

Affirm on the Run: Wearable Technology as a Tool to Improve Mentality in Runners

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(ABSTRACT)

Running is currently experiencing its second major boom as a pastime. It has been rapidly increasing in popularity at both the competitive and recreational level since the early 2000s. The development and rapid adoption of wearable technology for endurance athletes has accompanied this boom. Most runners now view wearable technology as integral to their sport. The wide adoption of this technology, in conjunction with the mental nature of endurance sports, makes it imperative for wearable technology developers to understand the potential for their technology to affect the mentality of endurance athletes. Current research on wearable technology investigates how it is used to benefit and track physical performance. This aligns with wearable technology's primary purpose, to track the physical aspects of endurance sport performance. The use of this technology as a tool to improve mentality during endurance activities has not yet been explored, despite psychological factors being one of the biggest determinants of physical performance in endurance sports. Wearable devices have yet to be used to their full potential. The goal of this study is to perform initial exploratory analysis of wearable devices as a psychological intervention tool in endurance sports. I created an application, called the Affirm on the Run App, for use on Global Positioning System (GPS) enabled sport watches. The Affirm on the Run App pushes positive affirmations to users with the goal of improving their mentality during activities. In a two-week user study, I analyzed the experiences of seventeen runners, ten men and seven women, using the Affirm on the Run App on their watch. The participant group

encompassed both competitive and lifestyle runners. I explored how the app affected their psychological state with relation to their training, their perceived exertion on runs, and their cognitive strategy. I found that runners had an overall positive experience using the Affirm on the Run app on their wearable device. Participants' experiences with the app left them feeling calmer and more motivated on runs. The results of this study show that runners experienced benefits to their psychological state that are linked to increased performance. I conclude that using wearable technology as a psychological intervention tool is beneficial to runners and recommend that development be done to integrate these tools more seamlessly into wearable device infrastructure. I also suggest future investigation of these findings via longitudinal and competition studies. The results of this study serve as a strong starting point to help wearable technology for endurance athletes to reach its full potential, so that all runners can bolster their mentality via the wearable devices they already use every day.

Affirm on the Run: Wearable Technology as a Tool to Improve Mentality in Runners

Mary Catherine McGranahan

(GENERAL AUDIENCE ABSTRACT)

Running is currently experiencing its second major boom as a pastime. It has been rapidly increasing in popularity at both the competitive and recreational level since the early 2000s. The development and rapid adoption of wearable technology for endurance athletes has accompanied this boom. Most runners now view wearable technology as integral to their sport. Wearable technology for runners mainly takes the form of Global Positioning System (GPS) enabled sports watches, that track the distance, pace, heart rate, and other performance metrics of runners. The wide adoption of this technology, in conjunction with the mental nature of endurance sports, makes it imperative for wearable technology developers to understand the potential for their technology to affect the mentality of endurance athletes. Current research on wearable technology investigates how it is used to benefit and track physical performance. This aligns with wearable technology's primary purpose, to track the physical aspects of endurance sport performance. The use of this technology as a tool to improve mentality during endurance activities has not yet been explored, despite psychological factors being one of the biggest determinants of physical performance in endurance sports. Psychological factors, like an athlete's own perception of exhaustion, have been shown to limit athletic performance. Furthermore, an athlete that is more confident, positive, and motivated is less likely to believe they have reached their limits and less likely to give up on an effort. Wearable devices have yet to be used to their full potential. The goal of this

study is to perform initial exploratory analysis of wearable devices as a psychological intervention tool in endurance sports. I created an application, called the Affirm on the Run App, for use on GPS enabled sport watches. The Affirm on the Run App pushes positive affirmations to users with the goal of improving their mentality during activities. Positive affirmations are short phrases centered around the writer's goals and designed to be a form of motivational self-talk. In a two-week study of runners utilizing the application, I analyzed the user experience of the application and how it affected runners' perceived exertion on runs, cognitive strategy, and psychological state. The participant group consisted of of seventeen runners, ten men and seven women and encompassed both competitive and lifestyle runners. I explored how the app affected their psychological state with relation to their training, their perceived exertion on runs, and their cognitive strategy. Cognitive strategy looks at whether a runner's thoughts are focused on the task at hand or other distractions, as well as whether these thoughts are internal or related to their external environment. Perceived exertion is the athlete's perception of how hard an effort is, lower perceived exertion is connected to better endurance performance. The five psychological state factors studied were: self-confidence, motivation, perceived physical fitness, cognitive anxiety, and somatic anxiety. I found that runners had an overall positive experience using the Affirm on the Run app on their wearable device. Participants' experiences with the app left them feeling calmer and more motivated on runs. The results of this study show that runners experienced benefits to their psychological state that are linked to increased performance. I conclude that using wearable technology as a psychological intervention tool is beneficial to runners and recommend that development be done to integrate these tools more seamlessly into wearable device infrastructure. I also suggest future investigation of these findings via longitudinal and competition studies. The results of this study serve as a strong starting point to help wearable technology for endurance athletes to reach its full potential, but can also help inform the design of psychological intervention tools for wearable technology targeted towards

other aspects of life, such as improving mentality in the workplace.

Dedication

*To the runners who don't know if they have what it takes to keep going;
To the young girls in computer science classrooms who don't know if they have what it takes
to keep going;
It is amazing where putting one foot in front of the other, and having a little self-belief, will
take you.*

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List of Abbreviations

GPS Global Positioning System

PE Perceived Exertion

RPE Rate of Perceived Exertion

GPS is a navigational system using satellite signals to determine the location of a radio receiver

PE is the perception of how hard, heavy, or strenuous an effort is

RPE is a scale used to measure perceived exertion

Chapter 1

Introduction

We are currently in the second running boom as, mainly across Western Europe and the United States, people are beginning to run as a pastime at an increasingly high rate. This running boom has come with a wave of creation in the form of wearable sports technology.

The first running boom in the 1970s was the start of casual running. Like the current boom, it unleashed a flurry of creation in the running space. During this time, Nike released their first running shoe, and many road races were founded not just for the competitive runner but for the casual runner as well. The first boom led to the founding of the New York City Marathon in 1970 with 127 registrants [21]. Now, amid the second running boom, the 2025 New York City Marathon had over 200,000 applicants, only 2-3% of whom will be given the opportunity to toe the line [15]. No one in the 1970 New York City Marathon was wearing a Global Positioning System (GPS) enabled running watch to track their race data, but evidence shows that many of the runners vying to get in the 2025 race cannot live without one.

Wearable technology has become an integral part of the lives of runners. The first GPS enabled running watch was launched by Garmin in 2003. Since then, GPS running watches, or other smart watches with running support, have become devices that most runners cannot live without. Research shows that 82.4% of competitive runners and 71.3% of recreational runners use a GPS enabled sport watch [7]. They use these devices every single time they train, with 90% of runners saying they check their wearable data after every run [7]. This

trend extends to other endurance athletes as well, as cyclists also purchase sports watches and bike computers to track their metrics.

These advances in technology mean that endurance athletes now have a constant companion, even when they are training alone and do not want to carry a bulky phone. The convenience of wearable technology has made it possible for runners to track and monitor every physical aspect of their training - from pace and distance to heart rate and cadence. These devices assist with the physical aspects of endurance performance, even implementing features such as pace coaches to send runners live pace monitoring alerts during an event. However, very little work has been done investigating the potential to use these devices as a psychological intervention tool. Just as a runner may receive encouragement from running with a teammate or coach, runners could also receive and benefit from encouragement from their wearable device.

Mentality is one of the greatest factors in determining endurance sport performance. Research shows that endurance athletes' limits are set by their own perception of what a maximal effort is. This means that if an athlete believes that they are exerting a maximal effort, they will feel the need to give into pain and slow down or stop [24]. However, psychological interventions that create a positive effect, such as positive self-talk, can lower an athlete's perception of effort and increase their endurance limits [3]. If wearable technology could be leveraged to create this positive effect, it would become an easily accessible performance boost for many athletes. It may also help to create more positive experiences with wearable technology overall, as many runners report that checking their sport watch often creates feelings of stress and anxiety, despite their reliance on the device [17].

This research consists of the creation of an application, called the Affirm on the Run App, for GPS sport watches that pushes user-written positive affirmations to a runner during their runs and the study of the application's effect on runners. The goal of this application is to

investigate whether wearable technology can be a useful tool in improving mentality during endurance activities and, if so, to determine the best ways of developing this technology further. The following research questions related to the use of wearable technology as a psychological intervention tool are answered:

- RQ1: How do runners experience receiving affirmation alerts on a wearable device?
- RQ2: How does the use of affirmations on a wearable device during activity affect a runner's psychological state in relation to their training in five major areas (somatic anxiety, cognitive anxiety, motivation, self-confidence, and perceived physical fitness) overtime?
- RQ3: Does the use of affirmations on a wearable device lower perceived exertion on runs?
- RQ4: Does the use of affirmations on a wearable device during activity affect a runner's cognitive strategy?

In this research, mentality is used to refer to an athlete's attitudes and thinking during an activity, determined by a large set of psychological factors including mental toughness [35], mental fatigue [25], motivation [12], and self-confidence [19]. Psychological interventions in endurance sports are a set of evidence-based practices designed to train mentality to be optimal for physical performance [26].

[Chapter two](#) of this thesis describes related scholarship in the fields of wearable technology, mentality in endurance sports, overcoming endurance athlete limitations, and positive affirmation research. [Chapter three](#) describes the methodology of the study, mainly consisting of how the Affirm App on the Run was created as a psychological intervention tool for wearable technology and the structure of the two-week user study conducted with the

application. This chapter highlights how each piece of the user study was designed to answer the aforementioned four research questions. [Chapter four](#) presents the findings of the user study. The results are organized into four categories: perceived exertion, psychological state, cognitive strategy, and overall app experience. This section also analyzes the types of participants that were involved in the study and the overall makeup of the data collected. [Chapter five](#) is a discussion on the significance of the results found, addressing the implications of changes found in psychological state when using the affirm on the run application and the overall positive user experience of the application as well as limitations of the study. [Chapter six](#) builds on the discussion from chapter five suggesting areas for future research that are inspired by the results and limitations in this study. [Chapter seven](#) concludes with a summary of the paper's main contributions.

Chapter 2

Review of Literature

Human Computer-Interaction (HCI) research in the field of wearable technology for endurance running analyzes the adoption of wearable technology for runners, as well as the metrics wearable technology users are tracking and how they feel when interacting with these metrics on the run. The [first section](#) of this chapter covers the current state of research on wearable technology in distance running.

However, very limited work has been done on the effect of wearable technology on mentality, and no work has tested wearable technology as a psychological intervention itself. To fully understand why mentality is so important to physical performance in distance runners and how a wearable device could affect a runner's mental state, I examine previous research on the mental strategies of long distance runners. I begin by reviewing anecdotal evidence that one's limits in distance running must be controlled by something beyond physical fitness. I then look at initial research done on the mentality of marathon runners, and how they are able to overcome phenomena such as hitting the wall, showing that their limits are set by something besides physical pain. After reviewing the experiential evidence, I dive into physiological research on the brain's role in setting limits in endurance sports, ending with the development of the psychobiological model that argues that limits in endurance sports are defined by the athlete's perception of whether they have reached a maximal effort. Perception of effort is measured using a metric known as perceived exertion. I describe the development of scales for measuring perceived exertion, and the body of research that determined creating

a positive effect using psychological intervention methods such as self-talk lowers perceived exertion and increases endurance limits. Finally, I describe how positive affirmations are used in the field of mental health and their potential to create a positive effect in endurance sports. All of this research informs the design of a wearable technology application to send positive affirmations to runners in hopes of improving their mentality.

2.1 Wearable Technology Use in Endurance Running

Wearable technology has become an integral part of distance running. As the number of participants in endurance running has increased, so has access to and adoption of wearable technology for use in the sport. Wearable technology was a top fitness trend in 2015, 2016, and 2017 [7]. A survey of race participants by Pobiruchin et al. in 2017 found that 75% of runners surveyed at a race used some form of wearable technology to track their race [30]. The most popular devices used were GPS enabled sport watches, greatly outranking mobile phones and other smart watches and activity trackers. A similar survey by Janssen et al. published in 2020 found that 86.2% of runners had used at least one monitoring device on their runs in the past 12 months [13]. Of those, 60.5% were using a GPS enabled sports watch, with the others mainly using mobile phone apps. In distinguishing the wearable technology user set between competitive and recreational runners, Clermont et al. in 2019 found that GPS sport watch use was favored by both groups, as 82.4% of competitive runners and 71.3% of recreation runners used a GPS enable sport watch [7]. In a longitudinal study of how a user's relationship with sports tracking technology changes overtime, Kuru 2016 found that beginner runners are more likely to use mobile apps because they are not yet ready to invest in a device specifically for one activity, but as runners become more invested in their running habits, they invest in and use GPS sport watches [18]. The main reason runners begin to

favor GPS watches over mobile devices is because carrying a mobile phone during activity becomes uncomfortable and checking it is disruptive, with the secondary reason being that runners begin to doubt the data accuracy of their mobile apps. As runners become more aware of their performance they want a device that tracks their performance more precisely.

The main reason runners use wearable technology is to track personalized physical data [7]. Wearable technology users find checking their data to be an integral part of their running practice with 90% of participants stating that they look at their wearable technology after every run and 75% stating they use it to check statistics during their run [7]. Prior work has studied what data runners are tracking and why. The most monitored parameters among sports watch users are distance, time, and speed [14]. Research also indicates that the primary reason runners use wearable technology is to monitor if they meet their goals [7]. Runners use their data for short term reflections after their runs [17]. Despite finding data helpful in tracking their performance and motivating them to reach their goals, runners have mixed feelings about looking at their tracker during runs. Runners whose goal is to simply complete and document their runs seem to avoid checking their tracker during runs, finding it distracting or nerve-wracking [17]. Runners with specific performance goals often use a tracker alongside a training plan to execute their workouts properly. These runners often check their tracking device during their run. Checking their tracker can be a positive experience, acknowledging their achievements or providing reassurance that they are doing the right thing. However, even goal-oriented runners sometimes find checking their data during runs as a source of obsession or doubt that distracts them [17]. For both goal-oriented and more casual runners, checking the tracker can become a source of anxiety. Runners from both groups reported that checking their data is a frequent unconscious action. Karanhanglu et al. suggest that alerts triggered by certain parameters may help alleviate some of this constant data checking [17].

The obsession with sports tracking technology is also evident in running's popular culture, with the popularity of applications like Strava. Strava is a social networking and fitness app that allows users to upload data from their fitness trackers as posts that can be shared with others. Online discourse uses phrases such as "If it's not on Strava it didn't happen" to joke about the fact that if you did not track your run and post it, you might as well not have run at all [31].

This prior work suggests that despite runners' fondness for trackers as a way of documenting, reflecting on, and planning their activities, improvements need to be made concerning how trackers affect a runner's mentality during activity

2.2 Mentality's Affect on Distance Running Performance

Studying how trackers affect a runner's mentality is vital because performance in endurance athletics has been proven to have a large mental component in addition to its physical one. Anecdotal evidence from runners themselves supports this claim, as the idea of a "finishing" kick in which the runner runs their fastest at the very end of the race, for example, defies most physical logic. Prior to the last portion of a race, most runners feel they have given it their all. They are often exhausted, and might have contemplated quitting, but once they realize that the race is almost over, they often manage to run the fastest they have the entire race for the short remainder of the race. In fact, in a study analyzing the pacing patterns of every 5,000-meter and 10,000-meter world record run since the 1920s, the last 1,000 meters of the race was either the fastest or second fastest portion of the race, with only one exception [34], [11]. Evidence indicates that the finishing kick is not a planned event, but rather a psychological phenomenon. A 2014 study of marathon runners found that the distribution of finishers at each time increases around major time barriers, such as right under four or

five hours. Far more people finish just below these barriers than you would expect from the rest of the distribution, and, more importantly, far fewer finish just above these barriers[1], [11]. This indicates that when runners see that they might not reach their goal, they are able to increase their pace and break a time barrier at the end of a marathon. These two phenomena demonstrate that mental barriers are just as present in both recreational road racers and elite track athletes. The concept of a breakthrough race is yet another example of the mental barriers in distance running. A runner will try many times to break some time barrier, like the four-minute mile, and fail each time. Then, one day, with the same training and preparation as before, the runner will run well under the barrier, often attributing it to a mental state of “flow” they felt during that one particular race [11].

While research acknowledges that these mental barriers in endurance performance exist, studying them and identifying how to overcome them presents a difficult challenge. One of the most common ways people have studied mental barriers in endurance sports is through analyzing the mentality of marathon runners. The marathon is widely studied not only because it is a standard distance, but also because of the phenomenon of “hitting the wall” that is common in the marathon. The “wall” is the moment during the race where fatigue sets in accompanied by a slowing of pace. Runners find this experience both mentally and physically difficult to overcome. Physiologically, the “wall” is the point when an athlete’s glycogen stores have been depleted. At this point they start to rely on fat metabolism, which is a much slower process [32]. However, research indicates that runners may be “hitting the wall” mentally before this physiological process occurs. Whether mental or physiological, studies show that anywhere from 40% to 50% of recreation marathon runners experienced “hitting the wall” over the course of their race [32], [5]. They believed that they hit a point where the race effort was suddenly insurmountable.

Runners’ ability to overcome the wall at the end of a marathon shows that there is a psy-

chological component to hitting the wall [32]. The correlation between a runner believing that they will hit the wall and hitting it, differences in onset and duration of the wall, and differences in cognitive strategies of elite runners who believe the wall is a “myth” also demonstrate the psychological component of hitting the wall [5], [32]. Research indicates most marathon runners begin experiencing the wall around mile 19 [5]. Stevinson and Biddle found the mean onset of hitting the wall to be at 18.25mi, with a mean duration of 4.91mi, meaning as participants neared the last mile of their race they were suddenly able to overcome the wall [32].

Stevinson and Biddle evaluated the cognitive strategies of different marathon runners to determine whether certain thoughts during a race were more likely to cause runners to hit the wall. They use Morgan’s concept of associative and dissociative mental strategies in marathon runners, as a base for further expanding the range of thought analyzation. Morgan defines an associative thought as any thought that relates to the physical, bodily sensations occurring, for example “My knee is sore.” Morgan defines a dissociative thought as any thought that distracts from the bodily sensations occurring, for example, “The view is pretty [33].” However, Stevinson and Biddle argue that the definition of the terms associative and dissociative have become muddled in marathon research throughout time [32]. For example, a runner checking their pace on a wearable complicates the associative/dissociative divide as the pace is not a bodily sensation but is related to the task at hand. Stevinson and Biddle introduce the identifiers of inward and outward to tag associative and dissociative thoughts. Using both inward/outward and associative/dissociative, Stevinson and Biddle classify marathoner’s thoughts into four groups: inward association, outward association, inward dissociation and outward dissociation. Inward associative thoughts are thoughts that involve looking inward at physical sensations, such as whether your legs are tired. Outward associative thoughts are thoughts relevant to performing the task at hand, but not related to

a physical feeling, such as thinking about pace and checking mile splits. Inward dissociative thoughts are thoughts irrelevant to the task but with an internal focus, like daydreaming. Outward dissociative thoughts are external distractions, like looking at scenery or spectators [32].

Research has addressed the role that these cognitive strategies may play a role in likelihood of hitting the wall, but no single strategy has emerged as more or less effective than others. Morgan and Pollock's study of both elite and non-elite marathon runners reveals that elite runners tend to believe that the wall is a myth. Elite runners often believe that associative cognitive strategies, like checking in with your body and adjusting your pace, allow you to avoid hitting the wall altogether [28]. However, non-elite runners believe the wall is inevitable and that dissociative strategies are needed to endure the pain of the wall [32]. To address these claims, Stevinson and Biddle interviewed non-elite participants of the 1996 London Marathon on their thoughts during the race and whether they hit the wall or not. Inward dissociation was the least common cognitive strategy among these recreational runners, while inward association was the most common [32]. Despite what was believed by elite marathon runners, outward dissociation did not have a correlation with whether runners hit the wall. There was no difference in levels of association between runners that hit the wall and those that did not, showing that paying attention to your bodily signals will not necessarily prevent the wall. However, they did find that greater inward association was correlated with early onset and longer duration of the wall. If a runner is paying too much attention to their bodily sensations, they may notice the wall earlier and feel its pain longer. More outward dissociative thoughts were related to a later onset of the wall, showing the inverse [32]. Overall, no results were found that showed that one cognitive strategy was necessarily more helpful than the others in preventing the wall, only in delaying its onset. Thinking about the physical sensations of performance too much may lead runners to have worse experiences

with the wall but thinking about the task at hand too little may make hitting the wall more likely due to ignoring physical signals, causing a drop in performance.

The evidence that runners can overcome physical setbacks using psychological tactics, such as when they are reminded of their goals at the end of a long race or in the correct headspace, shows that there could be valuable in using wearable technology as a psychological intervention to help get them to this headspace.

2.3 The Brain's Role in Endurance Performance

Despite the lack of one clear superior cognitive strategy, physiological research supports the idea that limitations in endurance exercise are determined both by physical signals from your muscles and cardiovascular system, and mental signals from your brain. Prior to scholarship establishing the connection between the brain and exercise limits, the field of exercise physiology was dominated by the “catastrophe model.” Catastrophe models believed that the limitations of exercise were entirely physical. Exercise limits, according to catastrophe models, were regulated peripherally by the muscles while the brain had no control over what occurred. Catastrophe models outlined that physical exhaustion occurs as a direct consequence of a failure of bodily homeostasis at the point of exhaustion. However, research has since found that there is presence of homeostasis in all organ systems at the point of exhaustion. In addition, exercise is terminated before all available motor units are recruited indicating that exercise limitations are in fact reached before any evidence of catastrophic failure [29].

Tim Noakes proposed the central governor model in the 1990s as a means of debunking previous “catastrophe” models of exercise physiology. Noakes’ central governor model proposed that the central nervous system controls exercise limits through a complex system. In

response to feedback from different afferent systems, the central nervous system regulates the number of motor units recruited during exercise and the work rate that can be sustained for the anticipated duration of exercise [29]. This system decides the amount of effort that will be given before starting the activity and has direct control over muscle recruitment. This model proposes that fatigue itself is not a physical event, but our perception of sensory feedback from other parts of the body [29]. The central governor model was the first to allow for psychological and neural factors in exercise performance. Introducing the brain into models of exercise limitation provides an explanation for phenomena previously unexplained by catastrophe models, such as why our body knows to sprint at the end, but not at the beginning, of a longer race. If exercise was not regulated in part by the brain, this would not be possible.

The central governor model influenced future research in the field by highlighting the importance of the brain in exercise performance, making way for the introduction of the psychobiological model and the concept of perceived exertion. Later scholarship argues that the central governor model is incorrect in its explanation of how the brain and body interact. Marcora expands the brain's role in exercise limitations by proposing the psychobiological model. Marcora argues that the central governor model breaks down when the idea of perceived exertion, or perception of effort is introduced [24]. Marcora defines perceived exertion as, "a conscious perception of how hard, heavy, and strenuous the exercise is, according to the sense of effort to command the limbs and the feeling of heavy breathing [22]." Perceived exertion is commonly used to prescribe exercise regiments and was legitimized by the work of Gunnar Borg starting in the 1960's [22]. Conversely, the central governor model was proposed without the concept of perceived exertion, though Noakes attempted to integrate it later, Marcora believes this integration does not align with the central governor model [24].

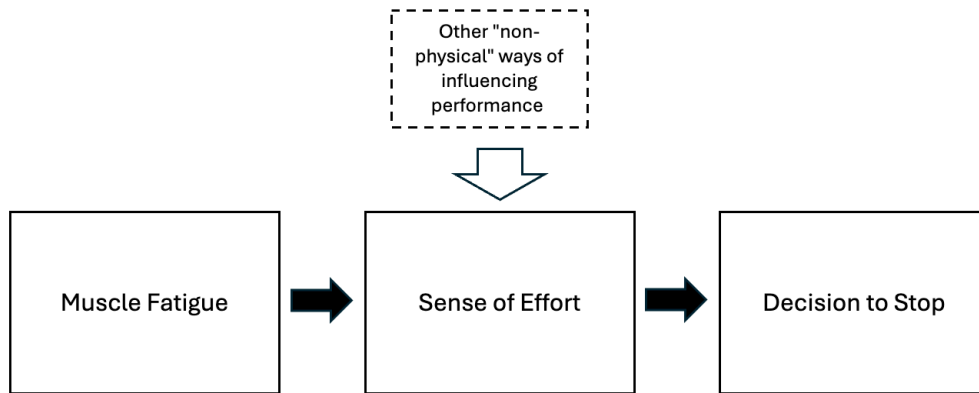


Figure 2.1: Psychobiological Model. Adapetd From:[25]

Marcora instead outlines his psychobiological model of endurance exercise limits (see [Figure 2.1](#)). The psychobiological model states that exhaustion occurs under one of two conditions, the first is that the effort required for the exercise task is equal to the maximum effort the subject is willing to exert to succeed at the exercise task, and the second is when the subject believes it has exerted a true maximal effort and the continuation of exercise is impossible. Within the first limit, an increase in the second limit will improve exercise tolerance [24]. Marcora's research also shows that afferent feedback from the skeletal muscles, heart, and lungs, does not contribute significantly to perception of effort during exercise. Instead, rate of perceived exertion is the conscious awareness of the central motor commands to locomotor and respiratory muscles [23]. Essentially, exercise is stopped when the athlete's rate of perceived exertion has reached either the level they determined they are willing to give for that task, or the level that they consider maximal. Athletes are aware of the effort they are asking their body to give to accomplish a task and aware of what they believe their limits are.

The psychobiological model provides an explanation for how the brain overcomes physical

limits to create the situations described in the [previous section](#). The concept of perceived exertion gives us a target when designing tools to improve physical endurance, as it is a metric that directly determines an athlete's physical limits.

2.4 Measuring Perceived Exertion

Using the psychobiological model, rate of perceived exertion (RPE) becomes one of the most important indicators of ability to perform in endurance exercise, making it crucial to measure RPE. Gunnar Borg's studies on rate of perceived exertion were seen as a landmark in exercise physiology and sports science. Borg argues that, "perceived exertion is the single best indicator of the degree of physical strain [4]." Borg intended to develop a scale to measure perceived exertion. He found that ratio-scaling methods commonly used for psychophysical relations were difficult to use for perceived exertion because they did not allow for strong inter-individual comparisons. Borg used verbal anchors to overcome these difficulties. Most people share a similar perception of maximum effort even if the task to get to that effort differs [22]. Verbal anchors turned the RPE scale into a category scale, making inter-individual comparisons possible. Borg created a six-to-twenty-point scale with 15 equidistant intervals and verbal anchors on some numbers. The six-to-twenty scale was designed to make comparisons with heart rate easier. After that, Borg designed a second scale to describe the mathematical relationship between a physical stimulus and sensory response, creating the CR10 scale. This is a simpler scale with similar verbal descriptors to the original RPE scale. Both scales align with Marcora's definition of quantifying perceived exertion. The properties of both scales have been verified across years of research, for example, against cycling ergometer tests, are designed to increase linearly with workload as oxygen consumption and heart rate do, and have been shown to have close correlation with blood and muscle lactate

measures [4],[22]. See [Appendix C](#) for scale. This scales is used in the Affirm on the Run app user study to evaluate participants' perceived exertion.

2.5 Self-Talk, Positive Effect, and Perceived Exertion

Positive effect and self-talk improves athletic performance in endurance sports by lowering perceived exertion. Studies evaluating tennis, swimming, and volleyball that have shown the positive effects of motivational self-talk on self-efficacy and performance [9]. However, such thinking may play an even greater role in endurance sport performance. Positive thinking and encouragement can lower perceived exertion during exercise, thus improving performance in endurance sports according to the psychobiological model. If perceived exertion is lower athletes do not feel like they have exerted a true maximal effort and will persevere in the effort, which raises their performance limits. Self-talk is a popular psychological intervention for improving performance in sports. Blanchfield et al. produced evidence that motivational self-talk can enhance endurance sport performance [3]. Blanchfield et al. used cycling time-to-exhaustion tests to assess the effect of self-talk on endurance. In these tests, the participant is asked to cycle on a stationary bike at a specific power output until they believe they have reached exhaustion. They found that time-to-exhaustion increased significantly in a group taught to use motivational self-talk, whereas there was no significant change in time to exhaustion in the control group. RPE at specific isotimes during this test indicated that this increase in time to exhaustion was most likely due to the self-talk reducing RPE, providing support for the psychobiological model. There were no significant differences in physiological factors between the test in which participants used self-talk and the one in which they did not [3]. The participants in the self-talk group were able to cycle for longer before feeling that they had exerted a maximal effort because the self-talk lowered their

perceived effort. The authors of this paper suggest that, “Strategies targeting beneficial changes in RPE through this psychobiological framework may offer a new paradigm for endurance performance enhancement [3].”

Evidence also indicates that non-conscious psychological manipulations can lower RPE and improve endurance performance by creating a positive affective state. It is not just the use of self-talk, but positive effect in general that is associated with better sport performance. Blanchfield et al. conducted a second study, again using time-to-exhaustion cycling tests, in which subjects were unknowingly primed with either happy or sad faces [2]. A monitor that flashed in front of the subjects displayed the faces as part of a scanning visual vigilance task. This priming had a significant effect on time to exhaustion, finding that participants cycled an average of 178 seconds longer when primed with happy faces, even though when asked afterwards participants did not recall seeing happy faces during the test. Similar to the self-talk study, RPE was significantly lower at isotime points throughout the test when primed with happy faces, despite there being no difference in physiological factors. The authors of this study also replicated its findings with action and inaction words, showing similar results. The authors suggest that in the future, some of these cues could be worked into contemporary technologies to be used during activity [3]. These findings have not yet been evaluated outside of laboratory settings or with elite athletes. Despite this shortcoming, these studies strongly suggest that positive thought interventions can lead to significant performance increases by lower perceived exertion in line with the psychobiological model. This study will test if wearable technology can create a positive effect that could lower perceived exertion as the mechanisms in the above research did.

2.6 Positive Affirmations and Self-Affirmation Theory

Much like the use of self-talk in sports, positive affirmations are known to assist with goal attainment and self-confidence in everyday life [10]. Positive affirmation practices are a popular and quick self-affirmation activity. They can help decrease stress and anxiety, which helps increase goal attainment. Positive affirmations are short phrases that a person repeats to bolster their sense of self. They can be written by the person themselves or taken from elsewhere, and are typically “I” statements such as, “I am kind and resourceful.”

Positive affirmations are a form of self-affirmations, supported by self-affirmation theory. Self-affirmation theory argues that humans become more resilient to psychological stress when they affirm one’s own adequacy and sense of self-integrity. Research indicates that self-affirmation practices can bolster self-confidence in future encounters, help clarify life purpose, promote closeness in interpersonal relationships, and foster a more optimistic outlook on challenges [10]. Even a small amount of self-affirmation practice can have long-lasting effects by starting cycles of adaptive potential. These cycles are feedback loops in which positive resolution and outside response to one’s problems, affirm the self and enable people to enter future situations with a bolstered view of their abilities [10], [8].

Positive affirmations have the potential to help athletes because self-confidence is reported to be significantly positively related to endurance sport performance [19]. Anxiety can be helpful in some circumstances for athletes, such as in high level races, but debilitating in excess, such as if experienced during training, or when interpreted negatively by the athlete. Self-confidence can protect against the debilitating side of anxiety but increasing a participant’s feeling of control over the situation [19]. As such, any practice that increases self-confidence and lowers anxiety should be beneficial to athletic performance.

This study aims to use self-affirmation theory to bolster self-confidence and lower anxiety

in endurance athletes by creating an application that sends them positive affirmations via the wearable devices they already use daily. The framework for writing positive affirmations can be easily explained to allow users to write their own affirmations. The short and quick nature of positive affirmations provides a method of self-talk that can be integrated into wearable devices and read while in motion. The study aims to determine if practicing positive affirmations on a run has the same benefits that using them as a daily mental health practice has been shown to have.

2.7 Impact of Related Work

The related work described above serves to inform the creation of a wearable technology application to improve mentality in distance runners during activity and to inform the design of a study to test this application. [Section 2.1](#) shows the necessity for such an application due to the constant reliance of runners on their wearable technology. Runners wear this technology constantly, yet they have mixed feelings regarding how it affects their mentality during efforts and work has not been done into whether there are ways to improve the mental experience with wearable technology, a gap this research sets out to solve. It also justifies the use of GPS sport watches as an effective way to integrate a psychological intervention into runners' preexisting routines. [Section 2.2](#) demonstrates the important impact mentality has on distance running performance and shows that any tool that could improve a runner's mentality could lead to large gains in performance. Runners have often felt that they have the ability to overcome physical setbacks when the right psychological state is established, a psychological state that could potentially be created with the help of wearable technology. [Section 2.3](#) provides the scientific justification for the experiences of runners described in [Section 2.2](#), showing that the brain and its perception of effort play a large role in endurance

performance. [Section 2.4](#) shows that psychological interventions of positive imaging and motivational self-talk have been utilized to lower perceived exertion in the past and provide the basis for using a different form of self-talk as the psychological intervention in this study. [Section 2.5](#) describes the previously developed processes used to rate perceived exertion that will be used over the course of this study. Finally, [Section 2.6](#) inspired the use of self-affirmations as the mode of encouraging positive self-talk through wearable technology.

Chapter 3

Methodology

3.1 Research Questions

This study was designed to answer four research questions that contribute to the larger goal of investigating the usefulness and future development of wearable technology as a psychological intervention tool for endurance sport performance. More specifically, the research questions aim to explore whether the Affirm on the Run app is a viable option for mentality improvement based on user experience and whether it had a measurable effect on psychological characteristics. The connection of each piece of methodology to the research questions is detailed in the following section.

RQ1: How do runners experience receiving affirmation alerts on a wearable device?

A wearable performance alert could be received in a variety of ways. Research shows that while frequent data checking can cause anxiety in runners, they still enjoy having the data for both planning and workout assistance [18]. While the intention of an affirmation alert might be to bolster positive motivation and lower perceived exertion, the influx of information from the alert may increase runners' data-checking anxiety. On the other hand, these alerts have the potential to relieve this anxiety. The application will give runners an affirmation screen on their watch that contains no data metrics, for those who wish to wear their watch so that they can collect the data they need to view post activity, but are looking to avoid

metrics during activity. In addition, it is possible runners will ignore these alerts or not notice them if they are in the flow of their run. To explore how runners experience these alerts, one of the questions on the post-run survey for the week that participants used the Affirm on the Run App (see [Appendix B](#)) asked the following free response questions, “Do you remembering viewing your affirmations on this run? Approximately many times do you remember seeing an affirmation?” and “Describe in your own words how you felt when receiving an affirmation notification on this run (approximately 2-5 sentences)?” These questions were designed as free response questions to allow participants to fully express the range of emotions a runner might feel throughout a run, potentially experiencing the alert differently in different moments.

RQ2: How does the use of affirmations on a wearable device during activity affect a runner’s psychological state in relation to their training in five major areas (anxiety, motivation, self-confidence, and perceived physical fitness) overtime?

Positive affirmations, when used consistently over time, are believed to increase self-confidence and motivation, while lowering anxiety [8]. This study was designed to investigate whether the use of positive affirmations will help runners lower their perceived exertion in the moment and have positive effects over time in relation to their mental state during training. Such positive effects also have the potential to bolster performance and general well-being. This research question was assessed in the study using the PODIUM questionnaire. The PODIUM questionnaire (explained in greater detail in the [Quantitative Variables](#) section) was developed to assess the psychological state of recreational marathon runners in the days leading up to their race [19]. Since its development, this questionnaire has been used in other longitudinal studies of runners, and we felt it was the best fit to capture the mental state of runners in relation to their training [20]. Participants answered the PODIUM questionnaire three times throughout the study: before beginning the study, after one week of training

without using the app, and after one week of training while using the app. This helped us establish participants' baseline psychological state in relation to their training and their psychological state in relation to their training after their use of the app.

RQ3: Does the use of affirmations on a wearable device lower perceived exertion on runs?

Perceived exertion is the largest determinate of endurance performance limits according to the psychobiological model. It has been shown that positive signaling, such as positive self-talk, has the power to lower perceived exertion during activity [3]. If receiving positive affirmations on a wearable device can lower perceived exertion, then wearable devices can be used to improve mentality via a method that also increases physical performance. After every run participants completed during the study, they were asked to use the CR10 scale (described further in the [Quantitative Variables](#) section) to evaluate their perceived exertion on the run overall. They were also asked to categorize whether the run was intended in their training cycle to be an easy, moderate, or hard run. This allowed us to account for different intended perceived exertions when looking at the data. We compared the average perceived exertion for each run type in the week without the app to the average perceived exertion for each run type in the week with the app to evaluate whether the app lowered perceived exertion in training.

RQ4: Does the use of affirmations on a wearable device during activity effect a runner's cognitive strategy?

Prior research shows that the cognitive strategies of long distance runners can be organized into the following four categories: inward association, inward dissociation, outward association, outward dissociation [32]. Runners may use these strategies to either be more in tune with their body to have the best run possible, or to tune out their pain to have the best run possible. There is no consensus from prior research on which of these strategies is

best for performance. This research investigated whether refocusing runners with positive affirmation alerts had any effect on their overall cognitive strategy over the course of their run. Runners were asked in their post-run surveys (see [Appendix A](#)) to, “Briefly describe what you thought about during your run, can be vague (ex: What I was going to eat for dinner, my mile splits, that I was going too slow/too fast, a problem I’ve been having):” Participants often described having multiple different thoughts over the course of their run. Each thought was coded into one of the four aforementioned categories. A comparison was made between the percentage of thoughts in each category during the week without the Affirm on the Run app and the week with the app to determine whether there was a change in thought strategy when using the app.

These four questions will determine the usefulness of wearable technology a psychological intervention tool to help mentality in endurance activities. If users have a positive experience with the app, if it lowers their perceived exertion, or if it improves their long-term psychological state towards training, athletes will further benefit from psychological intervention tools being integrated into wearable technology.

3.2 Study Design

A two-week study was designed to test the difference in runners’ mentality and experience when they used the Affirm on the Run app in their training. During the first week, runners were asked to complete their normal running routine without the use of the application. During the second week, they were again asked to complete their normal running routine, but this time were instructed to download and use the application.

The two-week duration was chosen because this was an initial exploratory study on the use of the affirmation app. There is limited amount of work done on wearable technology’s effect

on mentality during distance running. There is no work done specifically on how receiving affirmations via a wearable device could effect that mentality. This study was designed to gather initial results that could inform future work with a larger sample size. Two weeks allows for comparison between a baseline and treatment, while still being short enough to keep runners committed to filling out their post-run surveys. It was important that the study be done as a week-to-week comparison. Most runners structure their training on a seven-day cycle. This means that runners are likely to have the same amount of easy, moderate, and hard runs in week one and week two, ideally, they would complete almost identical training week-to-week if they followed their normal training habits. Throughout these two weeks, they filled out an initial survey, a post-run survey after every run they completed in their first week, a midpoint survey, a different post-run survey after every run they completed in their second week that included questions about their affirmations, and a final survey.

The first survey was an initial screening survey (see [Appendix A](#)). This survey was intended to gather demographic information, as well as gauge whether the runner trained enough over the course of a week to qualify for the study. The initial survey screened for runners who were over the age of 18 and typically ran four or more times a week. It also asked qualitative questions about running experience and goals in order to characterize the intensity level of the participants. Demographic information and contact information from the initial survey was stored separately from all other data collected in order to keep the participant's identity anonymized from their data. After completing their initial survey, their data was assigned a participant number that was used for the remainder of the study.

The initial survey also included the participants' first PODIUM survey, designed to get a baseline of how they felt about their training before the start of their first week of training in the study in five main psychological areas: anxiety, motivation, self-confidence, perceived physical fitness and perceived social support (see [Quantitative Variables](#) section).

After completing their initial survey, runners that qualified to participate were sent their week one post-run survey link (see [Appendix A](#)). They were instructed to fill out a post-run survey after every run they completed that week according to their normal running routine. The first week post-run survey asked users about different aspects of their run. They were asked about the length of their run, the type of run it was designed to be in their training, and to write out some of the thoughts they had. Participants were also asked to use the CR10 scale to rate their perceived exertion on their run. They were shown an image of the scale with its verbal anchors and asked to select a rating. They were not instructed as to why this question was asked or the role of perceived exertion in running.

Once it had been one week since a participant completed their first post-run survey, that participant received a midpoint survey (see [Appendix A](#)). The midpoint survey contained another PODIUM scale, to assess whether their psychological state towards their training had changed throughout a week of regular training without the app. After completing the PODIUM survey, the rest of their midpoint survey contained instructions on how to download and set up the Affirm on the Run App on their Garmin device. At the end of the survey, participants were required to either check that they had been able to successfully download and set up the app or email the study investigators for assistance.

Once their midpoint survey was received, a participant was sent a link to their week two post-run survey (see [Appendix A](#)). They were again instructed to fill out this survey after every run they completed during the week. The first half of the week two post-run survey was identical to the week one post-run survey. However, there were additional questions about the participant's experience with the Affirm on the Run app at the end of the week two survey. Participants were asked to describe when they had last rewritten their affirmations, what their affirmations focused on, how many times they remembered seeing an affirmation alert on the run, and how they felt receiving their affirmation alerts. These questions were

designed to evaluate whether users were finding the affirmation experience to be meaningful, intrusive, or possibly just forgettable.

When it had been one week since the participant filled out their first week two post run survey, they received their final survey (see [Appendix A](#)). Their final survey consisted of their last PODIUM questionnaire and a question that asked whether they had ever missed a post-run survey over the course of the study. This was done to gauge the accuracy of the week-to-week comparisons.

At the conclusion of the study, all participants who completed the study were compensated with a \$15 Amazon gift card.

3.3 App Design

The Affirm on the Run App

The Affirm on the Run App was designed to allow users to write their own positive affirmations that are then sent to them as alerts during their runs. Writing positive affirmations allows users to think about their goals and what they want out of their training. Users are able to personalize their affirmations according to their own strengths and weaknesses. Positive affirmations were used as a framework because they are short phrases that can easily be read while in motion, can increase positive effect similar to the happy faces in Blanchfield's 2014 experiments, are a form of motivational self-talk, and are shown to have longer term effects as a mental health practice [2], [10]. The framework for writing positive affirmations allowed us to give participants guidance on how to structure their statements. Upon downloading the Affirm on the Run App, participants were instructed to go to the app's settings, found on the Connect IQ mobile application. There, they could write between three and five



Figure 3.1: Affirm on the Run App Screen

personal affirmations. Three editable example affirmations were already filled in for them, so that if a participant declined to write their own, they would still receive positive alerts.

After writing their affirmations, participants were asked to add the application as a data field to their run activity. This application can be added to a variety of other activities, such as swimming or cycling, but running was the chosen activity for this study. App users can set up the affirmation screen to sit where they prefer in the scroll of metrics on their watch. The affirmation screen displays their affirmation in black text on a blue background (see [Figure 3.1](#)). Colors were chosen using Garmin’s recommended display colors that would be visible on all devices. The blue was chosen to help the affirmation stand out from other metrics, such as mile splits, which are displayed on a black background with white text by default. The affirmation screen is available to users at all times during their activity if they wish to access it.

The Affirm on the Run app alerts users with one of their affirmations every 10 minutes during their run. Participants were instructed on how to enable these alerts upon initial download of the application. The alert vibrates, makes a small ringing noise, and displays



Figure 3.2: Affirm on the Run Alert Screen

their affirmation. The alert noise was chosen from Garmin’s library of sounds to be different than the default alert noise of splits that users are used to hearing, so there is a notable difference in association. This affirmation covers whatever screen a user’s watch is currently viewing at the time (for example, their pace and distance would be replaced with the affirmation), for the default alert duration. The alerts rotate through their affirmation list in the order in which they were written in. The affirmation alert is simple black text on a green background, in a font size that was deemed legible in initial testing (see [Figure 3.2](#)). No participants complained of being unable to read their affirmation alerts during the study. Once the alert has been displayed, the watch returns to its default display screen, and that affirmation is visible in the user’s metrics scroll if they wish to view it until it changes at the next affirmation alert.

The code for the Affirm on the Run app consists mainly of a data field alert view. The data field alert class is built into the Garmin ecosystem. The code loads the first affirmation from the user’s settings upon initial start up of an activity. A compute function is used to keep track of the time elapsed in the user’s activity and send an alert update every 10 minutes.

The update resets the affirmation to the next one on the list, triggering a redraw of the main screen into a data field alert for a brief period of time, before returning to its default. The decision to use a time interval as opposed to a distance interval was based on the fact that study participants may run vastly different mileage at vastly different speeds. More experienced runners tend to run faster and longer, more novice runners tend to run slower and shorter. Using a time interval allowed us to do our best to even the playing field, so that a slower runner on a short run may get as many alerts as a faster runner on a long run. For future use outside of the study, runners would benefit from being able to set their own interval duration based on their training. The application is still available on the Garmin Connect IQ store.

The Garmin Development System

The Affirm on the Run application was built using Garmin's app development language, Monkey C, for deployment in the Garmin Connect IQ store. The decision to use Garmin's app development system came from research indicating that Garmin devices are the most popular among runners [13]. Using the most popular device type helps participants seamlessly integrate the application into their already existing training routine. In addition, the Garmin app store allows for quick application uploads and updates, and the API's (Application programming interface's) available in their app development ecosystem are designed specifically around the needs of athletes, with metrics such as miles run and minutes into a started activity readily available. There are five types of apps that can be designed using Garmin's app development ecosystem: watch faces, data fields, widgets, device apps, and audio content providers. The Affirm on the Run Application was designed as a data field, as data fields are the only app type that can be visible and send alerts during a Garmin activity such as a run.

3.4 Quantitative Variables

Two quantitative measurements were used throughout the surveys in the study. These were the CR10 Scale for perceived exertion and the PODIUM questionnaire for psychological state of runners.

The CR10 scale was developed by Gunnar Borg as a way for subjects to rate their perceived exertion in an activity (see [Appendix C](#)). The psychophysics properties of the CR10 scale have been carefully validated with many experiments over several years [22]. See [Review of Literature](#) for more in depth descriptions of perceived exertion. The CR10 scale depicts 11 numbers with verbal anchors to describe the perceived exertion of each number range. It begins at 0 (rest) and goes up to 10 (maximal). For the purposes of this study, we did not allow users to include decimal points or exceed the scale rating of 10, as we are not conducting tests to exhaustion there would be no need to record an effort higher than 10. Furthermore using a standard scale ensured consistency across the two weeks as users were completing surveys on their own without in-person guidance. The CR10 scale was chosen over the 6-to-20 point RPE scale due to its simplicity. Because subjects would be completing surveys and reading instructions on their own, we wanted the scale to be as straightforward as possible. In addition, this scale was used in Blanchfield's experiments on using self-talk and subliminal priming to lower perceived exertion, making it consistent across similar experiments [2], [3].

The PODIUM questionnaire was developed by Larumbe et al. and first published and verified in 2015. The scale was designed to measure the psychological state of recreational marathon runners [19]. The scale consists of 20 items placed along visual analog scales (VAS). Each item fits into one of six factors: motivation, self-confidence, perceived physical fitness, perceived social support, cognitive anxiety, or somatic anxiety. Anxiety can also be combined into one factor for a five-factor model, but the six-factor model has been proven

to have better model fit. An example of a VAS item would be “Overwhelmed” on one end of the scale and “Comfortable” on the other. Participants were asked to move the slider between the two choices based on how they felt about their training in that moment. The slider was on a scale of 0 to 100, but participants could not view the number scale. The PODIUM questionnaire has undergone a multiple study validation process and has been used in other published studies analyzing the mental state of endurance athletes [19], [20]. It was originally validated in Spanish but is currently undergoing its English validation. The English version was used in this study.

3.5 Participant Recruitment

Prior to the start of recruitment, the IRB at Virginia Tech reviewed the protocol and approved the study titled Affirmations on the Run. The approval letter for IRB #24-1137 is attached in [Appendix B](#).

Two Strava posts were used to recruit participants for a two-week study with the Affirm on the Run App. Strava is a social networking and fitness app that allows users to upload data from their fitness trackers as posts that can be shared with others [31]. One was posted to the author’s Strava page and the other was posted to a Strava club of 3,176 users entitled “D3 Glory Days.” This group contains many alumni of National Collegiate Athletic Association (NCAA) Division III college cross country and track programs. The language of these posts was approved by the IRB. It described that the study would look at wearable technology as a tool for improving mentality in endurance sports. It also described that the researchers sought runners who matched the following criteria: use a Garmin watch, are over the age of 18, and typically run four or more times a week. The number of times a week a participant runs was set in order to gather enough post-run surveys for each week to make a proper

week-to-week comparison. The call to participate also asked that participants not currently be part of a collegiate or high school team. This request was justified based on the fact that runners who participate in activities with a team and a coach everyday receive lots of feedback over the course of a practice that could affect their interpretation of the affirmation alert. Runners who run on their own majority of the time, which encompasses most adult and post-graduate endurance athletes, are more likely to have their own interpretation of the positive affirmations than runners who are already being encouraged by a coach during their workouts. Strava was used as a means of recruitment because of its ability to target runners who are currently active in their training. Strava users are often using a wearable device to upload their data to Strava. Users who are reading posts on their feed are most likely on the app because they are currently posting their own training and viewing the training of others. We received interest from 34 participants, 26 enrolled in the study. Nine participants failed to complete the study due to technical difficulties, an unplanned break in their run training, or unstated reasons, leaving us with 17 final participants.

3.6 Statistical Analysis

The quantitative data from this study was evaluated for statistical significance using paired t-tests in R. T-tests were chosen due to the need to compare means between week one, without the app as treatment, and week two, with the app as treatment, and due to the relatively small sample size. Paired t-tests were chosen as the same group of participants was used in both weeks. Each participant could have different baseline values at the beginning of the study, for psychological state, cognitive strategy, or perceived exertion. Therefore, it was important that the participant data be from week be paired with the data from week two. All data was downloaded from QuestionPro survey responses and formatted into excel.

The data was loaded into three data frames for use in R, a cognitive strategy data frame, a psychological state data frame, and a perceived exertion data frame. T-tests were run for each psychological state factor, each cognitive strategy, and each run type for perceived exertion. The categories and results of these t-tests can be found in the Results section.

Prior to performing statistical analysis on the cognitive strategy data, each thought had to be coded as inward associative, inward dissociative, outward associative, outward dissociative. This coding was performed by the primary researcher. In post-run surveys, runners submitted a block of text that contained a description of all their thoughts during their run. In the coding process, each topic change was taken as its own thought. The thoughts were then coded using the definitions provided in [Section 2.2](#). The number of thoughts each participant submitted per run varied widely. Once this coding process was finished, the percentage of thoughts in each category was calculated on a per participant per week basis. These percentages were used to conduct the statistical analysis.

No statistical analysis was performed on the app experience data. App experience data was only collected in week two of the study. In week two post-run surveys runners submitted written responses that described their experience using the app over the course of the entire run. Each run was coded as either a positive, negative, or neutral experience with the app based on the description given. If multiple experiences were described, the category of each experience was determined, and that run was deemed to be a mix of categories. No sentiment analysis was used, as the goal was not capturing the sentiment of the words but the benefit of the experience. Designations were based solely on the participant's reaction to the affirmation alerts provided by the application. For example, "It made me go faster" was marked as positive while, "I wasn't too enthusiastic to see them," was marked as negative.

Chapter 4

Results

This study examined how participants' survey responses changed between week one, before using the affirmation app, and week two, while using the affirmation app. It also investigated their personal experience with using a wearable affirmation app. The findings of this study can be organized into four categories: change in perceived exertion, change in psychological state, change in cognitive strategy, and app experience. I found that while perceived exertion was lower on runs in the week participants used the affirmation app, this difference was not statistically significant in any run category.

Changes in psychological state, however, were significant in three major areas: an increase in self-confidence, an increase in perceived physical fitness, and a decrease in cognitive anxiety. Cognitive strategy was found to have no mean change between week one and week two, with fluctuations in associative and dissociative strategies occurring without a pattern. Finally, participants' app experience was overwhelmingly positive with many participants stating that they enjoyed their app experience and felt it helped them in many moments on their runs.

4.1 Participants

We received interest from 34 runners, 26 of whom were enrolled in the study as participants. Of those 26, two abdicated from the study due to an unplanned change in running routine,

five left due to technical difficulties setting up the watch application, and two stopped responding to surveys with no explanation, leaving us with 17 complete participants. Of these 17 participants, 10 were male and seven were female. A wide range of participant ages was covered, with the majority of participants falling between the ages of 18 and 34. Six participants were aged 18 to 24, nine were aged 25 to 34, one was aged 45 to 54, and one was aged 55 to 60.

Participants were asked free response questions about their running experience and current running goals. From their responses, we categorized nine of the runners as being competitive runners. These runners have a competitive running background, having run in college or on another team at a high level, and continue to train at that level. Four were categorized as lifestyle runners. These runners have run on a regular basis for a few years, mainly for fitness or fun. Four were categorized as a mix of the two, they had a competitive running background in their pasts but currently identify as more of lifestyle runners later in life. These runners often still had goals they were trying to reach but reported being more casual about their training. When asked about their current goals for running, runners listed multiple goals simultaneously. 71% of runners encompassing competitive, lifestyle, and mixed runners stated that they have a current time goal they are trying to reach. Participants reported goals such as, “marathon training with a goal of running a Boston Qualifying time ($<2:55$)” or “my current goal is to run a 5k at a 7:30 pace.” The second highest goal category was an event goal, as 35% of runners reported that they are trying to complete a specific event, like a marathon later this year. Only two runners did not have a time or event goal anywhere in their goal list, instead prioritizing health and fun. In addition to time and event goals, 29% of participants stated they ran for their health. Other reasons for running that were listed included: making friends, building community, seeing new places, keeping themselves motivated in life, and having fun.

4.2 Data Collected

Overall, we received 191 post-run surveys for an average of about 11 post-run surveys per participant, or 5.5 runs per week per participant. 95 of these were submitted in the first week, the week without using the app, while 96 of them were submitted the second week. There was significant variance in the number of easy, moderate, and hard runs in each week. This indicates that, despite having almost the same number of total runs week-to-week, runners did not follow a perfectly identical weekly schedule in their training. The highest number of runs a participant reported in a single week was nine, while the lowest was three. Despite the fact that we searched for participants who run four times a week on a regular basis, six runners only submitted three reports for one of their weeks. From a question on the final survey, we have determined that most runs were reported accurately. A majority of participants reported that they did not miss any post-run surveys and filled them out within an hour after every run. One participant reported filling out a few surveys a day late because they forgot. Seven participants reported missing one to two post-run surveys over the course of the study, mainly due to being in a rush after their run.

4.3 Perceived Exertion Results

Runners were asked to rate their perceived exertion after each run they completed for two weeks. The first of these weeks they did not use the Affirm on the Run app. The second week they used the app during their runs. Runners also separated each run into easy, moderate, and hard training run categories for better comparison of PE.

Using paired t-tests, the mean perceived exertion in every category of run decreased when runners were using the app. The mean perceived exertion also decreased when all runs

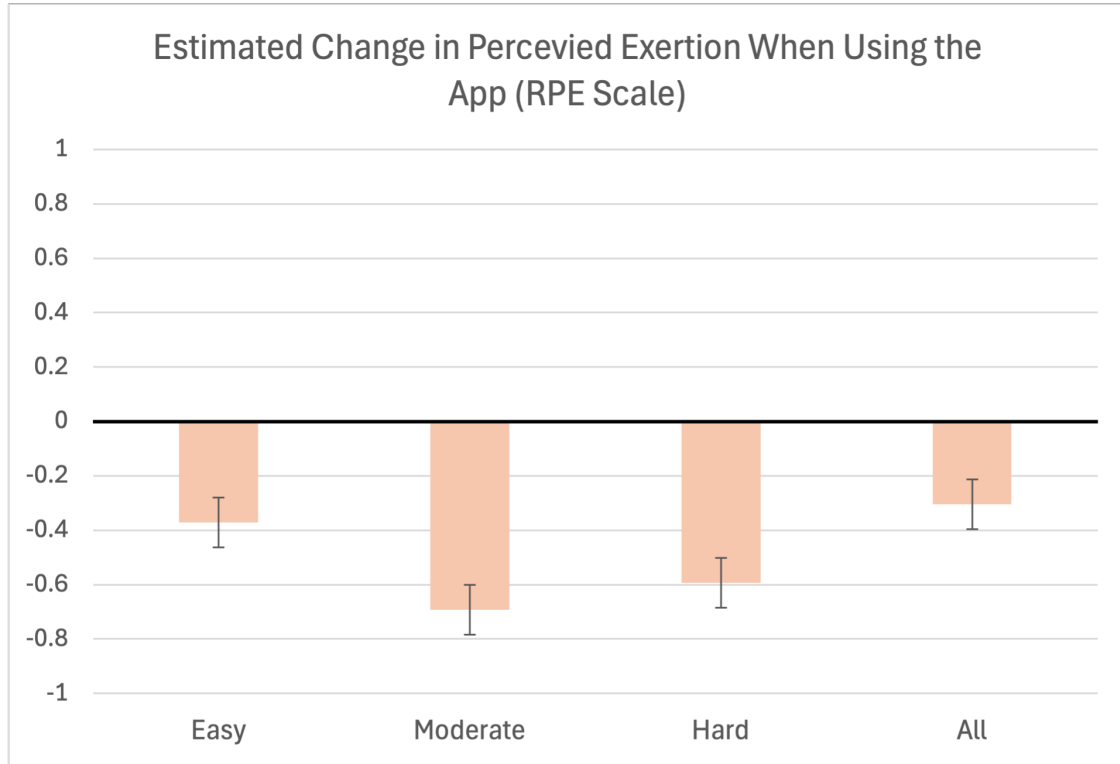


Figure 4.1: Estimated Change in Perceived Exertion on Runs Where the App was Utilized

were looked at as one category. However, this decrease was not statistically significant in a two-sided t-test for any single run category or the combined category. In a one-sided t-test, looking at only the alternative hypothesis of week one's perceived exertion being greater than week two, the results were statistically significant with a p-value of 0.047 for the moderate run category T-test results for perceived exertion can be found in [Table 4.1](#) and [Figure 4.1](#).

Table 4.1: Perceived Exertion Results

Run Type	Estimate	Statistic	P-Value	Parameter
Easy	0.371	1.659	0.117	16
Moderate	0.692	1.877	0.093	9
Hard	0.593	1.083	0.310	8
All	0.304	1.210	0.244	16

4.4 Psychological State Results

At the beginning, midpoint, and end of the study, runners were asked to fill out a PODIUM questionnaire designed to measure the psychological state of runners in six major areas: motivation, self-confidence, perceived physical fitness, perceived social support, cognitive anxiety, and somatic anxiety. Paired t-tests were used to compare the psychological state of the runners at the midpoint of the study, before they began using the Affirm on the Run app, to the psychological state of the runners at the end of the study, once they had been using the app for a week.

When using a two-sided t-test, a statistically significant increase in self-confidence was found with a p-value of 0.006. Participants' self-confidence about their training increased an average of 33.188 pts after using the Affirm on the Run app. We also found a statistically significant decrease in cognitive anxiety after use of the app. The decrease in cognitive anxiety was significant with a p-value of 0.025. In addition, we also observed a statistically significant increase in perceived physical fitness with a p-value of 0.022. T-test results for psychological state can be found in [Table 4.2](#) and [Figure 4.2](#).

To ensure these differences were due to use of the affirmation app and not due to the fact that the runners had completed another week of training and thus increased their confidence, we also compared the PODIUM scores at the beginning of the study to the PODIUM scores at the midpoint. This would capture any significant changes that happen across a regular week of run training with no affirmation app. We found no statistically significant differences in any of the six factors using two-sided paired t-tests when making this baseline comparison, including no significant difference in perceived physical fitness. This shows that simply training for one week did not significantly change runners psychological state, but training for one week with the Affirm on the Run application did have a significant effect in important

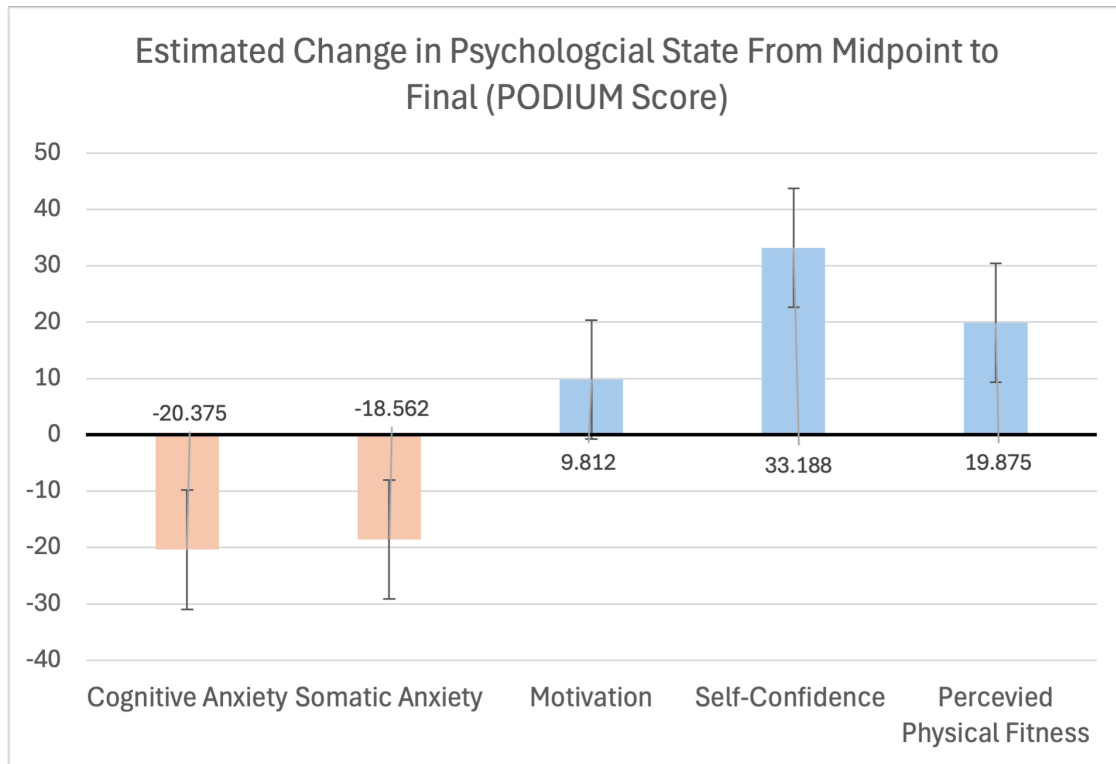


Figure 4.2: Estimated Change in Psychological State Between Midpoint and Final psychological areas. T-test results for baseline psychological state can be found in [Table 4.3](#)

Table 4.2: Psychological State Results Treatment

Factor	Estimate	Statistic	P-Value	Parameter
Cognitive Anxiety	20.375	2.492	0.025*	15
Somatic Anxiety	18.562	1.843	0.085	15
Motivation	-9.812	-1.514	0.151	15
Self-Confidence	-33.188	-3.178	0.006**	15
Physical Fitness	-19.875	-2.548	0.022**	15

Table 4.3: Psychological State Results Baseline

Factor	Estimate	Statistic	P-Value	Parameter
Cognitive Anxiety	-12.625	-1.285	0.218	15
Somatic Anxiety	-3.375	-0.333	0.744	15
Motivation	-0.938	-0.077	0.939	15
Self-Confidence	14.062	1.803	0.092	15
Physical Fitness	10.375	1.201	0.248	15

4.5 Cognitive Strategy Results

Runners reported the thoughts they had during each run via a free response question on the post-run surveys. Each thought was categorized as either inward associative, inward dissociative, outward associative, or outward dissociative to better understand each runner's primary cognitive strategy. I then calculated the percentage of thoughts each participant had in each category during week one and week two. I compared these percentages using paired t-tests. There were no significant differences in cognitive strategy between week one and week two. While we can see that some participants' primary cognitive strategy changed between weeks, for example, P12 had a 23% decrease in outward associative thoughts, and an increase in inward association and inward dissociation, there was no specific pattern of change across participants. Some participants became more associative, while others became more dissociative, causing the mean estimate of change in overall associative and dissociative thoughts between week one and week two to be zero. T-test results for cognitive strategy can be found in [Table 4.4](#) and [Figure 4.3](#).

Table 4.4: Cognitive Strategy Results

Strategy	Estimate	Statistic	P-Value	Parameter
Inward Association	-0.10	-2.53	0.804	16
Inward Dissociation	-0.007	-0.146	0.886	16
Outward Association	-0.005	-0.110	0.914	16
Outward Dissociation	0.022	0.568	0.578	16
Association	0.000	-0.007	0.995	16
Dissociation	0.000	0.003	0.998	16

4.6 App Experience Results

In each post-run survey during week two of the study, the week where runners were using the Affirm on the Run app, runners were asked about their experience using the app on that

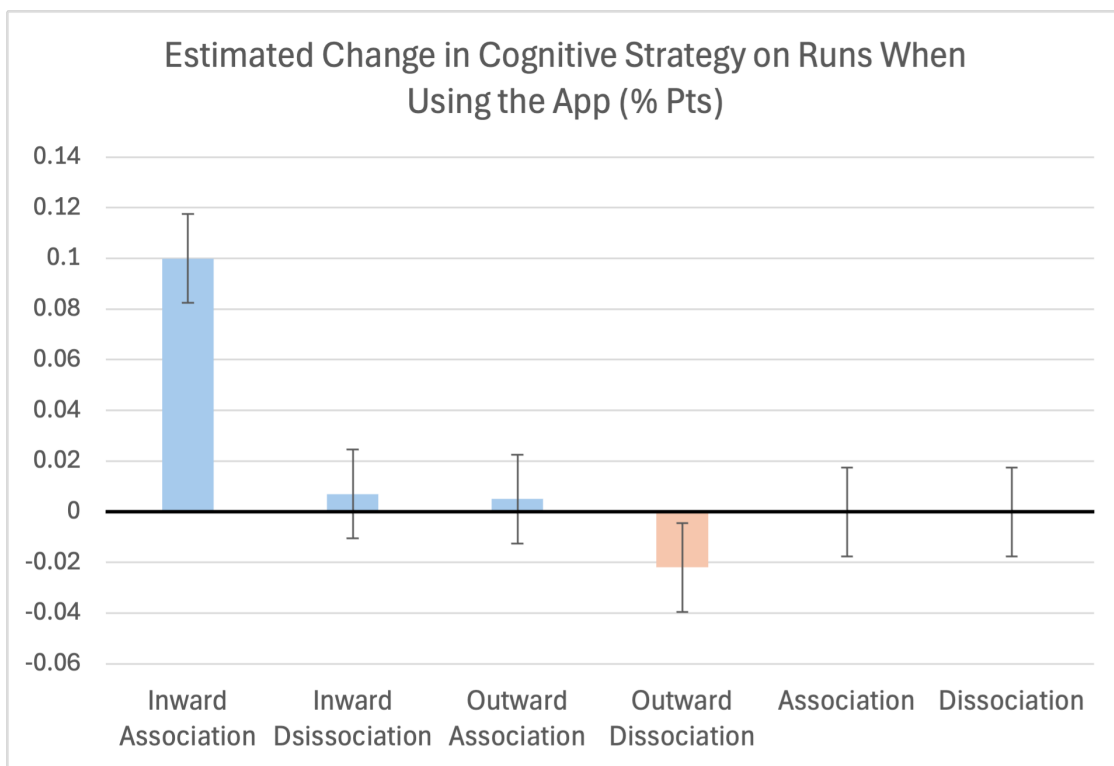


Figure 4.3: Estimated Change in Cognitive Strategy on Runs Where the App was Utilized

particular run. They were asked if they remembered viewing their affirmations and how they felt receiving the affirmations. This was a qualitative question. We took their written responses and coded them into positive, negative, or neutral experiences with the app.

Runners had overwhelmingly positive experiences with the app. Of the 96 runs participants went on while using the app, 58 of them had a completely positive experience with the app while on the run. Common themes among positive participant experiences were that the app helped them refocus, reminded them of their goals, distracted them from other metrics, caused a positive mindset shift, and was particularly helpful at difficult points of the run.

[Table 4.5](#) below shows examples of comments that fell into these themes:

19 runs were coded as neutral experiences with the app. On these runs, the app didn't seem to be particularly helpful to participants, but it was not annoying or harmful either. Runners often noted that they were running with friends, so they didn't look at the affirmations, or that their run was an easy run, so they did not feel an effect. Another reason participants cited for not feeling any effect from the notifications was already being in a good mood from something else, so they did not need them. Some runners had mixed emotions regarding the app over the course of run. Nine runners experienced positive thoughts towards some of their affirmations on the run, but felt neutral towards others. No runs were reported as a completely negative experience with the app, however some runs were reported as having negative experiences along with other neutral or positive experiences. Four runs were described as a mix of all three emotions towards the app in one run. Four runs were a mix of positive and negative experiences, while one was described as both negative and neutral. One main reason for having a negative app experience was the application interfering with other alerts the user wanted to see. The timing of their affirmation alert coincided with the timing of wanting to hit the lap button to mark a lap, or when a mile split should have occurred, and the watch only showed them the affirmation and did not allow them to complete these other

Table 4.5: Positive Experience Comments

Theme	Comment
Help in Difficulty	Very positive. Gave me a boost of energy and confidence to push the pace during my reps, especially near the end when I was fatigued.
Help in Difficulty	It did help a certain points when I was dying running up a hill though. Just a good mantra to repeat while finishing a hill.
Refocus	It helped keep me focused and shifted me to a positive mindset.
Refocus	I felt like it refocused me, instead of letting me get caught in the lulls of the run!
Positive Mindset Shift	Happy. My watch would buzz and I would read them and would think oh yeah I am strong or yes just stick the plan.
Positive Mindset Shift	They made me feel good enough, I was really struggling to get going this morning and the first mile was rough my legs were stiff. then when I got that first notification it started to feel easier and I enjoyed the run more
Goal Reminder	It was a good reminder that while today wasn't going the way I wanted it to go, the goal is on something bigger and further off in the distance.
Goal Reminder	It made me start thinking of my spring goals. Now that my legs have recovered from sickness and mileage is going up, I'm feeling more positive for training the next few months as it is easier to get out the door.
Distraction from Other Metrics	It was encouraging and centering to be brought back to my affirmations. It was helpful to have a notification besides the mile lap and split timers. This broke up the run nicely
Distraction from Other Metrics	it felt good to see those notifications during the run it helped keep me on track and stopped me from pushing the pace. When I would look down it would remind me to stop and look around and explore

actions. As such, it became a frustrating distraction. Some users also reported having issues changing and saving their affirmations before the run, so the affirmations did not correctly fit the scenario of the run they were on, causing a negative experience. Another common theme among negative experiences was the participant already being upset from something unrelated to running, causing a positive alert about running to be unhelpful towards their mood.

In addition to their qualitative answers, participants rated their app experience on a one to seven Likert scale after each run. The average Likert score across all runs in which the app was used was 5.7. Only one participant's average Likert score dipped below four, and this participant fell into the category of individuals who had a problem saving their affirmations and therefore never rewrote the default ones. As such, they found the affirmations did not fit their runs. Fourteen out of the 17 participants had an average Likert score of five or higher. This reflects the same results as their qualitative answers, as most participants reported very positive experiences with the affirmation app.

Chapter 5

Discussion

The Affirm on the Run App was designed to be a tool to improve the mentality of runners during their endurance activities. The goal of the Affirm on the Run user study was to investigate whether wearable technology is a useful tool to administer psychological interventions that improve mentality in endurance activities. Previous literature would suggest that positive messaging from wearable technology has the potential to create a positive effect during activity and lower perceived exertion, thus increasing exercise limits (see [section 2.5](#)) [2], [3]. In addition, affirmation practices have the ability to increase self-confidence and foster a more optimistic outlook on challenges, which are traits of more effective endurance athletes (see [section 2.6](#)) [10],[19]. The results of the study indicate that receiving affirmations from wearable technology does improve mentality during endurance running. Majority of participants had strong positive experiences with the application and the study produced quantitative indicators of improved psychological state. These findings suggest that wearable technology has a promising future in enhancing mentality during physical activity and future longitudinal studies may further uncover the sustained impact of wearable technology as a psychological intervention tool. The following paragraphs will discuss these findings through the framework of the four research questions.

5.1 RQ1: Runners' Experience Receiving Affirmation Alerts

Runners overall enjoyed viewing and receiving affirmation alerts on a wearable device. Participants expressed feeling more motivated and calmer when they received their affirmation alert. In contrast, previous literature on wearable technology found that runners often experience stress when checking data metrics on their watch during a run. Many runners find checking their data metrics —such as pace and distance— to be nerve wracking and distracting, taking them out of the activity instead of focusing them on their goals (see [section 2.1](#)) [17]. The affirmations evaluated in this study provided a more positive screen for users to view, while still allowing them to have their wearable device on to track their metrics for review after their run, which is the main purpose of wearable data for most runners (see [section 2.1](#)) [7]. Runners can still choose to view their metrics during their run, but they have other alerts and screens as a more stress-free option.

Participants' experiences with the affirmation app were uniquely different but still shared the same reports of benefiting from the app, showing the app's ability to benefit runners with different goals and competitive levels. The differences in app experience align with self-affirmation theory as affirmations work best when they are personal and bolster the user's idea of the self [8]. The experiences shared emphasized the fact that every runner's training, experience, and mindset is different. Even with this individuality, five distinct patterns emerged in the ways that the affirmations were found to be helpful. Participants found the affirmations to be helpful in pushing through in difficulty, refocusing, shifting to a positive mindset, reminding them of their goals, and distracting them from other metrics.

One of the main factors influencing affirmation interpretation was the goal of the run. On difficult runs, affirmations were seen as a reminder to push through difficulty. However, on

easier runs, they were taken as the opposite. Easy runs saw affirmations being viewed as a reminder to refocus, be positive, and enjoy the run. For example, on a run marked as hard, one participant stated:

”[It] gave me a boost of energy and confidence to push the pace during my reps, especially near the end when I was fatigued.” - P6

While the same participant on an easy run stated:

”Was tired and had a hard time getting out to do this run but affirmations helped me enjoy my time better.” - P6

On the difficult run P6 used the affirmations to help push further into discomfort, while on the easy run they used it as a reminder to enjoy their time. Runners saw a purpose in using the affirmations in both scenarios, even if that purpose was different. This is an especially important finding as some runners did not complete runs marked as hard, such as P2, but still reported positive benefits such as:

“I felt like it refocused me, instead of letting me get caught in the lulls of the run!” - P2

Not only did runners have positive experiences with the app, these experiences can apply to runner’s of all types and goals as they individualize their affirmations.

Of the 96 runs participants went on with the Affirm on the Run app, none were reported as completely negative experiences. Four runs contained a mix of positive and negative experiences over the course of the run, one run was described as a neutral and negative experience, and four runs expressed a combination of all three experiences over the course of

the run. The few negative experiences participants had while receiving alerts from the Affirm on the Run app resulted from technological difficulties. The two main issues encountered were difficulty saving newly written affirmations and conflicting watch alerts.

Currently, Garmin's app development language offers very limited options for designing user settings. These settings are difficult to save. The only way users can rewrite their affirmations is by accessing these settings. If a user was having difficulty writing their own affirmations, they were likely to use the default affirmations. As the individuality of user experiences showed, affirmations need to be personalized to a user's needs and goals for a specific run in order to be helpful. Users who used the default affirmations were less likely to have a positive experience and expressed negative feelings such as,

“One said ‘I am strong’, which made me think ‘no I’m not, I haven’t lifted weights in a month.’” - P25

Another technical difficulty that created negative experiences was the affirmation alert overtaking a different, more pressing, alert on the user's watch. When using the Affirm on the Run app, users were doing workouts where they wanted to receive their split alerts or hit the lap button to mark a repetition completed on the track. If an affirmation alert appeared while users were trying to complete these actions, it would block them from doing so, resulting in large frustration and a negative experience. For example, one participant wrote,

“At one point, the affirmation really annoyed me because the screen came up right when I was crossing the finish line for a rep and I wasn't able to get the split for the rep because when I hit the lap button, it just cleared away the affirmation and it didn't actually in the lap.” - P17

Currently, there is no way for an app developer or user to create a hierarchy of alerts or

button pushes in the Garmin app ecosystem. If users could create this hierarchy, they could prioritize their lap splits over their affirmation alert. This is another example of the need for individual user customization in order for wearable technology as a psychological intervention tool to reach its full potential.

Technical difficulties do not negate the fact that Garmin devices were the best choice for this study. It is important to build with the tools runners already use and enjoy. GPS sport watches are the most popular wearable for both serious runners and recreational runners. Beginner runners often transition to GPS sport watches as they become more involved in the sport, finding phone applications to be cumbersome (see [section 2.1](#)) [18]. The evidence I found therefore suggests that the developers of these devices should take a closer look at the importance of mentality in running and the role their devices play in it. They should consider how integrating customization of settings and alerts into their wearable devices could improve the mentality of their users and overall device experience, a topic discussed more in [section 6.2](#).

5.2 RQ2: Affirmation Alerts Effect on Psychological State

The results of this study showed that the Affirm on the Run app was useful in improving participants' overall psychological state related to their training, which could lead to an increase endurance performance. After a week of using the Affirm on the Run app during their training, participants were more self-confident with regards to their training and reported lower levels of cognitive anxiety. They also reported higher perceived physical fitness. This aligns with the benefits of positive affirmations as a general mental health practice. Pre-

vious research on positive affirmations as a mental health practice shows that affirmations decrease anxiety overtime while increasing self-confidence, with the end effect of increasing goal attainment (see [section 2.6](#)) [10]. The increase in self-confidence reported by participants is an indicator of increased endurance performance, as studies have shown the two are positively related (see [section 2.6](#)) [19]. The increase in perceived physical fitness found in the data could be correlated with the increase in self-confidence, as when athletes are more confident, they perceive themselves as more physically able. In addition, higher perceived physical fitness could eventually lead to lower perceived exertion at the same effort levels. If an athlete believes they are fit enough to accomplish a task, the effort may feel easier, lengthening their endurance limits. While we did not test for goal-attainment in this study, which is proven to be another benefit of using positive affirmations, this would be a good area of further research.

The decrease in cognitive anxiety found in this study has endurance performance benefits. The participants of this study were tested in a non-competition scenario. While anxiety has been shown to sometimes be interpreted as beneficial in a competitive setting, it has not been shown to be beneficial in training and is still believed to be an overall negative emotion for performance [19]. This significant decrease in anxiety aligns with qualitative comments that participants gave regarding receiving their affirmations, such as,

“I would see it and feel a sense of relaxation even though it was a hard workout.”

- P3

Mean motivation in participants increased in the week they used the affirmation app, aligning with the qualitative user experience feedback. While I hypothesized that the application would lead to an increase in motivation, it is unsurprising that this increase was not statistically significant, as it has been noted before that motivation is commonly assessed as a

long-term variable [19]. Many factors can affect a runner's motivation on any given day or in a given moment throughout a run. A runner's motives may change overtime as they change their goals. For the purposes of this study as an initial exploration of the use of wearable technology to enhance mentality, the increase observed is an indicator of potential long term motivational benefits.

Overall, the significant increase in self-confidence and perceived physical fitness and decrease in cognitive anxiety, coupled with the potential to further investigate a longer-term increase in motivation, shows that runners did benefit from the use of affirmations on their wearable during training. In addition, the increased confidence found could lead to increased goal attainment, which leads not only to success in running but other aspects of life as well.

5.3 RQ3: Affirmation Alerts Effect on Perceived Exertion

The use of the Affirm on the Run app lowered mean perceived exertion on all types of runs and qualitative user experience feedback found that the app helped runs feel easier for participants. The change in perceived exertion was not statistically significant, possibly due to not having enough data available to accurately capture the effects of perceived exertion. A difference in perceived exertion due to positive effect is more noticeable during difficult efforts, when perceived exertion is higher. This aligns with the fact that previous literature on using positive effect to lower perceived exertion made use of time-to-exhaustion tests to analyze perceived exertion (see [section 2.5](#)) [3], [2]. While the app is useful on both difficult and easy days, the help is more needed on difficult days. In their qualitative user experience feedback, runners reported that they felt the affect of the app the most on hard days. On

easy runs participants left comments such as,

“Since this wasn’t a workout or anything, I don’t think as much about the affirmations because I don’t feel like I have to lock in as much,” - P17

While on harder days more comments sounded like the one below:

“Was a hard workout but pace felt comfortable. Affirmations gave me confidence to push through my long cooldown and keep going.” -P6

Hard runs were the least captured type of run in the study. As runners were instructed to partake in their normal run training, we did not control the amount of hard, moderate, or easy runs participants had to complete. In the end, there were only 36 hard runs completed by all participants across the two weeks, compared to 110 easy runs and 40 moderate runs. In addition, the study did not force an identical week to week structure on participants. I hypothesized that runners would have nearly identical training in each week when following their natural training plans habits, but that was not the case. For example, one participant completed seven easy runs, one moderate run, and one hard run in their week without the application. In their week with the application, they completed two easy runs, four moderate runs, and three hard runs. Changes in perceived exertion need to be calculated on an individual basis, because individuals have a different baseline perceptions of effort. Some participants did not have a run in one of the categories to make a comparison with. This further limited the number of hard runs available for comparison.

Another difficulty this study had compared to previous studies using positive effect to lower perceived exertion is that perceived exertion metrics were not being taken in real-time. In our study participants were being asked to reflect back on what they believed their perceived exertion was during the effort. Perceived exertion can change at many points throughout

a run, this is why previous studies have taken PE measures periodically throughout the endurance effort instead, in order to properly chart this change.

I believe that the decrease in mean perceived exertion found in this study given the limited amount of difficult run data, and its alignment with qualitative feedback on how the app benefited participants' during difficult efforts, is a strong indicator that the Affirm on the Run App can lower perceived exertion on runs. Future testing for significance of this finding is outlined in [section 6.1](#).

Despite these limitations of a real-world training scenario, this study benefited from the use of a such a scenario. Previous work on positive effect to lower perceived exertion has all been conducted in laboratory settings mainly using time-to-exhaustion tests. Most endurance training does not consist of time-to-exhaustion efforts, but steady work at a manageable level of exertion. Our findings highlight how creating a positive effect using wearable technology can still be useful at these manageable levels of exertion encountered in training. Participants found benefits from positive effect in all run types, even easy runs. In addition, it is important to know how affirmations from a wearable affect an athlete when they are alone with their thoughts, as opposed to when they know they are being watched by researchers. If users found the technology to be disruptive or irritating, they would be more likely to notice this when using it regularly in their everyday routine than in a lab setting that they view as a temporary. As the goal of this study was to explore whether psychological interventions can be worked into runners' everyday tools, it is important to know whether it fits into their everyday life.

5.4 RQ4: Affirmation Alerts Effect on Cognitive Strategy

The use of affirmations on a wearable had no measured effect on a runner's cognitive strategy. This finding aligns with the fact that previous literature has not found that one mental strategy is superior to others in furthering the limits of endurance athletes (see [section 2.3](#)). This study found that between week one and week two the dominant cognitive strategy among the participant group shifted. In week one, outward dissociation was the most common strategy by a small margin while in week two outward association was the most common, again by a very small 1% margin. However, individual participants did not shift their cognitive strategy in any consistent pattern. In studying the cognitive strategies of marathon runners and their relation to hitting the wall, previous research did not find evidence that one mental strategy was superior to another, even though professional runners tend to use more associative strategies while recreational runners tend to favor dissociation [32], [28] (see [section 2.3](#)).

This findings provides evidence for the fact that it is not the specific cognitive strategy that determines the perception of effort, and ability to overcome one's endurance limits. It is instead the general positive effect that boosts endurance. Participants qualitatively reported that the app refocused them and shifted them to a more positive mindset, despite not having a large change in cognitive strategy. Many external factors can influence whether a runner's thoughts are associative or dissociative, especially when we are analyzing everyday training as opposed to a race. Some of the influences observed in this study included: whether runners ran with friends or alone, whether it was nice weather out or bad weather, and how the runner's day at work was. A runner can have positive dissociative thoughts, or positive associative thoughts, the important thing to endurance limits is that the thoughts remain positive.

Chapter 6

Future Work

This study was designed as an initial exploration of wearable technology's ability to bolster mentality in endurance efforts. Three main areas of future research emerged from this exploration. Given the positive results of this study, that the Affirm on the Run app was able to improve psychological state of runners and provide a positive experience, future research should be dedicated to longitudinal studies to understand the sustained impact of this psychological intervention. In addition, the few negative user experiences reported from this study can be used to inform design improvements for future development of psychological intervention tools for wearable devices. Finally, testing the Affirm on the Run app in other endurance sports and in race or group settings is an important step in applicability of these findings to other areas of endurance performance.

6.1 Longitudinal Study

This study consisted of two one-week training blocks. This study duration allowed for a good comparison of the baseline mental state of runners to their mental state when using the app and allowed us to gather 96 runs worth of app experience data. However, it did not allow us to chart the effects of the affirmation app overtime. It would be beneficial to the wearable technology field to know whether continued use of the Affirm on the Run app overtime leads to an increase in the psychological effects found here, namely a further

increase in self-confidence and perceived physical fitness, and a further decrease in anxiety. This study has also illuminated two areas for future longitudinal study that require more specific focus: perceived exertion and motivation. Future studies should not invest time into the study of cognitive strategy, as this study found it to be unaffected by the Affirm on the Run app and previous studies indicate it is not a significant factor in determining endurance performance (see [section 2.2](#)) [32].

The lack of hard runs recorded by participants in this study limited its ability to capture the Affirm on the Run app's effect on perceived exertion. This is something that should be investigated using a longitudinal study in the future as perceived exertion is the biggest indicator of endurance limitations [23]. In order to better inform future studies, a post hoc power analysis was conducted with the perceived exertion data from this study [16]. A post-hoc power analysis is designed to test the likelihood of detecting a true significant effect if one exists. The power was calculated for each category of run type. The easy run results had 31.7% power, the moderate run results had 13.4% power, and the hard run results had 8.4% power. These are all low power ratings, supporting the idea that more runs need to be collected over a longer period of time to yield significant results. This also aligns with the belief that the limited number of hard runs in this studied made it less likely for a significant effect to be found. A sample size calculation was also done with the same calculator to determine the sample size needed for adequate study power [16]. It was found that data from 302 easy runs, 220 moderate runs, and 408 hard runs would be necessary to reach adequate study power and determine the true significant effect of the Affirm on the Run App on perceived exertion. Future researchers should keep these numbers in mind when designing longitudinal studies.

Even with limited data, the findings of this study revealed indicators of a decrease in perceived exertion. This shows that there is potential to use an affirmation application for

this purpose. The ability to lower perceived exertion using a wearable device could lead to an endurance boost for many athletes [3]. A long-term study that only requires participants to fill out post-run surveys on days in which they complete difficult workouts may be warranted. Difficult workouts are where we expect a positive effect to be most useful in decreasing perceived exertion. This structure limits the survey burden on participants, keeping them engaged in the study longer, while still allowing for a proper long-term comparison of perceived exertion.

The results of this study revealed that use of the Affirm on the Run app was related to an increase in motivation. This short-term increase in motivation was not significant, but a longitudinal study may reveal significant effects of the affirmation app on motivation as motivation is a variable thought to be better examined in the longer term [19]. To study the applications' long-term effect on motivation, only weekly PODIUM questionnaires would be needed, greatly lessening the survey burden on participants which facilitates more engaged long-term participation. This format would also allow the researchers to track the other psychological effects, an increase in self-confidence and perceived physical fitness and a decrease in cognitive anxiety, over time to see whether these changes become more pronounced overtime [19], [20].

Finally, a longitudinal study of the same format as the one conducted in this paper could be beneficial in gathering further feedback on app experience. For many participants in this study, the Affirm on the Run App was a new and exciting addition to their technology. It is important to know whether users continue to have positive experiences with the application overtime, or if the novelty of receiving their affirmations subsides. In addition, users' habits in writing their affirmations play a large role in their experience. As we observed, users who did not tailor their affirmations to themselves had more negative experiences. It would be important to observe whether users continued to rewrite their affirmations overtime,

adjusting them to their new goals, or whether this task becomes too much effort as their use continues.

6.2 Design of Future Psychological Intervention Tools for Endurance Athletes

As noted in the results on app experience, the ability to customize the Affirm on the Run app to fit a user's needs played an important role in determining whether users had a positive or negative experience with the application. Both developers of wearable devices and developers of psychological intervention applications for wearable devices can learn from the importance of personalization stressed by the results of this study. At the time of this paper, the Affirm on the Run app currently has 100+ downloads from the Connect IQ App Store and a 4.6 star rating, showing that users outside the study have sought out an app to assist with their mental performance and enjoyed using it. Large interest and high ratings show that this is a promising area for future development. The app continues to be available on the app store today.

I suggest that wearable device developers should integrate personalization features for future tools to create not only a more positive experience with these tools, but a more positive experience with wearable devices overall [17]. To better support applications that send activity alerts, the Garmin ecosystem and other wearable technology ecosystems should support settings for a hierarchy of alerts. This would allow users to specify that alerts related to their physical activity should take precedence over alerts from a psychological intervention application. This would alleviate the mid-workout frustration users had with the application in this study. In addition, application settings should be designed to auto-

save or have a clearly denoted save feature. This would prevent the issues users had with saving their affirmations.

Developers of psychological intervention tools for wearable devices should take into account that every athlete will have their own goals and needs that may change according to training on a daily basis. This was evident in the nuanced experiences each user had with their affirmations that changed based on whether they were taking on an easy run or a hard run. In future versions of psychological intervention tools similar to the Affirm on the Run App, reminders should be integrated to alert runners to reevaluate and rewrite their affirmations. Without these reminders, runners become complacent with default settings and do not get the benefit out of the tool. Alert timing is another area I suggest improving in future versions of the Affirm on the Run App. To standardize the user study for the purposes of this research, affirmations were delivered at 10-minute intervals. However, in reality, users of this application would know their training better than the application developer. As such, features should be integrated that allow users to write specific affirmations for specific points on their run. Settings could be designed so that users have the option to write affirmations that appear at a looped interval, such as the one in the study, or to write an affirmations that will appear at a specific time. This would help with longer efforts, such as marathons or long training runs, in which users may find affirmations more helpful later in the effort. In addition, affirmations could be set based on distance run as well as time. To provide better default alert timing to users, future work can examine the desired balance between interruptions and reactions to alerts as alert timing was an area not examined in this research [27].

6.3 Testing in Other Endurance Efforts and Settings

This study focused on the effect of a psychological intervention tool being integrated into wearable technology for running specifically. However, Garmin watches and other GPS sport watches are used for many other endurance feats, such as cycling, hiking, or swimming. Many previous studies that evaluated lowering perceived exertion in endurance feats did so with cycling tests [2]. It will be important to the development of future wearable psychological intervention tools to know if using this application during other kinds of endurance training yields similar results, or if different endurance sports hold different design challenges [9]. This is especially important if the creators of wearable devices want to integrate these tools into the device themselves as opposed to using an externally downloaded application. Features integrated into the device should be beneficial for all its sport functions.

This study evaluated running mainly in a training setting. One participant did report wearing their device during a race, and having a positive experience, noting, “It kept me tough in the middle of my race when I started hurting and wanting to slow down, but I was able to grit my teeth and stay[ing] engaged in the race.” One participant also contacted us after the experiment, to let us know that they had continued to use the application to complete a marathon and found the app to be extremely helpful in the last six miles of their race when they felt physically bad and no longer wished to view their metrics. However, most participants did not participate in any races during their weeks with the device and thus all other reported runs were training runs. There is potential that users find this application more helpful in a race setting, when their anxiety is at its highest and they are trying to push through exhaustion [19]. This would align with comments that the application was most helpful on difficult runs. Testing this application in a competition may also result in the significantly lower perceived exertion when using the application that we did not see in

training. A competitive setting is more similar to the time-to-exhaustion tests conducted in previous studies [3]. There is, however, a possibility that participants find the app alerts disruptive or irritating in a competitive setting in which they are trying to focus. Examining the balance of alerts in competitive settings would be beneficial to further development of psychological intervention tools [27].

This study evaluated individuals in their running and did not look at teams or the motivation factors that can accompany team training. Confining the study within one running team would help alleviate some of the issues with differing run schedules encountered in this study and could yield interesting future results with respect to social support and motivation. Working with a group could also inform the design of a more social version of the affirmation application. Currently, the study enrolled users on an individual basis and was catered towards participants who train largely on their own. Conducting a similar study where all the participants were on the same team could solve the issue of different training routines making week-to-week comparisons difficult. Athletes who are on the same team tend to have similar training routines with the same number of easy, moderate, and hard days a week. In addition, the coach would be able to explain the training structure prior to the start of the research study and the study could be tailored towards that structure. Using a specific group of people would also allow for analysis of the social components of mentality in distance running. Perceived social support is a metric measured by the PODIUM questionnaire that we did not analyze in this research [19]. Higher perceived social support has the potential to increase running performance and may also improve other psychological state factors such as motivation. Group testing could inform a new application design in which users can connect with each other and write each other affirmations [6]. Social aspects of fitness applications have been linked to increase motivation. [31].

Chapter 7

Conclusion

This study concludes that wearable technology is a useful psychological intervention tool to improve mentality in endurance activities that should be developed further. The Affirm on the Run app is a psychological intervention tool for Garmin wearable devices that was designed to test how runners respond to receiving self-written positive affirmations via wearable technology on their runs. The results from this study showed that for the majority of participants the experience of receiving positive affirmations from their wearable was positive one on almost all training runs. The alerts from the app were seen as an asset in motivating them through runs and refocusing them towards their goals. This finding should encourage future developers of wearable devices to integrate psychological intervention tools or highlight psychological intervention applications available for download, as it stands in opposition to previous research on how runners often feel when checking a wearable during their training runs. While runners find their wearable devices helpful, they often experience stress and distraction when checking their metrics on them during activity. This anxiety was not present when checking the Affirm on the Run app creating an overall positive experience with the device. This not only shows potential for using wearable technology to create a positive effect that improves endurance performance but also suggests that the messaging received from wearable devices plays an important role in whether they are perceived as helpful or stressful.

In addition to positive qualitative feedback, this research found that self-confidence and

perceived physical fitness increased significantly when runners trained with the app, while cognitive anxiety decreased significantly. This shows that messaging from a wearable device has the potential to affect mentality not only in the time the wearable is being used during activity, but also afterwards as the runner goes about their daily life. This finding can inspire future wearable design for day-to-day life. Affirmations on a wearable device could have the potential to improve mentality even when used during the workday.

There were also signs of lower perceived exertion on runs when using the Affirm on the Run app. This finding needs to be explored further with more data as not enough difficult runs were collected to accurately make perceived exertion comparisons. However, as endurance athletes are thought to be ultimately limited by their perceived exertion, even the improvements noted in this study are a sign that this area is worth further exploration as the ability to lower perceived exertion using a wearable could lead to highly accessible performance increases.

The study found no significant changes in cognitive strategy when using the affirmation application, which aligns with previous research suggestions that there may be no single cognitive strategy that is superior for endurance performance. This finding could help future researchers focus their attention on the sentiments of thoughts instead of the cognitive strategy, because, while there is no proof of cognitive strategy as a performance indicator there is proof that creating a positive effect can increase endurance performance.

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Appendices

Appendix A

Questionnaires

A.1 Initial Survey



Initial Survey

Welcome to the Affirm on the Run Study! We appreciate your interest. Please see below for more information on the study. Check the box to consent and continue.

Affirmations on the Run: VT IRB # 24-1137

Principal Investigator: Dr. Scott McCrickard, mccricks@cs.vt.edu

Other study contact(s):

- **Primary Study Contact: Mary Kate McGranahan, mkmcgranahan@vt.edu**

Key Information: The following is a short summary of this study to help you decide whether or not to be a part of this study. More detailed information is listed later on in this form.

The goal of this research is to gain insight into whether wearable technology, in this case running watches, can be a useful tool to help improve mental performance during endurance efforts. If you chose to participate in this study, you are someone that already runs on a regular basis and owns a Garmin wearable device. You will be asked to complete surveys following your regular runs over the course of a week. Then, you will be asked to download an application for your Garmin device. The application will encourage you to write positive affirmations which you will then receive on your runs. You will be asked to complete a set of surveys about your runs while using the app over the course of a week. The study will take two weeks in total.

The following is more detailed information about this study in addition to the information listed above.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, **talk to the research team at mkmcgranahan@vt.edu.**

This research has been reviewed and approved by the Virginia Tech Institutional Review Board (IRB). You may communicate with them at 540-231-3732 or irb@vt.edu if:

- You have questions about your rights as a research subject
- Your questions, concerns, or complaints are not being answered by the research team
- You cannot reach the research team

- You want to talk to someone besides the research team to provide feedback about this research

How many people will be studied?

We plan to include about 20 people in this research study.

What happens if I say yes, I want to be in this research?

If you consent to this research, you will be sent your first study survey. You will complete a series of surveys over the course of two weeks as follows. You will be expected to download a Connect IQ app on your Garmin device. Surveys and survey reminders will be sent to you via email and can be taken on your own time, but post-run surveys are expected to be completed as immediately as possible following your run.

Beginning the study: 5min

Initial Survey- Consent to study, answer questions about running background, complete your first survey on your feelings about your running training

1 Week: 5mins per run

Post Run Surveys- Complete a post run survey after every run you do as part of your standard running routine

Mid Point: 15mins

Mid-Point Survey- Complete a survey on your current feelings on your running training, download the Affirm on the Run App for your Garmin device and set it up

1 Week: 5mins per run

Post Run Surveys- Complete a post run survey after every run you do as part of your standard running routine

Final: 5mins

Final Survey- Complete a final survey on your current feelings about your running training

What happens if I say yes, but I change my mind later?

You can leave the research at any time, for any reason, and it will not be held against you.

If you decide to leave the research, contact the investigator so that the investigator can remove your survey data from the study and, if the subject feels comfortable doing so, optionally share the reason for withdrawal. You may also refuse to answer any questions you don't want to answer and remain in the study.

Is there any way being in this study could be bad for me?

There are no known risks to participating in this study.

What happens to the information collected for the research?

We will make every effort to limit the use and disclosure of your personal information, including research study records, only to people who have a need to review this information. We cannot promise complete confidentiality. Organizations that may inspect and copy your information include the IRB, Human Research Protection Program, and other authorized representatives of Virginia Tech. The researchers will anonymize your survey answers using a random id value. The survey data will be uploaded to a secure password-protected account belonging to the researcher. The researchers will maintain a list that includes a key to match your contact information to the id values in a separate file from your survey answers.

If identifiers are removed from your private information or samples that are collected during this research, that information or those samples could be used for future research studies or distributed to another investigator for future research studies without your additional informed consent.

The results of this research study may be presented in summary form at conferences, in presentations, academic papers, and as part of a thesis.

Can I be removed from the research without my OK?

You will not be removed from the research without your request. If you do not complete the study, your data will be removed from the research summary.

What else do I need to know?

This research is being funded by Virginia Tech Center for Human Computer Interaction.

If you agree to take part in this research study, you will also receive \$15 in the form of an amazon gift cards for your time and effort. This is dependent on full completion of the study.

Your information and samples (both identifiable and de-identified) might be used to create products or to deliver services, including some that may be sold and/or make money for others. If this happens, there are no plans to tell you, or to pay you, or to give any compensation to you or your family.

We will not offer to share your individual test results with you.

If you consent to participate in this research study, check the box below and continue! If you do not consent, you can simply close the page as the survey will not advance without consent. Thank you!

I Consent to Take Part in this Study

Please insert your information in case you need to be contacted at any point in the study, contact information will not be stored with survey answers. This email address will be used to send you future surveys so please ensure it is one you check regularly.

* First Name

* Last Name

* Email Address

* How old are you?

Under 18

18-24

25-34

35-44

45-54

55-60

Above 60

Gender

Male

- Female
- Non-Binary
- Choose to self-describe
- Choose not to disclose

Use this box if you choose to self-describe

*** How often do you run**

- <4 times a week
- 4-5 times a week
- 6-7 times a week
- >7 times a week

*** Describe your running experience**

*** Describe your current goals for running (ex: training for a specific event distance, to stay healthy, training for a specific time goal, to make friends etc.) and experience with running (ex: ran in college for four years, picked it up for fun a year ago, etc.)**

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Tense Relaxed

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.



Next

Content Troubled

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.



Next



Optimistic

Pessimistic



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Insecure

Secure



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

With Help

Without Help



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Overwhelmed

Comfortable



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Fit

Out of Shape



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Not Worried

Worried



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Determined

Undetermined



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Doubtful

Confident



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Alone

Connected



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Motivated

Unmotivated



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



At ease

Nervous



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Driven

Not driven



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Prepared

Unprepared



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Supported by others

Without support



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Encouraged

Discouraged



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Weak

Strong



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.



Done



A.2 Post-Run Without App Survey



Post Run Survey- Without App

How long was your run (in miles)

On a scale of 1-10, 1 being the shortest you ever run, 10 being the longest you ever run, how does this length fit into your training?

1

1 - 10 Borg Rating of Perceived Exertion Scale	
0	Rest
1	Really Easy
2	Easy
3	Moderate
4	Sort of Hard
5	Hard
6	
7	Really Hard
8	
9	Really, Really, Hard
10	Maximal: Just like my hardest race

Based on the following scale, where would you rate your exertion during

this activity?

- 1
- 2
- 3
- 4
- 5

- 6
- 7
- 8
- 9
- 10

What type of run was this designed to be? (select what best fits)

- Easy Run
- Moderate Run
- Hard Run

Briefly describe what you thought about during your run, can be vague (ex: What I was going to eat for dinner, my mile splits, that I was going too slow/too fast, a problem I've been having):

A.3 Mid-point Survey



Mid-Point Survey

Congrats you are halfway through the study, thank you again for participating. This halfway survey will consist of a questionnaire related to your current feelings about your training, followed by instructions on how to download the app needed for the second half of the study. We recommend doing this questionnaire on a computer or other larger device and having your mobile phone and watch on hand to download the application. This is the longest task of the study, the survey and download should take about ~15mins to complete.

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Tense

Relaxed



Next

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Content

Troubled



Next



Optimistic

Pessimistic



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Insecure

Secure



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

With Help

Without Help



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Overwhelmed

Comfortable



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Fit

Out of Shape



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Not Worried

Worried



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Determined

Undetermined



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Doubtful

Confident



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Alone

Connected



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Motivated

Unmotivated



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



At ease

Nervous



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Driven

Not driven



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Prepared

Unprepared



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Supported by others

Without support



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Encouraged

Discouraged



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Weak

Strong



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Untrained

Trained



Done



The next portion of this study will require you to download an app from the Garmin Connect IQ app store, please follow the instructions below and contact mkmcgranahan@vt.edu if you have any questions.

Download the Garmin Connect IQ Store on your mobile phone if you do not already have it, available in both the App and Google Play Store.



Connect IQ™ Store

Garmin

Update



Sign into the Connect IQ store using the same credentials as your Garmin Connect account. Any devices currently synced on your Garmin connect account should automatically sync with the Connect IQ Store. You can connect or view your devices in the bottom right hand corner.

Featured Apps





How to Decorate a Christmas Tree?



How to Decorate a Christmas Tree?

4.5 ★



Hot & Fresh Apps

[See All](#)



GB Fenix8 Like PRO

\$3.99 USD 4.6 ★



Lumeo

\$2.49 USD 4.3 ★



YouTube Music

3.4 ★

Trending Apps

[See All](#)





Maps4Garmin (Free) with Weather Radar (Paid)

4.6 ★



Store



Search



Face it



My Device

Search for "Affirm on the Run" in the search bar. Select the app you see below and click Install.



Affirm on the Run



Affirm on the Run

MaryKateMcG

±100+ | 0.0 ★ (0) | ⊖ Data Field

↓ Install

Info

Reviews



Once installed, click on your device in the bottom right hand corner. You should see a list of installed apps categorized by type. Click on "My Data Fields" and you should see the Affirm on the Run app.

Forerunner 265S

✓ Connected





Installed Apps



5 installed

27 remaining

Space Available : 61.95 MB

-  My Watch Faces 0 >
-  My Device Apps 3 >
-  My Data Fields 1 >
-  My Music 1 >

Updates 0 >

Auto Update



Update Notifications



Receive notifications about available updates for the content you have downloaded.



Store



Search



Face it



My Device

Click on the Affirm on the Run App in My Data Fields and you should see an option for Settings.



Affirm on the Run

MaryKateMcG

↓ 100+ | 0.0 ★ (0) | ⊖ Data Field

 Settings

Uninstall

Click on Settings and here you will find a space called Your Affirmations where you can write your affirmations. You can come back here at any point during the study and rewrite your affirmations. Your changes should push automatically to your watch app when saved. You will see some default affirmations in there already, but please take a moment to write your own. You need to write at least three affirmations, but have space for up to five. Here is some advice to get you started:

- 1- Keep your affirmations in the first person, use I statements.
- 2- Consider your goals, your affirmations should be personal to you.
- 3- Keep your affirmations in the present tense, as if you already are what you want to be.
- 4- Make your affirmations positive, think about what your strengths are.
- 5- Come back and refresh them regularly!



Settings

First Affirmation

I enjoy the process I am in

Second Affirmation

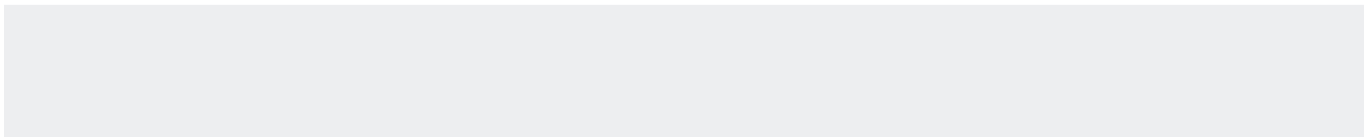
I am self-disciplined and consistent

Third Affirmation

I am strong

Fourth Affirmation

Fifth Affirmation



Almost done! Now we need to enable the Affirmation alerts on your watch. Follow the instructions below:

Add Affirm on the Run Data Field to your Running Activity



Go to start a run the way you normally would on your watch, but do not start it yet! Instead hold down the button you normally use to access settings or set your watch fields, this button will be different depending on which Garmin you have. Once in settings, select "Run settings".



Once in Run Settings Select Data Screens



Scroll down in your data screens until you see Add New

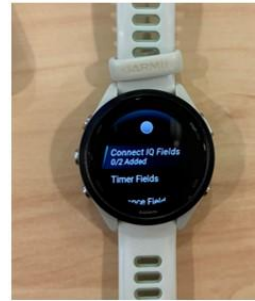
Add Affirm on the Run Data Field to your Running Activity



Select Custom Data



Select the blank field to see your options for Adding a Data Field



Select Connect IQ Fields

Add Affirm on the Run Data Field to your Running Activity



Select AffirmOneTheRun



From here you can select the order you want your data screens to appear in, place the AffirmOnTheRun screen wherever you would like.



The screen should now appear in your data screen scroll

Last Step: Enable alerts for the Affirm on The Run App, this is very important for the study! Follow the instructions below

Enable Alerts for Affirm on the Run Data Field



Go back to your run settings, but this time select Alerts instead of Data Screens



Select Add New



Scroll to the bottom of the list and select Connect IQ

Enable Alerts for Affirm on the Run Data Field



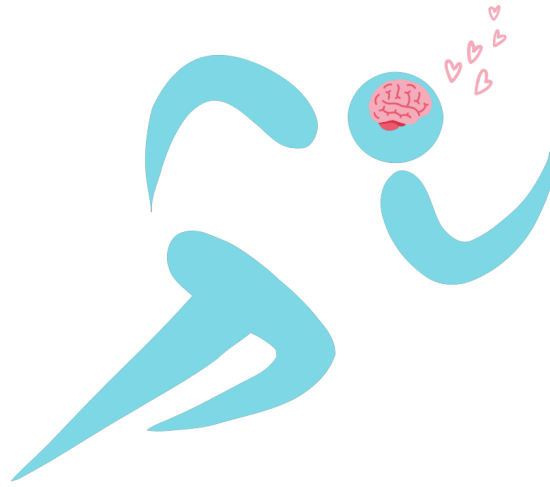
Toggle the AffirmOnTheRun Alert to On

All Done! Now you should be all set up to complete the next week of the study. Go on your runs as usual and complete your next set of post run surveys after each run, this time with the addition of your new app. Feel free to go in and rewrite your affirmations in the app settings as many times as

you see fit. If you had any issues with set up, please contact mkmcgranahan@vt.edu. If not, please check the box below to indicate you are ready to move on!

Keep Running!

A.4 Post-Run With App Survey




Post Run Survey- With Affirm on the Run App

How long was your run (in miles)

On a scale of 1-10, 1 being the shortest you ever run, 10 being the longest you ever run, how does this length fit into your training?

1



1 - 10 Borg Rating of Perceived Exertion Scale	
0	Rest
1	Really Easy
2	Easy
3	Moderate
4	Sort of Hard
5	Hard
6	
7	Really Hard
8	
9	Really, Really, Hard
10	Maximal: Just like my hardest race

Based on the following scale, where would you rate your exertion during

this activity?

- 1
- 2
- 3
- 4
- 5

- 6
 - 7
 - 8
 - 9
 - 10
-

What type of run was this designed to be? (select what best fits)

- Easy Run
 - Moderate Run
 - Hard Run
-

Briefly describe what you thought about during your run, can be vague (ex: What I was going to eat for dinner, my mile splits, that I was going too slow/too fast, a problem I've been having):

How many affirmations did you have written for this run?

- 3
 - 4
 - 5
-

What did you focus your affirmations on?

When is the last time you rewrote your affirmations?

Do you remembering viewing your affirmations on this run? Approximately many times do you remember seeing an affirmation?

Describe in your own words how you felt when receiving an affirmation notification on this run (approximately 2-5 sentences)?

Rate your App Enjoyment Experience

- 1- Completely Unsatisfied
 - 2- Mostly Unsatisfied
 - 3- Somewhat Unsatisfied
 - 4- Neither Satisfied nor Dissatisfied
 - 5- Somewhat Satisfied
 - 6- Mostly Satisfied
 - 7- Completely Satisfied
-

A.5 Final Survey



PODIUM Questionnaire Final

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Tense

Relaxed



Next

Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Content

Troubled



Next



Optimistic

Pessimistic



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Insecure

Secure



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

With Help

Without Help



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Overwhelmed

Comfortable



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Fit

Out of Shape



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Not Worried

Worried



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Determined

Undetermined



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Doubtful

Confident



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Alone

Connected



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Motivated

Unmotivated



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



At ease

Nervous



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Driven

Not driven



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Prepared

Unprepared



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Next



Supported by others

Without support



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Encouraged

Discouraged



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Weak

Strong



Next



Please select the point on the line that better shows how you feel, RIGHT NOW, about your training.

Untrained

Trained



Done



Did you ever neglect to fill out post run surveys after your runs over the course of this study? If so, please state how often you think this happened and your reasons for not filling out the post run surveys.

Do you consent to potentially being contacted in the future for follow-up research

Yes

No

Appendix B

IRB Approval



**Division of Scholarly Integrity and
Research Compliance**
Institutional Review Board
North End Center, Suite 4120 (MC 0497)
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-3732
irb@vt.edu
<http://www.research.vt.edu/sirc/hrpp>

MEMORANDUM

DATE: January 16, 2025
TO: Scott McCrickard, Mary Catherine McGranahan
FROM: Virginia Tech Institutional Review Board (FWA00000572)
PROTOCOL TITLE: Affirmations on the Run
IRB NUMBER: **24-1137**

Effective January 16, 2025, the Virginia Tech Human Research Protection Program (HRPP) determined that this protocol meets the criteria for exemption from IRB review under 45 CFR 46.104 (d) category(ies) 2(ii),3(i)(B).

Ongoing IRB review and approval by this organization is not required. This determination applies only to the activities described in the IRB submission and does not apply should any changes be made. If changes are made and there are questions about whether these activities impact the exempt determination, please submit an amendment to the HRPP for a determination.

This exempt determination does not apply to any collaborating institution(s). The Virginia Tech HRPP and IRB cannot provide an exemption that overrides the jurisdiction of a local IRB or other institutional mechanism for determining exemptions.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

<https://secure.research.vt.edu/external/irb/responsibilities.htm>

(Please review responsibilities before beginning your research.)

PROTOCOL INFORMATION:

Determined As: **Exempt, under 45 CFR 46.104(d) category(ies) 2(ii),3(i)(B)**
Protocol Determination Date: **January 16, 2025**

ASSOCIATED FUNDING:

The table on the following page indicates whether grant proposals are related to this protocol.

Date*	OSP Number	Sponsor

* Date this proposal number was added.

If this protocol is to cover any other grant proposals, please contact the HRPP office (irb@vt.edu).

Appendix C

CR10 Scale

1 - 10 Borg Rating of Perceived Exertion Scale	
0	Rest
1	Really Easy
2	Easy
3	Moderate
4	Sort of Hard
5	Hard
6	
7	Really Hard
8	
9	Really, Really, Hard
10	Maximal. Just like my hardest race

Figure C.1: Borg's CR10 Scale