1	10.2
Apple Music	P_02	3.1	3.2	2.1	2.0	2.3	2.3	16.4	15.8
Spotify	P_03	2.2	2.4	2.3	3.5	2.1	2.3	17.0	12.3
Spotify	P_04	1.4	1.4	2.3	2.3	2.1	5.1	8.7	15.2
Spotify	P_05	1.3	1.7	2.7	5.2	6.0	8.0	5.1	18.5
Spotify	P_06	1.4	2.8	2.3	2.5	2.2	3.2	6.5	10.1
YouTube Music	P_07	1.7	1.8	2.4	2.2	3.5	3.5	10.0	8.3
Spotify	P_08	2.2	1.4	3.1	2.1	4.1	5.3	5.3	9.5
Spotify	P_09	2.5	2.2	2.0	2.3	3.2	3.1	12.3	13.5
Spotify	P_10	1.8	2.3	2.5	3.0	2.1	3.0	8.2	15.8
	Average	**1.96**	**2.14**	**2.54**	**2.72**	**3.41**	**4.16**	**10.76**	**12.92**

4.2.6 Statistical Analysis of the Command Execution Times

A one-way ANOVA (Analysis of Variance) test was used to determine whether there was a statistically significant difference between the execution times for the commands (discrete groups of data) and, if so, between which pairs of commands. In the test, 'p-value' is commonly defined as '0.05', such that < 0.05 corresponds to the presence of a statistically significant difference between at least one of the test pairs. The ANOVA was run with eight groups, corresponding to the eight music playing commands, with data from the ten participants in each group (see Table 4.5). A Tukey's HSD post hoc test was used to identify which (if any) of the pairs from the ANOVA contained significant differences. An online statistics page (https://www.statskingdom.com/) was used to calculate ANOVA and Tukey's HSD.

Table 4.5 For the ANOVA and Turkey's HSD calculations, eight groups of music playing commands (in x) by ten sample size (in P) were used

Sample Size	**Groups** (music playing commands)							
	x1	**x2**	**x3**	**x4**	**x5**	**x6**	**x7**	**x8**
Participants	**Start the Playlist**	**End the Playlist**	**Volume Up**	**Volume Down**	**Change the Song**	**Change the Playlist**	**Pause the Song**	**Resume the Song**
P_01	18.1	3.7	2.2	2	5.8	10.2	6.5	2.1
P_02	16.4	2.1	3.2	3.1	2.3	15.8	2.3	2
P_03	17	2.3	2.4	2.2	2.3	12.3	2.1	3.5
P_04	8.7	2.3	1.4	1.4	5.1	15.2	2.1	2.3
P_05	5.1	2.7	1.7	1.3	8	18.5	6	5.2
P_06	6.5	2.3	2.8	1.4	3.2	10.1	2.2	2.5
P_07	10	2.4	1.8	1.7	3.5	8.3	3.5	2.2
P_08	5.3	3.1	1.4	2.2	5.3	9.5	4.1	2.1
P_09	12.3	2	2.2	2.5	3.1	13.5	3.2	2.3
P_10	8.2	2.5	2.3	1.8	3	15.8	2.1	3

One Way ANOVA test, using F distribution df(7,72) (right tailed) and relevant explanations can be found in Appendix E. The ANOVA test detected significant differences between some groups. The post hoc Tukey HSD test revealed which pairs of groups had the significant differences. The results of the Tukey HSD test are shown in Table 4.6, revealing the following pairs to have statistically significant differences: **x1-x2, x1-x3, x1-x4, x1-x5, x1-x7, x1-x8, x2-x6, x3-x6, x4-x6, x5-x6, x6-x7, x6-x8**.

Table 4.6 Tukey HSD / Tukey Kramer summary

Group	**x2**	**x3**	**x4**	**x5**	**x6**	**x7**	**x8**
x1	8.22	8.62	8.8	6.6	2.16	7.35	8.04
x2	0	0.4	0.58	1.62	10.38	0.87	0.18
x3	0.4	0	0.18	2.02	10.78	1.27	0.58
x4	0.58	0.18	0	2.2	10.96	1.45	0.76
x5	1.62	2.02	2.2	0	8.76	0.75	1.44
x6	10.38	10.78	10.96	8.76	0	9.51	10.2
x7	0.87	1.27	1.45	0.75	9.51	0	0.69

Both of the commands **"Start the Playlist" (x1)** and **"Change the Playlist" (x6)** took a significantly slower time to execute then all the other commands, except that no significant difference was found between **"Start the Playlist" (x1)** and **"Change the Playlist" (x6).** Apart from these results, none of the other commands had execution times that were significantly slower or faster. For example, the two commands with the shortest execution interval – **"Volume Down" (x4)** and **"Volume Up" (x3)** – were not significantly shorter than the other commands.

4.3 Part 3: Post-Running-Interviews

The aim of the post-running-interviews was to get feedback on the running activity, compare the difficulty levels of executing the commands given to the participants for music playing (see Section 4.2), reveal the advantages and challenges provided by the devices and their interfaces, and to gather recommendations from the participants for design improvements. Finally, the effects of the eye-tracking technology used during the running activity on the participants and the study were investigated.

The interviews were conducted in a semi-structured format, with follow-up questions posed as needed (see Appendix D for the full set of questions). Each interview session with each participant lasted between 9 to 12 minutes. Answers to interview questions and, all audio files captured during the sessions were entered into Microsoft Word as transcriptions, and the analysis was carried in stages to draw out the main points from the transcribed data.

Based on the group of questions directed at the participants, answers to interview questions grouped under the following sections: 1) ‘Advantages’; 2) ‘Challenges’; 3) ‘Recommendations’; and, 4) ‘Reflections on Eye-Tracking Technology’. Following, the transcribed data examined to reveal repeated expressions, and appropriate codes were assigned in accordance. At the end of this stage, the resulting codes were transferred to Miro (Online Visual Collaboration Platform) and distributed across different spreadsheets named: 'Challenge'; ‘Advantages’; and, ‘Recommendations’(see Figure 4.25).

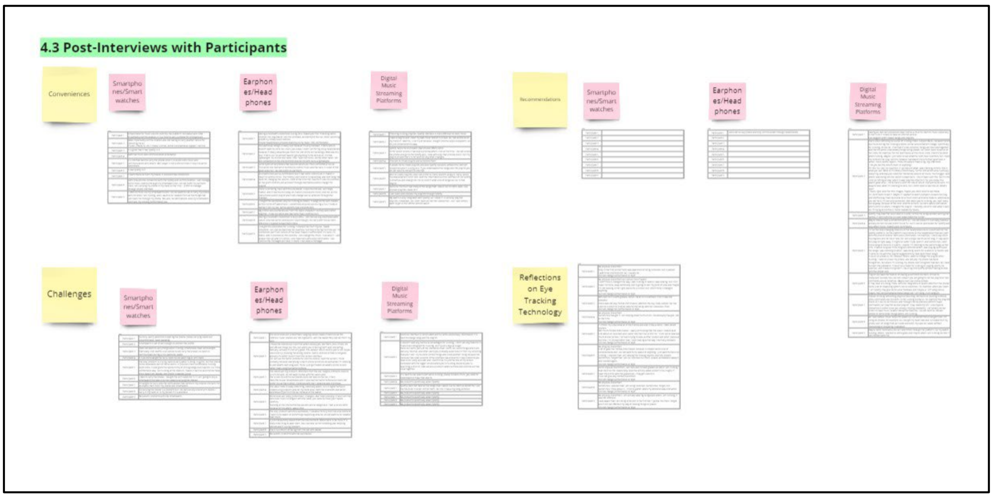


Figure 4.25 A screenshot from the Miro platform shows the transcribed post-running-interview data thematic analysis

Post-running interviews are thought to provide participants with a space to reflect, articulate insights, and share their perspectives. The results and analysis are presented in the sections mentioned above.

4.3.1 Advantages

The technological equipment that runners use to listen to music, such as smartphones, smartwatches, and music players, earphones, and digital music streaming platforms, is more than just a matter of personal preference; they also affect runners' experiences. In relation to this, the advantages reported by the participants will be presented in the following headings: smartphones/smartwatches; earphones/headphones; and, digital music streaming platforms.

4.3.1.1 Smartphones/Smartwatches

Amateur runners, may use smart devices to improve their running experience. Their choice of technological devices, whether smartphones or smartwatches, reflects their specific needs and preferences. A detailed exploration of the technology choices made by ten amateur runners and the reasoning behind their choices is presented under the following headings: i) *Smartphone for Music and Communication*, ii) *Smartphones for Integration with Digital Music Streaming Platforms*, and, iii) *Smartwatch for Isolation and Tracking.*

i) Smartphone for Music and Communication. The ability of smartphones to serve as both music and communication tools at the same time was cited as the most convenient benefit of carrying them around by participants. This dual functionality allows them to ignore the difficulties it may cause even if they have to carry the smartphone with them at all times.

> *"I can both control the music and communicate."* (P04)

Some participants prioritise communication and compactness, and the smartphone is the key to staying connected while running. The appeal stems from the smartphone's dual function, which eliminates the need for a separate device while listening to music. The compact design of the smartphone adds to its attraction.

"So, the compactness of my phone is good, I like this, and the convenience of having everything already on the phone anyway, and not having to have another device with me. Plus, of course, if I need to make a call or anything else, it's there, available to me, so I think the main thing is that I don't have to have another device to play music." (P02)

One participant finds it perfectly manageable to carry a smartphone during runs. As with the other participants thoughts, the appealing feature is in the smartphone's dual functionality, which combines music and communication. An MP3 player is not preferred over a smartphone because of the latter's reliance on wired earphones.

"It's easier to carry my phone because I don't want to carry anything else with me. You know, I have it with me for communication, when someone wants to reach me, when I'm doing sports, when I'm running, I can answer immediately. The phone is more comfortable than an Mp3 player. For example, Mp3 players cannot be connected with Bluetooth headphones." (P05)

ii) Smartphones for Integration with Digital Music Streaming Platforms. The emergence of digital music streaming platforms has introduced music into the culture of recreational running. The ease of access to platforms like Spotify, YouTube Music, and Apple Music readily accessible within these technological devices is an important development. The ability to stream music directly from a chosen platform, without the need for additional devices, eliminates unnecessary complexities from the running routine. In some cases, the smartphone stood out as a multifaceted utility, allowing not only control of music volume but also easy access to the participants chosen music platform, YouTube.

"I control the music volume control from my smartphone, which is also how I access the digital platform I use." (P01)

Similarly, having Spotify integrated into the smartphone was a key factor for some participants. This integration simplified access to their preferred music streaming platform, eliminating the need for additional devices. Participants valued the presence of Spotify on their smartphone. One participant stated how this situation is becoming a necessity rather than an advantage.

"But also, because it has Spotify in it, that's a good thing." (P03)

"Spotify is the reason I carry my phone. I wouldn't carry my phone if Spotify was in my headphones." (P06)

At times, the smartphone appeared to be an indispensable part of the participants' running routine as it facilitates connectivity through Spotify and serves as a means of communication. While their smartwatch has limited music control capabilities, the participants preferred to use the smartphone's interface, which is consistently carried in their hand.

"Since I listen to music on Spotify, I carry my phone with me all the time because it provides Spotify and also provides me with communication. I can actually do some music-related controls from my smartwatch, but I prefer to do them from my phone; it's easier because I carry it with me all the time." (P08)

iii) Smartwatch for Isolation and Tracking. For the participants seeking isolation from the world during their runs, smartwatches emerged as a compelling option. These wearable technological devices not only deliver music but also provide a break from the constant notifications and calls that often come with smartphones. Smartwatches can offer a focused running experience, allowing individuals to immerse themselves fully in the tempo of their footsteps and the beat of their chosen music.

One participant, for example, who avoided calls and notifications to disconnect from the outside world, chose to carry only a smartwatch for music listening while running. In some cases, the smartwatch serves as a comprehensive performance tracker, enhancing the running experience.

"I listen to music on my smartwatch because I don't want to carry my phone and I don't carry it because I want to disconnect from the outside world. So, I don't

want any calls or notifications. My watch also tracks and shows my running performance. It also has such an advantage." (P09)

In the realm of amateur running, technological equipment takes on the role of a trusted ally, catering to the unique needs and priorities of each runner. These choices represent a deliberate selection process, where integration of music and communication, compactness, and the desire for isolation from external distractions into the equation. Ultimately, these technological tools become integral components of the runner's journey, delivering the convenience and functionality they seek during their pursuit of personal excellence.

4.3.1.2 Earphones/Headphones

In the world of amateur running, earphone selection goes beyond simply selecting audio equipment; it becomes an important decision that influences the comfort and control experienced during workouts. The preferences and insights of ten participants regarding their earphones are presented. Within this array of choices, the runners navigate a delicate balance, considering factors such as connectivity, design, and functionality, all in pursuit of the ideal auditory accompaniment to their runs.

The following headings list the findings from the participants statements about the benefits of using headphones/earphones to listen to music while running: i) Bluetooth connectivity and freedom; ii) comfort and stability with on-ear headphones; iii) compactness and lightweight design; iv) wireless earphones and environmental awareness; v) simplicity and efficiency in music control; vi) purpose-built earphones for running; and, vii) ecosystem synergy with other devices.

i) Bluetooth Connectivity and Freedom. For many participants, the presence of Bluetooth connectivity was a significant advantage. Bluetooth technology gave them a sense of freedom, enabling wireless control of music playback, call management, and noise cancellation. The wireless connection is especially appreciated because it frees runners from the constraints of cords and wires. As one participant put it, it was liberating, with controls for play/pause, volume adjustment, call management, and noise cancellation, all accessible wirelessly.

"For one thing, Bluetooth connectivity gives you freedom. You can carry your phone anywhere and listen to music freely. You can even control some commands from the headset. I often use commands like turning music on/off or answering an incoming call. It has a noise cancelling feature, for example, which is very useful." (P01)

ii) Comfort and Stability with On-Ear Headphones. On-ear headphones were praised for their stability, giving runners confidence that their earphones will remain securely in place during intense running sessions. Additionally, the lightweight design of certain earphones was suggested to improve overall comfort.

"That's why most of the time I prefer the on-ear ones. I run very comfortably when it's fixed on my head, for example." (P01)

iii) Compactness and Lightweight Design. Some participants preferred compact and lightweight earphone designs, because of their unobtrusive nature. These earphones had a minimal, barely noticeable presence, ensuring runners to stay connected to their surroundings while running with music.

"It's that lightweight. So, on the one hand I feel I hear the music, on the other hand I still feel connected to the environment around me with such a lightweight." (P02)

iv) Wireless Earphones and Spatial Awareness. Wireless earphones not only provide comfort, but they also serve in spatial awareness. Participants appreciated the sense of connection to their surroundings that wireless technology allowed. Wireless technology allowed participants to listen to music while staying attuned to their surroundings.

"I don't like the big bulky headphones because it totally detaches you from the rest of the surroundings. Whereas this one, it feels like I almost haven't got anything in the ears at all." (P02)

v) Simplicity and Efficiency in Music Control. Bluetooth earphones were favoured by the participants for their simplicity and efficiency in music control. Participants highlighted the ease of using controls like play/pause, and track skipping. While volume adjustment was rarely necessary, the controls offered a comprehensive music management experience.

"If I'm using a Bluetooth headset, it's much more comfortable. You know, I can change it directly from the headset by touching it like this (pointing to the headset interface), which is a big advantage for me." (P04)

vi) Purpose-Built Earphones for Running. Some participants stated that they use earphones specifically designed for running. These earphones prioritise stability to prevent falls while performing dynamic activities. They are designed to stay securely in place throughout the workout, which enhances the overall running experience. A bone-conduction headphone, which does not cover the ears but instead rests on the cheekbones can be given as an example (see Figure 4.26).

"I bought this headset specially, by the way, for running. It has an ear strap like this. It feels like it won't fall off. I mean, when I'm doing weird movements, I don't know, when I'm running, sometimes I stop and do push-ups, sit-ups. It shouldn't fall off while I'm doing them. That's why I chose it." (P06)

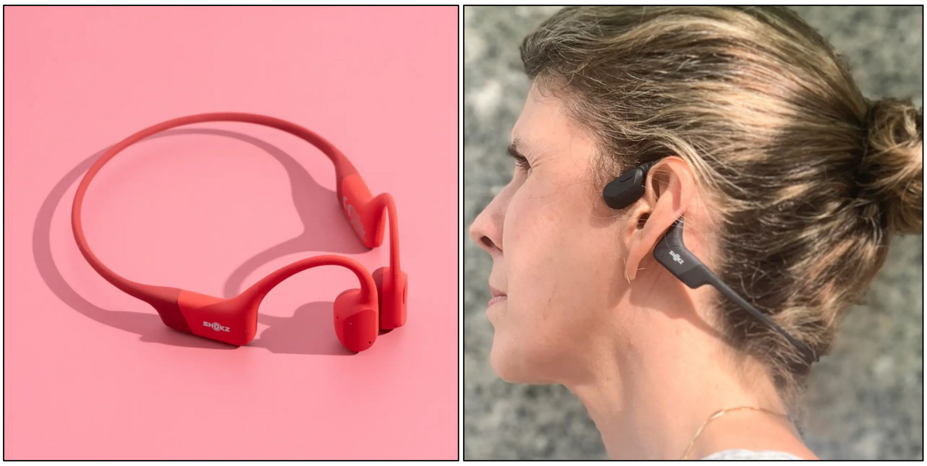


Figure 4.26 Bone conduction headphones (taken from https://www.nytimes.com/wirecutter/reviews/best-running-headphones/)

vii) Ecosystem Synergy with Other Devices. A subset of participants preferred the earphones that seamlessly integrated with their Apple ecosystem devices. This synergy contributed to the enhancement of their running experience, offering compatibility between their phone and earphones, along with basic controls.

"I have a playlist and I have my own music stored in iCloud, so I can access all of my tracks if I want to. I use it just because I bought into the Apple ecosystem, so it's just convenient this way." (P02)

In summary, the preferences of amateur runners regarding earphones are a complex interplay of comfort and functionality. Bluetooth connectivity, lightweight design, physical controls, and stability into their choices. These preferences are a testament to the individualized nature of earphone selection, demonstrating how each runner tailors their choice to align with their unique running needs and preferences.

4.3.1.3 Digital Music Streaming Platforms

For recreational runners, the selection of a music streaming platform is more than just a matter of entertainment; it is a strategic decision that can have a significant influence on their running experience. The preferences of the participants reflect the careful integration of conveniences that transform the everyday act of listening to music into a dynamic and motivating companion during the workouts. The analysis of the participants' insights and preferences for music streaming platforms highlighted how these platforms improved the runners' engagement and enjoyment of their runs.

The findings will be presented in the following headings: i) tailored playlists and user-friendly interface; ii) seamless integration within the ecosystem; iii) archiving playlists; iv) offline music listening; v) playlist creation and predictive interface; vi) a rich library and playlist preparation; and, vii) smartwatch integration.

i) Tailored Playlists and User-Friendly Interface. According to participant statements, Spotify emerges as a favoured choice among participants due to its ability to provide running playlists and its user-friendly interface. Runners appreciated the convenience of accessing customised playlists that match their tempo and mood, and its intuitive interface simplified music management during their runs.

> *"It's a great comfort to have it in my running-specific playlists."* (P01)

> *"When it comes up on the screen, for example, it comes up on the phone (when the screen is locked). I can change music from there. I use it very often. I mean, I don't open Spotify (the app page) very much. I usually know my mood. I open a list accordingly and continue from that list."* (P03)

Spotify's preview feature was also favoured, as it saved users from having to unlock their phones or access the app directly, streamlining their running experience. The example screenshots from Spotify can be seen in Figures 4.27a, 27b.

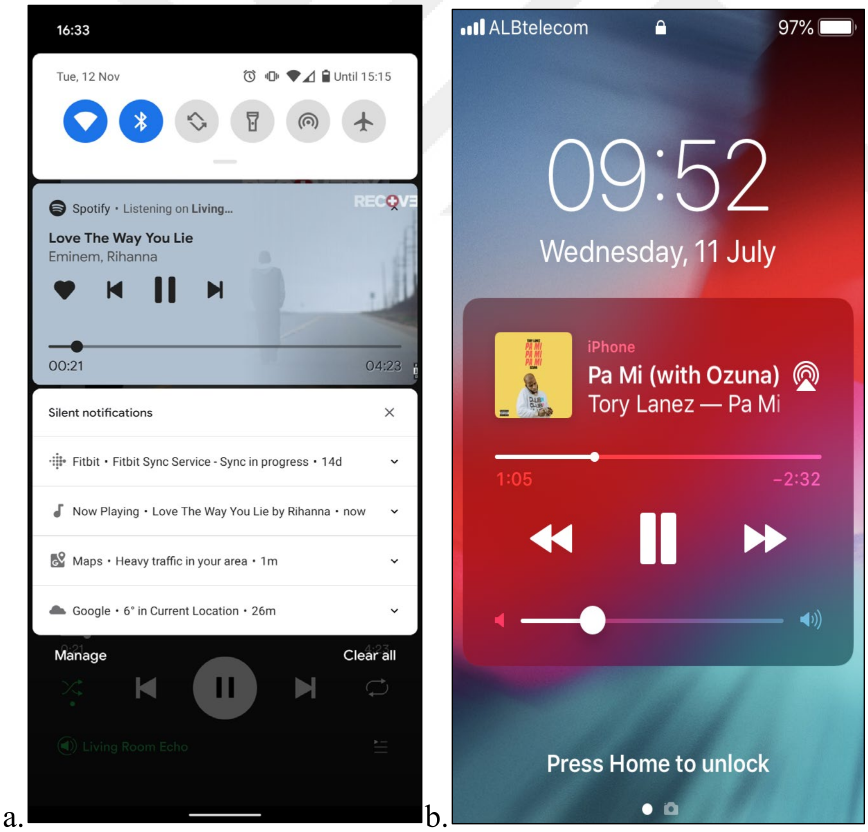


Figure 4.27 Spotify's lock screen preview view examples in Android and iPhone (both taken from https://community.spotify.com/)

ii) Seamless Integration within the Ecosystem. Apple Music is favoured among those who are already invested in the Apple ecosystem. The participants claimed that it integrates seamlessly with their devices and provides easy access to their personal music library on Apple iCloud, providing a sense of familiarity and convenience.

"I have a playlist and I have my own music stored in iCloud, so I can access all of my tracks if I want to. I use it just because I bought into the Apple ecosystem, so it's just convenient this way." (P02)

iii) Archiving Playlists. Spotify's feature set includes archiving playlists and the ability to create customized lists. This feature streamlines music organization and allows runners to create playlists that complement their workouts.

"It allows me to create the playlist that I use, basically. And it provides the song archive." (P04)

iv) Offline Music Listening. Offline music listening capability appeared as a significant advantage. This feature is favoured by runners since they can download songs and playlists, ensuring uninterrupted music enjoyment even in areas with limited internet connectivity. Spotify's offline music listening feature was praised as follows.

"I mean, when I download songs, I can listen to them anytime and anywhere on Spotify. Even if I don't have internet, I can access it everywhere. For example, sometimes my internet package runs out, I can listen to it." (P05)

v) Playlist Creation and AI Music Generator. Auto, or more accurately AI-generated, playlists were appreciated by participants because they allowed them to listen to music of their choice without being interrupted, or they could see what songs were coming up next (if they looked at their screen), which improves the running experience.

"Also, the information on the interface of the Spotify is beneficial and enough for me to predict what kind of songs will be in that playlist." (P06)

It is possible to easily create a personalised soundtrack that suits specific tastes and preferences using the power of technology. A playlist generator enables to select songs from various genres and moods to accompany one's run. This feature has now become standard practise and was available under different names on all three music streaming platforms used by the participants. For example, 'Genius Playlist' (Apple Music / iTunes), 'Enhance' (Spotify), and 'Auto-Generated Playlist' (YouTube).

vi) A Rich Library and Playlist Preparation. Music playing platforms with a large song library and playlist creation capabilities appeal to their users because their diverse offerings contribute to a rich auditory experience for runners. This was mentioned by a participant using YouTube Music Premium service.

"YouTube helps me find most of the songs I'm looking for and I can also make playlists." (P07)

vii) Smartwatch Integration. The compatibility of music streaming platforms and smartwatches provides a convenient and immersive music experience. Runners can access downloaded playlists without an internet connection, which aligns with their desire to disconnect from the outside world during runs.

"My watch only integrates with Spotify, that's why I chose it. It only plays the playlists I downloaded. So, I don't need an internet connection." (P09)

In essence, the participants' preferences for music streaming services for their running playlists show a subtle balance between functionality and convenience. Particularly praised features were customised playlists, user-friendly interface, offline listening, and playlist creation (e.g., Spotify). The seamless integration of the Apple ecosystem was also found appealing, while YouTube Music Premium stands out for its large song selection. These choices are a testament to the runners' dedication to creating the ideal soundtrack for their runs, making sure that each stride resonates with motivation and rhythm.

4.3.2 Challenges

Recreational running combines personal goals with modern technology. When it comes to things like using smartphones, smartwatches, music players, headphones, and digital music streaming applications while running, it is not just a matter of personal preference, it is also about making things as easy as possible. In the world of recreational sports, how runners handle the challenges that come with their choices is just as important as the equipment they use. By examining the challenges that runners encounter, it is possible to understand how the use of music-playing devices and platforms can affect the experience of running. The analysis of the challenges reported by the participants will be presented in the following headings: smartphones/smartwatches; earphones/headphones; and, digital music streaming platforms.

4.3.2.1 Smartphones/Smartwatches

Amateur runners often find themselves at a crossroads when it comes to carrying devices during their runs. The choice to carry a smartphone, a music player, a smartwatch, or other accessories carries its own set of considerations. In this exploration of their experiences, the challenges associated with these choices are delved into, shedding light on the various factors that influence their decisions.

The analysis of the participants statements about the challenges that they had with the music playing devices running are grouped under the following headings: i) smartphones: weight and sweat concerns; ii) smartwatches: convenience and connectivity challenges; iii) music players: the weightless alternative; and, iv) distraction management: notifications and focus.

i) Smartphones: Weight and Sweat Concerns. Carrying a smartphone while running is a common practice, but it can be a challenging choice at times. Participants cited the extra weight as a primary concern, sometimes necessitating the use of waist bags or armbands. Sweaty hands and the possibility of phones becoming wet due to perspiration are also recurring discomforts that impact the running experience. Almost all participants stated that the weight of the smartphones that they needed to carry around was a biggest problem.

ii) Smartwatches: Connectivity Challenge. Smartwatches offer the advantage of convenience by eliminating the need for a smartphone. However, some runners find them lacking in connectivity with their phones, raising concerns about their "smart" capabilities.

"I use the music controls from the phone because this smartwatch is not smart enough to connect my phone." (P02)

iii) Music Players: Wired Headphone Requirement. Music players emerged as an appealing option for the participants looking to remove the extra weight of a smartphone. Participants appreciated lightweight design, which allows for an isolated, phone-free running experience. This was motivated by a desire to eliminate distractions and maintain focus during workouts. However, most of the music players requires wired headphones and this may create uncomfortable experience for the runners.

"I like the iPod Shuffle. The phone is too much weight." (P03)

iv) Distraction Issue: Notifications and Focus. Notifications from smartphones can be both convenient and distracting. Some participants said that they disable notifications on their phones and smartwatches to maintain focus during their runs.

"Sometimes I get distracted by notifications. That's why I run without my phone at most events and I set my watch so that I don't get notifications." (P07)

In essence, the dilemma of carrying devices during runs embodies a nuanced balance between convenience and discomfort. Smartphones provide versatility, but come with weight and size challenges. Smartwatches can replace smartphones, but may not meet all connectivity needs. This study highlights how amateur runners navigate these options, attempting to find the best solution that improves their running experience while minimizing discomfort.

4.3.2.2 Earphones/Headphones

Some runners often wear earphones to enrich their running experience with music. However, these seemingly simple accessories come with their own set of challenges. The study's findings revealed the challenges that runners encountered with their earphones and presented under the following headings: i) tangled cables and ergonomics concerns; ii) tactile controls vs screen interface; iii) environmental awareness vs sound isolation; and, iv) sweat-related challenges

i) Tangled Cables and Ergonomics Concerns. Many participants express frustration with wired earphones due to tangled cables, especially during high-tempo runs. Additionally, in-ear headphones present ergonomic challenges, with some users finding them uncomfortable and prone to popping out of their ears during sweaty workouts. There were also complaints cable chaos, leading to cumbersome controls and in-ear discomfort. Sweaty workouts contributed to the problem as earphones tend to pop out, making the running rhythm harder to maintain. In some cases, minimalist running philosophy of the participants clashed with the cable clutter, the constant battle to keep the wires in check disrupted the flow of their runs.

"When I use wired headphones, it is very likely that the cables get tangled and uncomfortable. It may also be related to the ear structure, it is uncomfortable for my ear." (P01)

"As I said, I like to run in a minimalist way, so it's more important to have things that don't interfere with my running rhythm and distract me as much as possible. Cables distract me." (P03)

ii) Tactile Controls vs. Screen Interface. Tactile controls on earphones posed usability challenges for some runners. While visual cues were useful, the tactile controls on their earphones were less so. The risk of pressing the wrong button, prompted them to choose for the familiarity of the screen interface. This preference stemmed from the need for precision and uninterrupted joy of music.

"I mean the controls on it are fine when visually you see them, plus, minus, on and off and things like this, but when you're feeling them and interacting tactually, actually it's not very good. You wonder which control you're on, so you could end up pressing the wrong control. Tactile controls of the headphones are not good. Actually, it's better to do it from the screen interface." (P02)

iii) Spatial Awareness vs. Sound Isolation. Spatial awareness versus sound isolation from the environment emerged as a recurring theme. While some participants appreciated the ability of earphones to block out external sounds, others found it disconcerting, especially when they needed to remain aware of their surroundings.

"Blocking all the environmental sounds can be dangerous, I had a car accident because of this when I was a child." (P05)

"The only problem with the earphones, it isolates me fully from the environment. I need to be aware of things happening around, I do not want to be isolated that much." (P06)

While blocking out the sound can be enticing as an immersive experience, it also poses safety risks. The complete isolation from the environment becomes a source of contention for runners. As emphasized by P06, maintaining some level of awareness during the run is important. This implies that complete isolation can diminish the overall running experience.

iv) Sweat-Related Challenges. Sweat-induced slippage appeared as a common problem, with participants noting that both Bluetooth and wired earphones can become dislodged during runs.

"Both the Bluetooth and wired earphones slips from the ear because of the sweat." (P04)

"There is a problem of falling from the ear with sweat." (P08)

Earphones, though may appear simple on the surface, present some challenges for runner, including cable entanglement and ergonomic (physical) discomfort to the delicate balance between sound isolation and spatial awareness. How runners navigate these challenges reveals the complex interplay between technology and the pursuit of an enjoyable and seamless running experience.

4.3.2.3 Digital Music Streaming Platforms

Challenges emerging from digital music streaming platforms highlight the complex web of relationship between technology and music. This section presents the study's findings regarding the interplay between technology and the auditory experience of running, including connectivity issues and restrictions on the availability of music content. Participants' reflections on the challenges of the digital music listening platforms were based on the three platforms they used: Spotify, Apple Music, and YouTube Music Premium. The findings are presented under the same headings.

i) Limited Song Achieve. Participant 5's statement underscores a common dilemma faced by music enthusiasts on digital platforms, including Spotify and YouTube. While Spotify is widely regarded for its extensive library, it may not have every single song or track that a user desires due to licensing agreements and negotiations with record labels. This can lead users, like Participant 5, to turn to YouTube in search of those missing tunes. YouTube, with its vast repository of music and videos, stands as a prominent digital music platform, beckoning amateur runners with its diverse audio-visual offerings.

"I don't have all the songs on Spotify. I have to find them on YouTube and open them instead." (P05)

ii) Interface Related Challenges. Spotify's interface (see Figure 4.28) was found too small to search for songs or artists while running: it was difficult to focus on the required location on the phone's interface, especially with the movement and shaking caused by running, and it was suggested that the running speed be reduced in order to make such a search.

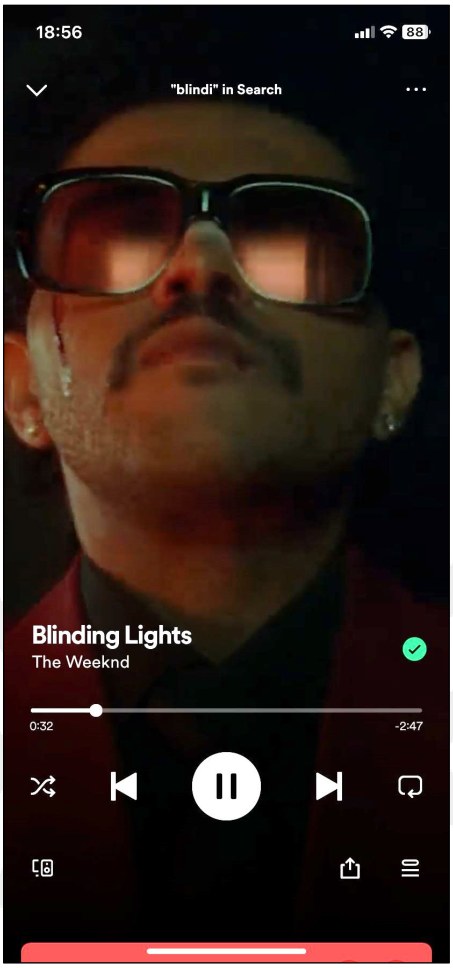
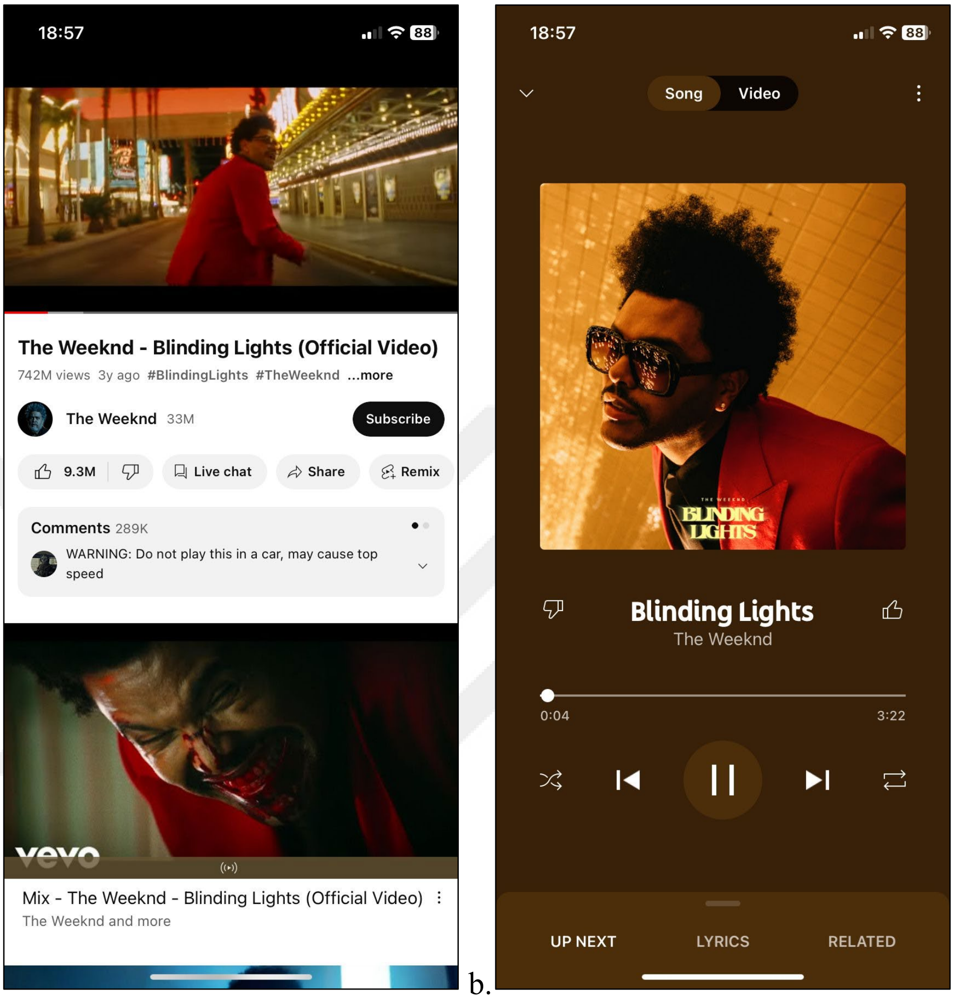


Figure 4.28 A screenshot from Spotify's 'Now Playing' screen

Participant 1 unravels the intricate layers of YouTube's interface, revealing its convolution and the challenges it poses to those seeking a harmonious running experience. However, a further explanation should be added about the origin of this difficulty. The YouTube interface mentioned by the first participant is different from the YouTube Music interface. As can be seen in Figure 4.29.a, the YouTube platform used by Participant 1 is the interface of the main platform that contains all the content. This platform is not specialized for listening to music. On the other hand, as can be seen in Figure 4.29.b, YouTube Music contains only music content, and its interface is customized accordingly. Participant 7 who uses the YouTube Music platform, stated that he does not have any problems with the digital music listening platform he uses.

"YouTube interface is complicated and full with unnecessary information. It is hard to change the song and the playlist." (P01)



a. b.

Figure 4.29 Screenshots from a. YouTube video playing and b. YouTube Music song playing screens

Apple Music is only one participant's choice of digital music streaming platform, mainly because of its compatibility with the other Apple devices within the Apple ecosystem. Apple Music song playing view can be seen in the Figure 4.30.

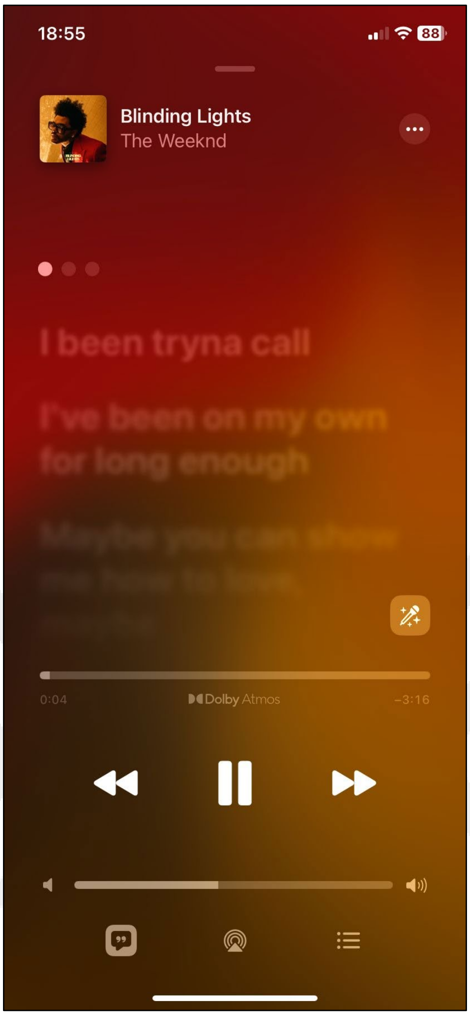


Figure 4.30 An example screenshot from Apple Music song-playing screen

The Participant 2, who uses Apple music, detailed the problems he had with the platform's interface and offered insights into how it could be improved. The spacing of icons and controls on Apple Music's screen interface impacts their interaction, raising questions about user-friendliness in the context of a physical workout.

"It doesn't have any particular advantages for running. I don't see any features in it which are designed for running, so it's just a regular player. There are some parts of the interaction that I don't like, some things which are not very intuitive, and other parts you probably experience it from my recording that you'll see I try to press certain things and press another thing because the icons are too close so some of the interface has problems. You have to be really accurate and I

don't think it's just the size of my screen compared with the bigger screen when you're running obviously you're searching a little bit, that causes a problem when buttons and controls are too close together." (P02)

4.3.3 Suggestions by the Participants

The analysis of the research findings in relation to advantages and challenges participants encountered with the smartphones/smartwatches, earphones/headphones, and digital music platforms they interacted with to listen to music while running has been covered in previous sections. In the following section of the post-running-interviews, participants were asked for their suggestions for the improvements of various aspects of running with music experiences. This section summarises the key insights of the participants, and offers a roadmap for future improvements and innovations in the field. Synthesising the participants' suggestions provides a comprehensive view of the potential avenues through which technology can be optimized to increase runner engagement and satisfaction in their pursuit of physical activity.

Participants did not make many suggestions for improvements or changes to both about their technological devices and their headphones. The reason why there were not any suggestions about their technological devices and accessories is that the suggestions given about the digital music streaming platforms, inadvertently created the need to improve the design of the technological devices and headphones that are often used.

The role of digital music streaming services assumes new significance in the world of amateur running, where the fusion of technology and physical performance is increasingly common. The equipment that runners use to access music becomes an essential part of their experience as they push themselves to new heights and lose themselves in the beat of their strides. In this context, insights were shared by participants in this study on the conveniences and challenges encountered while using digital music platforms, and valuable recommendations were offered for enhancing these platforms. Their suggestions highlight the potential for digital music streaming platforms to be specifically designed to meet the needs of athletes and shed light on the changing expectations of runners. In the following sections, it is delved into these recommendations, exploring themes, such as offline listening, user-friendly interfaces, voice commands, integration with wearables, user interaction, and accessibility enhancements. These suggestions pave the way for a more seamless integration of technology and running, where the pursuit of individual excellence is accompanied by the rhythms of music.

The analysis of the participants' statements about their suggestions for the digital music streaming platforms used while running is provided under the following headings: i) offline music listening and rhythm-based playlists; ii) running-focused mode; iii) voice search and commands; iv) integration with wearables; v) user interaction and feedback; and, vi) enhanced accessibility.

i) Offline Music Listening and Tempo-Based Playlists. Participants emphasized the importance of being able to listen to music without requiring an internet connection, especially during remote activities, such as trail runs. Some proposed that music streaming platforms offer tempo-based playlists to match the rhythm of their runs, thereby improving motivation and performance. This was an intriguing suggestion because there have been scientific studies (Karageorghis and Priest, 2012) mapping music tracks to specific types of training sessions and investigating their effect on running performance. This was not the scope of the current study, but having a soundtrack to choose from seems like a good solution.

ii) Running-Focused Mode. Participants expressed a need for a dedicated "running mode" within music streaming apps, such as Apple Music. This is analogous to the 'Focus' feature in iOS 15 or later, where users can use Do Not Disturb to silence calls, alerts, and notifications received while the device is locked. Some of them complained that the current interfaces are cluttered, with controls placed too closely together, making it challenging to navigate during runs. Runners proposed much simpler layout with larger, well-spaced controls, to ensure ease of use while moving.

Some suggestions included removing irrelevant icons, displaying only essential information such as ‘the next track’, and optimizing screen readability for runners.

"There could definitely be a kind of running mode in Apple Music, because there's too much during the running process, so the screen doesn't change, specifically for running, of course. I find that it's too cluttered, things are too close together, and there's some unnecessary things being shown. So, I don't need to see all icons, for example, all the list of the next tracks. There's no point when running. Maybe I just need to see what is the next written track. But I need the controls like play, volume, forward, backwards to be further apart and a better, more careful layout. I think this would make a big, big difference." (P02)

iii) Voice Search and Commands. While participants acknowledged the convenience of voice control, they also expressed their concerns about potential interruptions during runs. They suggested integrating voice search for song retrieval without the need to type. There were also suggestions that music streaming platforms improve voice command functionality to avoid disrupting the runner's flow. A few proposed using voice commands to manage playlists, perform actions, such as counting or ranking playlists, and receive song recommendations based on their sports-related listening history.

"Spotify can have the voice search in order to find the songs without typing their names, as it interrupts the run and slows down the runner." (P03)

"Maybe [Spotify] should have a connection with Siri/ I do not know whether it is already possible. I actually do not like and prefer to use Siri but it can be specialised for Spotify and only offers music related voice commands." (P04)

iv) Integration with Wearables. Participants who were using smartwatches or fitness trackers suggested that these devices might be integrated with streaming platforms. The suggestions included enhancing the music experience and tailoring the music to runner's performance by utilizing health and workout data, creating playlists based on heart rate, running pace, or specific workout goals.

v) User Interaction and Feedback. Some participants highlighted the need for minimal physical interaction while running, favouring voice commands over touch interfaces. Some propose incorporating a commenting feature for playlists, allowing users to leave feedback and recommendations for others. Suggestions included developing of a more interactive and personalized running experience, where the platform provides real-time feedback or motivational messages during the run.

"Some kind of rewarding system can be executed. For example, when you reach 1 km, Spotify may give some voice feedback and maybe a 1 km song can be played. You can personalise these songs like 1 km song, 2 km song etc." (P06)

vi) Enhanced Accessibility. In relation to this topic, the participants proposed enhanced accessibility features within music streaming apps, particularly when using facial recognition or biometrics for device access, including the implementation of a running-specific mode that bypasses phone locks, ensuring quick access to the music.

"It could be a feature, for instance. When I want to change the playlist while running, I have to unlock my phone, and actually my phone has facial recognition. But when I'm running, my phone can't recognize that face, so I have to enter the password. It could be a mode for running or playing sports, for example, and it would be great if I could log into Spotify without having to deal with the phone lock." (P05)

These recommendations reflect the evolving needs and expectations of runners who seek a seamless and personalised music experience while working towards their fitness goals. Implementing such upgrades in digital music streaming platforms may result in a more satisfying and motivating running experience.

4.3.4 Reflections on the Running Activity Instructions

As the final questions in the post-running-interview, participants were asked to indicate how easy or difficult it was for them to follow the instructions given to them during the running activity on a 5-point Likert scale [Very easy (1), Easy (2), Moderate (3), Difficult (4), Very difficult (5)] (see Table 4.7). In addition, the participants were given multiple-choice questions to find out which instructions were challenging and simple to follow.

In this part of the interview, it became clear that the participants had trouble separating related commands into individual evaluations. Therefore, in this section, commands requiring opposite actions were decided to be paired (e.g., 'Volume Up/Volume Down') for easier analyses in contrast to the analysis in the earlier sections where the commands and reaction times to them were analysed separately (e.g., 'Volume Up' and 'Volume Down').

Table 4.7 Rank order averages for commands and Likert scale scores based on evaluations from 10 participants

Participants / Instructions	P_01	P_02	P_03	P_04	P_05	P_06	P_07	P_08	P_09	P_10	Average
Change the Playlist	4	3	4	3	3	5	4	3	3	4	**3,6**
Change the Song	3	2	4	3	2	2	3	2	1	1	**2,3**
Pause/Resume Song	1	1	3	3	1	3	3	1	1	1	**1,8**
Volume Up/Down	1	5	1	1	1	1	1	1	1	2	**1,5**

Change the Song. Distribution of the answers: 'Very easy' 20% (2/10), 'Easy' 40% (4/10), 'Moderate' 30% (3/10), 'Difficult' 10% (1/10). No participants answered 'Very difficult'. The average score for the instruction is 2,3.

Volume Up/Down. Distribution of the answers: 'Very easy' 80% (8/10), 'Easy' 10% (1/10), 'Very difficult' 10% (1/10). No participants answered 'Moderate' and 'Difficult'. The average score for the instruction is 1,5.

Pause/Resume the Song. Distribution of the answers: 'Very easy' 60% (6/10), 'Moderate' 40% (4/10). No participants answered 'Easy', 'Difficult' and 'Very difficult'. The average score for the instruction is 1,8.

Change the Playlist. Distribution of the answers: 'Moderate' 50% (5/10), 'Difficult' 40% (4/10), 'Very difficult 10% (1/10)'. No participants answered 'Very easy' and 'Easy'. The average score for the instruction is 3,6.

Participants were asked to list the easiest and most challenging instructions they performed. 80 % (8/10) of the participants answered 'Volume Up/Down' instruction as the easiest instruction. 10% (1/10) of the participants answered 'Pause/Resume the Song' and 10% (1/10) of the participants answered 'Change the Song' as the easiest instruction. 90% (9/10) of the participants answered 'Change the Playlist' and 10% (1/10) of the participants answered 'Volume Up/Down' as the most difficult instruction.

Table 4.8 Difficulty level of the commands as stated by the participants

Difficulty Level Statements of the Participants		
Participants	Easiest	Hardest
P_01	Volume Up/Down	Change the Playlist
P_03	Volume Up/Down	Change the Playlist
P_04	Volume Up/Down	Change the Playlist
P_05	Volume Up/Down	Change the Playlist
P_06	Volume Up/Down	Change the Playlist
P_07	Volume Up/Down	Change the Playlist
P_08	Volume Up/Down	Change the Playlist
P_10	Volume Up/Down	Change the Playlist
P_09	Change the Song	Change the Playlist
P_02	Pause/Resume Song	Volume Up/Down

Participants chose 'volume up and volume down' instruction as the easiest command most likely because their tangible volume control buttons were useful for this purpose. They stated that it was easier to use these buttons rather than reaching the screens of the digital music platforms they use, and that interacting with this physical interface was preferable to the digital one (see Table 4.8).

‘*I used the buttons on the phone since they are tactile. Physically feeling and touching buttons are easier and more effective.’* (P04)

Participants described the instruction to change the playlist as the most difficult instruction to perform because they had to interact with multiple screens multiple times to perform it. At the same time, they stated that they could manage to do all the instructions through their headphones except from the change the playlist instruction. These statements of the participants about the most difficult and easiest command to manage are supported with the results of the ANOVA analysis of the execution times, which is detailed in the Section 4.2.6.

4.3.5 Reflections on Data Collection with the Eye-Tracking Technology

During the running activity, participants carried the eye-tracking glasses as well as their own music-playing devices. The eye-tracking glasses were used to record where participants were looking on their devices while interacting with them to execute a command, as well as to measure the time between the researcher issuing a command and them carrying it out. The participants' experiences with eye-tracking glasses varied in terms of physical comfort and sense of awareness of being recorded. However, some common themes and observations can be made.

Most participants did not report notable physical discomfort while wearing recording glasses during their runs. While some reported initial discomfort, such as feeling the frames or cables, they generally adapted quickly. For many participants, the physical aspect of wearing the glasses did not hinder their running experience. The fact that the eye-tracking device had a comfortable eyewear structure did not alienate the participants from the device and provided a more familiar experience (see Figure 4.31).

Figure 4.31 An example from the participants wearing eye-tracking glasses during the study

Most participants stated that they were aware of being recorded while wearing the glasses at the start of their runs. This awareness, however, faded as they continued their runs. Only a few participants kept the recording in mind throughout their activities. The psychological effect of being recorded was generally minimal.

Several participants mentioned consciously changing their gaze patterns or trying not to focus too much on one spot due to the awareness of being recorded. This suggests that the presence of recording glasses influenced their observational habits to some extent. However most importantly, the participants' running styles and performances did not undergo significant changes when wearing the recording glasses according to their statements about the eye-tracking technology and their performance. The glasses had a relatively unobtrusive impact on their overall running experiences. Participants stated that they maintained their usual running routines and styles.

In conclusion, most participants experienced no significant physical or psychological discomfort as a result of wearing recording glasses while running. While there was awareness of being recorded, this awareness tended to fade as the run continued. Importantly, participants maintained their usual running styles and performances. This suggests that recording glasses had a relatively subtle and manageable impact on their running experiences, with participants successfully adapting to their use over time.

4.4 Discussion

In the previous sections, the advantages, problems, and suggestions regarding tangible and digital interfaces for listening to music while running were presented and discussed by the participants. In this section, design insights are given from a designer's perspective, both considering the data and comments received from the participants and related literature. This section aims to examine the important aspects that contribute to the interactions between the digital and tangible interfaces that runners use to listen to music while running. The discussion includes all three phases of field research.

4.4.1 The Impact of Music on the Running Experience

The impact of music on the running experience is a topic of interest in the field of exercise psychology. Previous research has shown that self-selected, motivational, and stimulative music can enhance affect, reduce ratings of perceived exertion, improve energy efficiency, and lead to increased work output during repetitive, endurance-type activities (Karageorghis and Priest, 2012). Music has been found to have ergogenic and psychological benefits during high-intensity exercise, particularly when it is used to accompany self-paced exercise or in externally valid conditions (Karageorghis and Priest, 2012). These findings suggest that music can be a motivating factor for runners, enhancing their overall running experience.

The use of digital and tangible interfaces can influence runners' engagement with music during their runs. For instance, Karageorghis and Priest (2012) discuss the importance of selecting music according to its motivational qualities to maximize its positive impact on psychological state and performance. This suggests that the design of interfaces that allow runners to easily select and control their music can enhance their engagement and motivation during running. This situation was also mentioned by the participants throughout the present study. Participants mentioned the ability to prepare playlists and archive them as the most useful features of the digital music listening platforms they use.

Another issue that emerged from the study's ‘Start the Playlist and ‘Change the Song’ instructions was that participants usually scrolled through the playlist to start a playlist or change a song and tried to find the song that suited their current mood. Similar to this situation, a study by Karow et al. (2020) investigated the effects of preferred and non-preferred warm-up music on subsequent exercise performance. The study found that listening to preferred warm-up music improved subsequent exercise performance compared to no music, while non-preferred music did not have the same ergogenic benefit (Karow et al., 2020). This suggests that the preference for music can play a role in its impact on exercise performance.

Furthermore, a few of the participants stated that the reason for listening to music while running was only to improve their performance. For this reason, the playlists they prepared to listen to while running were also purposeful. They customized the order of the playlist to keep their energy at an optimum level and perform at their best. In relation to this aspect of music listening, Bohm et al. (2015) conducted a study on the use of tempo-pace synchronized preference-based audio-playlists in a structured exercise program. They found that patients who received personalized audio-playlists with tempo-pace synchrony achieved higher weekly volumes of physical activity compared to those in the non-music usual-care group. The use of tempo-pace synchronized music was shown to improve adherence to physical activity (Bohm et al., 2015).

In summary, the evidence suggests that the BPM (beat per minute) of the playlist can have an impact on the performance and adherence of amateur runners. Selecting music with motivating qualities and synchronizing the tempo with the runners' pace can enhance affect, reduce perceived exertion, and improve performance. However, it is important to note that individual preferences and responses to music may vary, and further research is needed to explore the optimal use of music playlists for different individuals and exercise contexts.

Overall, the impact of music on the running experience can be influenced by factors, such as the motivational qualities of the music, the design of interfaces that allow for easy music selection and control, and individual preferences for music tempo. Future research can further explore these factors to optimize the use of music in enhancing the running experience.

4.4.2 The Interface Design in the Context of Running

The study's findings for interface design in the context of running provided insights for the development of future running applications and wearable devices. The results revealed that certain interface features were more engaging or more distracting than others. For example, managing the volume control or pausing/resuming song were easier to achieve and changing the song or changing the playlist were relatively more difficult. These findings can help designers create interfaces that improve the runners' overall experience.

Intuitive Physical Controls

Runners often need to make quick adjustments to their music while on the move. Designing music devices with large, tactile buttons or touch-sensitive areas can provide intuitive physical controls. These controls should be strategically placed, ensuring easy access without the need to remove the device from its storage location, such as an armband or pocket. The buttons should be responsive and provide tactile feedback, allowing runners to change tracks, adjust volume, or pause playback without breaking their stride.

Voice Commands

Hands-free control is paramount for safety and convenience during running. Implementing voice recognition technology in music devices and apps enables runners to interact with their playlists using simple voice commands. For example, they can say, "Next track," "Increase volume," or "Play my motivational playlist." This not only minimizes distraction but also enhances accessibility for runners with physical limitations.

Gesture Controls

Gesture-based controls can offer an alternative to physical buttons and voice commands. By incorporating sensors into wearable devices or smartphone apps, runners can perform intuitive gestures like swiping left to skip tracks or tapping twice to pause playback. These controls should be customizable to cater to individual preferences, ensuring that runners can tailor their music interaction to their liking.

User-Friendly App Interfaces

Mobile apps designed for runners should prioritize user-friendliness. The interface should be easy to navigate, with clear icons and straightforward menu options. Runners should have the ability to customize their music experience, create running playlists, and seamlessly integrate their music libraries. The app's layout should prioritize essential functions, allowing runners to access music controls and track their performance metrics with minimal effort.

Adaptive Interfaces

Adaptive interfaces consider the dynamic nature of running. These interfaces can adjust music playback based on a runner's pace, location, or heart rate. For instance, when a runner speeds up, the app can automatically switch to high-energy tracks to match their cadence. Additionally, adaptive interfaces can provide motivational audio cues or feedback based on performance data, helping runners stay motivated and informed throughout their run.

Integration with Health Data

To offer a holistic running experience, interfaces should seamlessly integrate with health data collected by wearable devices or smartphones. This includes displaying real-time information, such as heart rate, distance covered, and calories burned alongside music controls. Runners can benefit from having all their essential data in one place, allowing them to make informed decisions about their workout and music choices.

Social Features

Social integration can add a layer of community and motivation to running with music. Interfaces can allow runners to share their favourite playlists, achievements, or recent runs with friends or fellow runners. Users can engage in friendly music challenges, compete for achievements, or collaborate on curated running playlists. Also, a rewarding system can be integrated to the running with music experience, such as deciding some milestone songs to their running goals and listening to them when their goal is achieved. These social features foster a sense of camaraderie and encourage runners to stay motivated and connected through their music experience.

Feedback Mechanism

Incorporating tangible interfaces, such as haptic feedback controls, can be a potential avenue for enhancing the multisensory experience of running with music. Haptic feedback can provide runners with tactile sensations that synchronize with the rhythm or beat of the music, creating a more immersive and engaging experience. This can potentially enhance the motivational qualities of the music and further improve the running experience. However, within the scope of this study, when the participants were asked about their suggestions for improvement regarding the digital music platforms and technological equipment interfaces they use, voice feedback was more common than haptic.

Comparing haptic and voice feedbacks on interfaces, the available references provide insights into the advantages and implications of each modality. Haptic feedback has been shown to enhance user experience and acceptance of interfaces. Studies have found that incorporating haptic feedback into user interfaces increases user confidence, pleasantness, and satisfaction (Breitschaft et al., 2019). Haptic feedback can also improve performance in tasks, such as text entry on touch screens (Wintergerst et al., 2010). Additionally, haptic feedback can provide context-corresponding information, improving interaction speed and accuracy (Wintergerst et al., 2010). However, it is important to consider the latency of haptic feedback, as high latency can decrease task performance and satisfaction (Breitschaft et al., 2019).

On the other hand, voice feedback, particularly in the form of voice user interfaces, offers the advantage of hands-free and eyes-free interaction. Voice interfaces have been explored in various domains, including in-vehicle music retrieval systems (Garay-Vega et al., 2010). Voice feedback can provide real-time information and guidance, and it has the potential to support natural and intuitive interactions (Moore, 2019). However, the effectiveness of voice feedback may depend on factors, such as the clarity and intelligibility of the voice, as well as the user's familiarity and comfort with voice interactions.

It is worth noting that the literature on haptic feedback is more extensive compared to voice feedback in the context of interface design. Haptic feedback has been studied in various domains, including automotive user interfaces (Breitschaft et al., 2019). On the other hand, the available references provide limited information specifically focused on voice feedback in interface design.

In the context of this study, the preference for voice feedback may not have been as beneficial as expected. Although there are artificial intelligence elements that can receive voice commands integrated into their smartphones, the fact that they do not prefer to use them or are not aware of them may be the explanation for this. At the same time, since the music listening experience is also sound-oriented, it should be taken into consideration that these voice feedbacks may disrupt the integrity of the music listening experience.

In conclusion, both haptic and voice feedbacks have their advantages and implications in interface design. Haptic feedback can enhance user experience, improve performance, and provide context-corresponding information. Voice feedback, particularly in voice user interfaces, offers hands-free and eyes-free interaction and has the potential for natural and intuitive interactions. Further research is needed to explore the specific design considerations and implications of voice feedback in interface design.

The study's findings have implications for interface design in the context of running. The design of future running apps or wearable devices can be informed by the study's findings on engaging and distracting interface features. Additionally, incorporating tangible interfaces, such as haptic feedback devices, can enhance the multisensory experience of running with music.

4.4.3 The Role of Eye-Tracking Technology in Capturing the Runners' Experiences and Interactions with the Interfaces

The role of eye-tracking technology in capturing the runners' experiences and interactions with interfaces can provide valuable insights into visual attention and gaze patterns. Eye-tracking technology offers the advantage of providing objective data on where runners are looking and how their attention is distributed during their running experience.

The use of eye-tracking technology can help researchers understand how runners engage with different interface elements and features. By analysing gaze patterns, researchers can identify which elements attract the most visual attention and whether certain interface designs or features are more effective in capturing runners' attention. This information can inform interface design decisions, allowing for the creation of more visually engaging and intuitive interfaces for runners.

However, it is important to consider the limitations of eye-tracking technology in this context. One limitation is the potential for measurement errors or inaccuracies in eye-tracking data. Different eye-tracking systems may vary in their accuracy and precision, and it is crucial to select a reliable and validated eye-tracking system for research purposes (Funke et al., 2016). The eye-tracking system used in this study (PupilLabs) had difficulty in providing data with the precision required for this study.

At times, the device was unable to record the participants' gaze and could only produce fixation maps. At the same time, the raw data provided by the device required extra competence to analyse them. For this reason, the recordings provided were only manually monitored and analysed. The system could not provide heat maps or area of interest analyses on its own

Additionally, eye-tracking technology cannot capture other aspects of the runners' experiences, such as their emotional state or subjective perceptions. Therefore, it is important to complement eye-tracking data with other measures, such as self-report measures or physiological measures, to gain a more comprehensive understanding of the runners' experiences.

Future research can explore the integration of eye-tracking technology with other physiological measures to provide a more holistic understanding of the runners' experiences. Combining eye-tracking with measures such as heart rate or electrodermal activity can provide insights into the runners' cognitive and emotional responses during their interactions with the interfaces. This multi-modal approach can offer a more comprehensive understanding of the runners' experiences and help identify the underlying mechanisms that contribute to their engagement and motivation.

In conclusion, eye-tracking technology offers valuable insights into the runners' experiences and interactions with interfaces by providing objective data on visual attention and gaze patterns. While there are limitations to consider, such as measurement errors and the need for complementary measures, the integration of eye-tracking with other physiological measures holds promise for future research in understanding the runners' experiences.

CHAPTER 5

CONCLUSIONS

5.1 Overview of the Study

The study's main aim is to comprehend the experience of running with music while observing the runners' interactions with the digital and tangible interfaces that they use to achieve simple controls. Furthermore, the study attempts to present design recommendations based on the needs and expectations of the runners in order to make their experience more user-friendly.

Firstly, in order to provide a background for the study, the literature on running exercise, the effects of music on running exercise, motivations for listening to music while running, and devices and interfaces that provide the experience of listening to music while running were reviewed, and the relationships between these topics were examined (Chapter 2). The relevance of the findings to how digital and tangible interfaces was analysed, which are experienced while running and lead to interactions, was discussed. This was followed by a three-stage fieldwork with amateur runners, including pre-running-interviews, running activities, and post-running-interviews. In Part 1, interviews were conducted with the selected ten volunteer participants before the running activity for warm-up purposes and to learn about the participants' running routines, their motivation to listen to music while running, and the advantages and disadvantages they think music provides while running. This information was also useful for comparing what participants thought about the experience of listening to music while running before and after the running activity and for analyses later in the study.

In Part 2, a running activity was carried out with the same ten participants at ODTÜ Devrim Stadium. Eye-tracking glasses were used to record the participants' experience of listening to music while running. In addition to this device, participants carried out the running activity with the devices and accessories they used to listen to music while running. During the activity, eight different directions related to music control were shown to the participants via written banners at different points in the stadium. The participants followed these instructions, and the running activity was completed. Eye-tracking recordings of this activity helped analyse the music control interfaces in the study.

In the final part of the fieldwork (Part 3), the same ten participants were interviewed after the running activity. In these post-running-interviews, feedback was received about the running activity and music control related instructions performed. The participants were asked to compare the degree of difficulty in performing the instructions with the 5-point Likert scale questions. At the same time, they were asked to report the conveniences and difficulties provided by the digital and tangible interfaces of the devices and accessories they use and to suggest improvements to these interfaces.

The fieldwork results and analysis are presented together with the design insights about the current digital and tangible interface interactions in the context of running and the discussion of the role of eye-tracking technology in capturing runners' experiences in Chapter 4. In this final chapter, the research questions raised in Chapter 1 are revisited, as are the study's limitations and recommendations for future research.

5.2 Revisiting Research Questions

The previous chapters provided in-depth responses to the research questions. This section provides direct answers to research questions. The research aimed to find answers to the following main and sub-questions.

- What devices and streaming platforms do runners use to listen to music?

- What effects do the interfaces of the devices and digital music streaming platforms have on the experience of running with music?

- What are the most difficult and easiest music controls for runners who prefer to listen to music while running?
- What design recommendations can be made to enhance the running experience while listening to music through both digital and physical interfaces?
- Can eye-tracking technology be effectively used to study the experience of running while listening to music?

Q1. What devices and streaming platforms do runners use to listen to music?

Runners use a variety of devices and streaming platforms to listen to music while running. Common devices include smartphones, MP3 players, smartwatches, and fitness trackers with built-in music playback capabilities (Berghe et al., 2021). These devices allow runners to store and play their music libraries or stream music from various platforms. Ten amateur runners, the participant group in the study, were also asked what kind of devices they used during the pre-running-interviews (see Section 4.1). The answer to this question was that most of them used their smartphones to listen to music while running. The duality of smartphones enabling runners to communicate as well as listen to music was explained as the motivation for the participants to carry their smartphones with them all the time. In addition to the respondents who used only their smartphones as music providers, one participant stated that he used only his smartwatch for this purpose. In fact, he stated that he did not want to carry his smartphone with him and that he wanted to be closed to messages and calls that may come from the external environment and people, and that he made his choice of smartwatch type based on this. Finally, some participants noted that they can also use music players in scenarios where they prefer not to carry their smartphones, depending on the type of headphones they use. In addition, most of the participants had their fitness trackers or smartwatches, which do not have the ability to provide music but only track their exercise.

In addition to these smart devices used to provide music while running, there are also accessories that runners use to transmit music, namely headphones. The runners also gave information about their choice of headphones. The headphone types revealed by these choices can be listed as follows in terms of preference intensity: Bluetooth earphones, wired earphones, and Bluetooth headphones. The criteria that the participants consider in their headphone choices can be listed as the comfort of using the device, audio quality, and ease of music control. The comfort and fit of the chosen earphones or headphones are critical for runners. Ill-fitting devices can cause discomfort or distraction during a run. In addition, the quality of audio output from the chosen device plays a role in the enjoyment of music during a run. Many runners prefer devices with good sound isolation to block out external noise. And lastly, the type of interface (touch, physical buttons, voice) affects how easily runners can control their music while on the move. Convenient interfaces can enhance the overall experience.

Streaming platforms such as Spotify, Apple Music, Amazon Music, and Google Play Music are popular among runners (Datta et al., 2018). These platforms offer extensive music libraries, personalized playlists, and features like offline listening, which allow runners to access a wide range of music during their runs (Datta et al., 2018; Danielsen and Kjus, 2017). In this study, the music listening platforms used by the participants were stated as Spotify, YouTube and Apple Music according to their intensity of choice. Participants claimed their preferences of the devices and streaming platforms in the pre-running-interviews of the fieldwork.

Q1.1 What effects do the interfaces of the devices and digital music streaming platforms have on the experience of running with music?

The first part of the fieldwork, which is the pre-running-interviews focused on the choice of the devices and platforms that the runners use while listening to music and their considerations and motivations to use them (see Section 4.1). The interfaces of devices and digital music streaming platforms have a significant impact on the experience of running with music. The design and features of these interfaces can influence factors, such as arousal, mood, enjoyment, and performance during exercise.

Research has shown that music can enhance affect, reduce perceived exertion, improve energy efficiency, and increase work output during repetitive, endurance-type activities (Karageorghis and Priest, 2012). The effects of music on exercise performance are most potent when it is used to accompany self-paced exercise or in externally valid conditions. Therefore, the interface of a digital music streaming platform should allow users to easily select and control the music they listen to while running, enabling them to match the tempo and rhythm of the music to their running pace.

Furthermore, the type of music selected can also impact the running experience. Studies have found that music with motivational qualities has a positive impact on psychological state and performance (Karageorghis and Priest, 2012). Therefore, the interface should provide options for users to discover and select music that is motivating and energizing for their running sessions.

In addition to the music itself, the interface should also consider the overall user experience and engagement. Music streaming platforms aim to attract and engage users by accommodating their contrasting needs and providing lean forward and lean back experiences (Hracs and Webster, 2020). This means that the interface should be user-friendly, intuitive, and customizable, allowing users to easily navigate through the platform, create playlists, and access personalized recommendations.

Moreover, the interface should consider the preferences and behaviours of different user groups. For example, millennials perceive broadcast radio and music streaming services as both substitutable and complementary (Chan-Olmsted et al., 2019). Therefore, the interface should provide options for users to seamlessly switch between different audio media platforms, allowing them to access a variety of content and experiences. These interfaces play a pivotal role in shaping the overall satisfaction, convenience, and safety of the running experience, in addition to arousal, mood, enjoyment, and performance.

One of the key factors in determining the quality of a run with music is convenience. Intuitive and user-friendly interfaces on both devices and platforms are essential. While on the move, whether on a trail or around the neighbourhood, a runner needs to be able to navigate through your music effortlessly. Complex or non-intuitive interfaces can disrupt the flow and hinder the enjoyment of the run.

Accessibility is another critical aspect. Runners should be able to access the controls quickly and easily. Features like play, pause, volume adjustment, or track selection should be at their fingertips. An interface that requires excessive attention or interaction can divert their focus from the road or trail, potentially compromising safety.

Safety is crucial when running with music. The interface design can either enhance or hinder safety. Cluttered or poorly organized interfaces may require more attention, leading to distractions that could result in accidents. To mitigate these risks, some interfaces now offer voice commands, allowing runners to control music without having to physically interact with a device. This hands-free approach minimizes the risk of accidents by reducing the need to take one's eyes off the path.

The ability to customize runners' music experience is a significant advantage. Effective interfaces enable runners to create, edit, and manage playlists effortlessly. Customization options, such as reordering tracks or adding songs on the go, contribute to a more personalized running experience. Additionally, interfaces that allow adjustments to audio settings, like equalization or sound profiles, can enhance the listening experience by tailoring it to individual preferences.

For a truly dynamic running experience, some interfaces integrate health data from wearable devices, such as heart rate monitors or GPS trackers. This integration allows the music's tempo to adjust in real-time to match the runner's pace, creating a synchronicity between the body's movements and the music's rhythm. Moreover, interfaces that provide voice feedback on performance metrics, like distance covered or heart rate, can be motivating and informative for runners seeking to optimize their workouts.

When considering devices like earbuds with touch controls, ergonomic design and comfort are paramount. Runners should be able to interact with controls without discomfort or having to adjust their gear frequently. Interfaces that offer tactile or auditory feedback can confirm actions, ensuring that runners know their commands have been executed without having to check a screen repeatedly.

Lastly, digital music streaming platforms should offer offline access to playlists and songs. This feature is especially crucial for runners who may not have a stable internet connection during outdoor runs. It ensures uninterrupted music playback, preventing the frustration of songs suddenly cutting out due to poor connectivity.

In conclusion, the interfaces of devices and digital music streaming platforms significantly influence the running experience. Interfaces that prioritize ease of use, safety, customization, and integration with health data can enhance the overall satisfaction and convenience of running with music. Ultimately, runners are more likely to have a positive experience when their chosen interfaces align with their needs and preferences. In addition, by providing a user-friendly and customizable interface, offering a wide selection of motivating music, and accommodating the needs and preferences of different user groups, these interfaces can enhance the enjoyment, arousal, mood, and performance of individuals during their running sessions.

Q2. What are the most difficult and easiest music controls for runners who prefer to listen to music while running?

With the help of the fieldwork -running activity and interviews-, both the actions and the statements of the participants showed that the difficult levels of the music controls can be ranked and compared. In the running activity, thanks to the eye-tracking technology, participants' actions were recorded and the time intervals to manage music controls were detected (see Section 4.2). Also, the post-running-interviews obtained the statements of the participants about the music controls that they executed (see Section 4.3.4). For runners who prefer to listen to music while running, the difficulty or ease of music controls can vary depending on their preferences and the interfaces provided by their chosen devices and platforms. However, some general observations were made.

The play/pause button is typically the simplest and most intuitive control for runners. A large, easy-to-press button allows for quick management of music playback without much thought or effort.

Volume controls are often straightforward, especially when physical buttons or touch-sensitive surfaces are well-designed. Runners can easily adjust the volume to suit their preferences or situational needs.

Selecting a song and controlling the music can be challenging. Runners find it difficult if the interface is complex or if they have to navigate through multiple screens or menus to find and play their desired music. If a runner wants to search for a specific song, artist, or album while on the move, this can be quite challenging. Typing or voice recognition for searching might not be as accurate or quick as desired. On the other hand, an interface that allows for quick and intuitive music selection and control, such as a simple swipe or tap gesture, can make it easier for runners to manage their music while on the move.

Interfaces that offer fine-tuned navigation, such as rewinding or fast-forwarding within a song, can be challenging to use while running. These controls often demand precise touch gestures or screen interactions that are not conducive to a smooth run.

Creating or editing playlists on the go can be complex. This task is often better suited for a pre-run setup or post-run session when the runner has more time and focus. Making changes to a playlist, such as reordering songs or adding new ones, can be cumbersome, if the interface lacks user-friendly drag-and-drop features. Changing the playlist while running is also the most difficult command for the participants. Interacting with multiple icons and screens to change the playlist results in participants spending more time in this orientation. Another reason for a runner's difficulty in changing their playlist is that they often already had a single playlist prepared before the run and did not need another one. Therefore, they also can spend their time trying to find a playlist to switch to as soon as they received the instruction.

In summary, the easiest music controls for runners tend to be those that require minimal effort, such as play/pause and volume adjustments. On the other hand, controls involving precise navigation, searching, or playlist management can be more challenging during a run and may require extra attention, potentially distracting from the overall experience. Runners often appreciate devices and platforms that strike a balance between functionality and ease of use while on the go.

Q.3 What design recommendations can be made to enhance the running experience while listening to music through both digital and physical interfaces?

Based on the fieldwork analysis, participants' design suggestions about the digital and physical interfaces of the devices and music streaming platforms that they used are presented under related headings with examples (see Section 4.3.3). Researchers and practitioners are expected to benefit from the design insights because the research findings are applicable to a variety of disciplines, including design, development, health and well-being, sports, and design research. Accordingly, the following insights, including general and feature-specific ones, can be offered while designing the digital and physical interfaces of the devices and the music streaming platforms that runners use.

Enhancing the running experience while listening to music through digital and physical interfaces requires thoughtful design considerations. Here are some design recommendations to improve this experience:

Intuitive Physical Controls

- Provide large, tactile physical buttons for common functions like play/pause, volume adjustment, and track skipping.
- Design buttons that are well-spaced and easily distinguishable by touch, allowing runners to control their music without looking.

Voice Commands

- Implement voice command functionality for hands-free control of music playback, track selection, and playlist management.
- Ensure that voice recognition works effectively in noisy outdoor environments, such as while running on busy streets

Gesture Controls

- If using touchscreens, design gesture controls that are easy to execute during physical activities. These gestures should be intuitive and responsive.
- Consider customizable gesture shortcuts, allowing runners to assign specific functions to gestures of their choice.

User-Friendly App Interfaces

- Design mobile and smartwatch app interfaces that are easy to navigate with minimal taps or swipes.
- Include large touch targets for essential controls and gestures that are intuitive for actions like changing tracks or adjusting volume.

Playlist Management

- Simplify the process of creating, editing, and organizing playlists within music apps. Allow users to customize playlists easily before a run.
- Implement features for automatic playlist suggestions based on a runner's preferences and past listening habits during workouts.

Adaptive Interface

- Implement adaptive interfaces that consider a runner's pace and movement. For example, reduce touch sensitivity during high-speed runs to prevent accidental inputs.
- Provide customization options for interface sensitivity to accommodate individual preferences.

Integration with Health Data

- Integrate health and fitness data, such as heart rate and GPS information, to enhance the music experience. For instance, tempo-synced playlists that match a runner's pace can be generated automatically.
- Enable voice feedback on performance metrics during the run, such as distance covered or calories burned.

Social Features

- Incorporate social sharing features within music apps for runners who enjoy sharing their progress or music choices with friends.
- Allow runners to discover new music through social interactions, such as playlist recommendations from fellow runners

Feedback Mechanism

- Provide feedback mechanisms to inform runners when they've reached specific milestones, like distance goals or personal records.
- Customize feedback to be motivating and encouraging, enhancing the overall running experience.

As previously mentioned in the Section 1.1, the inspiration was to discover more about these interfaces and to find out if the runners need an interface which only focused the activity of running with music. By incorporating these design recommendations, digital music streaming platforms, devices, and interfaces can offer a more seamless and enjoyable music experience for runners, enhancing their overall motivation and performance during runs.

Q.4 Can eye-tracking technology be effectively used to study the experience of running while listening to music?

Eye-tracking allows researchers to measure and analyse eye movements and gaze patterns, providing insights into attention allocation, visual focus, and cognitive processes during running with music. While there is limited research specifically focusing on the use of eye-tracking to study the experience of running while listening to music, the existing literature demonstrates the potential of this technology in understanding attention allocation, cognitive processes, and visual focus during music-related activities.

Eye-tracking technology has not been effectively used to study the experience of running while listening to music due to a lack of research specifically focusing on this context. While eye-tracking has been utilized in various studies to investigate the effects of music on reading comprehension and attention allocation, there is a focus of research that has applied eye-tracking specifically to examine the experience of running while listening to music.

The existing literature on the effects of background speech and music on reading comprehension has not utilized eye-tracking as a method to gain insight into the research issues. These studies have primarily focused on the impact of background speech and music on reading performance and recall. Therefore, the specific effects of music on attention allocation, visual focus, and cognitive processes during running remain largely unexplored using eye-tracking technology (Cauchard et al., 2011).

Furthermore, the nature of running as a physical activity introduces additional challenges for the effective use of eye-tracking. The movement and vibrations associated with running can potentially interfere with the accuracy and reliability of eye-tracking measurements. The motion artefacts caused by physical activity may affect the quality of eye movement data, making it challenging to obtain precise and consistent measurements of gaze behaviour. These challenges about the usage of the eye-tracking technology in this study, in the running activity, are also mentioned in Section 4.4.3.

Moreover, the practical constraints of using eye-tracking technology during running sessions should be considered. Eye-tracking typically requires specialized equipment and controlled laboratory settings to ensure accurate data collection. These requirements may not be easily met in the context of outdoor running, where environmental factors, such as varying lighting conditions and outdoor distractions, can impact the quality of eye-tracking measurements. These setting and environmental factors are also mentioned in Section 3.5.2 where the fieldwork venue and equipment are introduced. In order to gather more precise data and clear footage for the eye-tracking recordings, running activities should be planned during the day before the sun goes down.

In summary, the lack of specific research focusing on the experience of running while listening to music using eye-tracking technology, along with the challenges posed by the physical activity and practical constraints, may limit the effective use of eye-tracking in studying this particular context. Further research is needed to explore the potential applications and overcome the challenges associated with using eye-tracking to study the running experience while listening to music.

5.3 Additional Findings

These additional discoveries provide a deeper understanding of the multifaceted relationship between running, music, and technology. Even though these results are not at the heart of the main research questions, they give us important information about how this dynamic intersection works.

One notable observation that emerged from the interviews with the participants was the diversity of music genres preferred. While the study primarily focused on how interface design influenced the running experience, it became evident that runners' choices of music genres varied widely. Electronic dance beats, rock anthems, and hip-hop tracks were among the diverse genres cited by participants. This finding highlights the need for music streaming platforms to offer a wide array of genre options to cater to the eclectic tastes of runners.

An unexpected but intriguing revelation was the profound emotional impact of music during runs. Several participants reported experiencing a heightened sense of motivation and exhilaration when certain songs played. Upbeat, fast-paced songs were often thought to give people more energy and make them run faster, while slower songs were thought to make running more relaxing and enjoyable.

Understanding these emotional responses to music could inform the development of personalized playlists tailored to runners' desired emotional states.

Many participants emphasized the significance of wearable technology, such as smartwatches and fitness trackers, in their running routines. These devices not only facilitated seamless control over music but also provided real-time performance metrics. Runners appreciated the ability to monitor heart rate, distance, and pace without the need for a separate device. This integration between wearable technology and music streaming platforms was seen as a critical aspect of the modern running experience.

While not a primary focus of the study, safety considerations did arise in the discussions with participants. Some runners expressed concerns about distractions caused by adjusting music controls during runs. Instances were reported where participants had to slow down or stop momentarily to interact with their devices. This raises questions about the design of interfaces and the importance of ensuring that music controls are easily accessible without compromising safety.

5.4 Limitations of the Study

The fieldwork was carried out with ten participants, which is a relatively small group of runners, and it might limit the generalizability of the findings of the fieldwork to a broader population of runners. In addition, the fieldwork carried out in a stadium (ODTÜ Devrim Stadium) might not fully represent the conditions of various real-world running environments, such as trails, roads, or urban areas.

Another limitation of fieldwork is the influence of study participation. Being aware that they are part of a study and that their eye movements will be recorded could have influenced the participants' behaviours and experiences during the runs, potentially altering their natural interactions with music and technology.

Lastly, technology related limitations should also be considered. For example, the technology used, the eye-tracking glasses, could have had limitations, including accuracy, calibration issues, or participant discomfort, which might have affected the quality of the data. Moreover, technology, especially in the field of wearables and digital interfaces, evolves rapidly. This study’s findings might become outdated relatively quickly as new devices and interfaces are introduced.

5.5 Suggestions for Future Studies

In the fieldwork, ten amateur runners participated in the interviews and the running activities. Future studies can be conducted with larger participant groups in order to gather more generalizable findings about the experience of running with music.

The running activities that are a part of the fieldwork are conducted in a stadium environment. However, exploring the impact of music and technology in various running environments, such as trails, urban settings, or competitive races, can provide a comprehensive understanding of context-dependent preferences and challenges. Future research can also delve into how environmental factors interact with music choices.

Participants’ preferences for the digital music streaming platforms were concentrated on three platforms: Spotify, YouTube Music, and Apple Music. All the digital interface related outcomes are provided through these applications’ interfaces and interactions. Apart from these platforms, it may be useful to examine the interfaces and interactions of various platforms that broadcast digital music and are used by runners.

To enhance the usability of the eye-tracking technology for studying running experiences, future studies can focus on refining eye-tracking interfaces. This includes developing more comfortable and unobtrusive eye-tracking glasses and software that can seamlessly integrate with runners' activities. As wearable technology continues to advance, future studies can focus on how emerging devices, like augmented reality glasses, smart fabrics, or neural interfaces, impact the running-music-technology relationship. These studies can explore novel user interfaces and experiences.

Design insights for the interface design in the context of running were presented as a result of this research. Lastly, future studies may concentrate on the implementation of these insights and then investigate their effectiveness on runners' experiences of running with music.

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APPENDICES

A. ONLINE SURVEY CONSENT FORM

Çevrimiçi Anket Gönüllü Katılım Formu

'Koşarken Müzik Dinleme Deneyimini Göz Takibi Teknolojisi ile İncelemek' (Açelya Küçükkurt)

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu çalışma, Prof. Dr. Bahar Şener-Pedgley danışmanlığında, ODTÜ Endüstriyel Tasarım Bölümü öğrencisi Açelya Küçükkurt'un 'Müzikle Koşmak: Koşucuların Dijital ve Somut Arayüzlerle Deneyimlerinin ve Etkileşimlerinin Analizi' başlıklı yüksek lisans tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacı nedir?

Çalışmanın amacı koşarken müzik dinleyen koşucuların kullandıkları cihazlarla olan ürün-kullanıcı etkileşimini değerlendirmek ve bu alana yönelik ürün tasarım ve etkileşim kriterlerini belirlemektir.

Bize nasıl yardımcı olmanızı isteyeceğiz?

Bu çevrimiçi anket 9 sorudan oluşmakta ve yaklaşık 5 dakika sürmektedir. Anket çoktan seçmeli ve açık uçlu sorulardan oluşmaktadır.

Katılımınızla ilgili bilmeniz gerekenler:

Bu çalışmaya katılmak tamamen gönüllülük esasına dayanır. Herhangi bir yaptırıma veya cezaya maruz kalmadan çalışmaya katılmaya reddedebilir veya çalışmayı bırakabilirsiniz.

Araştırmaya katılanların kimlik bilgileri gizli tutulacak ve kimlik bilgileri herhangi bir şekilde eşleştirilmeyecektir. Toplam verilere sadece araştırmacı ulaşabilecektir. Bu araştırmanın sonuçları bilimsel ve profesyonel yayınlarda veya eğitim amaçlı kullanılabilir, fakat katılımcıların kimliği gizli tutulacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Çalışmayla ilgili soru ve yorumlarınızı araştırmacıya iletebilirsiniz.

☐ ***Yukarıdaki bilgileri okudum, bu çalışmaya tamamen gönüllü olarak katılıyorum.***

B. ONLINE SURVEY QUESTIONS

1. **Ad-soyad:**
2. **Email address:**
3. **Phone number:**

4. **Do you have the habit of running regularly?**

- o Yes
- o No

5. **Do you listen to music while you're running?**

- o Yes
- o Sometimes
- o No

6. **Do you wear glasses number one when you're running?**

- o Yes
- o No

7. **What devices do you use to listen to music while you're running? (You can choose more than one.)**

- o Smart Phone
- o Play Music
- o Smart Clock
- o Other (please indicate):

8. What kind of headphones do you use to listen to music while you're running? (You can choose more than one.)

- Cable Headset (In-Ear)
- Cable Headset (overhead)
- Wireless Headset (In-Ear)
- Wireless Headset (Outdoor)
- Other (please indicate):

9. Which digital platform(s) are you listening to while running? (You can choose more than one.)

- Spotify
- Apple Music
- YouTube
- Other (please indicate):

C. FIELDWORK CONSENT FORM

Araştırmaya Gönüllü Katılım Formu

'Koşarken Müzik Dinleme Deneyimini Göz Takibi Teknolojisi ile İncelemek' *(Açelya Küçükkurt)*

ARAŞTIRMAYA GÖNÜLLÜ KATILIM FORMU

Bu çalışma, Prof. Dr. Bahar Şener-Pedgley danışmanlığında, ODTÜ Endüstriyel Tasarım Bölümü öğrencisi Açelya Küçükkurt'un 'Müzikle Koşmak: Koşucuların Dijital ve Somut Arayüzlerle Deneyimlerinin ve Etkileşimlerinin Analizi' başlıklı yüksek lisans tezi kapsamında yürütülmektedir. Bu form sizi araştırma koşulları hakkında bilgilendirmek için hazırlanmıştır.

Çalışmanın amacı nedir?

Çalışmanın amacı koşarken müzik dinleyen koşucuların kullandıkları cihazlarla olan ürün-kullanıcı etkileşimini değerlendirmek ve bu alanda daha iyi bir kullanıcı deneyimi sunmaya yönelik ürün tasarım ve etkileşim kriterlerini belirlemektir.

Bize nasıl yardımcı olmanızı isteyeceğiz?

Bu çalışma üç bölümden oluşacaktır. Ön mülakat, koşu etkinliği ve koşu sonrası mülakat.

Koşu etkinliği öncesi gerçekleştirilecek ön mülakat yaklaşık 10-15 dakika uzunluğunda olacaktır. Ön mülakat 12 soru içermektedir ve açık uçlu sorulardır. Sonrasında 10-15 dakika uzunluğunda bir koşu etkinliği gerçekleştirilecektir. Size kullandığınız müzik dinleme platformları ve cihazları üzerinden basit yönlendirmeler yapılacak ve gerçekleştirmeniz istenecektir. Son olarak da koşu sonrası mülakat gerçekleştirilecektir. Bu mülakat 13 soru içerecek ve 10-15 dakika sürecektir.

Katılımınızla ilgili bilmeniz gerekenler:

Bu çalışmaya katılmak tamamen gönüllülük esasına dayanır. Herhangi bir yaptırıma veya cezaya maruz kalmadan çalışmaya katılmaya reddedebilir veya çalışmayı bırakabilirsiniz. Yapılacak koşu etkinliği çalışması koşu performansınızı değerlendirmeye yönelik değildir., Koşu sırasında kullandığınız müzik dinleme cihaz/ve veya platformlarına yönelik ürün-kullanıcı etkileşiminde yaşanan zorlukları ve bu zorlukların ortadan kaldırılması için yapılabilecek tasarım müdahalelerine yönelik bilgi derlemeyi amaçlayan bir çalışmadır. Etkinlik öncesi ve sonrasındaki mülakatlarda istemediğiniz sorular olursa cevap vermeyebilirsiniz.

Araştırmaya katılanların kimlik bilgileri gizli tutulacak ve kimlik bilgileri herhangi bir şekilde eşleştirilmeyecektir. Toplam verilere sadece araştırmacı ulaşabilecektir. Bu araştırmanın sonuçları bilimsel ve profesyonel yayınlarda veya eğitim amaçlı kullanılabilir, fakat katılımcıların kimliği gizli tutulacaktır.

Araştırmayla ilgili daha fazla bilgi almak isterseniz:

Çalışmayla ilgili soru ve yorumlarınızı araştırmacıya iletebilirsiniz.

Yukarıdaki bilgileri okudum, bu çalışmaya tamamen gönüllü olarak ve düzenli koşucu olduğumu kabul ederek katılıyorum.

Ad Soyad **Tarih** **İmza**

D. INTERVIEW QUESTIONS GUIDE

Pre-Interview Questions

In the beginning, I'm going to ask questions to learn the participant's running habits and warm them up to work. (Q1). I'll cross these questions with music listening habits and try to get information about the devices and platforms they use to listen to music while they're running. (Q2). Finally, I'm going to try to get some preliminary information about the motivations of listening to music while running. (Q3).

Q1: What time of day do you prefer to run? Night, day...

Q1P1: How do you prefer to run? Alone, running with a partner, running in a group...

Q1P2: What kind of field do you prefer to run on? Road run, land run...

Q2: What technology equipment do you carry when you run? Smart phone, smart watch...

Q2P1: Which device do you use to listen to music while you're running?

Q2P2: What kind of headphones do you use to listen to music while you're running?

Q2P3: On which platform do you listen to music while you're running?

Q3: What kind of runs do you prefer to listen to music?

Q3P1: What are the factors that influence listening/not listening to music while running?

Q3P2: Why do you prefer to listen to music while you're running?

Q3P3: Do you have any advantages of listening to music while you're running?

Q3P4: Do you have any difficulties listening to music while running

Post-Interview Questions

In the interview that I'm going to conduct after the running activity, I'll get their evaluations primarily from the platforms and devices they're using. (Q4). Then I'll get comments from the participants on eye-tracking technology. (Q5). Finally, I'm going to ask questions about the directions in the activity and the difficulties she encounters in implementing them (Q6) and ask participants to evaluate some of the statements in the range of 1-5 (1-Very Easy 2-Easy 3-Moderate 4-Difficult 5-Very Difficult).

Q4: How does the technological equipment you use while running contribute to your music listening experience?

Q4P1: Does the technological equipment you use make it difficult for you to listen to music while you're running? What are the difficulties, if any?

Q4P2: How does the headset you use while running contribute to your music listening experience?

Q4P3: Does the earphone you use make it difficult for you to listen to music while running? What are the difficulties, if any?

Q4P4: How does the music listening platform you use while you're running contribute to your listening experience?

Q4P5: Does the music listening platform you use make it difficult for you to listen to music while running? What are the difficulties, if any?

Q4P6: What are the points of the platform you are using that can be customized for your running experience, can you suggest?

Q5: Did the glasses cause any physical discomfort?

Q5P1: Did the tracking and recording of your eye movements alter the flow of your behaviour and your running, give you any psychological discomfort?

Q5P2: Did wearing glasses affect your running/running?

5-point Likert Scale Questions

Q6: Which routing was the most difficult for you to do?

- Start playlist
- Change song
- Reduce sound level
- Increase sound level
- Stop singing
- Start the song
- End playlist

Q4P1: Which routing was the easiest?

- Start playlist
- Change song
- Reduce sound level
- Increase sound level
- Stop singing
- Start the song
- End playlist

Q4P2: "I can change songs while I run." Rating from 1 to 5.

- 1-Very easy
- 2-Easy

- 3-Moderate
- 4-Difficult
- 5-Very Difficult

Q4P3: “I can raise/reduce the sound level while running.” Rate from 1 to 5.

- 1-Very easy
- 2-Easy
- 3-Moderate
- 4-Difficult
- 5-Very Difficult

Q4P4: ‘I can easily stop and start a song while running.’ Rating from 1 to 5.

- 1-Very easy
- 2-Easy
- 3-Moderate
- 4-Difficult
- 5-Very Difficult

Q4P5: ‘I can easily change the song list while running.’ Rate from 1 to 5.

- 1-Very easy
- 2-Easy
- 3-Moderate

- 4-Difficult
- 5-Very Difficult

E. ONE WAY ANOVA TEST GUIDE

Using F distribution df(7,72) (right tailed)

1. H_0 hypothesis

Since p-value<α, H_0 is rejected.
Some of the groups' averages consider to be not equal.
In other words, the difference between the averages of some groups is big enough to be statistically significant.

2. P-value

p-value equals **1.11022e-16**, [p(x ≤ F) = 1]. It means that the chance of type1 error (rejecting a correct H_0) is small: 1.11e-16 (1.1e-14%)
The smaller the p-value the stronger it supports H_1

3. The statistics

The test statistic F equals **33.482569**, which is not in the 95% region of acceptance: [-∞ : 2.1397]

4. Effect size

The observed effect size f is **large** (1.8). That indicates that the magnitude of the difference between the averages is large.
The η^2 equals 0.76. It means that the **group** explains 76.5% of the variance from the average (similar to R^2 in the linear regression)

5. Tukey HSD / Tukey Kramer

The results of the Tukey HSD test, revealed the following pairs to have statistically significant differences: **x1-x2, x1-x3, x1-x4, x1-x5, x1-x7, x1-x8, x2-x6, x3-x6, x4-x6, x5-x6, x6-x7, x6-x8**.

Pairs	Difference	SE	Q	Lower CI	Upper CI	Critical Mean	p-value
x1-x2	8.22	0.7383	11.1334	4.9604	11.4796	3.2596	6.901e-10
x1-x3	8.62	0.7383	11.6752	5.3604	11.8796	3.2596	9.462e-11
x1-x4	8.8	0.7383	11.919	5.5404	12.0596	3.2596	2.013e-11
x1-x5	6.6	0.7383	8.9392	3.3404	9.8596	3.2596	5.275e-7
x1-x6	2.16	0.7383	2.9256	-1.0996	5.4196	3.2596	0.4447
x1-x7	7.35	0.7383	9.9551	4.0904	10.6096	3.2596	2.585e-8
x1-x8	8.04	0.7383	10.8896	4.7804	11.2996	3.2596	1.498e-9
x2-x3	0.4	0.7383	0.5418	-2.8596	3.6596	3.2596	0.9999
x2-x4	0.58	0.7383	0.7856	-2.6796	3.8396	3.2596	0.9993
x2-x5	1.62	0.7383	2.1942	-1.6396	4.8796	3.2596	0.7768
x2-x6	10.38	0.7383	14.059	7.1204	13.6396	3.2596	0
x2-x7	0.87	0.7383	1.1784	-2.3896	4.1296	3.2596	0.9906
x2-x8	0.18	0.7383	0.2438	-3.0796	3.4396	3.2596	1
x3-x4	0.18	0.7383	0.2438	-3.0796	3.4396	3.2596	1
x3-x5	2.02	0.7383	2.736	-1.2396	5.2796	3.2596	0.5324
x3-x6	10.78	0.7383	14.6008	7.5204	14.0396	3.2596	0
x3-x7	1.27	0.7383	1.7201	-1.9896	4.5296	3.2596	0.9245
x3-x8	0.58	0.7383	0.7856	-2.6796	3.8396	3.2596	0.9993

x4-x5	2.2	0.7383	2.9797	-1.0596	5.4596	3.2596	0.4205
x4-x6	10.96	0.7383	14.8446	7.7004	14.2196	3.2596	0
x4-x7	1.45	0.7383	1.9639	-1.8096	4.7096	3.2596	0.8594
x4-x8	0.76	0.7383	1.0294	-2.4996	4.0196	3.2596	0.9959
x5-x6	8.76	0.7383	11.8648	5.5004	12.0196	3.2596	3.228e-11
x5-x7	0.75	0.7383	1.0158	-2.5096	4.0096	3.2596	0.9962
x5-x8	1.44	0.7383	1.9504	-1.8196	4.6996	3.2596	0.8637
x6-x7	9.51	0.7383	12.8806	6.2504	12.7696	3.2596	0
x6-x8	10.2	0.7383	13.8152	6.9404	13.4596	3.2596	0
x7-x8	0.69	0.7383	0.9346	-2.5696	3.9496	3.2596	0.9977

Table of Tukey HSD / Tukey Kramer summary calculations