THESIS

RIDE, RECORD, REPEAT: TRACKING OF CYCLING DATA AS COMMUNICATION ON THREE LEVELS AND HOW EACH MEET A CORRESPONDING BASIC PSYCHOLOGICAL NEED

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ABSTRACT

RIDE, RECORD, REPEAT: TRACKING OF CYCLING DATA AS COMMUNICATION ON THREE LEVELS AND HOW EACH MEET A CORRESPONDING BASIC PSYCHOLOGICAL NEED

Self-tracking of health related data has grown more popular in the last decade. It is helpful to view this behavior as communication on three levels: communicating with the device, communicating with the self, and communicating with others. One theory of motivation, Self-determination Theory claims that motivation is internalized and therefore more effective to the degree to which the basic psychological needs of autonomy, competence, and relatedness are met. In this qualitative study, 18 cyclists (9 male and 9 females) were interviewed regarding their own self-tracking of their rides on training apps like Strava and Training Peaks. The cyclists in this thesis provided some correlation between uploading their data to a device and the satisfaction of the need for autonomy. When viewing and responding to data visualizations of their rides, they were able to meet the need for competence. And they found that by using the social aspects of the apps they could satisfy their need for relatedness.

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AUTHOR'S NOTE

I began tracking my own cycling related data in 2006. Fascinated by the technological advances, I soon carried that information online first with simple spreadsheets to the powerful programs of today. To say that I am obsessed with tracking my own training would be an understatement. I appreciate the continued advice both writing and research related that I have received from my Advisor and friend, Dr. Joseph Champ. I am also grateful to Dr. Greg Luft and Dr. Kathy Hutcheson for agreeing to sit on my committee and sticking with this project. I am grateful to the participants in this study for their time and insight, my family for their patience, and to Colorado State University and the department of Journalism and Media Communications for their support.

INTRODUCTION

The digital cycling diary

Digital mobile technologies, dedicated smartphone applications (apps), wearable technologies, and self-tracking interfaces are popular, modern, fashionable, and "cool". Mobile phones, capable of running smartphone apps have diffused into the hands of more than one-half of the adult population of the United States. This has provided a platform and a market for developers to design third-party apps that are specialized for the task at hand, whatever that may be. Currently, there are over 20,000 health and fitness apps on Apple's iTunes Store that offer, to varying degrees, easy, fun and cost-effective ways to monitor a number of daily activities.

With the expeditious evolution of online data logging and sharing tools, the use of products such as training software and fitness applications, has exploded in the United States. Currently, anyone with a smartphone can track performance, monitor aspects of their health, document their sleep, physical activity, caloric intake and heart rate, and connect with other recreational athletes. Not only are the adopters of this technology interested in their own personal achievements they tend to place themselves in a larger network of sports partners that challenge and support one another's efforts. The willingness to be open and share personal data has led to the rapid rise of self-tracking communities on the web.

While these data tracking possibilities and complex metrics may be considered remarkable on their own, there are dimensions that elevate this phenomenon to a new level of human experience. Self-tracking is proactive and preemptive and must be viewed as a cultural and social practice that can lead to a deeper self-knowledge, improved health and empowerment. The self-tracking process consists of integrated and overlapping actions, behavior and reflection

that ascribe meaning to work and play while mediating the conditions of everyday life. Self-tracking makes it possible for its practitioners to accomplish goals, identify trends, strengths, and weaknesses, as well as initiate lifestyle changes in a way that is possible, suitable and meaningful to the individual. But, self-tracking is not just meaningful in a rational, technical and utilitarian way, it is a source of joy, pride, and pleasure that can illustrate for the user their sense of self-improvement (Wolf, 2010). That which is tracked and the meaning derived thereof is largely defined by the motivations of the user as it remains situated in the broader context of their complex lives.

Lomborg & Frandsen, (2016), who first put forth self-tracking as communication and to whom this thesis has turned for guidance define the process of self-tracking as:

> *"...accumulating a tracking log or diary in a digital system, interacting with the analysis features that are often built into the interface of tracking applications, sharing tracking activities and communicating about self-tracking with others"*

This process contains certain aspects that are fundamentally communicative in nature as they, in different ways, result in conveying information about oneself to others and to a mobile fitness app. Also, the data allow interaction with a "digital double" derived from user input with whom the user can view feedback or effect toward a desired outcome (Ruckenstein, 2014). Through a social and cultural lens a data double is seen to act as a mirror for the user and a digital dossier for others to evaluate. This thesis draws upon empirical knowledge regarding how a select sub-group of self-trackers, practice and experience self-tracking as communication within the context of cycling.

Consider a common use of Strava, one such training app used by the cyclists in this study. A grown man dressed in spandex, as colorful as tropical fish, gets off his bicycle at the end of a

ride, stretches his legs, and enjoys a recovery drink. Soon after saying goodbye to the group or shutting the garage door, he heads over to the laptop or home computer, connects his cycling computer via USB cord and uploads the "data" from the ride. Engaging with the data, he begins to form an opinion of the ride and of his overall fitness. He feels the buzz of online congratulations collected from other riders whom he respects. He may spend a few moments searching an area for a new ride from the posted rides of other users. Much that is cycling specific is communicated to him via this cycling app. He connects with others, tracks progress toward skill improvement, and as such he takes charge of the outcomes to the extent to which he is faithful to input the data. While cycling still takes place out of doors and on the pavement, this typical cyclist and user of a training app finds himself tracking through a device, analyzing the clear and concise visualizations of his data for personal reflection, and interacting with a self-tracking community. He can compare his digital cycling self to other cyclists or to his previously recorded rides. He can also respond to other riders who also have a digital form of their cycling self from their computer or smartphone.

Strava markets the process thus; "Grab a GPS device, Go out for a Run or Ride, View your Activities on Strava.com". Strava, Swedish for "strive", is a fitness based social networking site that uses GPS to record and track rides. In addition, users are able to mark specific road segments online and then compare their efforts to other users. The fastest riders on any given segment are crowned King or Queen of the Mountain (KOM, QOM) a term borrowed from professional cycling. Strava provides an online place for social interaction while encouraging asynchronous competition among local riders earning the label "social fitness". Unlike more general social networking sites, Strava's website and database provide the analysis of a serious

training tool. These features have attracted 1.2 million users as of 2016 who have logged 304 million activities on its' site.

How and what is logged? As an example, it is a nice day outside and a user wants to go out for cycling training ride. He or she has a dedicated GPS tracking device, either a cycling specific "computer" (e.g. "A Garmin"), a smartphone application (e.g. Strava), or a wearable such as a smartwatch. Before the ride, the cyclist puts on his or her heart rate monitor sternum strap, dresses up in lightweight, form-fitting, aerodynamic cycling clothes, special cycling shoes, sunglasses, and helmet, turns on his or her device and heads out for a ride. This ride might be one he or she is familiar with or not. This could also be a group ride with several other cyclists or a solo effort.

During the ride, the a GPS enabled, watch, bike computer or smartphone monitors such metrics as speed, distance, route, heart rate, power (measure in watts), cadence, elevation gain and loss, time, time of day, % grade (useful in describing climbs and descents), direction on the compass, calories expended, and air temperature. When the cyclist returns from his or her ride, the GPS tracking device is signaled to stop monitoring. Finally, he or she can connect the device to a computer via a USB port and upload the data onto Strava. If the cyclist is using the app then the data are automatically recorded and stored for future viewing. Once the cyclist logs into his or her account at the site, the data collected on the ride can be "analyzed" by the user and can either be shared with the public or a selected few, or the data can remain private if the rider chooses. The progress of the cyclist can be measured over time using many variables. Common measures range from the simplest, average speed and accumulated distance, to the more complex "Training Stress Balance", "Intensity Factors", "Chronic Training Load," and "Power Analysis" to name a few.

Social cyclists might share routes as Strava is now building a substantial (160 million routes and counting) mapping database that other users can mine to find unfamiliar routes in their area or in destinations beyond their home city. The rider may also choose to look at his or her ride statistics and compare them to other riders in his area. He or she may compete with a virtual self by comparing data in the past for the same route or he or she may compete with other users willing to share data via the site on pre-determined "segments" (portions of road marked out by users as having special significance) or for the entire ride in a bit of competition.

In addition to the lateral relationships discussed above, vertical relationships are accommodated as well. Users and coaches are able to work together to meet a user's specific goals (a particular race, distance, speed or weight loss). Coaches use the sites to send tailored workouts to the athletes and users respond with the appropriate data (Heart Rate, Power, distance, time et al.) collected from their GPS enabled devices. According to Strava's company website:

> *Strava is a community of athletes from all over the world….Strava lets you experience what we call social fitness - connecting and competing with each other via mobile and online apps….Strava lets you track your rides and runs via your iPhone, Android, or dedicated GPS device and helps you analyze and quantify your performance. Strava provides motivation and camaraderie, and helps us prove that we're out there doing what we love to do (http://www.strava.com/about).*

Given the ubiquity of self-tracking technologies and their potential healthcare uses, it is crucial that we develop an understanding of self-tracking as communication and what drives users to persist in healthy behaviors.

Rationale for studying self-tracking in cyclists as communication

Lindlof and Taylor (2007) suggest that researchers offer, as rationale, strong arguments for studying a particular communication research topic. Qualitative research should contain the following rationale:

1. Trends in certain sectors of society - for example the media, education, labor, religion - indicate underlying issues that are not yet understood.
2. A communication phenomenon has yet to be interpreted effectively.
3. The cultural variations of communication phenomena have not been well documented or explained thus far.
4. The contextual meanings of communicative action in specific culture, group, or institution have not been studied extensively - or studied with a particular conceptual approach.
5. Ambiguities, weaknesses, or potentials in a theory or construct need to be examined.
6. A theory or construct has not yet been validated with in-depth study (Lindlof and Taylor, 2007, pp. 128).

The overall rationale for this current study is borrowed from Lindlof and Taylor and encompasses several of the above rationale. Mobile training apps are a popular trend in the health and fitness ecosystem. A training diary began the use of technology for self-tracking. Getting together with your peers to talk about the day's ride, comparing yourself to other riders, coaching, and competition have been around the sport of cycling for as long as two bikes were headed in the same direction. However, a recent development in interactive media has allowed modern life to be conducted on-line via the Internet, social media, and smartphone applications

integrated with cycling computers featuring GPS technology. A recent report in the *New York Times* showed that the phenomenon is not just for serious athletes. The author reports that the makers of devices capable of tracking movement are urging the larger population of consumers "to get wired and start recording their every move" (2014). This phenomenon likely will remain in the national conversation as the technology improves making self-tracking as communication and as a potential source of satisfaction of basic psychological needs ripe for study.

In addition to the growth in sites dedicated to tracking fitness, cycling has gained popularity in the United States over the last ten years as well. Most of this cycling activity is for recreational rather than transportation purposes (Xing, Handy, & Mokhtarian, 2010). Once viewed as a leisure activity, riding a bicycle has morphed for a growing number of persons into cycling for fitness and cycling to compete. No place is this trend more apparent and readily available for study than Colorado. The area that makes up the triangle of Boulder, Denver, and Fort Collins is positively affiliated with recreational cycling and has a reputation as a home for the outdoor enthusiast/part-time athlete (2010).

As Lindlof and Taylor note, a communication phenomenon that has yet to be interpreted effectively is ripe for study. Self-tracking and its' synonymous co-conceptualizations self-monitoring, quantified self, personal analytics, personal informatics, e-health, and mobile health encompass a considerable amount of literature particularly as it has pertained to physical activity. Health researchers have shown that self-tracking technologies offer promising solutions, empower the user, and help those with chronic illness (Wang, Wang, Wei, Yao, Yuan, Shan, & Yuan, 2014 p. 571). Further, Whittaker, Borland, Bullen, Lin, McRobbie, & Rodgers (2009) found that coupling the mobile device with other intervention methods could provide longer term success for those who wish to quit smoking cigarettes. Additionally, mobile applications and

smartphone use has been applied to sleep screening for people with sleep disorders, (Behar, Roebuck, Domingos, Gederi, & Clifford, 2013), tracking heart rates in children with irregular heartbeats, (Ho, Fu, Lin, Chan, Hwang, & Jan, 2014), to encourage physical activity in patients with Type II diabetes (Arnhold, Quade, & Kirch 2014; van der Weegen, Verwey, Tange, & Spreeuwenberg, 2014) to train self-regulation and self-control, (Cranwell, Benford, Houghton, Golembewski, Fischer, & Hagger, 2014), and to record diet and physical activity in obese adolescents, (Oliver, Baños, Cebolla, Lurbe, Alvarez-Pitti, & Botella, 2013).

Qualitative research in sport and exercise is gaining popularity as researchers are called to "bring the body back in" to sport and exercise research and to consider the promise of phenomenology for such research (Allen-Collinson, 2009). Jonas Larsen (2013) conducted his "auto ethnography and cycling" by following Belgians as they cycled in the city. Other qualitative studies related to apps and the outdoors include Doherty, Lemieux, & Cannaly (2014) who used smartphones to gather rich information about user experiences in nature. Also, qualitative research has examined motivations behind utility cycling or riding for transportation, (Handy, van Wee, & Kroesen, 2014; Heesch, & Sahlqvist 2013; Pucher & Buehler, 2008), cyclists' use of supplements to increase performance, (Stewart, Outram, & Smith, 2013), or the benefits of cycling in aging, (Zander, Passmore, Mason, & Rissel, 2013). So far no qualitative study has looked at the relationship between self-tracking and motivation among cyclists. Similarly, self-tracking, as a communication phenomenon, has rarely been examined.

A communicative phenomenon

Lomborg and Frandsen (2016), set out to develop a theoretical understanding of self-tracking and to conceptualize self-tracking as a communicative phenomenon along three

dimensions: communication with the system, the self, and a network of peers. These dimensions provide a framework for understanding in this thesis and contribute to the existing blind spots in the scholarly literature. As the quintessential "active" users, cyclists interact with the training apps and software from the moment they begin a ride and carry this interactivity forward through the completion of the ride and beyond. Sundar and Limperos (2013), note that "the notion of an active audience has steadily moved from an assumption to obvious reality". Indeed, as action and interaction has become such a foregone conclusion, "audiences" can safely be called "users", a definitive switch in communication research conceptualization.

Like (Carey, (1992; 1989)), Lomborg and Frandsen take a ritual view of communication that not only gives credence to the spread, transmission, and dissemination of knowledge, ideas, and information but also to the ritual view where communication is a symbolic process that creates, maintains, repairs and transforms reality. The form and content of communication is mediated by the technology available to the user, the affordances of that technology, as well as the social norms that arise as a result of that use (Hutchby, 2001). Taking this ritualistic view of mediated communication indicates a particular interest in specific acts of communication and how a group of sampled users, in this case cyclists, interact, share, and reflect upon their self-tracking practices as it pertains to their cycling lives. Features of this technology become communicative when they serve to stimulate and augment the experiential value of cycling for these participants who are supported and guided by this app to evaluate themselves and others (Hutchby, 2001).

Through a unique set of social relations applied in a particular way, self-tracking is a habitual practice of media use governed by and interwoven with social and cultural practices found among recreational athletes in general and recreational cyclists in particular as it pertains to this study. In the next section, the literature regarding communication with a digital system

will be reviewed for a better understanding of how users interact with and accumulate data in Strava or exercising apps in general and the network of connected media that affords this habit.

Communicating with the technology

Cyclists enter various data on a given ride. Some of these data are accumulated over time showing running totals for the week, month, or year. With continued use, cyclists leave a data record behind them that should be included in any contemporary theory of communication. Data become both products of communication with the system as well as processes of communication. Metrics become the message as a cyclist uploads and analyzes data in the computer application. Communication becomes more explicit when the information is shared or made available publicly. Various modes of codification afforded by the technology take on meaning in the context of relationships on the site and in the real world. This "meta-communication" is thus "one constitutive element in the interaction between user and medium" (Jensen, 2013).

Traditionally mass media scholarly literature has reflected on codification and relationships by genre. Current research from a more humanistic point of view, offer genre as a discursive structure and social practice (Lomborg, 2009). The cyclist, depending on his or her fitness level may in the same online session view data from his or her ride, give "kudos" to a friend, (equivalent to a Facebook "Like") and view for curiosity's sake some professional cyclist's ride that day. He or she may knowingly or unknowingly provide a route for a visitor from out of town or gather information on tomorrow's group ride with friends or teammates. Thus, digital media are iterative forms of communication and share the communicative affordances of face-to-face communication and traditional mass communication. Subtler methods of communicating in this system such as a cycling identity gleaned from a photo could

be viewed as a remediated body language for others to receive and interpret. As such, the users co-create and co-articulate identities for themselves from the present information.

Finally, when we view data as sources of meaning as well as information, we can understand data as a representation of reality and a resource that determines our action in response to this reality. Cyclists enter a variety of information and leave behind a trail of communication across space and time.

Communicating with the self

Also of interest is how the cyclist reacts and responds to his or her accumulated data input into the system. Daily bike rides are translated into information. In other words, we are converting the human body into numbers. Tracking heart rate, steps, miles on a bike, location in time, routes, we begin to create a digital representation of our lives, or at least a slice of our lives that is active and that goes places. These digital representations, or "data doubles" result from "the conversion of human bodies and minds into data flows that can be figuratively reassembled for the purposes of personal reflection and interaction" (Ruckenstein, 2014, p. 68). Participants in Ruckenstein's study tracked heart rate and revealed that there is an "affective" and "purposeful" relationship between the user and their visualized personal data. From a perspective of self-optimization, this relationship is as significant as the technological affordances of the devices, programs, and apps. It is the visualization of the data in the form of maps, charts, performance tables and icons that invite the cyclist to engage and interact with this partial view of himself or herself. Legible bodies are material bodies and serve to help the user to understand and value this part of their life.

A great deal of pleasure can be derived from the visualizations of their physiologies and movements on the bike as the cyclist indulges in post ride reflections of short-term or long-term

performance history. The possession of this converted exercise is empowering and can show growing competence thus fulfilling basic psychological needs (Bryant & Vorderer, 2013; Deci & Ryan, 2012). The need to feel autonomous and in control, the need to feel competent, and the need to feel connected to others when present, can motivate interactions between the self and the visualized data double.

When the device is switch on and the athlete is aware that he is being tracked, the rider may choose to augment his ride as the route is changed or plan abandoned to meet some new goal or go for some award. After the ride, the psychological experience of the ride is prolonged as the cyclist seeks immediate feedback. The rider can feel as if science is being performed injecting a sense of seriousness about their sport and reinforcing self-confidence independent of the cyclist's ability (Lomborg & Frandsen, 2016). As such, looking at these data amounts to more than an empirical review, and may be considered a communication ritual where the physiological experience is transformed into a psychological experience. Indulging in this behavior, the user can seek others with whom to share their slice of self-expression both to encourage and to be encouraged, or for competitive social comparisons.

Communicating with others

Many of the fitness tracking apps available, including Strava, laud themselves as "social fitness". The apps afford user-to-user connectivity and communication. Much like other social networks, Strava can be used for sharing information, connecting with others, "liking" in the form of "kudos" and commenting. When viewed from this social media perspective, self-tracking of cycling activity is closely related to work on Computer Mediated Communication (CMC) as a vehicle for social connection and as a way to procure social capital (Morris & Aguillera, 2012; Ellison, Steinfield, & Lampe, 2007). This literature has shown how people's

lives intertwine and relationships develop across different aspects of everyday life whether on or off digital networks.

Communication is gratifying in that users of Strava and their peers achieve common goals, develop common habits, and share a common understanding of the activity at hand. One also finds a definite social order that gives the user the pleasure that stems from a sense of belonging (Lomborg & Frandsen, 2016; Carey, 1989). In other words, this practice of communicating on an activity based social network establishes for the athlete what is appropriate and relevant in this context.

The degree of connectedness and the amount of communication within one's network varies a great deal. Predictably, participants who rode together on occasion were more likely to continue the relationship online. Friendship deposits in the form of congratulations and peer to peer comments on training rides nourish ongoing friendships. Cycling acts as the hub around which the majority of communication takes place inside the apps. Social fitness is a networked communicative practice and it taps into the competitive spirit of the cyclist who enjoys receiving accolades from peers within their sport (Frandsen, 2013). Thus, the activity of self-tracking and cycling becomes a way for the users to meet his or her need for connectedness with others (Deci & Ryan, 2012).

Communicating our basic psychological needs through a training app

The nature of needs in Self-Determination theory (SDT), Deci and Ryan's landmark theory of motivation moves beyond the concept of imposed motives into "innate psychological nutriments that are essential for ongoing psychological growth, integrity, and well-being" (Deci & Ryan, 2000). In the theory three needs were identified: the need for autonomy, the need for

competence, and the need for relatedness. This thesis seeks to understand how cyclists come to meet each of these needs through communicating with a system, communicating with themselves, and communicating with relevant others on social fitness apps like Strava.

In tracking a bike ride, the cyclists in this thesis communicate on three distinct levels. First, a dialogue occurs between the physical activity and physiology of the user with the mobile monitoring devices that measure, record and visually represent the metrics predetermined by an individual cyclist empowering him or her to direct their training, health, and fitness. Second, a visualization of these data make it possible for the cyclist to interact and reflect on his or her activities and take from them what he or she chooses as they believe that this digital reflection of their cycling self is a fair and accurate representation of their performance and skill level. Confronted with a digital double of their cycling life, a cyclist can become a witness to the rising and falling of their fitness and skill levels, in other words, their competence as riders. Finally, he or she steps out into a public arena with two settings, on the bike and online within the app to share the daily ride, to invite feedback and encouragement, to compare and compete with others while establishing his or her sense of belonging to a social group and their common goals and habits. In this thesis, cyclists found their source of motivation to communicate on the above three levels rooted in the basic needs of autonomy, competence, and relatedness as laid out in Self-Determination theory.

Finally, the questions for this thesis were sourced in the experience of the researcher. While some may flinch when encountering these research circumstances, many researchers before me have argued for the researcher as an instrument. I came to study the subject of this thesis from first being an interested user. I track my own health and exercise related data and have recently become interested in tracking my own financial data. I have used the visualizations

and interacted with my digital double to prepare for long cycling races and mountaineering objectives. Not to mention, I am currently employed by a company who offers a skiing version of a self-tracking app. This app has potential to drive value for the company and while corporate interests did not sponsor this study, the retail potential for this technology is clearly positive in both the healthcare and sports markets.

LITERATURE REVIEW

Self-tracking in the digital age

In the scholarly literature, self-tracking is known by many names. Life-logging, personal analytics, self-monitoring, and the quantified-self all relate to the practice of monitoring and recording certain measurable aspects of life with the use of digital technologies for the purpose of deeper self-knowledge (Lupton, 2014; Stragier, Evans & Merchant, 2015; Lomborg & Frandsen 2016). Once the domain of medical labs and funded research, movements, heart rates, caloric intake and a host of other variables can be tracked by the everyday person, with the help of mobile digital media, as they go about their daily business. Smartphones and wearables, such as smart watches and wristbands with built-in sensors automatically or through manual recording, help users to track and analyze specific aspects of the self and daily life.

Logging certain details of one's life isn't new. Before the spreadsheet, there was pen and paper and before that, human memory. Nevertheless, mobile digital media has made self-tracking easier while requiring less effort (Fox & Duggan, 2013). Further, technology has expanded what can be tracked and by whom. One study, conducted by the Pew Research Center, suggested that nearly 70% of the population tracks at least one aspect of their life and frequently more. Weight, diet and exercise are the most popular aspects for tracking (2013).

Mobile devices connected to the internet, cloud servers that can be accessed from ever more remote places at any time make collecting and sharing data more commonplace than ever (Goggin, 2011). Bodies and behavior are now subject to detailed measurement in real time and can be analyzed and reflected upon at will. The technologies of self-tracking are attracting a lot of attention from developers and businessmen. Estimations of the size of the wearables market

put it at 485 million dollars by 2018 with tens of thousands of smartphone self-tracking apps available at the iTunes store for downloading. This technology reaches far beyond the realm of health and fitness and intrudes upon our driving, our home climates, and our medical records. At first glance, self-tracking seems like a private and harmless practice carried on by fitness nerds, computer geeks, the chronically ill, or others who are obsessed with themselves. However, this highly specialized subculture represents only a partial picture. While some data are collected voluntarily and for private use, not all of this information is localized (Lupton, 2014). On the opposite side of the spectrum, "big data" is often collected involuntarily and put to use for marketing purposes. For the purpose of this thesis, voluntarily collected data will be the focus, but it is interesting to look at the different modes of self-tracking.

"Private" self-tracking is the first mode put forth by Lupton (2014) and applies to that data which can be collected by the individual in order to raise self-awareness, improve life and to optimize personal health. Lupton identifies a second mode called "pushed" self-tracking, tracking that is initiated due to the influence of an outside actor or agent. This mode may remain voluntary but users track some variable at the suggestion of someone like a doctor or insurance agency. The third mode is called "communal" self-tracking. While the term self-tracking implies a one on one engagement, many self-trackers engage in self-tracking communities. Strava, the online fitness community, one of the platforms for this thesis, is made up of private self-trackers linked by common interests. Users are able to share and compare their personal data with other cyclists in their neighborhood or around the globe, at their fitness level or well beyond it. "Imposed" self-tracking marks the end of the voluntary self-tracking modes and enters the world of surveillance. Imposed self-tracking is becoming more popular as companies install productivity self-tracking devices with features designed to monitor employees in order to

maximize productivity and profits. Any of the data collected either privately, pushed or imposed, whether it is shared communally or not, can be "exploited" self-tracking. Data is often refurbished and sold either knowingly or unknowingly to third parties for commercial uses. Personal data then can be mined for information that is useful and informative to some interested party who then can make inferences about consumer habits or preferences (Lupton, 2014).

Wired editors Gary Wolf and Kevin Kelly (2014) coined the term "quantified self" and created a blog by that name that has become a sort of digital town square for people who wish to track and share personal data. Their motto is "self-knowledge through numbers". Many studies have been conducted on the quantified-self movement. Members of the quantified self movement (Q-selfers) tend to be a diversified group. Some use pen and paper and some members develop applications for tracking their data. In the academic world, most of the data cannot be termed generalizable because the Q-selfers are, by any measure, an extreme user group. However, their stories, their successes, and even their failures can give researchers direct insights because they have spent hours using the applications and creating the processes of self-tracking (Choe, Lee, Lee, Pratt, & Kientz, 2014). Examples of self-trackers' attempts to improve other aspects of their lives fall outside the direct heading of healthcare and include users who wanted to maximize work performance and to be more mindful. Users found they could improve efficiency at work by tracking their use of time. To be more mindful, users could "check-in" with themselves and record their state of mind at random intervals during the day. To find new life experiences, self-trackers were observed using self-tracking technology to satisfy curiosity and to have fun by logging laughs throughout the day. Some users, tracked their movements around a city to measure their desire to explore new things. To learn something interesting about themselves, one group in the Choe et al. (2014) study tracked their heart rates for as long as possible to see what

could be learned from it. For the purpose of this thesis, it is helpful to think of the cyclists in our study as self-trackers in the cycling community using Strava, an application and internet site. Our cyclists are self-trackers and are therefore Q-selfers but Q-selfers are diligently recording much data that is not cycling related. The cyclists in this study are but a subset of Q-selfers everywhere.

Returning to the private and voluntary mode of self-tracking, research has come from the more technical aspects that allow the users to collect, analyze and reflect on data. This research lauds the digital systems and devices that make self-tracking possible. They define the synonymous "personal analytics" and "personal informatics" as "those systems that help people collect personally relevant information for the purpose of self-reflection and gaining self-knowledge" (Li, Dey, & Forlizzi 2010). Li, et al. urge other researchers to think critically about the systems and make suggestions to improve them. However, the literature on self-tracking also focuses on the practice of collecting and accumulating data about one's everyday habits and then making this data visible in a way that allows the user to reflect on their activities, make self-discoveries and use their knowledge to make meaningful changes to their lives (Ruckenstein, 2014).

Key to the user's ability to self-optimize are the visualizations of accumulated information collected by the system such as plots of exercise over time, routes, or heart rate during a session. This involves summarizing collected data and presenting it in a way that supports interactive analysis and interpretation. Many questions remain about how to best represent data visually. Epstein, Cordeiro, Bales, Fogarty, and Munson (2014) tried to find visualization methods that were able to display complex data gathered from self-tracking users in a useful and appealing way. They verified that meaningful visualizations can help self-trackers identify insights regarding self-improvement.

As self-tracking becomes more prevalent in our lives, more and more everyday processes end up translated into information. In other words, we are converting the human body into numbers. Tracking heart rate, steps, miles on a bike, location in time, routes, and then sharing this information with people who are tracking the same things, creates a digital representation of our lives, or at least a slice of our lives that is active, that goes places, and that interacts with other people's digital representations. These digital representations, or "data doubles" result from "the conversion of human bodies and minds into data flows that can be figuratively reassembled for the purposes of personal reflection and interaction" (Ruckenstein, 2014, p. 68). Ruckenstein, whose study participants tracked heart rate, showed that there is an affective and purposeful relationship between the user and the data double. He or she finds a connection between visibility and knowing and sets up this thesis to investigate the communicative nature between tracking system and the self.

In the existing research literature on self-tracking, three areas of focus emerge; healthcare, app development (specifically the optimization of design and user experience), and surveillance studies resulting from critical sociological analyses.

Healthcare

At the intersection of health studies and computer science, the research on quantified self-tracking centers around empowering the individual, no matter their age or their diagnosis, to self-monitor and self-manage their own conditions, health, and well-being. This is happening not in some distant future, but now, with tools already available. In the healthcare literature we find self-tracking as a means to an end and commonly referred to as *patient activation or preventative medicine* depending on which side of the stethoscope one finds oneself (Swan, 2012). In a Pew

Internet study, Fox, (2011) found that 80% of internet users look for health information online. In the U.S., 18% have searched for others with similar health concerns via the internet and 27% have tracked health data online. These statistics suggest that patient activation is becoming a mainstream behavior as people begin to take a more active role. As mentioned above, the recent rise in devices that enable self-tracking and the communities rising up alongside represent a developing need of a small minority of data obsessed pioneers to optimize their health and wellness through the accumulation of information, sometimes inanely trivial, about themselves. They are equipped to monitor or track systematically, heart rate, speed, sleep, overall feeling, mood, weight, calories and more.

Four distinct discourses, pertaining to self-tracking and healthcare, emerge in the literature. They are empowerment, behavior change, chronic conditions and improved communication, all of which will be elaborated on below. The literature contains a separate discourse on improving communication between patients and providers. Patient empowerment can also be found in the literature as *patient-centric, participatory medicine, patient driven healthcare, digitally engaged patients, personalized medicine, and the participatory biocitizen* as well as the aforementioned *patient activation.* The second group of discourses related to self-tracking focus on how self-monitoring apps can be used to gently push or "nudge" a person into some behavioral change. Finally, other discourses are concerned with chronic disease management among diabetes, cancer patients or other forms of chronic illness and improved communication.

Empowerment

Three key innovations have developed over the past few decades that have empowered patients to participate and engage in their healthcare. Wearable devices, social media and

personal health records have enabled a meteoric rise in the amount of health-conscious patients who can track, store, and analyze information regarding their health status while informing health related decisions, (Hansen, 2012). Because of this, patient empowerment emerges as a core principle of future health research and indicates a shift toward the empowerment of the individual. The person, the patient, the individual, n = 1 becomes the "nexus of action taking" equipped with the self-tracking tools to help him or her understand their own patterns and baseline measurements and to be quickly warned when a variance from homeostasis occurs (Swan, 2009; Swan 2012; Swan 2013). Paper recording of dietary intake and physical activity in diaries and the use of mobile devices to collect participant data has a strong theoretical foundation in behavior weight loss programs (Burke et al. 2011). The use of mobile devices to collect participant data has also shown potential benefits to the user by making self-tracking easier and by automatically calculating energy expenditures. The use of a physical activity tracking app in weight loss programs is only one example of how an empowered patient becomes an informed participant who possesses the tools, knowledge, skills and confidence to become active in his or her care. Weight loss is not the only place where patient empowerment proved effective. Greene and Hibbard (2010) found that higher levels of patient activation lowered the probability of an emergency room visit, of being obese, or of smoking. In short, people who took an interest in their health in a proactive way were healthier.

Patient empowerment represents a shift in responsibility for personal health from the provider to the patient. The empowerment discourse suggests that patients can better serve their complex and ever-changing bodies by using these mobile digital media. However, the intrusion of notifications beeping, requests that medicine be taken, some activity performed, or some

health marker recorded can turn this “empowerment” into another “set of obligations” (Veitch, 2010) or drawing on Foucaultian philosophy, a “disciplinary regime” (Lupton, 2013).

The discourses surrounding the use of such sophisticated digital technologies for self-monitoring and self-tracking suggest that a person can take control of their own health and stave off their ills by technological means. This change in the culture of medicine is not without its critics and is currently being embraced by only a handful of patients and physicians, (Frydman, 2010). Nevertheless, preventative medicine can be viewed as less mechanical than in the past and more informational and communicative. Qualitatively, comparing notes with other active participants on behavior, environments, treatments and symptoms shows much promise and could be as important in empowering the patient as the quantitative feedback available. Recently, Electronic Medical Records (EMR) compiled by providers during patient visits that allow individuals to access their own personal medical data have been identified by the Institute of Medicine (IOM) to be the major consumer health IT development of the current time (Committee on Patient Safety and Health, 2012). One can easily imagine combining personal health records with self-accumulated data. The IOM is so concerned for the safety and the reliability of such a system that they have recommended monitoring this new development since 2012 and suggest FDA regulation in the future (Hansen, 2012). As digital literacy increases, we might find that self-tracking of health data and sharing these among patients with similar conditions and/or with providers becomes the new normal as we partner with the healthcare community to optimize our health.

Behavior change

Another set of discourses in the healthcare literature regarding self-tracking revolve around promoting health behavior change. But, behavior change is extremely difficult for

humans (Swan, 2012). However, according to self-tracking discourses the practice of collecting and analyzing one's own physiological data must produce some end or it's not worthwhile. Self-tracking is an approach to a better life not just a data collection method.

> *Self-tracking has to be understood in relation to behavior that is predominately about getting things done in ways that are possible, suitable, and meaningful for the individual.* (Choe et al. 2014).

The goal is to maximize healthy behavior and to minimize unhealthy behavior (Ruckenstein, 2014).

Li, Dey & Forlizzi (2010) found that self-trackers are motivated most by their desire to change some behavior. Self-tracking and data sharing on social media sites has shown great potential for studying health behavior change (Stragier, Mechand & De Marez, 2013).
For example, empirical studies have shown that self-tracking technologies can be an effective way to "nudge" patients toward a change in behavior (Lomborg & Fransen, 2016). Also, Turner-McGrievy, Beets, Moore, Kaczynski, Barr-Anderson, and Tate (2013) found self-monitoring of physical activity using an app a "key component" to their weight loss success. App users reported a higher level of intentional physical activity over a six-month study period, had a significantly lower Body Mass Index (BMI) than non-users and the physical activity app users lost more weight. Self-monitoring was found to be "the centerpiece" for behavioral weight loss programs in a systematic review of the literature of self-monitoring (Burke, Wang, & Sevick, 2011). Personalized coaching programs with interactive encouragement and tailored feedback have been tried experimentally to promote smoking cessation (Obermayer, Riley, Asif, & Jean-Mary 2004), to curb marijuana use (Shrier, Rhoads, Fredette & Burke, 2014) and alcohol consumption (Weitzel, Bernhardt, Usdan, Mays, & Glanz, 2006). And, mobile phone text

messaging was accepted by participants in a feasibility study as a source of on-going communication relating to healthy eating and physical activity (Gerber, Stolley, Thompson, Sharp, & Fitzgibbon, 2009).

Behavioral change may result through self-tracking as a result of the feedback on behavior that is received by the users (Stragier, Evens, & Mechant, 2013). Researchers have tested visualization methods as feedback that support behavior change and concluded that different visualizations were required at different stages of change. For people contemplating change, visualizations that established baselines were more meaningful as comparison became possible over time. Users who were committed to behavior change might be better served by highlighting aspects of their behavior contrary to their goals (Epstein, 2014; Swan 2013).

Behavior change is a broad topic in the research. For the purpose of this thesis we find it permeating the discussion of the need for competence. Self-tracking can act as an arrow in an individual's quiver enabling the patient, the athlete, the dieter, or the addict to achieve some end.

Chronic conditions

Long-term health management for those with a chronic illness or disease is a difficult challenge. According to the healthcare literature, smartphone app use and internet connectivity among patients with chronic conditions is a relatively new area of study. The government, major medical centers, non-profit organizations, and pharmaceutical companies have developed technology based self-management programs for persons with chronic diseases (Handel, 2011). These programs attempt to increase patient involvement by promising enhanced control over their disease and treatment while minimizing its effect on their lives (Liu, Zhu, Holroyd, & Seng, 2011). Dedicated social networks are available for specific conditions such as Diabetes, Cancer and Parkinson's Disease (Steele 2013). Facebook pages are not uncommon and can help connect

patients with similar conditions. Similarly, these social networks can improve communication between patients and providers. One national study found that people with chronic conditions are motivated to connect with one another and are significantly more likely to gather information about their disease online, track a health indicator or symptom, and to look for people with similar conditions than people who report no chronic illness (Fox, 2011; Choe et al. 2014).

Researchers have remained cautious in their approach to introducing self-tracking technologies into the worlds of chronic disease management and long term care for a number of reasons. Monitoring or expecting those with a chronic condition to do so is a complex undertaking with several obstacles to overcome before wide use of smart phone apps and the sharing of self-collected data can become more prominent. Patient resistance to using an app to self-monitor health behavior has traditionally been attributed to incompetence, indifference, or technophobia on the part of older presumably ignorant people in need of behavior intervention but even digital natives, those born into the internet age, and in general more experienced in using digital technologies, may resent and even ignore demands put on them by telemedicine and can find the idea of self-monitoring "too confronting, tiring or depressing" (Lupton, 2013). Many refuse to add responsibilities to their treatment and to their day-to-day lives. This can be a very frightening time full of uncertainty for the patient. The idea of "self-management" may intimidate patients who view their care as too complex to assume even the simplest monitoring duties (Kim, 2014).

Barriers to using self-tracking technologies are lowered in the treatment and support of patients with chronic diseases or in personal long-term health management if users find the technology accessible, easy, and effective. A review by Wang, Wang, Wei, Yao, Yuan, Shan, & Yuan (2014) revealed that patients used apps to self-monitor symptoms related to chronic

diseases such as cancer and diabetes and to prevent illness such as acquired immunodeficiency syndrome (AIDS). They also found that these self-tracking apps could facilitate medication compliance improving the quality of drug therapy. Qualitatively, Wang et al. concluded that patients felt secure in knowing they were being closely monitored, they felt empowered as they took a larger role in their treatment, that is, they were more autonomous, and they felt that they were not being forgotten by their doctors because of the improvement in communication afforded to them by the technology.

Only 1% to 2% of individuals in the United States have used a wearable device to record and report any health related behavior (Patrick & Canevello, 2011). This does not, however diminish the healthcare community's optimism over this technology's potential. Multiple data streams generated by health and other sensor networks may be integrated with success to simplify care, reduce inefficiencies or redundancies in treatment or to quickly identify population level health issues such as dangerous drug interactions sooner even than clinical trials.

Improved communication

Review of the medical and healthcare literature regarding self-tracking reveals a discourse on improving communication between patients and providers. Concerned about addressing the health problems stemming from reduced physical activity such as obesity, diabetes and cardiovascular disease, healthcare professionals are seeking ways in which they can persuade people to improve their activities and enhance physical activity. One way to accomplish this has been using smartphones to record and report daily activity patterns of patients to their clinicians. By reporting captured data to physicians, Chiang, Yang, and Tu (2014) found that this improved communication between healthcare providers and individuals did result in improved and increased physical activity during non-working hours.

Another interesting development surrounding improvements in communication between healthcare professionals and patients has been the use of smartphone interventions acting as a "counselor in your pocket" providing treatments in real time and in environments where unwanted behavior such as marijuana use is actually occurring. Dubbed "Ecological Momentary Interventions", providers were able to send messages to youth who were reporting social and emotional contexts that caused them to want to use marijuana. Providers found that voluntary self-monitoring was effective in itself and the youth discovered that the messages encouraged them to think about their behavior and use the healthy coping strategies developed in tandem with the therapist during counseling sessions, (Shrier, Toads, Fredette, & Burke, 2014).

App development

Another body of research on self-tracking and self-monitoring comes to us from the field of computer science and focuses on the optimization and design of user experiences. The best of this research seeks a theoretical foundation for the design strategies. Some research tested the functions of self-tracking technologies against actual user experience (Ahtinen, Isomursu, Ramiah, & Blom, 2013) and found key factors in the design that could motivate or impede the user to pursue some associated beneficial behavior. For example, users wanted an app to interact and communicate with them along anthropomorphic lines. Participants in the study wished their app would act as motivator and advisor, provide positive feedback, adapt and grow with their changing circumstances and progress, as well as provide entertainment to keep them engaged.

While some of the research on self-tracking app development focused on the user and the affordances received from his or her perspective, other research sought to describe self-tracking behavior through the actual devices. Analysis of this sort sought to develop more streamlined

technology that is easier to use and therefore adopted at a much higher rate. Ease of use is a factor that can repel or encourage users to pick up and stick with a system. Activity, sleep and diet, the categories that can be tracked most easily by current devices, also happen to be, the activities that are tracked most often. The extra effort of marking the beginning of sleep by turning on the tracking device or remembering to turn it off in the morning upon awakening is a significant enough barrier to make sleep less likely to be tracked. Diet, which relies on self-reporting and estimation of calories because current technology cannot achieve this level of automation, is the least tracked of these three health measures (Kim, 2013).

Research also shows that because app developers come from a wide variety of fields of study, the apps themselves are lacking in health behavior theoretical content. In a content analysis of exercise apps, Cowan, Van Wagenen, Brown, Hedin, Seino- Stephan, Hall & West (2012) concluded that developers should adhere to theoretical constructs regarding behavior change and implement behavior change theory-based interventions into the design which they identified as an opportunity for health behavior change experts to partner with app developers to produce superior apps, grounded in health behavior theory that could possibly result in better health related outcomes. Their search for the presence of prominent behavior change theories turned up very little consistency across the 127 apps they looked at. However, they concluded that higher priced apps were more likely to contain a theoretical basis. West, Hall, Hanson, Barnes, Giraud-Carrier & Barrett (2012) urged practitioners to use caution when recommending the use of apps for health related purposes as most apps do not include all known theoretical factors recommended for behavior change.

Li, Dey & Forlizzi (2010) interviewed and surveyed people who collect and reflect on personal information and found that a stage-based model was helpful in the development of these

systems. Each stage, *preparation, collection, integration, reflection,* and *action* were iterative, user-driven or system-driven, uni-faceted or multi-faceted and that barriers found in one stage cascaded into later stages. Kranz, Möller, Hamerla, Diewald, Plotz, Olivier, & Roalter (2013) tested exercise apps along four heuristics; *app utility and usability for regular training, instructional quality of apps, sensor data usage, and motivation* and offered recommendation for improvement in each of these areas.

From a developer's perspective, mobile health apps still have much room to grow in order to make the best use of unique mobile platform features (Liu, Zhu, Holroyd, & Seng, 2011). Most promising for both developers and practitioners are the two-dimensional and three-dimensional data visualization charts that can be produced quite readily for immediate feedback. Data collection is the engine that powers self-tracking, but extracting value from collected data requires imaginative tools that can synthesize and display in a visually intuitive manner so as to communicate feedback that is contextually aware and emotionally relevant to user goals (Epstein, Cordeiro, Bales, Fogarty, & Munson, 2014). Aesthetic displays turn out to be more effective than no visualization of the data at all. One study showed that participants with a readily accessible display of their physical activity were able to maintain their level of physical activity during the course of the trial. Participants without visual feedback saw activity drop significantly (Consolvo, Klasnja, McDonald, Avrahami, Froehlich, LeGrand, Libby, Mosher, & Landay 2008).

Surveillance

Research related to self-tracking for preventative medicine or health promotion is noticeably uncritical of itself. Instead, authors tend to focus on the potential benefits of these technologies while ignoring the possible social, political and ethical misuses of the collected data

(Lupton, 2013). The technologies, applied in the name of health, may be used on unwitting self-trackers to discriminate or marginalize individuals, populations or other groups of people. As French & Smith (2013) concluded, monitoring bodies, monitoring populations and monitoring polities are each fraught with processes that may threaten social justice. Individuals find themselves engaging with products that make surveillance fun. Further, populations as a whole can have a disease attached to their identity which can then inscribe those characteristics to a collective identity, that is further communicated to individuals who identify with this population. It is not hard for some researchers to imagine powerful actors who might use these data collected from health screenings to discriminate or exclude parts of the citizenry.

Not all self-tracking data are privately collected and held or shared communally by willing participants. Nor does surveillance in the new digital landscape of self-tracking bear the stigma of more covert forms imposed on people without their knowledge. Though mostly theoretical in nature, critical analyses of self-tracking claim that surveillance is an implicit part of the act. When we collect data on ourselves, we are free to monitor, analyze and display it so that we might see ways to improve ourselves. But, our data are accumulated on systems, analyzed by service providers and occasionally sold to unidentified third parties (Lupton, 2014).

In recent years, the value of user generated data to corporations has become clear. Foresighted companies have positioned themselves well to monetize user data by improving products and services meant for consumption. This is done primarily through improved targeting of users based on the data collected from them. Critical examination of this process of commodification has found that exercise data have been exploited, positioning self-trackers as "labor" (Till, 2014). Information such as name, email addresses, usernames, exercise information, diet information, gender and geo-location have been gathered, sold, or shared through corporate

takeovers for advertising and other purposes (Klauser & Albrechtslund, 2014; Till, 2014). Perhaps the biggest surprise to researchers is the willingness of users to contribute such a complete picture of themselves voluntarily and how quickly we are becoming habituated to the concept (Patterson, 2013).

Data are far from neutral despite our tendency to ascribe objectivity to the cold, hard, numbers. In fact, researchers claim that self-tracking data hosted on third party servers can objectify human subjects and their digital doubles that are defined by, augmented by, and may be controlled through their relationship to the numbers (Reigeluth 2014, Ruckenstein 2014). Reigeluth goes on to explain that Big Data, to confine individuals into narrow parameters, harkens back to the beginnings of Critical Theory and the works of Michel Foucault. For him, subjectification and the subsequent dependence on the technology by users would be no different than the governmentality mentioned in Foucault's work. It sets up a domination of the governed based on the techniques of the self. Algorithms that act as a set of instructions, lead to certain outputs. By limiting the input side of the equation, programmers reduce the uncertainty and improbability of the output. "Algorithmic governmentality" and "digital subjectification" occur as a result of this attempt to reduce indeterminacy and could possibly incorporate data meant for self-control for the control of the self (Patterson, 2013).

Motivation and the basic psychological needs

Motivation comes from the Latin *motives*, which literally means, "to move". While not always overt, it is this allusion to action that makes motivation such an interesting topic and one that has been the subject of a vast amount of literature. Motivation is not like a switch that is turned on and off, rather it is a constant flow of input that drives our actions and behaviors.

Motivation involves two axes of measurement; intensity and persistence. The first, intensity, is directly proportional to the level of motivation. According to Petri and Govern (2004) "more intense behaviors are considered to be the result of higher levels of motivation (p. 21). Also consistent with highly motivated behavior is the tendency for it to persist over time. (2004, p.16). Motivation consists of the forces acting on or within an organism to initiate a change in behavior or to sustain some behavior over time. Latham and Pinder (2005) defined motivation as "a resource allocation process where time and energy are allocated to an array of tasks."

Motivation to collect data about one's own physical activity, in this case cycling, should not be confused with the motivation to participate in physical activity. Li, Dey and Forlizzi introduced a stage-based model for collecting data and found the preparation stage, a stage dedicated to determining what data to collect and how to collect them and the first stage in the model, to be the stage where users are most motivated to measure certain aspects of their life. In their study, they concluded that understanding trends about themselves to be a common motivator. Choe, Lee, Lee, Pratt, & Kientz (2014) classified motivations to self-track into three categories: (1) to improve health, (2) to improve other aspects of life and (3) to find new life experiences.

Few studies other than the Choe, Lee, Lee, Pratt & Kientz (2014) have been conducted regarding motivations for tracking aspects of everyday life. In the quantified self-movement, Choe et al. (2014) studied the motivations of extreme self-trackers. Based in communications studies, one study looked at user's motivations for sharing physical activity on social media (Stragier, Mechant, & De Marez, 2013). Social cognitive theory, goals theory and the transtheoretical model guided motivational research throughout the 1990s. These theories are important in that they address key cognitive conditions related to behavior change. However,

they do not consider the individual user's desire to perform better or how social conditions can motivate people to work for competence in recreational activity. (Patrick & Canevello, 2011). Also, previous research on motivation has focused on achievement motivation that is, winning the big game or setting the record but recently the motivation literature has turned its' attention to participation motivation. One theory, self-determination theory, provides a comprehensive theoretical framework to understand motivation from a personal needs-based perspective (Deci & Ryan, 2000).

Self-determination theory

To understand motivation from a personal needs-based perspective, this thesis uses self-determination theory (SDT) because it provides a comprehensive theoretical framework that is ubiquitous across the medical, health, exercise, and education fields. The basic premise of SDT maintains that to understand human motivation one must consider innate and basic psychological needs. These needs are identified as the need for autonomy, competence and relatedness (Deci & Ryan, 1985). SDT proposes that when these needs are met participants are more likely to take ownership and responsibility for their actions by internalizing and integrating behavioral regulations. (Deci & Ryan 2000). When these needs are not met, self-determined motivation is undermined.

SDT proposes a continuum between amotivation and intrinsic motivation with extrinsic motivation, say, from a virtual coach, falling in between the two (Harris & Watson, 2011). Figure 1 shows this continuum in graphic form. At one end, the least self-determined type of motivation is amotivation, which consists of non-regulation and is characterized by impersonal locus of causality. On the other end of the continuum, the most self-determined type of motivation is intrinsic motivation, which is highly self-determined as the motivation for acting derives from

the activity itself. These are activities that individuals would participate in without any operationally separable consequence. The SDT literature is somewhat unique in the way that extrinsic motivation is handled. Rather than considering extrinsic motivation in an invariably antagonistic relationship to intrinsic motivation, SDT researchers pursue a fuller consideration of extrinsic motivation. Ryan and Deci (2000) organized extrinsic motivation according to varying levels of internalization. According to Ryan, Connell, & Deci (1985), internalization is "an active, natural process in which individuals attempt to transform socially sanctioned mores or requests into personally endorsed values and regulations." The more an individual can internalize formerly external regulations, the more the individual can act self-determined while taking part in the activity.

Deci and Ryan (2000) identified four types of extrinsic motivation. From the most self-determined to the least, these are: integrated, identified, introjected, and external regulations. Integrated regulation occurs when the activity is seen as valued and consistent with the individual's other life goals, objectives, and needs. This is the fullest, most complete form of internalization of extrinsic motivation as it involves identifying with the underlying importance of a specific behavior but also integrating those identifications with other aspects of the self. In identified regulation, behavior is seen as personally important and worthwhile but represents less than fully self-determined behavior. By identifying with a behavior's value, they have more fully internalized its regulation and accepted it as part of their identity. Introjected regulation marks actions that are driven by an attempt to impress others, or by shame avoidance. While not entirely external in nature, introjection is still characterized by self-imposed controls that have not been assimilated and therefore are not self-determined. External regulation refers to regulation that occurs when externally controlled rewards or punishments direct action. People

behave to attain desired consequence like a tangible reward or to avoid a threat or punishment (Pelletier, Rocchi, Vallerand, Deci, & Ryan 2013).

Behavior	Nonself-determined					Self-determined
Type of motivation	Amotivation	Extrinsic Motivation				Intrinsic Motivation
Type of Regulation	Non-regulation	External Regulation	Introjected Regulation	Identified Regulation	Integrated Regulation	Intrinsic Regulation
Locus of Causaility	Impersonal	External	Somewhat External	Somewhat Internal	Internal	Internal

Figure 1. *The self-determination continuum, showing the motivational, self-regulatory, and perceived locus of causality bases of behavior that vary in the degree to which they are self-determined* (Deci & Ryan, 2000).

In SDT, interest gives way to the basic psychological needs as the more critical defining characteristic of intrinsic motivation. While interest is sufficient to motivate someone to begin exercising, persistence is largely determined by the degree to which the need for autonomy, competence, and relatedness, the basic psychological needs, are being met. The participation motivation literature tends to focus on the need for autonomy and competence because satisfaction of these needs have been shown to be necessary for intrinsically motivated behavior (Frederick-Recascino, 2002).

Autonomy

Autonomy has been defined as regulation of the self, a state of being independent and self-governing, the ability to direct one's life, independence from outside control, or more narrowly, an internal perceived locus of causality. Behaviors and activities that are judged to be autonomy supportive have been shown to improve goal performance, increase persistence, enhance affective experience, and improve the quality of relationships (Ryan and Deci, 2006).

Autonomy reflects the need to engage in behaviors with a sense of choice or personal endorsement (Patrick and Canevello, 2011).

Stragier, Abeele, Mechant, & De Marez, 2016) were able to conclude that a smartphone app like Strava gave its users ample opportunity for autonomy need satisfaction. Strava and other fitness apps have removed some of the obstacles once faced by the cyclist who desire to self-direct his or her training plans and have enhanced the capabilities of the cyclist in this position to take charge of their overall fitness and their health. Some of these training apps build in design autonomy for the user who can now choose what to track and when allowing the motivated self-tracker to pursue self-determined goals more fluently (Calvo, Peters, Johnson, & Rogers, 2014).

Competence

Autonomy and competence have been found to be the most powerful influences on intrinsic motivation. Any activity or practice that can be intrinsically motivated must address these two basic psychological needs. Competence represents the need to feel optimally challenged and capable of achieving goals and desired outcomes (Deci and Ryan, 2000). A reciprocal relationship exists between satisfaction of the need for competence and the interaction with the digital self that provides the positive feedback that signifies growth to the user. As mentioned earlier, communicating with the self is made possible by the data doubles that are produced by the technology and conveyed to the user in a handsome and handpicked visualization. Visualizations produced from data assemblages are informational and provide proof in the form of negative feedback that can foster perceived incompetence, which tends to undermine intrinsic motivation or positive feedback that foster perceived competence and therefore have positive effects on intrinsic motivation. The positive feedback and its' accompanying increase in competence results from a communicative seriousness and respect, as

if science were being conducted, that the data visualizations bring to the dialogue. No matter the level of the rider, this is a powerful motivating tool.

Relatedness

Relatedness reflects the degree to which an individual feels connected to and understood by relevant others. Research shows that relatedness plays a lesser role than either autonomy or competence in the building and maintenance of intrinsic motivation (Ryan and Deci, 206). Relatedness that is meaningful and secure can provide a scenario where intrinsic motivation can flourish. Certainly, many intrinsically motivated behaviors take place in solitude, a walk in the woods or meditation for example, but relatedness can provide a needed backdrop of distal support in which intrinsic motivation can thrive.

None of the cyclists in this study were extrinsically motivated to ride their bikes. These were not paid professional cyclists. Conversely, no one forced them to ride with the proverbial stick. Steele (2013) found competition on social media sites to be a benefit to patient health groups. Very little else has been written about sharing physical activity on social networking sites. However, one study, Stragier, Evens, and Mechant (2015) focuses on Strava, the community platform for this thesis, and the motivations for sharing physical activity on the site as well as on Facebook and Twitter. They categorize Strava as an online fitness community that serves a specific audience of recreational and (semi)-professional athletes. In their review of the literature they were able to identify six potential determinants for sharing physical activity on social media, each rooted in self-determination theory. The intrinsic determinants included altruism, information sharing, and self-monitoring. Extrinsic determinants were goal commitment, social support, and connecting to others. They concluded that intrinsic motivations have a significantly

greater impact on sharing physical activity on social media sites than extrinsic motivations, which were found to have no significant impact at all.

Purpose and research questions

The purpose of this thesis, is to understand and describe the self-tracking of cycling activities as a communicative act for the participants in this study. When cyclists interviewed for this study record their rides in Strava, Training Peaks, and other training apps, they reported communicating on three levels: with the technology, with the self, and with others. A meaningful exchange of information appears to be taking place on each of these levels (meaningful in the sense that the cyclists' basic psychological needs for autonomy, competence, and relatedness are being met).

RQ1: To what extent does communicating with the device seem to satisfy the cyclists' need for autonomy among the cyclists I interviewed?

RQ2: To what extent does communicating with the self appear to satisfy the cyclists' need for competence among the cyclists I interviewed?

RQ3: In what ways are the cyclists in this study communicating with others through training apps and to what extent does this appear to satisfy the need for relatedness?

METHODS

Qualitative methods in sports research

Lofland and Lofland (1995) recommend that you commence your journey in social research by "starting where you are". I have taken great interest in tracking my own fitness for many years now. I have watched the process grow from hand written journals to powerful databases accessible through a smartphone. Because of this experience, I find myself privy to an emic or insider's perspective useful in qualitative research (Guba & Lincoln, 1994).

It is important to let go of the assumption that all quantitative data is capable of eliminating intersubjectivity and present cold, hard, unquestionable facts, particularly in the social sciences (Vidich & Lyman, 2003). But what is qualitative research other than a jack-of-all-trades approach resembling that of the local handy man? A distanced theorizing of self-tracking in cyclists is not sufficient if one wants to capture affective encounters between humans and their self, their data doubles, or their peers (Ruckenstein, 2014). Qualitative research is:

> *a situated activity that locates the observer in the world. It consists of a set of interpretive, material practices that make the world visible. These practices transform the world. They turn the world into a series of representations, and include field notes, interviews, conversations, photographs, recordings, and memos to the self. At this level, qualitative research involves an interpretive, naturalistic approach to the world. This means that qualitative researchers study things in their natural settings, attempting to make sense of, or interpret, phenomena in terms of the meanings people bring to them. (Denzin & Lincoln, 2005, p. 3)*

As Rallis and Rossman (1998) suggest the role of the interpretive researcher is to seek to understand, from the perspective of individual experience, the basics of the social world as it is. Creswell (2013) recommends qualitative methods when an exploration is needed as when the issue, problem or phenomenon is relatively new or when variables are not easily measured. Qualitative methods are useful when we need a rich description, thorough and in depth. A qualitative study allows the researcher to hear the voices of an isolated population and to understand the context and setting. In this case, qualitative methods are favored.

Qualitative research can reveal subjective answers to researchers' questions. Obermayer, Riley, Asif, & Jean-Mary (2004) uncovered hidden barriers to interventions delivered by smartphone for college students in their study on the effectiveness of a smoking cessation website (2004). Clinicians with treatment expertise and youth who use marijuana frequently reported favorable attitudes toward smartphone interventions in a qualitative study. They found "a counselor in your pocket" to be a helpful aid in saying "no" to drug use (Shrier, Rhoades, Fredette, & Burke, 2014).

The literature contains an increasing number of qualitative studies conducted in order to describe smartphone applications that pertain to physical activity. Rabin and Bock (2011) conducted structured interviews to identify positive and negative aspects of smartphone applications that promote physical activity. To evaluate a virtual coaching system among participants, researchers employed qualitative methods and found acceptance of individualized and personalized automated feedback through a smartphone (Kranz, Möller, Hammerla, Diowald, Plötz, Olivier, & Roalter, 2012).

Although the dependence on analytics remains intact, the literature also provides some history of using qualitative methods in sports studies. To understand the motivations of extreme

sports participants, Brymer and Schweitzer (2013) conducted interviews to get at the essence of extreme sports enthusiasts' motivation to engage in an activity where miscalculation will lead to certain death. The researchers valued qualitative methods for their ability to "penetrate deeper" into the phenomenon. The aim is to get as close to the phenomenon as possible. Cycling appears in the literature as well. Zander, Passmore, Mason, & Rissel (2013) used qualitative methods in the form of semi-structured interviews to explore motivators, enablers, and barriers to cycling among older people. And Consolvo, Klasnja, McDonald, Avrahami, Froehlich, LeGrand, Libby, Mosher, & Landay (2008) found during a three-month field experiment that visual representations of exercise data can be an effective way of raising awareness of and potentially influencing behavior. Their qualitative results confirmed that participants appreciate a summary of their data at a glance and thought it was essential to any system of feedback.

Cronkhite, (1986), who described human symbolic activity, would suggest that to understand self-tracking as a meaningful communicative phenomenon, researchers should view human performance within context. A cyclist's communication with the system, with themselves and with others occurs within their life mosaic. To describe this phenomenon, it is crucial to view the process *in situ.* Qualitative research accomplishes this by enabling researchers to view performances, in this case, the tracking, viewing and sharing of data, within the "generic and routine" dimensions of the communicative acts (Lindlof and Taylor, 2011). Cowan, Van Wagemen, Brown, Hedin, Seino-Stephan, Cougar Hall, & West (2012), in their study designed to quantify the presence of health behavior theoretical constructs embedded in health and fitness apps, acknowledged a need for qualitative methods in further studies. In summary, understanding self-tracking as communication among cyclists is particularly conducive to a largely qualitative research strategy.

Phenomenological research methods

Creswell (2013) compiles five approaches to qualitative inquiry; Narrative research, Phenomenological research, Grounded Theory research, Ethnographic research, and Case Study research. The purpose of this study was to explore cyclists' self-tracking through a communicative lens within the context of phenomenology and to test this interaction's ability to meet basic psychological needs. According to Creswell, this approach has several features. First of all, phenomenological research places an emphasis on a phenomenon to be explored. Second, phenomenological research explores a phenomenon with a group of individuals who have all experienced the phenomenon. Third, authors of this type of study spend a brief amount of time discussing the basic ideas involved in conducting phenomenological research. Fourth, the researcher brackets himself out of the study by acknowledging personal experience with the phenomenon. Fifth, phenomenological research involves interviewing individuals who have experienced this phenomenon. Sixth, data analysis follows a systematic approach, which begins with significant statements as the unit of analysis, which can then be gathered by meaning and grouped into themes. Creswell's final feature common to phenomenological research is an exhaustive description of the "essence" of the phenomenon. Phenomenology generally seeks thorough and comprehensive accounts of subjective human experience in narrow contexts. Phenomenology acknowledges that these cyclists differ according to their gender, skill level, and age, and that no one-size-fit-all explanation will be available.

Exploratory in nature, unstructured interviews were conducted by Rooksby, Rost, Morrison, & Chalmers (2014) to ascertain how activity trackers were being used by people in the study and how personal tracking is enmeshed with everyday life and people's outlook on their fitness. Further, in studies of sport and exercise, phenomenology has been shown to be a fruitful

methodology. Allen-Collinson (2009) posits that phenomenology in sport remains "largely under-realized". Ryba (2008) employed hermeneutic phenomenology in order to study athletes' figure skating experiences and claims that the method holds great potential in the study of sport.

Mixing methods

The case being made for phenomenological research methods, the potential for mixed methods allows the qualitative researcher to combine rich descriptions of self-tracking as a communicative act with quantitative markers along the trail of discovery. This is not unprecedented among smartphone tracking of physical activity research. For example, a combination of qualitative and quantitative methods was used to aid in the development of and improvements to a smartphone app associated with a physical activity promotion website (Kirwan, Duncan, Vandelanotte, & Mummery, 2012). Researchers found that through interviews and surveys, subjective preferences of the participants could be identified, and if implemented, could lead to a design that was easier to use, used more, with better adherence to a health maintenance program. Patterson (2013) administered a privacy "attitudes, behaviors, and knowledge" questionnaire together with structured qualitative interviews regarding real world use of self-tracking apps and outlined privacy risks inherent in the mobile health and wellness self-quantification tool set.

Measuring motivation in sport

According to Self-Determination Theory (SDT), motivation is complex. Often, athletes possess multiple motivations for their pursuits. They can be motivated by external factors such as rewards or by pressure from coaches, peers, or insurance companies. They can also be motivated by the excitement they feel when they go out on a ride, the pleasure they feel as they begin to

master new skills or the thrill of meeting new people with whom to share their experiences. SDT provides a framework for understanding motivation. It can help explain why people participate in cycling and what types of motives lead to persistence over time. SDT also speaks to how various motives are differently associated with engagement in recreational cycling and the benefits derived from this particular behavior (Hagger & Chatzisarantis, 2007).

When people experience support for autonomy, competence, and relatedness within a given domain like cycling, the more likely they are to begin to internalize the behavior and take responsibility for their actions. This level of internalization represents the potential for intrinsic motivation and the positive benefits associated with it. The more self-determined types of motivation, identified regulation, integrated regulation and intrinsic motivation, thought to be present when an individuals' need for competence and autonomy are being met, have been found to result in a number of positive outcomes in the sports domain and several studies have used the SDT framework to understand and promote exercise involvement. Vallerand (2007) confirmed that greater autonomy and competence yields better personal outcomes and predicts long-term commitment. Thus, autonomy and competence are strongly related to intrinsic motivation but the need for relatedness can uncover behavior that is extrinsically motivated. In this case, it is useful to follow Deci & Ryan (2000) and measure the various types of extrinsic motivations. From the least to most self-determined, they are: external, introjected, identified, and integrated regulations. The sports motivation scale can measure these.

Sports Motivation Scale

Early sports motivation scales did not adequately measure all forms of motivation as laid out in SDT (Pelletier, Rocchi, Vallerand, Deci, & Ryan, 2013). Researchers proposed regulatory scales along the SDT continuum adjacent to one another had higher positive correlations than

scales further apart. As a result, subscales were created for each regulatory type 1-7 and the seven factor Sports Motivation Scale (SMS) was born. This first attempt measured three types of intrinsic motivation (intrinsic motivation to know, intrinsic motivation to experience stimulation, and intrinsic motivation to accomplish), three of the four types of extrinsic motivation (external regulation, introjected regulation, and identified regulation), and amotivation. Extensive validation testing confirmed the simplex ordering and the scale was validated for male and female participants (Li and Harmer 1996). Researchers have investigated the outcomes of sports motivation using the SMS. Results have shown that the SMS is useful in predicting persistence in sport training (Pelletier, Fortier, Vallerand, & Brière (2001) and that the more autonomous forms for motivation have important implications for athletes.

Response to criticism of the SMS, chiefly that it combined internal regulation into one subscale, led to the development of the SMS II. In the new scale, one measure of intrinsic motivation is used. In addition, the amount of items for each subscale was reduced to ease administration. Finally, an integrated regulation subscale was added to the extrinsic motivation types. Researchers found that the SMS II maintained its' consistency, and construct validity across multiple studies and performed as well or better than the SMS (Pelletier, Rocchi, Vallerand, Deci & Ryan 2013). The SMS II has been useful in answering important questions pertaining to sport participation. For example, researchers have investigated practice frequency and the likelihood of participating in physical activity. More self-determined behavior has been shown to predict positive outcomes like higher self-esteem, positive emotions, vitality, and well-being. Conversely, the non-autonomous subscales associated with external regulation, have been able to predict athlete burnout and physical activity cessation (Pelletier et al. 2013).

Research design

Using surveys, conducting content analyses and other quantitative methods are often easily planned and executed. However, Lindlof and Meyer (1987) warn that qualitative projects conceived early in the phenomenon's history rarely leave the researcher equipped with fully operationalized or standardized measuring instruments. Such is the case for understanding cyclists' self-tracking as communication and the underlying motivations found in this phenomenon. Nevertheless, following the Moustakas (1994) phenomenological method as laid out in Creswell (2013), can provide a structured approach for the novice researcher.

In phenomenological research, a suspension of prior knowledge and experience is required of the researcher in order to fully understand the phenomenon on a deeper level than he would be able to attain on his own. It is the researcher's openness to new descriptions, the result of setting aside or bracketing prior beliefs, feelings, preconceived notions, and perceptions of the phenomenon, that distinguishes phenomenology in its' ability to produce rich and descriptive data consisting of significant and meaningful themes (Willis, 2001).

Colaizzi (1978) claimed that the success of phenomenological research questions lay in their ability to touch lived experiences distinct from theoretical explanations (1978). Hearing of cyclists' experiences of communicating in the context of their self-tracking, analysis, and sharing of rides illuminates a personal experience that is only beginning to gain interest from the academic community. Lomborg and Frandsen (2016) used two successive sets of qualitative data to develop a conceptualization of self-tracking as communication. Their study has provided the beginnings of a theoretical framework, also useful to the novice researcher.

The approach of this thesis was not an either/or, QUAN/QUAL but a both/and research scenario. Researchers with differing epistemologies can work together in a multi- or mixed-

methods approach. “Thinking with” theories of communication rather than testing alone is one of the ways in which scientific inquiry can achieve complementarity among the differing approaches within the field of media and communication research (Creswell, Clark, Gutmann, & Hanson 2003). Lincoln and Guba (1985) noted that interviews of participants in their natural setting was not necessarily anti-positivistic and that the rich descriptions gathered by the qualitative methods could be enhanced by incorporating quantitative methods into this research approach. Through a process of triangulation, multi-methods research can enhance the validity and reliability of findings by assessing a) the extent to which similar questions illicit similar responses and b) the extent to which the responses seem to get at the same underlying issues (Hesse-Biber, 2010). Specifically, qualitative data can provide a deep understanding of the determinants and motivations of recreational cyclists when it comes to tracking, viewing and sharing their activities with fellow athletes. The quantitative data can help further differentiate between the types of extrinsic and intrinsic motivation. Combined, they describe for the reader what individuals gain from self-tracking their cycling data and how the experiences differ along the continuum of motivation.

Sample

A purposive sample of 18, 9 males and 9 females proved to be the amount where new data failed to add new themes. Training Peaks, a fitness app developed and based in Boulder, Colorado reports a clientele ratio of 40% female and 60% male thus supporting even distribution between genders. Figure 2 reveals the age, gender, and use in mileage of the participants in this study.

Name	Total logged miles (2014)	Total logged miles (2016)	Age	Gender

James Smith (Timm Shase)	4280.1	4040.5	49	M
Chris Van Patten (Pitta Narschav)	2051.4	3727.7	56	F
Carrie Meyer (Mica Rereery)	439.3	2014.6	32	F
Steve Austin (Nat Sautuisee)	538.2	0	36	M
Todd Stanley (Teddy Loanst)	3065.6	2119.6	50	M
Brad Nichols (Rich Slabond)	0	0	53	M
Dirk Friel (Ferril Kid)	0	0	46	M
Fernando Yuste (Denny Fouster)	600	0	50	M
Geoff Quinter (Tern Goffique)	596.2	67.2	24	M
Dawn Orwick (Kic Rowwand)	2454.6	3686.2	32	F
Tammy Sadle (Lea Dammyst)	753.9	0	32	F
Laurie Allin (Lanie Airule)	2815.6	3417.3	38	F
Lydia Holmes (Shelly Maid)	4906.5	5000.7	28	F
David Lytton (Tony T. Laddiv)	297	12.7	34	M
Cindy Squires (Dynisse Quicry)	1093	0	24	F
Charla Dury (Laury Drach)	1999.5	133.7	36	F
Jenn Koscelnik (Sonie)	602.6	644.5	40	F
Ronald Koscelnik (Leon)	393.8	773.8	42	M
Ted Altshuler (Rauld)	4450.7	3112.1	45	M

Figure 2 – *participants name, mileage in 2014 and 2016, and their age*

Data from the SMS II indicated a highly motivated and active participation group, see table 1. Exercise is a big part of their life. Most of these individuals would ride their bikes as long as they were able. Inclusion criterion for this sample required that participants should be actively using a training app and they should be cyclists. Most of the participants in this study used both Strava and Training Peaks. The study was advertised as follows:

"CYCLISTS WHO USE STRAVA WANTED for research purposes. Talk about your experiences tracking your cycling, logging your rides, and communicating with other cyclists. Confidential. Research purposes only. No marketing. Contact Graduate Student Jeff.McAbee@colostate.edu or by phone 970 389-3117. No more than one hour of your time required."

From here, snowball sampling was employed. The method of snowball sampling "yields a study sample through referrals made among people who share or know others who possess some characteristics that are of research interest" (Biernacki & Waldorf, 1981, p. 141).

Procedure

After approval from Colorado State University's Institutional Review Board, persons who met the criterion for inclusion were approached and asked to participate. They were then scheduled for in-depth interviews of approximately one hour in length or until no new themes emerged. The interviews were conducted during the peak of the 2014 cycling season in Colorado. The interview is the "rhetoric of socially situated speakers" (Lindlof and Taylor, 2011, p. 171) For the purposes of this study, I sought to "understand the social actor's experience through stories, accounts and explanations"(p. 174), elicit the language forms used by social actors, gather information about processes that occur on the bike and therefore cannot be readily observed, and to verify and validate information collected from other sources including my own experiences and the SMS II. With years of experience with training apps, I was able to develop a baseline of questions based on that experience and conversations that I had with many friends and acquaintances prior to beginning the study. Answers to initial questions produced connections between the researcher and the interviewee, which opened other areas to exploration.

This is the intersubjectivity Lindlof and Taylor (2011) spoke of and provided some of the deepest insights of the study, co-created by researcher and participant.

For this thesis, the SMS II was administered to participants nested among the semi-structured interviews and rewarded the researcher with more insight into the motivations of participants concerning data sharing and communicating with others on Strava by quantifying the participants' dispositional motivation, in turn furthered the goals of the qualitative research. Drawing from Hesse-Biber (2010), Figure 3 shows and example of a nested mixed methods design.

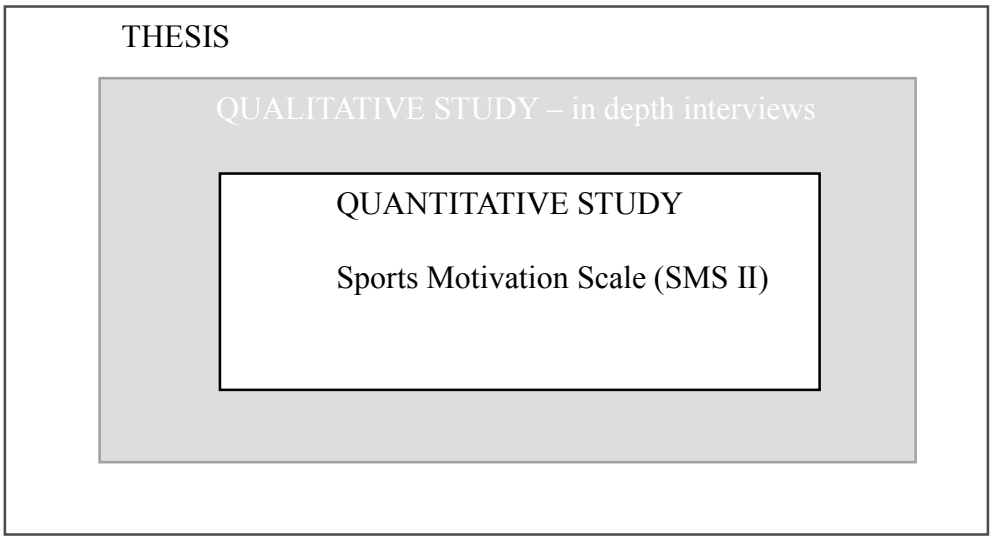

Figure 3. *Nested mixed methods design.*

The SMS II in its current revised form is a 28-item scale developed to measure the various types of motivation as operationalized in SDT (Pelletier et al., 2013). Seven 4-item subscales representing the continuum of self-determination from amotivation to intrinsic motivation. This scale was selected for use and included in a questionnaire entitled "Why are you a cyclist?"

Analysis and interpretation

Creswell (2013) recommends that those who employ a phenomenological study should adopt a simplified version of the narrative analysis method developed for psychologists by (Moustakas, 1994) and engage in the following procedure of data analysis. First, the researcher should make plain to the reader the extent of their personal experience with the phenomenon. This is done so that the researcher can set aside their own experiences to better focus on the participants in the study. Phenomenological interpretation assumes a co-creation of meaning between the researcher and the participant. Complete objectivity is a myth and should be acknowledge early in the analysis. After the researcher has bracketed personal experience, all written transcripts of the interviews are read several times, that is, until a list of significant statements can be developed. This list should include commentary about how individuals are experiencing self-tracking as communication that is, communication with the devices, communication with the self, and communication with others. Commentary should also relate to the satisfaction of the basic psychological needs of autonomy, competence, and relatedness and how they are supported by the three phases that make up the communicative component of this thesis. Each significant statement about the phenomenon is treated with equal worth as the researcher seeks to keep these statements non-repetitive and non-overlapping. Significant statements can then be grouped into larger units called themes. Considering the clusters of themes that emerged from the interview transcripts, the researcher is then ready to write a composite description of what the cyclists experienced firsthand and how this phenomenon affects the cyclists. Drawn from this small slice of the participants lives, the researcher seeks through an exhaustive passage to get at the essence of how cyclists in this study are motivated to

communicate around and about their self-tracked data and how each level of communication corresponds to one of the basic needs.

DISCUSSION

Communicating with the technology

Riding a bike invokes a sense of personal freedom for each cyclist in this study. Cycling stands on solid ground as a vehicle for a discussion on autonomy as most of the riders remember their first experiences of riding a bike as one of newfound freedom. This sense continues as they ride their bikes today and riders feel in control of many aspects of themselves as they cycle. Among the reasons for cycling among the participants in the study was weight loss, staying fit, long-term health, and other usual suspects pertaining to exercise participation. Several participants including Pitta, age (56) found that, for her, the act of cycling itself contributed to a personal freedom:

> *You are out there riding your bike. It is you and your bike and you're connected as one and you can go anywhere.*

The sense of personal freedom is not to be discounted, especially in the realm of exercise participation. Tim (49), more experienced than Pitta, nevertheless found common ground:

> *I remember the first time I rode a bike without training wheels. It was a very liberating feeling. The fact that you can go anywhere quick with very little effort. The first time I was on a bike, there was no place I could not go and go quickly. As long as I had two wheels, two legs, and healthy lungs, I could go do it.*

Generally, all of the participants in this study loved riding their bikes and would probably do so if there were no training apps at all. One fit but no longer competitive rider, Tim (49) added a few of his more practical sentiments toward cycling when asked why he rides a bike:

> *Because it is a good stress reliever. It makes me feel alive. I have that feeling of the wind through my hair. I can go fast. It makes me feel like a kid again. It's a great way to meet people. I can go into some really cool areas and I can get to them pretty fast compared to if you'd walked.*

Yet, this thesis is not about riding a bicycle. It is about technology that has been developed to enhance the experience of being active.

Autonomy does not equal freedom although they can be related. Denny (50) does not compete in races, nor is he all that fit but he sums up his experience with tracking his rides:

> *I would hope I would ride my bike if there were no phones, apps, spreadsheets, lycra, or power meters but I can tell you, all that stuff makes it more motivating. I'm motivated by the numbers.*

Denny communicates with his devices and his devices communicate back to him. The smartphone, GPS tracking, and creative fitness formulas allow the cyclist to exchange physiological and physical information with the technology. In essence the cyclist says, "Hey, my heart rate is this. My power is this. Did you know that my maximum heart rate is this? My body starts to metabolize here and begins anaerobic work here." The device listens to this information and says, "Let me put a number to all of that for you. By the way, it is 72 degrees out, the time is 12:43 pm and your friend Jim just congratulated you on your effort."

Training apps have empowered even the newcomer and the novice to take control of his or her training, personal fitness, and goal realization. Self-tracking of the various metrics that participants in this study are able to input into the system and the capability of the system to represent this input visually has allowed everyday athletes to take charge of their sporting life. In other words, one of the key motivators for engaging with their digital selves is the sense of autonomy that is realized. This thesis views autonomy as it relates to the empowerment of the individual cyclist that is achieved through the input and interaction with cycling related data collected, analyzed, and interpreted by the athlete.

Speaking into systems

There are devices that are explicitly communicative in manner. "Keep going! You can do it!" The device cheers. Yet, another more meaningful and implicit manner of communicating exists. Self-tracking as a communicative phenomenon begins when our cyclists begin to speak into systems. They speak a binary language interpreted by their GPS device and related to a digital platform. Riders communicate speed, power output, distance, time, and cadence. They share with the device the day's route and the device replies in a meaningful way for the cyclist and in real time. Heart rate, overall feeling, and anything else the rider would like to disclose, is given freely to this system, imprinting these aspects about themselves onto the recording device and its storage. And then the medium responds. Data are given back to the rider in easily interpreted visualizations.

The device responds and the rider makes sense of the data. The device feeds back to the user and in turn the rider continues to provide input. For the purpose of this study, we can see this looping interaction as a dialogue of sorts. In communication studies, consensus tells us that words do things. This is, of course a ritual view of communication (Carey, 2008), which stresses

the symbolic nature of communication where the production of meaning is shared in communicative actions at least equal to the transmission of information. “When technologically mediated, the form and content of communication are negotiated by the communicative affordances of the medium at hand, as well as the social norms that have been constituted around its uses” (Lomborg & Frandsen, 2016, p. 1019). Digital data perform when they help users construct, share, and maintain certain values and beliefs in an everyday context. The genius of platforms like Strava or Training Peaks is that it takes data from a ride and uses it to create a picture for the user. These visual representations become vehicles of information out of which a cyclist is able to construct a reality pertaining to his or her cycling life. The device offers the rider sources of meaning and in turn the rider has contributed to the fine-tuning of the apps’ algorithms, however slightly he or she has helped to reconfigure the system.

How one makes the leap toward self-tracking seems to be an individual decision. Goals and plans to reach those goals can be a factor as Ferril (46), a former pro cyclist explains:

> *It can be very spur of the moment because your guys are like, you know just egging you on and there’s a bet. A lot of times it starts with that. And then you’re like “Hell yeah! I could do that.” And they’re like “No way you could do a triathlon” or whatever. And you’re like “Shit yeah, I could do that”. Now all the sudden you talk yourself into it and you’re like “Damn. I am kinda fat. I could lose 20 pounds and it would probably help me”. So you just jump in, go and sign up, pay your $50 and the race or whatever is like four months from now. And you’re just like stuck and you have this like black hole in front of you with absolutely no direction on how to get started so you start looking for solutions for what you should wake up and do tomorrow.*

Thus, Ferril needed a plan to get to this new version of himself. A reformed version that will have accomplished what he has set out to accomplish. Once the goal is set for the future and the plan is in place, it is widely held in the cycling world that a good way to ensure the goal is reached is by tracking one's progress and training. This seems to be intuitive even among cyclists in the study, like Mica (32) who were lackadaisical in their interactions with the technology:

> *I think if I was serious about really getting better, I think I would be monitoring them (training apps) ride to ride. I think those programs do make you better because you're trying to improve your ride.*

Deci and Ryan (2000) asked readers to consider the basic psychological needs of autonomy, competence, and relatedness as the "what" and "why" of goal pursuits and how the satisfaction of these needs can lead to long term positive outcomes. Thwarting these needs in any way led to poor motivation, performance, and well-being. As such, it is important to examine ways in which tracking personal exercise data can be a need supportive activity. Patrick and Canevello (2011) identified three elements crucial to a need supportive context. First, is there a meaningful rationale for the prescribed behavior, in this case for tracking exercise data? Second, are the feelings and perspective of the user acknowledged? Finally, is choice emphasized and outside control minimized? To the extent that the riders in this study could answer yes to these questions, their tracking satisfied their need for more autonomous forms of regulation, which would lead to more self-determined behavior.

The rationale for tracking exercise data given by the cyclists in this study is best articulated by Ferril (46):

I find that keeping track makes a big difference. It allows me to plan 6 months in advance. I set the goal and work backwards. This is where I want to be and this is where I am. Now, this is what I am going to have to do each week to get there. Based on my experiences and looking back at other times when I was in good form, I can look and see, yeah I was here on that day and felt great. So, that's the number I need for this next goal. I'm not going to be able to get that kind of clarity just feeling.

The number he references is calculated from the intensity of his workouts as measured through his heart rate monitor and power meter as a function over time which is further compared to the amount of rest and active recovery he is getting.

The cyclist in this study were able to see that their perspective and feelings about training were supported. Tim (49) had this to say:

The people who create these apps are better athletes than I am. I think there is a lot of science behind what can be tracked. I think this science is getting better and better. It's made by athletes for athletes.

The riders in this study did not feel that they were being forced in any way. Choice is emphasized and outside control is minimized. Tern (24) explains:

I have the choice of what I'm going to track based on these apps. I don't really need a coach. I just need someone who knows how to get to a certain goal. I can just follow someone who has done it before. That's enough for me. I don't have to track everything that everybody else does. I can just pick out a few

markers that indicate good fitness and I can track those things. If those things seem to be in place, then I tend to feel pretty good.

For the cyclists in this study, self-tracking provides the standard for autonomous regulation and thus provides an example of highly self-determined behavior.

What they tracked and why?

Good data build an honest history. Memories are fallible and not remembering your past times can color future training and define expectations in an unhealthy way. Quality data are a result of exhaustive and consistent tracking. Kic (32), explains:

I like tracking all of this stuff because it provides proof for me. I can look back if I want or when I get home, there it is. That's why my legs are tired. That's why I'm going to sleep well tonight. It's a confirmation of the effort and a validation of my feelings.

The cyclists in this study tracked a variety of metrics to help them meet their goals. The gold standard in cycling related tracking for training purposes is power output and heart rate. However, since these require a power meter or a heart rate monitor to measure, metrics that can be measured with only a smartphone were tracked more often by the cyclists interviewed for this study. Distance, time, speed, and route are commonly tracked via the GPS device. Some record directly onto a smartphone and never look at it while they ride. Others use a bike computer in plain view for the duration of the ride and then sync the device with a web application after they return home. Typical of participants in this study, Teddy (50), a machinist and former time trial champion of Colorado discloses:

I have all these measurement devices on my bike. I've got the cadence, speed and the power meter.

Nat (46), a retired veteran who found his love of bikes again after the army, has his favorite Strava features:

I like that the heart rate zones are there. I like the "suffer score". I'd actually like to see the true algorithm.

The apps use an algorithm to calculate various proprietary "scores" that help the rider further categorize his or her ride. They all differ but seem to be some function of heart rate and time, elevation gain or loss, power, and outside temperature. Nat also really likes the mapping function that tracks the route he rode. Still, Teddy (50) and others will track less objective, less quantitative measures. Teddy's Strava performed the functions of a diary:

I'll keep track of what the weather was like, who I rode with, equipment issues and stuff like that. A lot of times my comments on the ride are kinda like my excuse list sometimes. What went wrong on a particular ride?

Riders in the study also added mood, overall feeling, nutrition, and sleep to their conversations with the device. Some of the riders in the study were strictly record keepers and require no more from the device than an individualized performance history. For Denny (50):

I use it for record keeping. I love that it comes in a way where I can see it all at once. I can see my heart rate. I can see my cadence. Everything is in there. And it's very simple to transfer into an excel file where I can do anything else if I need to.

Participants found ways to interact with the device in real time while it is recording and use it as a meaningful resource in the decision-making process. This can be done explicitly, as Nat (46) has done in a longer ride:

> *I set my timer on the GPS to go off every 15 minutes and I was sucking down a gel pack.*

Here the device communicates audibly to the rider and reminds him to take on food. During the ride, participants in the study are able to receive and interpret feedback from the training app in surprising ways. Pitta (56), a female rider, uses the feedback to gauge effort:

> *If I notice my heart rate drop, then I know I can go harder. Or, at the beginning of a climb or something, I'll use my bike computer and say "okay, you cannot go below 10mph on this freaking hill."*

The digital data being collected performs for Tern (24) as well. Tern is an amateur racer on a local team:

> *Sometimes I'll be going along and I'll be totally jamming and I'll look down and I can see that I could push it a little bit harder. Or I need to back off or I'm going to pass out. If I know this ride is 48 miles then I'll look and thank God we only have five more miles. Okay, I can get through this.*

Kic (32), a female teammate of Tern's, uses her Strava in the same way on race day:

> *We knew going in that it was going to be a seven-mile climb. I always have Strava running on my phone but have it put away. I never look at it but there*

were a couple of times where we're pushing up the hill and I'm looking at it and I would say 'okay, two more miles. I can do this. Two more miles.'

Cyclists, even professional ones, are not robots. Often there are things going on outside the realm of cycling that can affect how an athlete is performing. Several cyclists found it useful to get a visualization of metrics complimentary to their training. Below is an example of a chart of two metrics an athlete can follow as long as the data are entered manually.

Figure 4. *Tracking weight and percent body fat*

Satisfying the need for autonomy

Autonomy reflects the need of the participant to engage in behaviors with a sense of choice. The activity is experienced as volitional, consistent with his or her values, and an authentic expression of the self. When athletes find themselves in an autonomy supportive environment, they tend to internalize their motivation which leads to several positive outcomes. In a coach/athlete relationship an autonomous athlete is the best pupil. Ferril (46), a professional cycling insider and coach elaborates:

The best coaches are aiming to get rid of their clients in a way. They educate the athlete so they can self-regulate. You'll see these athletes begin to come up with the next day's formula. The Great Britain cycling team actually does that. They want the athletes to be able to become educated enough to make decisions for themselves.

Even the most thorough tracking by coaches at the highest level cannot account for all the factors that go into how an athlete is going to respond to training.

Further, there was some criticism regarding the presence of the device among the cyclists in this study. When the context is perceived as controlling by the participant, self-determined behavior is undermined. Only two participants mentioned that tracking devices got in the way and diminished the experience. Sonie (40), a female participant in the study who is inconsistent in her tracking said:

When I go out and want to be free on my bike, I don't take my computer. I don't record it. Because when I take it, I feel like I have to look at it. I think that when you have your gadget, you are a slave to your gadget. There are times when I want to go out and ride and be free when I just don't take it.

To combat this, some of the participants recorded their rides on their phones but kept the phone out of sight.

This did not appear to reduce the post ride interest in their data. Despite what seemed like bravado, they were all too willing to engage and interact when, after they got off the bike, they sat down at the computer to analyze their ride and themselves. The effect of taking the ride captive seemed to everyone to be a fine line that the cyclist must walk. Rauld (45), a machinist who tracked 4450 of his miles in 2014, the second most in the study, plays down his data input:

I just never got into it. It's very difficult to maintain the numbers because I'm out there to have fun and sometimes I feel like I want to go faster and I just go faster. Or I want to go hard so I go hard. If I don't feel like going hard then I don't go hard. I like to use perceived exertion versus targeting a specific heart rate.

In the case of Rauld, perceived exertion represents how he feels regarding his level of effort at any given moment. As he was once the state time-trial champion of Colorado, it follows that he is in tune with his body when it comes to his performance on the bike. Below are two visualizations that take much of the subjectivity out of the equation. It is possible for an athlete working only on feel to be this precise, but how do they know?

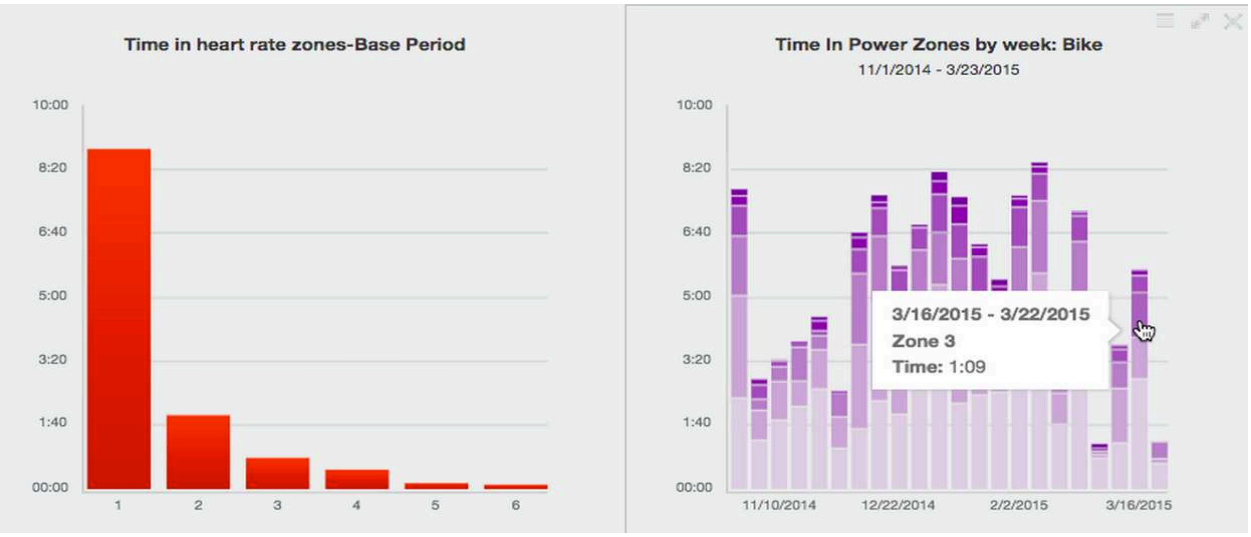

Figure 5. *Accuracy in these charts showing heart rate and power zones would be hard to achieve by sensing by the cyclist.*

Only one of the cyclists in this thesis had a coach while participating. Not only does it appear that the athletes do not need a cycling coach to prod them to take charge of their own training, they preferred to be their own coach. They invest a lot of time in their health and fitness.

Cycling has moved beyond the hobby realm and has become a lifestyle in which the markers of successful living are tracked in the form of miles and speed. The participants, no matter their level of cycling, paid a great amount of attention to their health and fitness. Like good scientists, they were thorough, open to new ideas, and experimental. They rack up miles, not vocationally, but as something deeper and affective. They are disciplined enough to want to know in a concrete way the progress they are making or not making. They are free enough and brave enough to see themselves in this digital mirror.

Denny (50), who had among the lowest miles logged of any of the participants illustrates clearly this resolve in its simplest form:

> *I was 280 pounds and now I'm 230. I can go 18 mph. That motivates me. To me the motivation is that I am going to do it. I am going to go up there and keep track of it. I don't do this to show off. I don't need anybody to do this. I can do it on my own. And then once I do it, then okay, maybe next time I want to go a step further, you know?*

The cyclist becomes his own coach, trainer, team mate, support wagon, and sport scientist. Tim (49) shows his thought process of analyzing a breakthrough in his fitness level:

> *What's neat about Strava is the segment aspect of it. I like to ride the same routes and repeat them with the same amount of effort and see if my speed is faster or my heart rate is decreasing. My speed is going up and my heart rate is going down with less effort, that's a good thing. With longer rides, it's impossible to stare at your computer and get that kind of feedback. You just*

can't remember what you did last time but the way it tracks how you did on previous rides; I think it's phenomenal.

Tim needs his digital double, compiled from and dependent on the quality of his accumulated input into the system, to be able to assess and then augment his training to achieve the results he desires.

Accommodating the system to personal needs

As the athletes take charge of their workouts and show much progress over time, they begin to make changes to both their workouts and what they track in order to accommodate their own personal needs. Nat (46) was experimenting with his nutrition:

I like to see caloric intake. What am I eating? How many calories have I burned versus what I am putting back into my body?

Kic (32), decided that it was not in her best interest to make all of her workouts available for public viewing:

I just didn't want to blast my workouts to everyone every time. Sometimes I just want to look at whatever I'm doing in a solitary environment.

Rauld (45), on the other hand, likes to ride with others and allows himself to be tracked by his followers:

I like to let everybody know that hey, I'm out there riding right now. You can track me and know where I am while I'm riding. Maybe we can hook up.

The apps give the cyclist a little bit of space to assert their true selves into the equation. They can track what they want to track and display what they want to display fueling their need for

autonomy. The app is more than compliant. On the road, feedback obviously helps the riders as they interact with the technology while they are on their bikes but the deeper analysis takes place when they get home when the medium provides the participants with some aggregate data.

Analyzing

Most participants in this study spent at minimum 15 minutes interacting with the data, post-ride. Strava responds to its user with a minute-by-minute graphical representation of the metrics that the rider has chosen to track. One can look at heart rate, power output, speed, cadence, temperature, and location at any given time from the ride. The depth of this analysis, a closed communication loop at this point, can remain near the surface like Dynisse (24), the novice female rider who searches for variety:

A lot of times I get different routes. I like to explore different areas. I'm A.D.D. I have to find different places to ride.

It can also go much deeper like Tim (49):

The apps help me to stay focused. It really helps me to track my training for what I have coming up. I can prep myself going into battle, if you will.

Lea (32), a female professionally sponsored rider who is intense and knowledgeable toward their data talks about keeping track for herself:

I look at my PMC (performance management chart) every day just to see. I don't want my fitness to get too low because it's easier to keep up than catch up.

There is a sense among the riders that you get what you put into the system. That while this is a two-way conversation between device and rider; the rider is responsible for the quality of this interaction. Kic (32), empowered by her data, notes pleasure with her autonomy:

Well, I think it's just being able to get as much data out of it as what you want to put into it. I'm on Strava so I can at least see where I'm at and I'm able to track my own progress. Of course, I want to see where I fall as compared to the girls I ride with, people I know or someone I perceive to be really good. I kinda gauge myself.

It is this last part that highlights another theme of the initial analysis that takes place after the ride. Cycling is a sport but these training applications can make it seem like a game.

Gamification

Input from the rider is presented back to the user in a visual way. Riders can view the route they have taken or focus in on one segment of that route. Visualizations represent skills, like riding with a higher cadence, and can help the cyclist in his or her pursuit of mastery, and if not mastery, then improvement at the very least. The visualizations are fun to play with. Progress can be seen on the computer, personal records can be pursued, and comparison with friends or other riders can bring much joy to the users as they play around with the data visualizations. These vehicles of information contribute to a fitness-based reality, one that can be manipulated and enjoyed, and to which the participants in this study give much significance.

These vehicles of information feeding back to the user are helpful to him or her but they are also fun. Ferril (46) notes:

It's like a little bit of gamification because I can see where I've been graphically. I can see where I started and where I am today. I can forecast into the future to where I want to be. I can see where I've set personal bests so it's gratifying to me to set a new top five time or power output or whatever. Now, I'm motivated to keep the app up to date so I can have an historical view,

literally, graphically, of what it took to produce that result. Then, I can leverage the data going into the next year and it actually becomes motivating because the data in itself becomes an event because my goal becomes to at least do what I did last year, right?

For the thorough self-tracking cyclist, the data become an event. Beat yesterday becomes the mantra of the training session. It sets up a scenario where one is competing with himself or herself in order to improve along a continuum toward mastery. The device is happy to oblige, providing many numbers for Tim (49) to delve into at his desk at home:

Okay, this is my lunchtime ride yesterday. I started coming down with a cold and I just did a PR from Cherryvale to Baseline. I like to look at my 'Analysis' tab so that I can look at different segments of the course, from here to here, maybe a hill segment. I can see my max speed. I can also see my heart rate. I can go back to this same course from a previous day and I can look at my heart rate to see what it was back then. I can do the same for my average speed. Same hill, same course, different day. That tells me that, being a little under the weather, I'm getting fitter because my heart rate is dropping and my speed is increasing.

While the data themselves are not a game, the cyclist gamifies the data in his or her own mind. Nevertheless, the data invite the rider to play. Again, Tim (49) explains:

Being aware of my heart rate, being aware of my cadence, being aware of segment improvement, being aware of the type of mileage I'm putting in, all of those things sort of lead me to being better overall. I'm an ex-CPA and CFA so

I'm kind of a data guy. I like statistics to drive me to be better at what I do. Seeing that improvement actually happening is exciting. I can dig more into the stats. It's not all about the stats, obviously you have to put in the time but that could drive you to become a better rider, a better performer. I don't like to do anything half-ass. I like to be the best I can possibly be for myself.

The device asks the rider to look. The rider imprints information on the device, and the device leaves imprints on the rider as well.

One of the affordances of this technology is that it allows the user some assurance of accuracy. Participants felt the information they were getting from the device was real. Not only has the metrics that can be measured increased but also these metrics are stored indefinitely. A coach in decades past responsible for producing top athletes, stubby pencil and notebook in hand, is going to have a difficult time remembering what specific heart rate zones a rider was training in three years ago leading up to World Championships. Now, this information is a few clicks away, even for the amateur. Teddy (50), a regular club rider, likes to view data from past years:

I type in keyword 'Buff' (The Buffalo Bicycle Classic) and all three of them come up. I can go across and see power, speed, and all that kind of stuff. It's not like I'm necessarily going to do anything about it. I'm just interested in what might have changed. This year I got the exact speed as I got last year on the ride, to the penny. I like to see if I'm improving, declining, or holding steady.

The feedback is valuable to the cyclists in this study because the data are personalized and immediate. Nat (46) explains:

I like being able to see the data on a computer screen versus the old school way. I think computers and apps have allowed us to realize an immediate gratification or an immediate dissatisfaction to what we just performed.

The cyclists feel validated by this feedback. They have visual proof of their ride. Tern (24), a club racer elaborates:

When you're able to see your stats, it validates you. It's that much more important to you, as a cyclist, to see without anything else, your raw physical ability. You look at your time and you can't believe it because you weren't gauging it the whole time. It wasn't your primary focus during the ride. Your primary goal wasn't a certain time. It was just to do something you couldn't have done before. That's where something like Strava is really important. It just backs up what you hoped or dreamed that you could do in a moment. Yeah, in terms of how I felt. It validates how I felt on the ride.

If the cyclist doesn't like what the device is telling him or her, then they are able to manipulate the data going in. Pitta (56), a noncompetitive female rider who nevertheless puts in the miles, tells how she responds to the data and augments her behavior:

I think it's enough to motivate me. I don't think I'm motivated to get better but like today, you know? I didn't have anybody to ride with and I really pushed it on the Tour of the Moon this weekend. I could have easily not ridden today. So, I looked at how many miles I've got in the year just for fun. And I was like, 'Well, hell. I'm 22 miles short of 2000. I've got to go. I can get 22 more miles.'

While the device is furnishing this data, the rider responds to the visualizations. The cyclists in this thesis communicate with devices and devices communicate back to them. Information is personalized in order to optimize practice and to meet specific goals. When they speak into this system, an imprint is left behind and an online cycling identity is created and then expressed on the app. The participants play with the data and make a game of competition with themselves and with others. A dialogue can then take place with this digital version of themselves, an act that is as fundamentally communicative as this interaction with the device. The cyclist is able to go deeper with his data double and press toward digital optimization.

Communicating with the self

The athlete speaks into the system and the system speaks back as mentioned above. The language is one of science or at least the appearance of science in the form of charts, graphs, and maps, with the added competitive flare of leaderboards. Data visualizations communicate feedback to the user regarding his or her bike ride that day or they display a representation of the accumulated input over a specific amount of time and consequently say something about the athlete's level of fitness and their progression in the sport. These visualizations range from the crude; duration over time of a particular exercise activity, to the impressive; time spent in particular heart rate zones, to the remarkable; a Training Stress Score figured using an algorithm with intensity and duration among the variables.

A data visualization communicates to the athlete concerning his or her persistence in training or changes in personal fitness habits. The cyclist is provided a mirror into which he or she can gaze. The mirror will show nearly as much detail as the cyclist would enjoy. A brief glance at one participant's screen shows the ability to view in graphical form, distance over time,

elevation gain, maps and other geo-locating metrics. Less numeric forms of information can also be viewed such as overall feeling or mood, urine color (a measure for hydration), motivation, injury to a specific body part, and the timing of female menstruation. Other metrics witnessed in this study useful to the athlete included sleep and the sub-heads of time in deep sleep and REM sleep.

The better software, available as part of a premium plan with Strava or Training Peaks, takes several metrics and combines them into a measurement of fatigue, overall fitness, and form. For the most astute user, it is possible to project into the future in a way that is helpful in preparing for a big event on a certain date like a race. And while this sort of fitness forecasting is for the more advanced user, such data visualizations allow communication with the self regardless of ability and commitment. Once the athlete dismounts and uploads his or her bike ride, a conversion takes place. Physiological and physical attributes of the ride become data flows and variables that produce Ruckenstein's "data double" (p. 69), a digital representation of the self. This analyzable self can be in high definition as the user chooses or can focus on one attribute for study. There is a direct relationship between the inputs from a cyclist to the quality of the visualization. It is possible to enhance the auto-communication between the user and the reassemble data double by being thorough in your data collection. The cyclists in this study found the documentation of their rides to be very gratifying. Below is Training Peaks' Performance Management Chart. The unshaded area to the right of the visualization represents the future levels for the athlete.

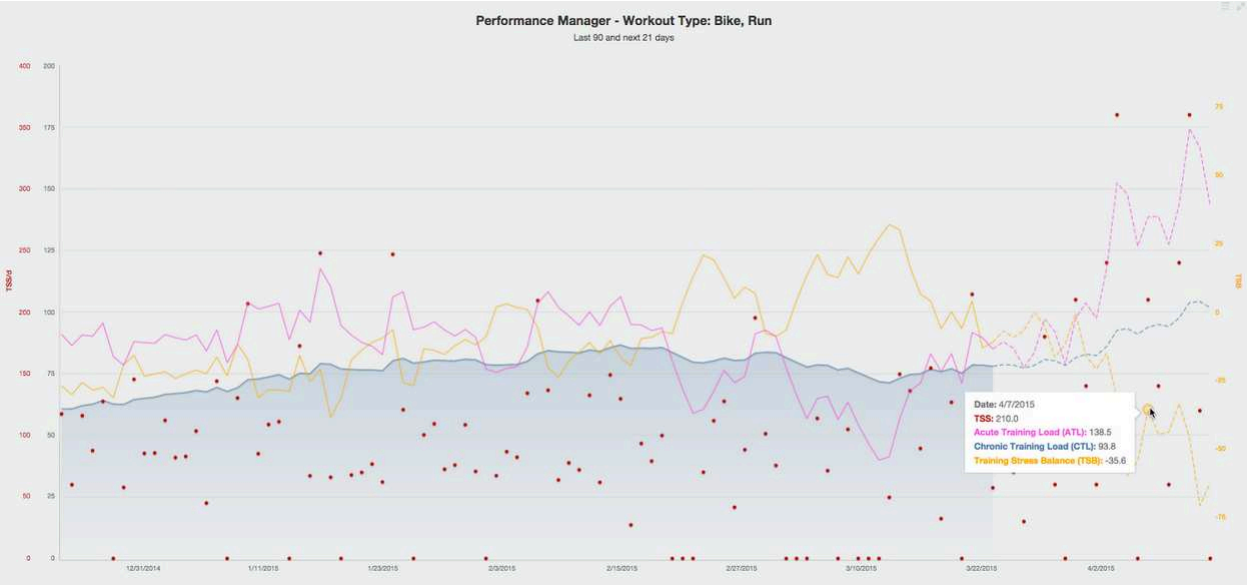

Figure 6. *Sophisticated data visualization showing numbers derived from heart rate data and time.*

As noted earlier, most cyclists interviewed allotted 15 minutes for uploading and analysis. But Tim, (49) a rather dedicated cyclist spent a little more time at home. He showed me what a dialogue between himself and his digital double might look like:

> *After every ride, I'll spend a half hour or 45 minutes looking at stuff, trying to wrap my mind around the ride. I'll go in there and try to dissect the ride. Flagstaff (a local mountain frequented by cyclists) is a good example because it is a big hill. All the way to the top so, for that section, I maxed out at 14 mph, average 7.8 mph.*

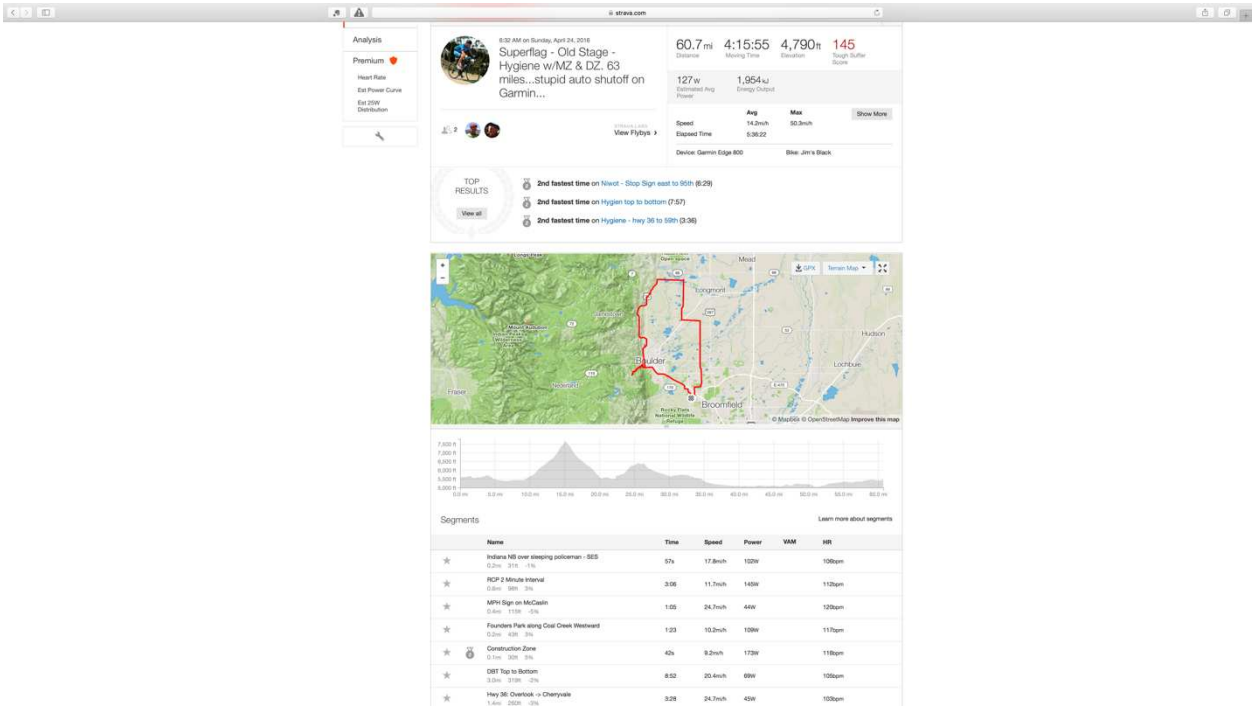

Figure 7. *Screenshot of Strava visualization for one ride. Note the map, elevation profile and suffer score.*

Tim is able to take in a lot of information on his home screen, in this case on his Strava page. His total miles and average speed, moving time and a host of other metrics. His ride is reassembled right in front of his eyes for personal reflection. He engages the data visualized before him:

> *My heart rate, even though it went up to 186 bpm, it was a flat part, I think my monitor got messed up because I wasn't even on a hill so I don't think that's right. I was probably in the 150s or something like that as I'm going up the big hill. I averaged 134 bpm.*

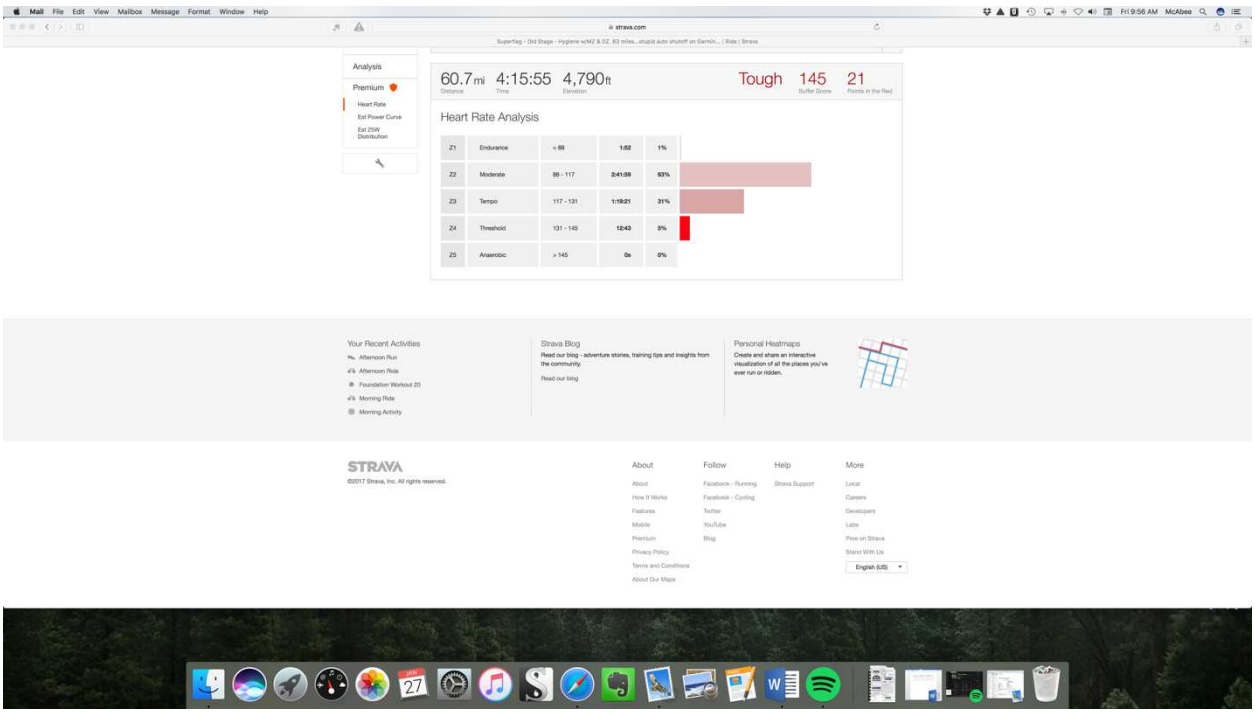

Figure 8. *Heart Rate Analysis in Strava.*

Even as Tim is able to "see" the data in front of him, he is able to "sense" that a heart rate of 186 bpm on that particular ride is too much for what is normal for him. He suggests the anomaly is due to a malfunctioning heart rate monitor, an interrupted signal, or some other cause is responsible. This sense is the mark of an experienced athlete, someone who is familiar with his body.

Tim has spoken into the system, the system has spoken back, and Tim seeks to understand his bodily and mental details during the ride reflected back to him for both his long-term and short-term reflection:

> *I look at my cadence a lot too. I averaged 66 rpm. So, a lot of the times I'm trying to get into a cadence of at least 75 which is hard to do on some of the bigger hills. I'll spend time on that and then compare it to a previous ride.*

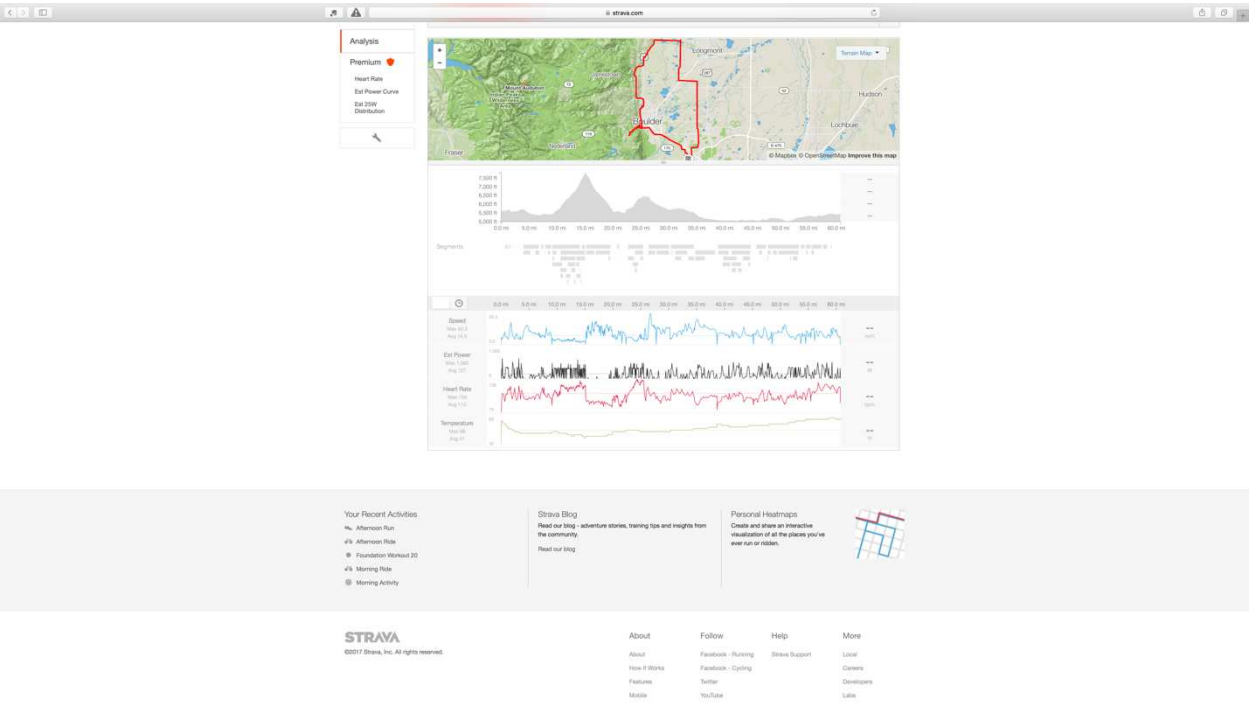

Figure 9. *Power, speed, heart rate, and temperature compared against one another.*

The data visualizations allow this experienced rider to improve his technique, (a faster cadence is more efficient on hill climbs), and to make a judgment of his performance with himself by himself. His time in front of the computer allows him to prolong the exercise experience and convert it from a physical experience into a psychological one. The legs that were spinning during the ride become a cadence graph, the circulation system becomes a red line, the hill he or she climbed is represented now by a sharp up-turn in profile, and his route is visible as an irregularly shaped polygon.

Charts, tables and graphs give self-tracking an air of validity, seriousness, analysis, and competent expertise usually found in the scientific world. It seems that this science effect that surrounds the user exists no matter what level of cyclist they are. The visualizations help the cyclist to validate what they were feeling on the ride, good or bad. This is enjoyable for the riders. It provides a pleasurable feeling for Denny (50):

I do a lot of the same routes very often. And what I do is I compare it. And yeah, I try to go a little faster, you know you always try to push yourself a little bit. At the beginning of the season which is typically March or April. I go slower. It's very gratifying later in the summer to see you are going faster and better.

This affective response to seeing the data double was repeated in other individuals as well. Lea's (39) interest in the numbers borders on obsessive:

I did my workouts the last two days. I was digging through the data this morning. I think the numbers are good but I emailed my coach and told him 'I need you to look at my files. I'm just curious like how did last night compare to maybe how I would have done last year.

For some, these interactions with their digital selves provide a lot of personal satisfaction They judge themselves through these numbers that may exceed in importance many other indicators of overall health and happiness. For others, it reinforces an identity that they have created for themselves. An identity that says "I'm a fit individual, respectable, and persistent in my habits." They are competent people taking agency in their own lives.

The feeling goes beyond just personal satisfaction and a fitness identity. Shelly (28) likes that she can express her individuality:

It's a psychological deficit that I definitely have that I need to feel like I am accomplishing something and feel like I am set apart from the rest in some sort of way. I need to feel like I did something that probably no one, well this is Colorado, maybe 50% of the people are doing. To me that sets me apart from the rest. I want something to be unique about myself.

The relationship between Shelly and her data double is both affective and purposeful. Cyclists in this thesis exhibited a tremendous amount of self-esteem and self-confidence. Tim (49) takes pleasure in what his training allows him to do:

> *The fact that I could go out and run a marathon tomorrow because I cycle or do a 100 mile ride because I run, at any given time is a pretty phenomenal thing to be able to do. I can go out and really enjoy any experience anyone wants to go and do because I am fit enough to go do it. Cycling does that for me.*

Clearly, the cyclists in this thesis feel, as they reflect upon their bodily experiences on the roads and thus prolonging the ride, like they are in control, competent, and interesting.

Affective and personal

After completing a ride, the cyclists in this thesis report doubling the exercise experience by reliving it in the digital world. These activities mean a lot to the participants. For example, Shelly (28) speaks of her tracking as such:

> *I guess for me; I need that measurement. I need to see how I compared to last time. I need to see how many miles I got. I need to see how much elevation I did for my own sense of accomplishment.*

It is interesting how the visualizations bring with them feelings of accomplishment and satisfaction. Teddy (50) adds,

> *So, it's really just wanting to prove that I can accomplish something difficult for my own satisfaction and to see if I'm improving or not.*

Tony (34), a beginner cyclist, sees value in his new life on the bike:

It's personal satisfaction. Whether you're racing and pushing yourself to do something better, discovering something new, or realizing that you can do something that you didn't think you could do.

Clearly, seeing their rides in this new way, like science, digitally and graphically displayed, has a big impact on how they feel about themselves. This is true at every level. Dynisse (26), finds her own personal meaning behind her rides:

I'm not fast up the hills but that sense of accomplishment when you make it up Deer Creek Canyon or wherever you're going. That sense of accomplishment once you get there. That I've tackled this. I've done it. It might take me all day to get there but that doesn't matter. I feel good about it.

One rider in the study talked about what it's like for him when he does and does not have a goal that he is striving for. Ferril (44) says:

If I don't have a goal out there then I really don't have direction. I'm going to work out but what am I going to do? Am I going to lift? Am I going to ride? Am I going for a run? You know, there has to be some kind of objective around a day's effort so it doesn't feel like a waste of time. You can leverage a one-hour workout to a greater degree if it is specific to a goal. Then, I can have a specific goal for the day. My event is 6 months away but I have a goal for today. That's more self-motivating to me to go and try to master today's workout.

Even though there were many racers in the group of cyclists studied, several were moving towards more intrinsic motivators and away from strictly competitive goals. Kic (32) was just one of these converts:

For me, it was always a matter of personals satisfaction. Whether I came in 1st or 4th didn't really matter as long as I felt as though I was performing better. It's not like I want to be the best or the fastest. I just like to see progress. I want to feel better and more confident in my riding. So for me, that's why I go out there and keep doing it.

Again, two themes, "sensing" and "seeing" emerge. Where sensing one's progress is not enough for the athlete, the data visualizations help her to "see" her progress. This progress, if pursued can lead the cyclist to feel as if they are performing better, in other words she feels as if she were competent.

Satisfying the need for competence

Communicating with the self through interaction with the digital double allows cyclists to track progress toward a goal or compete against an idealized version of themselves that they hope someday to live up to. On this level, between an individual and himself or herself, communication is taking place that is both affective and meaningful. This thesis seeks to identify the vehicle that carries the emotion and meaning. Deci and Ryan (2000) defined a basic psychological need as an "innate psychological nutriments that are essential for ongoing growth, integrity, and well-being." One of the questions guiding this research is how communicating with the self can lead to increasing levels of competence among cyclists in this thesis.

Personal satisfaction rooted in the mastery of certain difficult training techniques represents a form of intrinsic motivation (Pellitier, Fortier, Vallerand, Tusun, Briére, & Blaise, 1995). Cyclists in this study were goal oriented. In short, they liked to accomplish things on their bike or in other sports. Not only did the cyclists find this affective and purposeful, they also

found that getting better, even just a little, motivated them to continue on, to invent new challenges and to persist when they otherwise just did not feel like it.

Competence or mastery is not something unique to the cycling world. It is a human need, a personal quest, or an infinite line that we approach but never reach. What makes it important to this thesis and what makes it a universal trait is that no matter our level of fitness, humans need to feel improvement. This desire for mastery was voiced by both the female and male participants. For one male, Denny, (50), a low mileage cyclist but one who rated himself high for intrinsic motivation in the SMS II, found his lack of mastery frustrating:

> *I tried this Strava and it's all about competition. 'Oh yeah. I'm posting my ride here and I am number one.' I don't like that. Why don't you show me how to get better? Why don't you give me a hint of what to do when you're in the middle of a hill going up? I don't know if there is a trick or not but give me something to do to get better in that situation.*

Denny, at his cycling level, was unable to link his tracking on the bike to the skills necessary for climbing better. For example, he could work on getting his cadence up, something that is measureable with the device he uses. However, he found another enjoyable way to track his improvement on the bike, his mileage and his speed.

> *I love cycling. When you first start out, to ride like 10 miles and you're dead. But then soon, you can ride 50 miles and you're fine. I love that about cycling. That's what motivates me. You do it once and all the sudden you say 'I need to do it faster.' So some other day you do the same thing and you try to do it faster. That type of competition I like. Competition with yourself.*

Again gamification enters the picture as Denny tries to beat his previous performances and uses the training apps as a mirror.

Teddy (50), an avid cyclist despite less than five years of cycling experience is another example of a rider in this study who engages and interacts with his digital cycling self to move toward mastery of a particular skill. He explains how he uses measurable inputs to improve upon his cycling skills.

> *I have all these measurement devices on my bike. I've got the cadence and the speedometer. This year I got the power meter but since I'm not using that as much as I thought I might, I've been more focused on getting a higher cadence, you know, I've been told that's the way to go, I watched Chris Froome zoom up Alp D'huez last year and he was just like 'swoosh' right on up it with a high cadence and I wondered if it would work for me. So I started trying to get a higher average cadence for each ride. I track it and I'm riding maybe 5 rpms faster than I did last year. Good. Check that box. Next year, I'll probably do something with power. You know just having a year to see what my data is, to see where my base is.*

Teddy doesn't sound all that different from an elite level professional cyclist. Ferril, (44) a former pro, speaks about how performance gains tap into a deep emotional need:

> *Oh man, it's such an incredible rush. You're like, 'Oh my God, I can't believe I did that. That was crazy!' I've been mountain biking a lot lately and I'm looking back up. I was on the edge the entire time. I could have crashed at any moment but I held it up and I didn't go down. I got through it. Maybe I've*

never done that section before. You know, those types of emotions. It's the rush of the high performance aspect of it while in the moment.

Ferril could easily rest on his cycling laurels, take up other sports, or quit altogether, but the data keep him going.

I can see graphically where I've been. I can see where I started and where I am today. I can forecast into the future to where I want to be. I can see where I've set personal bests. It's gratifying for me to set a new top 5 best time or power output. It's motivating to keep the app up-to-date so I can have an historical view, literally, graphically of what it took to produce what result. I can leverage that data going into next year and it actually becomes motivating because the data in itself becomes an event. My goal becomes to at least do what I did last year.

The data become an event, like a race, something to work toward and to improve upon. His second self, the digital one, becomes a benchmark and a rival.

Female participants in this study seemed more willing to discuss their fears and how mastery of skills on the bike made them feel more comfortable. Competence is personal feat but critical to the cyclists' intrinsic motivation in that it reinforces fitness gains and technique improvements. This progression toward competence can be rather simple like Laury (36) who describes her comfort level regarding her hand positioning on the bike handlebars:

When I first got into cycling, I had a hard time getting into my drops. I had those old style brakes so I just sat there teetering on the crossbar. Then, I

worked my way into the hoods and now I'm totally comfortable in the drops, off my saddle, and over the top tube. That was a progression of mastery for me.

Progressions of mastery can also be rather specific and aided by the technology. Lea (32), the pro cyclist has already achieved a basic level of comfort, nevertheless she still possessed an edge to her comfort zone:

There's a tipping point. You have to have an aggressive mentality or you're not safe for yourself and others. You need to either slow down and do what's comfortable or get comfortable being a little bit risky. You need to perfect your skill to the point where you can really go fast and keep up with the pack and be comfortable.

Although comfort levels seemed to be a more prevalent motivator toward mastery among women than the men, Lea illustrates how she can also use her digital double in a very scientific way to increase her performance level on the bike:

I measure progress by focusing on functional threshold power (FTP). How much power? What is the maximum I can create and sustain? I think one of the nice things about the apps is that they are malleable. Let's say you're training for the Leadville 100. Then you can focus on Kjoules. How much energy is your body using to produce power over the course of a week? We can stimulate that and get the number up so that when you hit your higher training blocks and move into the actual race day, your body is prepared to handle the stress and strain and push it through.

This level of feedback from the device is reserved for the more advanced user. Lea shows that more than one metric can be combined to form combinations that the user can experiment with on her pursuit of mastery. Indeed, the data are malleable and the cyclist responsive. The fitness history chart below is a great way to view progress over time.

Power

Week of	Duration	Distance (mi)	TSS	kJ	5s	1m	5m	20m	60m
3/23/2015	*1:13:28*	*0.35*	*57.4*	*685*	*238*	*229*	*220*	*186*	*163*
3/16/2015	5:43:25	59.8	281.1	3128	453	299	261	201	194
3/9/2015	3:45:46	70.4	199.2	2161	509	335	263	205	181
3/2/2015	1:10:25	0.14	75.5	611	596	345	245	194	158
Recent Months									
March '15	*11:53:03*	*131*	*613.1*	*6584*	*596*	*345*	*263*	*205*	*194*
February '15	26:53:57	167	1414.1	15580	574	379	291	254	199
January '15	32:31:59	258	1869.1	18362	614	351	285	253	210
December '14	25:13:01	166	1459.5	14287	638	366	259	236	197
November '14	17:05:20	129	938.0	8566	657	419	284	248	212
October '14	14:26:38	227	811.4	6116	785	318	254	223	210

Peak Pace by Distance

Week of	Duration	Distance (mi)	TSS	400m	1km	1600m	5km	10km
3/23/2015	--	--	--	--	--	--	--	--
3/16/2015	6:07:05	40.9	413.6	06:11	06:13	06:14	07:12	08:08
3/9/2015	3:00:00	22.1	240.9	05:47	06:25	06:24	07:01	07:04
3/2/2015	3:20:08	23.0	185.0	05:52	06:34	06:53	07:08	07:43
Recent Months								
March '15	*14:31:06*	*98.3*	*940.7*	*05:47*	*06:13*	*06:14*	*07:01*	*07:04*
February '15	15:44:38	103	992.7	05:42	05:53	06:12	06:51	07:50
January '15	16:45:53	113	1091.1	05:53	06:19	06:23	06:55	07:23
December '14	11:04:35	77.9	789.2	05:51	06:19	06:33	06:38	07:07
November '14	10:07:51	68.4	687.0	05:31	05:56	06:08	06:23	06:29
October '14	9:02:54	66.2	722.2	06:08	06:29	06:34	07:05	07:40

Figure 10. *Fitness history chart in Training Peaks.*

> *This isn't always fun. Especially as you get older. I am not a tomboy. I didn't do anything that in my mind would give me the skills to be a good competitive cyclist. Women who I see are really good, come from a BMX, skateboarding, or snowboarding background. They're just comfortable going fast and leaning over but that sort of thing scares me. I had to take a break from racing after a series of crashes. It made me unsure of myself. In my head, I couldn't get back into road cycling. I wasn't into it like I felt I needed to be to really race aggressively and descend aggressively because you need that.*

To really enjoy cycling and feel like their psychological need of mastery was being met, participants showed a need to be fit and to feel confident in their bike handling skills. Kic (32), a cycling team member and weekend warrior type, tells of what it is like when mastery on the bike is achieved:

I had it in my head that I was not going to win that race and I was fine with that. But I have never had as much fun on a bike as I did that day. Everything felt better. My skill level was up. My fitness level was up from the last time I did a hard climb. The equipment worked and I was just climbing and climbing and yeah, it was horrible but there were points when I was just looking around at the scenery and I couldn't believe that I was up there and feeling really good. Hurting and everything but mentally, it was a lot of fun. I loved it. It was so hard but it was so much fun because I felt so much more confident than I have on any other bike ride.

Kic finished fourth in this race but her enjoyment due to mastery trumped the fact that she failed to make a podium, illustrating the intrinsic nature of motivation derived from mastery.

Competition with the self

In a bit of gamification several of the participants were able to look at the digital representation of their rides and view them as something to compete with. They viewed themselves, that is, their previous rides as a rival. Sonie (40), explains how she makes this work for her:

I think it increases my motivation because you're racing against yourself. It's an individual sport, I mean yes, I can race against other people but what I really want is to get better and that means, for me, improving upon my time from the last ride and not me trying to be better than X.

In this way competition is sustainable as a motivator. As opposed to competing against others because as you compete to beat opponents, eventually your ability to do so declines. Again, Pitta

(56), knows that her strongest, most competitive days are behind her. Nevertheless, she is able to still scratch her competitive itch:

> *I don't have that huge competitive drive. I do a self-competition. Occasionally, I'll look to see how I'm doing compared to the people I ride with but more often than not I compare myself with past performances.*

Neither is Denny discouraged by not being able to compete at a very high level:

> *So you do it once and all of the sudden you say 'I need to do it faster.' So, another day you do the same thing and you try to do it faster. That type of competition I like; competition with myself.*

There is a fine line between competition with the self and competition with others. Not only that, but competition easily turns into comparison. Kic illustrates the rubber-necker like qualities that begin to pull on the participants as they move from seeing themselves as they really are, trying to beat that version of the self, and the temptation, available through the social aspects of training apps, to look at the digital version of the other:

> *Well, you get as much data out of it as you are willing to put into it. I'm on Strava so I can at least see where I'm at and I'm able to track my own progress. Of course, I want to see where I fall as compared to the girls I ride with, the people I know, or someone I perceive to be really good. I gauge myself. I look at her and see that we were actually pretty close together. I must be improving or maybe not. Maybe she's regressing.*

Kic shows how easy it is to slide down the slope of external regulation.

Communication with others

Self-monitoring, analyzing, and interacting with one's own data is considered intrinsic motivations. They are typically high in autonomous support and undertaken for the enjoyment, pleasure, and fun of the participant. Extrinsic motivations come from an external source of some kind. There tends to be some reward for the behavior and thus the behavior becomes a means to an end. Going out for a bike ride and then coming back to examine the data captured during that ride because it is enjoyable to do so would be considered an intrinsic motivation for doing so, whereas doing the same thing in order to establish a reputation among local athletes would be considered extrinsic motivation. It is this line that marks the difference between intrinsic motivation, which makes an activity more sustainable, and extrinsic motivation, a fire that burns hot but not long.

Intrinsic motivation may not be the gold standard that it has been made out to be and athletes should not feel badly for having some forms of external regulation. Lea (32) an accomplished professional cyclist does not always go out and ride for the fun of it. As she notes:

> *"I feel like I need a certain amount of prestige. You know, you work hard and set yourself up for a certain amount of success and that keeps you going and reaching for more."*

The prestige of standing on a podium, riding a bike provided by a sponsor and wearing the team colors all served to motivate Lea. It allows her to be well regarded by people that she knows. The opinions of others seem to color the perception of her cycling. She is rewarded and punished depending on the circumstances surrounding her. However, it very much depends on where, when, or how she arrives at her perceptions whether or not this is an intrinsic or an extrinsic motivator.

Shelly (28) uses her cycling to deal with some self-esteem issues left over from her childhood:

> *I lived in very conservative and religious home. I was a missionary kid, home schooled my entire life. So, I didn't have the social interactions with other people. But, I remember distinctly as a kid having my mom criticizing me. It is definitely something engrained deep down inside that I am fully aware of. It makes me feel like I need to prove something to people. I want people to think highly of me.*

Shelly's defiance works for her at this age but getting her validation from outside herself is fraught with long-term red flags. More promising for the long-term outlook of participation is found in Teddy's demonstration of a form of identified regulation:

> *"I think cycling makes me a better person. It makes it easier for me to endure long processes at work. There are times when you spend a year or two developing a product and something goes wrong and you go, 'okay, it's a little setback but, I climbed Pikes Peak so this isn't so bad. I can get through this.' It kinda helps me calm down about stuff that may not be playing out according to plan. I've had this conversation with my boss. We'll talk about a project not going well or something and it's beyond our control and I said 'This is why I do those long bike rides because I know that if you just keep turning the pedals and keep working the process, eventually you will finish.'"*

The contrast between the two athletes show the latter to be more autonomous and thus self-determined. Yet, Teddy's words represent an extrinsic form of motivation as his cycling represents a means to an end when he thinks about it in this way. His riding makes him more effective at work. Nevertheless, it is more self-determined than Shelly's in that Teddy has decided that cycling is beneficial and important and thus chooses to perform it freely. Whereas,

Shelly, needing to prove herself to others, feels pressure and obligation. It is important to note that to nail down motivators for all cyclists would be beyond the scope of this study.

Making fitness "social"

The training apps available to cyclists today bring sociality to the somewhat singular sport of cycling. The previous discussions focused on communication with the technology in the form of physiological input and data gathered by an embedded GPS unit that travels with the cyclist on his or her ride. The training app is able to create a visualization of this data which acts as a mirror for the cyclist to peer into and lay the grounds for another dialogue with his or her digital double. In addition, training apps contain some of the same key functionalities embedded in more familiar social networking sites such as Facebook, such as commenting, and a "kudos" button which acts as Strava's version of the "like" on Facebook. Social fitness occurs as the users of training apps communicate through the technology where relationships are forged, maintained and amplified, both on and off the digital network.

Training apps and Strava in particular allow a network of close friends to meet on and off Strava, often extending to face-to-face relationships as well where riders benefit by satisfying their need to connect with others. While many of the cyclists' rides are performed alone, this appeared to be more out of necessity due to scheduling difficulties than desire. When Lea (32) first got into cycling, she began to form bonds with the people she rode with who became more than just riding partners with her. Sharing this part of her life with them led to friendships off the bike.

> *"It was a way to meet people. I knew no one when I first moved here. I started training again so that I would enjoy riding with my new friends, so I wouldn't be breathing so hard and could keep up, relax, and carry on a conversation."*

Teddy, (50) a self-proclaimed introvert found himself swept into cycling with others one step at a time.

> *"I went on a blind date. She told me about a spin class. I started going regularly and they talked me into getting into the 'outdoor' thing. Somewhere in the midst of that I bought a bike and started riding on the bike paths. I was terrified of the roads but the spinning instructor at the gym urged me to come out with them on a group ride. I was hooked. I love the social aspect of it. I was lucky to fall in with this little club here. They've been very welcoming. It's the brotherhood of the bike."*

Clearly, cyclists are meeting their need for connection when out with a group of friends, but like communication with the device and communication with the self, the social experience of training with others is extended in time when the riders return home only to continue the conversation online.

The culture of recognition

It may be rather obvious that those who ride together on a regular basis tend to communicate and socialize more in the self-tracking system. What is less clear is how these cyclists are redefining online communication by moving beyond the encouraging comment to other more selfish and self-serving motives. What little literature that has been written on the phenomenon of social fitness (that is, the action of sharing information about a ride for the purposes of cooperation, comparison, competition, and self-improvement), has focused heavily on the "culture of recognition" in which users broadcast their exercise data for the buzz they receive when their efforts are appreciated by knowledgeable peers (Lomborg & Frandsen, 2016). Stragier, Evens, & Mechant (2015) found that a person's willingness to share physical activity via social networks were due mostly to intrinsic motivators like altruism, information sharing,

and self-monitoring for self-optimization, and less likely to be a result of extrinsic motivators such as goal commitment or social support from online peers.

Levels of communication

Many of the participants noted that because these apps are cycling or sport specific, they play a special role in their lives, one that fills a gap in their online social networks occupied by more familiar sites such as Facebook and Instagram. Four levels of communication were found to be taking place on the social platforms of the training apps used by the participants in this study. Descriptions, research, social learning, cooperation, evaluations, social comparison, competition, “Kudos”, similar to the Facebook “Like”, and direct comments intended for other users were all observed in this thesis..

Descriptions

With built in GPS tracking capabilities, and the systematic breaking down of routes into smaller segments, the training apps include with its data visualization a georeferenced description of each ride that is recorded by the cyclists in this study. This first level of communication expressed through the app and based on the riders collected data seem to take the form of a ride description. Where and when they ride, for example. As well as any and all the metrics discussed above that the rider has chosen to share. The riders have the option to keep this information private. Once they have decided to share, many other stories are told as well. Persons interested in delving deeper into a particular ride can discover a significant amount about the other person or just catch up on club happenings. Participants in the study who were also a member of a cycling team or club reported finding information regarding the time and place of upcoming rides through Strava.

Unique descriptions of cycling data seemed to appeal to the participants. Some made a distinction between their friends and their cycling friends preferring to keep them separate. Mica (32) explains why she likes having a dedicated social network for cycling:

> *"With Facebook, it's like you're wasting your time on meaningless shit whereas with Strava you are looking at cycling specific stuff, different routes, speeds and those types of things."*

Mica wants her online communication to be sports specific.

Research

With detailed information about rides available for viewing by competitors and friends alike, participants in this study found that researching the data of other individuals could be helpful to their own experience. Kic (32) is relatively new to town. However, her interest in other riders' data go beyond finding new rides in new places:

> *"I know that I've used Strava to try to find new routes and mapping them out. But there are also a few women that I know of on different teams who I perceive as being very fast and very far ahead of me. I look at their data and think 'okay, she did it in 3 hours. I can do it.' It ends up being 5 hours for me but that's not the point. I wonder if I could get to that point. There's some kind of motivation for me. There's some level of research to it."*

Research leads to social learning.

Social learning

The riders can view the data of any rider who shares their information publicly. This is a tremendous advantage to the beginning rider as so much information is available to them with little cost to themselves. While less insidious and damaging than Ignatieff's (1998, p. 11), "promiscuous voyeurism" made possible by our visual culture, participants in this study readily

admitted to viewing other profiles without identifying themselves to the person belonging to the data being viewed. They were more like a young person who emulates the mannerisms and style of his favorite football player. Again, Kic (32), gathers information and uses this information to make herself into a better rider:

> *"I definitely use Strava to see what my friends have done. But I also like to see who they're riding with and who else is out there because I'm at the point where I'm trying to figure out whether or not to join a cycling team or not. And if I'm not then who can I surround myself with who I consider to be very good riders who can, again, help me build those skills."*

Here is an example of a participant in the study actively seeking mentors through the app for rides on the road. This is a positive aspect of the app use.

Several riders in this study used were more nefarious in their research. Nat (36) liked to keep tabs on his competition:

> *"I'm friends with people who I consider arch enemies on the course. You know, I never rode with them as far as training rides but I wanted to see what they were doing. I also think that they wanted to see what I was doing to get ready for the next race."*

Pitta (56), held nothing back when describing how she liked to use other people's rides to enhance her own experience:

> *"You have all these different rides and it's like having a bud that you aren't even talking to and you can literally pilfer their rides. It's like 'hey, they rode this ride and it's 62 miles and they took this long.' That's interesting."*

Even in jest, Pitta's language brings to mind the image of an online stalker in a one-way relationship. However, there are others who find ways to cooperate inside the app.

Cooperation

Where voyeurism ends, real relationships can be forged by more traditional communication methods. Cooperation of this sort differs from functionalities such as "kudos" and comments that are found in other social media sites. Once another athlete's data are evaluated and some common ground is presupposed, the more assertive riders can make contact with a rider from whom the initiate wants some information. For example, Lanie (40) has no problem making contact through Strava.

> *"Strava can certainly be helpful in connecting you with much better riders. I've gone on to meet people I've connected with on Strava on actual bike rides. I just ask, 'I was just looking for a really cool, epic ride this weekend, what do you suggest?' Sometimes we go together or they can just send me the ride. 'Here, check this out.'"*

Knowing that voyeurism occurs alongside the willing sharing of data, one rider, Kic (32) will often mislead competitors on her Strava account. She explains:

> *"If I want to be competitive and I want you to think I am competitive and I want to put that image on Strava then I'm probably only post the rides where I got a QOM or if I have a top 10. Anything else and I'm not going to post it. I'm not going to post a 5 mile, 20-minute ride. I want you to think that I'm just doing all these training rides. I don't want you to see where I came in 4th or 5th in this race because I want you to think more highly of me."*

Competition and comparison make up much of the content and the motivation for posting among the participants in this study. As we will see in the next section, this willingly shared information is evaluated by each user and they begin to fit themselves into the order of skill.

Evaluations

Not far behind descriptions of exercise data, participants find themselves evaluating their performance against other users' recorded rides. This type of communication differs from the communication with the self that occurs when the participants are evaluating their digital double that has been created by their own input. Evaluating takes place when a rider sizes up another user based on the data they have shared. But, the participants in this study were also concerned what people in their social circles were posting. The interviews for this research showed that participants reported great interest in comparing oneself with others in the realm of cycling-related data among participants. On the intrinsic side of this acute interest, we find riders who evaluate other cyclists for the normative influence that can be attained. For example, Kic (32) who recently moved to Colorado seeks out cyclist to emulate by first evaluating their data:

> *I just saw someone at a race last weekend. She was really good and we hit it off so I looked her up on Strava. I saw some of the rides she was doing and actually went to ride one of them. She is still faster than I am but it was fun to go out and follow her, so to speak.*

Still, other participants were prone to a type of social comparison which had disheartening results. Laurie, (28), mother of three gets a little intimidated by what she finds:

> *I look at some of these girls (on Strava) and I'm like, no way. I could never beat her.*

The language of comparison and competition reigns on Strava. It would not be too bold to call competition Strava's raison d'être.

Social comparison

Several of the riders in this study used the collected data of other cyclists, some of whom they know and some whom they were not acquainted with, as a surrogate benchmark for themselves and their own performances. This extrinsic comparison led them away from the personal satisfaction that was reported to occur when cyclists compare their past performances and are able to see improvement in performance and led them instead to a place of despair when they compared themselves to someone out of their cycling league, so to speak. As soon as the activity, in this case a bike ride, begins to take on some significance outside of the simple personal satisfaction gained for the sake of the activity itself, as when the participants in this study found themselves in an unfavorable comparison, motivation slipped into an extrinsic mode and as such could then be seen to decrease motivation as a result.

Determining our social and personal worth by measuring ourselves against other people is what psychologists call Social Comparison Theory. People then find themselves constantly making self and other evaluations across many domains: attractiveness, wealth, intelligence and success. Cyclists in this study were able to evaluate others without their knowledge, but when the interview started, envy and discouragement were voiced, showing that it was possible to be "defeated by the app" as one participant, Rauld (45) put it. It seemed very easy for people in this study to get caught up in the numbers and to become "depressed" or discouraged. Shelly (28), a very active cyclist, at first takes a very affirmative tone toward her need to compare herself to others:

> *"I want to know. I need to have a peer group who I can measure myself against. I have my boyfriend but he just blows me away. So I had to find some other peer group, some group of women or some other group that I could say, 'okay, you are my speed and I still*

beat you.' So if I can use Strava to compare myself to some other peer group that doesn't race, then I feel better about myself."

But, she admits that there is another side to her comparison coin:

I'm comparing myself and I'm like, 'damn it!' I'm not even close to that QOM (queen of the mountain) How am I ever going to do that?

On the one hand, Shelly uses these comparisons to boost her confidence but when the data communicates something that is currently out of her reach physically she becomes discouraged.

This reaction was found in men as well. Tern (24), found that he could become discouraged if he was not careful:

"I'm think that you can diminish a person's feeling of accomplishment to some degree because you are able to see some of the top cyclists in the world who are on Strava, especially in this area. I mean, there are some otherworldly athletes in Colorado. Even the old guys are fast. You can't fathom how these individuals are able to post these times or go as fast as they do. I mean, you understand how hard you train but it becomes unthinkable to see how fast they are going, like it doesn't even seem physically possible."

Tern, in this instant is not using the comparison functions of the app to his advantage. Several other riders had strategies to combat negative thoughts due to unfavorable comparisons. Lanie (38) explains the way she avoids this situation,

"There are people I will not follow on Strava because in my head I feel like I should be better than them and it just messes with me mentally if I see they rode something faster than I did."

Tim (49) uses functionalities embedded in the app to mitigate his negative feelings caused by comparisons:

> *Clif Bar had a segment challenge in a ride I did. They tracked the speed of everyone who wanted to participate going up Vail Pass. 566 people participated. But I can filter out people by age so the age group for me is 45-54. I was 10th out of 152. I knew they were going to track us but while I was going up I had sorta forgotten about it but when I finished the race, Strava automatically threw me in. So, I'm looking around in the app and asking if I know any of these people and where they are from. Is the person 45 or 54? I'm right in the middle of the group. How far was I behind? I was 46th overall. I was 9:35 behind the overall leader which is a lot on a bike but this guy could be 25 years old. He could be a pro. He could be racing up it just because he could.*

Tim shows mature discernment in not getting down on himself. For him, this was a good ride. He felt that he had nothing to be ashamed or upset about.

Tim's ability to categorize himself by age and ability and to accept his level of fitness as being good enough for himself has much to do with his ability to have a positive relationship with other people's data. In fact, later on in his interview Timm shared how comparisons can have a normative influence:

> *We share this stuff and you can see if you've been riding well or not at all. Especially when you are pretty religious about posting. I have friends who, if I haven't ridden in a while, will reach out to me and ask me why I haven't been riding. They ask me if I'm okay. They ask me to go ride with them. Especially members of our team. You're held accountable and it's very transparent.*

Tim is "pretty religious about posting." This provides a stable and consistent display for his mates to view. They obviously feel comfortable commenting on what he puts out there and in a way extends the comradery on the bike to time spent on the computer and begins to show how

Timm's need for communion with others is being met. Before this need is discussed, however, another outcome of the evaluations going on within the app must be discussed. As cyclists say, whenever two bikes are headed in the same direction, the race is on.

Competition

As discussed above, communication with others within a training app tends to be in the form of descriptions of rides that are uploaded from devices designed to track certain sports specific variables. The riders then go through a process of evaluating themselves for the purpose of bettering themselves. Often this process of evaluation extends to other riders who share their ride data on the sites. Cyclists inevitably begin to socially compare themselves either favorably, unfavorably, or near equal to one another. As a result, a competition breaks out, but it is not the competition of sanctioned races. This competition takes place asynchronously. The crown is awarded online, and while the results are compiled from actual bike rides, the race for a segment King or Queen of the mountain is always on and ready for the taking. The apps also afford users the ability to filter results based on gender, age, and weight, thus fine tuning results such that it is possible to be the King of your age group.

The impact of this communication through competition varied from within this study but consistently mattered more to participants who practice cycling with others on a team or in groups and who met up afterward on Strava. These cyclists used the togetherness and competition in joint practice of exercising as motivation. Still, other cyclists in this study, cyclists who might lack the skill to find themselves on top of a local leaderboard, found competitive features of Strava fun. They actually enjoyed the gamification aspect of the feature a lot. Rauld (45) illustrates this for us:

I have a Strava account. I only use it for fun. I don't use it for training, if you will. Oh, I load it in just to play with it. The most fun I get out of it is looking at KOMs and things like that.

Nat (36) wants to compete but takes a measured approach:

"In open class racing, I don't stand a chance against the younger guys but when I'm in that selective class 36-40, I have a chance because I'm racing like aged ability type people. Strava is just another way to compete with one another, against my friends, to prove to them that they can't catch my KOM."

However, Shelly (28) obviously cares a lot about being on top of a leaderboard.

If I'm in the top ten, then I'm going for that QOM. I had a QOM on the 470 trail and some bitch took it away. I was right up there with some really strong cyclists and somebody took it away. She had a tailwind that day. I'll tell you what. The next time we commuted to work and I hit that hill, I was hauling ass because I wanted my QOM back.

For Shelly (28) winning is very important. She feeds off the competition growing stronger and stronger in her pursuit of the top. Other riders in the study who might still be competitive in nature but the realities of skill or age won't allow them to sit atop a leaderboard still find the comparison features alluring.

Teddy (50) is one such rider. Resigned to compete amongst his friends, he enjoys making a game out of comparison by using it for a basis of encouragement, comradery, and old-fashioned ribbing between friends:

I might take a screen shot and send it to a friend and say, 'Hey, I got you on this one.' He might go right back out and get it back because he can do that but with a little luck, good timing, and a tailwind, I can beat him and brag a little.

Teddy's stance on the competitive aspect of Strava mirrored many in the study. Most just felt that with all of the great cyclists in this part of Colorado, many of whom are professional who also use the app, there just wasn't much of a chance to compete at the highest level. Yet, this is not to say that the presence of these competitive segments did not augment the rides for some of the cyclists.

Some of the riders were hyperaware of the location, distance, and direction of these segments, especially on routes they travelled often. For example, Rauld rides the roads close to his work so often that his familiarity with the local Strava segments actually causes him to change his training ride to accommodate the segments:

> *I turn on the app on my phone when I go out for a ride and then at the end, I upload it. However, I have to say that if I know that there is a KOM in the area, that might be my play interval, you know, tempo. If you ride the same roads constantly you start to know where they are and you want to get this one or that one. There is satisfaction in that once in a while. I really like it when I get a KOM on a highly travelled segment.*

You find cyclists training on the segments that are important to them, memorizing the contours of the route, and measuring the effort in an attempt to give it their best and perhaps, one day, capture the King or Queen of the mountain. Timm (49) has a favorite segment that he believes should be his one day. Notice how he changes his game plan to focus on a particularly meaningful KOM:

> *There's a segment going up Buffalo Mountain, that's where my house is, up at the top and I have to ride it every single time I go up to my house up there. I saw there was a segment going up that road. I found out that I was making huge improvements. I actually got into the top 20. I thought 'well, heck, I'm not even racing up this. I've been doing long rides*

before getting here. It'd be fun to just power up this one day to get my name on top of the list.' It's always in the back of my mind. 800 people have done it and now I'm number 5. Some people live for the KOM. I'm not like that right now. But if it's something where if I put in some effort into it, it'd be fun to be KOM. Why not go for it?

In this way, the asynchronous competition that the app allows, provides extrinsic motivation for the participants in this study. In lieu of head-to-head racing on the road, the app provides an easy yet meaningful way to measure yourself against other cyclists. Nat (36) shows how the lines are blurred between synchronous and asynchronous competition, competition that takes place on the road and competition that takes place in the cloud:

I introduced Strava to a lot of buddies in the group. I started racing with it and it became a thing. On our rides it went from 'are you,' pardon the expression, 'beating the shit out of your friend,' to 'I'm moving up. I'm in the top 10 on this segment'. Can I knock that number 1 guy off the pedestal?

Competition is a complex motivator and can be driven by an intrinsic desire to master the necessary skills, for the pure fun of being "in the game," or the support of a community of relevant others who encourage one another along the way. At the same time, depending on the mindset of the cyclist, competition can be an extrinsic need for social recognition from a knowledgeable audience, an ego boost, and a way to feel superior to others. Either way, this recognition from one's peers takes place through a readily available comment system with a one-click approval button resembling the Facebook "like" that Strava calls "kudos"

Comments and kudos

The cyclists in this study appreciated it when their efforts on the bike were recognized by the group. Social fitness that occurs within the province of the app is not unlike the well-known

dynamics that occur in social media in general (Lomborg, 2004), but also to themes that are central to sports participation in general. Clearly, the cyclists who enjoy communicating with others in this space seek communion with like-minded individuals who share a bond based in cycling and enjoy the fact that the experience on the bike can be extended.

Cycling can be enjoyed in a variety of ways. Look around on a nice day and you will notice the solo riders, the couples, groups of three or more, and as much as a dozen, cruising around the roads of Colorado in petit pelotons. Solo riding is the most convenient, but riding in a group has a few benefits of its own. First, pairing up with people with similar skill levels can make a group ride less intimidating. There also some physiological and practical reasons for it. Groups can draft off of one another to reduce overall effort on a ride. Also, riding in a group seemed to confirm for participants in this study an identity related to cycling. This strong affiliation with related others can be as personal as a conversation, an offer of help to a stopped cyclist, or a subtle as a nod of the head. Denny (50) illustrates this well:

> *The other day I had a flat tire, actually two in a row. I think I ran over a thorny branch. So, I stop. I'm with a friend who is new to cycling. I show him how to change a tire. This is another cycling thing. We are not willing to keep that knowledge to ourselves. I didn't know how to change a tire and somebody taught me. I didn't have to google it. It was all with people. Plus, I ride hard on my own but I ride harder with other people for whatever reason.*

Mica (32), very much enjoys the social aspect of her rides and seeks to ride with others as often as she can:

I view riding with the girls as a chance to catch up with my friends. I get to find out what's going on with them. Everybody's so busy. It's a good way to get some exercise and catch up on what's going on in their life at the same time.

Mica can become a better cyclist and met her psychological need for community at the same time. Teddy (50) had his needs met as well. However, his focus seemed to rest less on the catching up and more on skills acquisition:

I like the group aspect. When I first joined the group, I clearly didn't know what I was doing. I was riding in the drops all the time. I was nervous about riding in the hoods. We went out for a ride and someone said, 'God, take your hands out of the drops, man.' They were giving me a little advice and giving me a hard time. Most of my learning process has been that way, a hodgepodge of advice I've gotten from the club folks.

No doubt, a connection is felt among men and women who cycle together.

Recognition

As mentioned earlier, Strava, with its' "kudos" function and comments section, resembles other social media in several important ways. Participants in this study had plenty to say about how they use these functions. After a ride, whether or not it takes place with any member of your group, the cyclist is free to get online and analyze his/her own data, but also to engage other members in their group or members who have chosen to make their profile a public one. Once this type of communication begins, many of the same themes from other social media come up in the conversation. For example, some of the cyclists in this study enjoyed getting "kudos" from other people, several did not appreciate the gesture as much. It was clear that getting this form of recognition was not a motivating factor as made clear by Dynisse (24):

I'm not posting it to get kudos. I'm posting it because I'm super excited about it.

Rauld (45) displayed a take it or leave it position but he could acknowledge the value of this type of communication. He seemed somewhat confused when people he did not know made contact but he remained comfortable when communication came from someone within his circle:

> *There are all kinds of people who follow me and I don't know who they are. Maybe I'm really bad at names and maybe I do know who they are. I mean, I try to encourage my teammates and the people I'm connected with. I don't really care to go around commenting and giving kudos except that it seems like people enjoy getting it. I seem to get a lot of comments. I'm the title sponsor of the team so guys are like, 'Hey, good job.' But I'm not trying to get kudos from people.*

For Nat (36), a sense of validation accompanied the recognition through "kudos".

> *I guess getting kudos sort of affirms the effort for the day. I appreciate it. When I see a friend come in and post a ride or post a challenge, I might give them a kudos if it looks like a good hard ride or it looks like they've set some PRs in there. I may go further and give them a comment and say 'way to go', or 'good job.'*

Notice that Nat makes a judgment about whether or not the ride warrants more than just a one-click "kudos". He is evaluating other cyclists' rides.

The participants, particularly female, had much to say about their enjoyment of the kudos function in Strava. They enjoyed receiving the recognition from their peers. Mica (32) internalizes this attention:

I always feel bad saying this but there is something to be said about the bragging rights that go with it. Knowing that people are looking at you who could never accomplish what you're doing.

With this Mica may be using favorable comparisons to boost her ego. Lanie says:

I like to get kudos. It makes me feel pretty good. I like to see how I'm doing and to know that other people are watching what I'm doing.

Tim sat down at the computer and commented on how others were evaluating, giving kudos, and commenting on one of his recent difficult rides:

> Okay, on SuperFlag *(a local ride with a large climb up Flagstaff Mountain)* comments. People give me kudos. One says "nice ride". These two people are from my team. This person is my neighbor. Krista is a brand new rider. She is the girlfriend of my neighbor. She says, "Looks like I'll be getting all PRs. First time to ride there, eeek." I'll comment back to her. So, I'm using it like a Facebook page.

Like Facebook, Strava's kudos function elicits similar complaints from users as the Facebook "like". For example, it seems that ubiquitous kudos-ing can cheapen or dilute the meaning for folks. Kic's (32) take on the situation was typical of the female riders in this study:

> *For me, I see some people giving everyone on the team kudos every single time. That's not what I like. I think that makes it lose the whole point. It's obvious the equivalent of liking something on Facebook and you always have this one person who is going to like every single thing you put up there and it's like alright, that's nice and all but really?*

She goes on to give her criteria for giving kudos or commenting on her teammates' rides:

> *I usually look through and see what their PRs were or how fast they were going and you can tell if they were really out there busting their tails. I know what that's like on the receiving end. It's great, especially if it is someone I really respect or admire. They say something like 'Hey Kic, way to kill it out there today!' Wow. That's really nice. I don't do it for the kudos but…*

Taking the time to comment being a more meaningful form of expression was a common theme among participants. None voiced this as strongly as Shelly (28):

> *To me, 'liking' or giving 'kudos' to someone is a lazy way of acknowledging. I'm guilty of it too. You don't really care unless, okay Lanie got her 2000 miles today. I said 'congratulations.' I didn't just like it or give her 'kudos'.*

When Lanie (38) was asked about Shelly's comment she responed:

> *That comment was more meaningful to me than other people who just gave me "kudos". Your're going out of your way.(when commenting) You're taking that extra step.*

Shelly went on further:

> *If you care then say something. Otherwise, I'll assume that you saw it and you gave two shits about it. I don't really care, social media is kinda a half-ass way of being nosy and keeping tabs on somebody without really being invested in what's going on in their life.*

For Shelly, what redeems Strava is that it is sports specific.

You have so many options with Facebook. You're much more limited on Strava. It's kinda hard to have a discussion on Strava. You can post on somebody's ride but beyond that someone can't go in and post 'Man, I'm frustrated.' Oh, look at the traffic.' Oh look, a rainbow.' The mindless shit isn't there. So you know, it's less garbage.

Fair or not, the criticism was there but most were okay with the limitations of online relationships, understanding full well that these relationships could be carried on and developed on the tarmac.

Facilitation

Finally, according to many of those interviewed, the social affordances of the app proved to be most effective when they were facilitating human-to-human contact around the sport of cycling. Friendships made around the sport of cycling, at local rides and races for example, grew into online relationships which led to more rides and altruism between cyclists.

Nat (36) found friends from his past, like one might do on Facebook and reconnected with them.

It has helped me connect with people from years ago that weren't on Strava. I guess they put their email address in or allowed the application to go through their address book and it pulls different people. I've gotten follow requests from people like that.

Once connected with his friends on Strava, Nat is able to then do what comes naturally to him, bring people together:

I'm kinda like the ringleader for a lot of things. I tend to be the hub that everyone comments to. I'm usually the one who likes to put rides together through Strava.

What is unique about meeting up through Strava is that you can reach out to people of your own ability level and be confident in the comparison because the data is out there for someone to evaluate. Here is an example of how Timm might choose someone from his very large team:

If you go back here to our club, which is really cool, we can see the leaders of the actual team. We can see who had the most distance for the team and who had the longest rides last week. I had the second longest ride last week for the entire team. If I notice that someone else is doing long rides then I'll click on him and see where he's at because we have a lot of people on our team and if I find out that he's riding on some of the same courses that I am, then I will reach out to him and say 'Hey, next time you go out for a long ride, why don't we go together.'

Strava just takes making contact to a new level where more data are available to use in deciding whether or not a friendship should be pursued but it reinforces for the athlete what cannot be ascertained by sight alone. The data can confirm much in terms of pace, skill, and ability. This can have a normative influence on the participants as well leading to self and team improvement.

Pitta (56) found that Strava provided a communication vehicle through which to connect and carry on a friendship made at a race. The two women were talking about their race, connected on Strava after they both went to their respective homes, and later made time for ride together for fun:

The woman from the cross race and I hooked up after online. I met her at the race and she actually started following me on Strava. I sent her a message and said 'Hey, it was fun racing with you. I was dead afterwards so we didn't talk much but I live in Parker so if you want to come ride with me that would be great.' And we did that.

The ritual of adding and sharing data through the exercise app becomes a means of achieving a common practice and shared understanding of the situation at hand. In other words, the cyclists in this study carry on meaningful conversations among relevant others and the experience is both fruitful and enjoyable.

A certain amount of fandom was observed as participants in the study were able to find pro cyclists whom they admired and were able to follow their posted efforts. Lance Armstrong has a large following just to name one. But, Strava also allowed users to get unusually close to local pros, something unique to the Front Range of Colorado, especially around Boulder, Colorado. In fact, cyclists in this study were not afraid to admit that they looked at other people's profiles and got ideas for new rides to explore. Other times, the app afforded the users to share rides in a very altruistic way. Kic explains:

We were trying to find some fall rides. We talked to one of my girlfriends through Strava and ask 'Hey, where's a good place to go mountain biking this weekend?' And she says, 'Oh, try Kenosha. I've got it mapped out.' She had the file and I was able to look at one of the rides she did and see the route she took and about how long it took her to do it. Then we started to play around with and think that maybe we can get a group together or see the people she rode with.

CONCLUSION

Research questions

Borrowing largely from Lomborg and Frandsen (2016) this thesis has set out to view the self-tracking of 18 cyclists in Colorado through the lens of communication by viewing the daily tracking and exercising habits of 18 individuals along three dimensions: communicating with the device, communicating with one's self, and communicating with others through the affordances of this highly specialized mediated platform. When laid beside the basic psychological needs put forth in Self-determination Theory, that is, the need for autonomy, the need for competence, and the need for relatedness, the participant interviews revealed a possible correlation between the level of communication and the satisfaction of a particular need. These cyclists reported finding autonomy through communicating with the device, competence through interacting with digital visualizations of their training selves, and relatedness through recognition from knowledgeable peers via the social affordances of the apps.

RQ 1: To what extent does communicating with the device seem to satisfy the cyclists' need for autonomy among the cyclists interviewed?

The tools are powerful and they have given the weekend warrior, the avid amateur, the professional and semi-professional, and the tinkerer the keys to their own fitness engines. In the hands of amateur cycling scientists, progress is being tracked by people who are empowered to see the truth about their rides and to adjust them accordingly. Rather than freedom to do as one pleases, the participant interviews contained a view of autonomy as the freedom from outside control. Not only does it appear that the athletes do not need a cycling coach to prod them on but they seemed to prefer being their own source of coaching and motivation. For these participants cycling has moved beyond the realm of hobby and into a lifestyle in which the markers of

successful living are tracked in the form of miles and average speed. Their results confirmed for them a certain amount of fitness, a certain amount of discipline, and a certain amount of seriousness that reinforced an identity for which they strive. In this structure, participants find pleasure and meaning because they are able to accommodate the system to their personal needs. The participants in this study felt that being in charge of their data collection satisfied their need for autonomy.

RQ 2: To what extent does communicating with the self appear to satisfy the cyclists' need for competence among the cyclists interviewed?

The beauty of competence is that it is a moving target. No cyclist interviewed for this thesis lived with the illusion that they would one day become one of the world's elite cyclists. They knew very well both what kind of rider they were and what they were capable of if they applied themselves. They were more than willing to put in the time, were open minded toward new ideas, and were willing to experiment. For some, interacting with their digital self provides much personal satisfaction as they enhanced their sense of competence.

The device furnishes the data, which are personalized and immediate, however, it is the rider who responds to the visualizations by evaluating the performance and then adjusting his or her practice in order to optimize it in relation to some goal. The interaction with the self in the form of a data double allowed the participants to feel secure in their progress toward mastery or at least competency. They were able to use the technology to improve in certain skills and this improvement motivated them to invent new challenges and to further encourage compliance to an exercise routine. Still others found it fun to compete with their digital selves in a bit of gamification with the data. In the most extreme case, the data could become the event itself, where exceeding some threshold becomes the reason for the ride, eclipsing the more material

aspects. Seeing this data compliments what the riders sensed about their health and fitness and confirms their progress toward competence.

RQ 3: To what extent did communicating with others within the training app appear to satisfy the need for relatedness among the cyclists interviewed?

Communication with others through the use of social fitness apps like Strava facilitates the meet-up and allows users to match themselves with people of similar ability levels. The need to feel connected to others is extended in time and space to the personal computer at home. The recognition one receives through Strava is important to the users because it comes from a relevant and appreciative audience who understands the nuances of cycling. Communication between riders in the form of descriptions of rides, numbers really, that are evaluated and interpreted by other users and then can be given "kudos" or commented on, can also be the elements of competition between riders, not out on the road, but on an all-time leaderboard where participants compete again and again on the same segment of a course. Users gamify this experience and enjoy bonding with friends over it. Finally, the observable data makes social comparison both motivating and de-motivating, depending on who is comparing and with whom they are comparing. Self-tracking as communication with others is a rich environment for the communication researcher.

RQ 4: To what degree have the cyclists interviewed seemed to internalize their motivations for participating in their sport?

Internalization is the process of moving up the self-determination continuum from more external regulation toward more intrinsically motivated behavior. The more intrinsically motivated behavior is said to be more self-determined and therefore more pleasurable and satisfying contributing to long-term persistence. The Sports Motivation Scale (SMS II)

developed in France but validated in English was designed to assess individuals' level of motivation toward a sport using self-determination theory framework. The participants' motivation was assessed before the interview using a 7-point Likert scale ranging from 1 (Does not correspond at all) to 7 (Corresponds completely). The scale consisted of the 28 items measuring seven factors (three types of intrinsic motivation, four types of extrinsic motivation, and amotivation).

Table 1. *Participant levels of intrinsic motivation using the SMS II*

Measure of intrinsic motivation	Mean	Standard Deviation
For the pleasure I feel in living exciting experiences	5.889	0.936
For the pleasure it gives me to know more about cycling	5.278	1.274
For the pleasure of discovering new training techniques	4.389	1.720
Because I feel a lot of personal satisfaction while mastering certain difficult training techniques	5.389	1.754
For the pleasure I feel while improving some of my weak points	5.556	1.423
For the excitement I feel when I am really involved in a ride	6.111	0.9
For the satisfaction I feel when I am perfecting my cycling	5.333	1.495
For the intense emotions that I feel while I am cycling	5.056	1.798
For the pleasure that I feel while executing certain difficult aspects of cycling	5.5	1.505
For the pleasure that I feel while learning training techniques that I have never tried before	4.833	1.581
Because I like the feeling of being totally immersed in a ride	6.111	1.023
For the pleasure of discovering new performance strategies	4.778	1.734
Because it gives me pleasure to learn more about cycling	5.278	1.074
Because it is very interesting to learn how I can improve	5.5	1.465

Because I find it enjoyable to discover new performance strategies	5.056	1.697

Comparisons of the means between participants in this study and the athletes in Pellitier et al. (2013) revealed that the cyclists in this study scored higher than the other athletes. For intrinsic motivation (M = 5.34), integrated regulation (M = 5.02), identified regulation (M = 5), introjected regulation (M = 4.4), this group came into the interviews with motivation leaning more toward the internalized forms of motivation than they were toward the extrinsic forms of motivation, external regulation (M = 3.33) and amotivation (M = 1.96).

Table 2. *Participant levels of integrated regulation using the SMS II*

Measure of integrated regulation	Mean	Standard Deviation
Because cycling reflects the essence of who I am.	5.056	1.697
Because through cycling, I am living in line with my deepest principles	4.444	1.617
Because cycling is an intergral part of my life	5.611	1.195

Table 3. *Participant levels of identified regulation using the SMS II*

Measurement of identified regulation	Mean	Standard Deviation
Because in my opinion, it is one of the best ways to meet people	4.778	1.437
Because it is one of the best ways I have chosen to develop other aspects of myself	5.086	1.519
Because it is a good way to learn lots of things which could be useful to me in other areas of my life	4.889	1.182
Because it is one of the best ways to maintain good relationships with my friends	5.222	1.517
Because I have chosen cycling as a way to develop myself	5.056	1.685
Because I found that cycling is a good way to develop aspects of myself that I value	5.222	1.396

There is no way to make the case that self-tracking individual cycling behavior contributed to the internalization of this behavior except that the interviews showed that these participants found it enjoyable to track themselves and this is a known antecedent to intrinsically motivated behavior. The surveys showed that coming into the interview, these participants were already highly motivated individuals.

Table 4. *Participant levels of introjected regulation using the SMS II*

Measurement of introjected regulation	Mean	Standard Deviation
Because it is absolutely necessary to do sports if one wants to be in shape	4.44	2.121
Because I must ride to feel good about myself	3.722	1.809
Because I would feel bad if I was not taking time to do it	4.833	1.618
Because I must ride regularly	4.5	2.036
Because I would feel bad about myself if I did not take the time to do it	4	2
Because I feel better about myself when I ride	5.786	1.424
Because I would not feel worthwhile if I did not ride	3	2.148

Table 5. *Participant levels of external regulation using the SMS II*

Measurement of external regulation	Mean	Standard Deviation
Because it allows me to be well regarded by people that I know	3.889	1.711
For the prestige of being a cyclist	4.167	1.249
Because people around me think it is important to be in shape	3.5	1.383
To show others how good I am at cycling	3.444	1.247
Because people I care about would be upset with me if I did not	2.214	1.626
Because people around me reward me when I ride	3.214	1.968

Because I think others would disapprove of me if I did not	1.786	1.121

Table 6. *Participant levels of amovitation using the SMS II*

Measurement of amotivation	Mean	Standard Deviation
I used to have good reasons for cycling, but now I am asking myself if I should continue doing it	2.222	1.734
I don't know anymore; I have the impression that I am incapable of being a successful cyclist	2.111	1.734
It is not clear to me anymore; I don't really think my place is riding a bike	1.389	1.249
I often ask myself; I can't seem to achieve the goals that I set for myself	2.611	1.65
It is not clear to me anymore; I don't really think my place is in cycling	1.357	0.842

Limitations and future research

A limitation inherent in qualitative research is that generalizations toward the public at large cannot be drawn from the thesis. This is not to say that the research is fruitless. On the contrary, the researcher's nearness to the topic can provide insights that other researchers might have missed.

The cyclists in this study were able to persist in training and to reap the rewards along the way. They showed that this type of motivation gained during each level of communication is not reserved for the elite athlete alone. However, while not elite, these were highly motivated individuals who regarded their fitness and their cycling as an important part of their life. Approaching self-tracking from the perspective of communication theory illuminates the relationship between self-tracking practices and the motivation to be fit and healthy. The data collected on the app represents for these cyclists something more than just speed and distance.

The data are biomarkers with traces of cycling specific metrics that indicate good physical and mental health.

In hindsight, this study could have been expanded by adding more interviews. There are some unavoidable limitations associated with only interviewing 18 people. Further, the method snowball sampling is not without criticism. This method limited the diversity of the subjects by collecting essentially one class of cyclist. The general health of the participant would have been a helpful variable to record as this might have verified some of the bias in the sample.

Each year, more health records are being stored electronically. Electronic Medical Records could someday be capable of handling self-reported exercise data, giving healthcare providers an even broader picture of a patient's health. Further research should, of course, focus somewhat on making this transition user-friendly and aligned with current medical recommendations. Real barriers to use exist for less motivated patients and pathways to overcome these barriers should be tested. In order to test app use and the satisfaction of basic needs for their potential to encourage and facilitate behavior change in a broader public, future research should seek to recruit participants who are not as intrinsically motivated as the participants in this thesis. Future participants would not be motivated to exercise and the basic needs supported by the app could be isolated and tested for effectiveness. Software developers, healthcare providers, administrators, regulators, and patients should take steps to support self-reported data to ensure that the basic needs of autonomy, competence, and relatedness are taken into consideration. Future research could mine the vast amount of quantitative data that are available to researchers through these self-collecting apps. Particularly cases in which the data become the event, that like a race become a benchmark for progress and satisfaction in and only in the relationship between the athlete and the device. More research is needed, however, this

technology appears to influence the well-being of its users today and will probably continue to do so in the future.

We should anticipate a race to develop ways to incorporate self-collected data with data collected by medical providers in the office during visits and in tests. Exercise and sports participants can look forward to more advanced metrics and algorithms that will give a clearer picture of progress to users allowing them to take charge of their sporting life. Visualizations will improve as metrics are improved allowing developers to charge more for subscriptions.

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APPENDIX A

What is your name?

Where are you from?

Do you own a bike? What kind?

Do you prefer Mountain or Road biking?

How long have you been riding a bike?

Tell me about your first experience riding a bike.

What does riding a bike mean to you now?

How often do you ride your bicycle?

What do you think of when you hear the word “cyclist”?

Why do you ride now?

What are the characteristics of a cyclist?

Are you a cyclist?

Are you a serious cyclist?

Tell me what other cyclists are like?

Have you ever used a training app like Strava or Training Peaks?

What effect do you expect as a result of your use of training apps?

How long have you used training apps?

What features do you find most helpful? Why?

What features do you neglect to use? Why?

What metrics do you keep records of and why?

Are there any metrics that you wished that you kept?

Do you have any cycling goals?

What are your life goals and how do your cycling goals relate?

What do you value about cycling?

When you use the training apps, do you follow your own personal achievements or do you place yourself in the larger network of cycling partners?

Do you enjoy a challenge?

Where do training apps fit into the cycling culture?

Does using training apps make you a better cyclist?

Do you participate in any other sports?

Are you a social person?

What is the number one reason you use training apps?

Are you a motivated person?

Where does that motivation come from?

What do you think of me and this study?

Are training apps simple to use? If not, why not?

Do you engage the training app while you are out on a ride? If so to what degree? To what end?