SELF-KNOWLEDGE THROUGH SELF-TRACKING DEVICES: DESIGN GUIDELINES FOR USABILITY AND A SOCIO-TECHNICAL EXAMINATION FROM POSTHUMANITY PERSPECTIVE

by

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SELF-KNOWLEDGE THROUGH SELF-TRACKING DEVICES:
DESIGN GUIDELINES FOR USABILTY AND A SOCIO-TECHNICAL
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ABSTRACT

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The Digital Era introduces emerging product categories that have evolved around certain habits and concepts. One tendency in the Information Age is recording and storing quantitative and qualitative data based on an individual's life by using ubiquitous computing devices. Such products, bringing self-observation and autobiographical memory capabilities to an extreme level, have the potential to morph human beings by augmenting and altering their self-understanding through presenting previously non-existent information regarding their lives. The diversity found in this product range is increasing parallel to the growing demand. However, the meaning of these products for human life is rarely discussed. It remains a question whether these personal logs lead to an enriched self-knowledge for their users or not. This thesis aims to investigate the design principles and the influences of self-tracking products and services on daily life within a socio-technical framework in order to establish a connection between self-tracking by ubiquitous computing devices and the notion of self-concept.

Keywords: lifelogging devices, personal informatics, self-awareness, user experience, posthumanity.

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ÖZET

DİJİTAL TAKİP CİHAZLARIYLA BENLİK ALGISI:
KULLANILABİLİRLİK İÇİN TASARIM PRENSİPLERİ VE
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Dijital Çağ ile birlikte, çeşitli alışkanlıklar ve kavramlar etrafında gelişen ürün kategorileri ortaya çıkmaktadır. Bilgi Çağı'ndaki eğilimlerden biri de gündelik hayatta yaygın hale gelen bilgisayar cihazlarıyla kişinin hayatına dair nicel ve nitel bilgileri kayıt altına alması ve saklamasıdır. Bu ürünler, kullanıcıların kendilerine dair daha önceden mevcut olmayan bilgilere erişimini sağlayarak kullanıcıların kendi kendini gözlemleme ve otobiyografik hafıza yetilerinin sınırlarını zorlamaktadır. Bu açıdan bakıldığında benzer teknolojilerin kullanıcıların benlik algılarını değiştirerek insanlığı şekillendirdiği söylenebilir. Büyüyen taleple birlikte bu ürün kategorisindeki çeşitlilik de artış göstermektedir. Buna rağmen bu ürünlerin insan hayatı açısından anlamı nadiren tartışılmaktadır. Oluşturulan kişisel kayıtların kullanıcılar için zenginleşen bir benlik bilgisine dönüşüp dönüşmediği cevaplanması gereken bir soru olarak değerini korumaktadır. Bu tezin amacı, günlük hayatı kayıt altına almak amacıyla kullanılan dijital ürün ve servisler ile benlik kavramı arasında bir bağ kurmaktır. Bu amaçla, bu cihazların tasarımla ve insan hayatıyla ilişkisi sosyo-teknik bir çerçevede incelenecektir.

Keywords: aktivite takip cihazları, dijital hayat kayıtları, özfarkındalık, kullanıcı deneyimi, posthümanite.

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METHODOLOGY

For mapping the dynamics between self-tracking devices and self-knowledge, a descriptive exploratory study method is going to be used for this thesis. Instead of developing a hypothesis from the beginning, the discussion is going to focus on raising questions and exploring the subject matter in depth before reaching conclusions. For examining the relationship between digital self-documentation and self-knowledge, literature review is going to be used as the method of survey. The reasons for using these methodologies are; posing questions regarding an emerging product category, defining problems in connection with these product-service systems, getting an in depth understanding of related issues through surveying the literature and lastly reaching solutions within the framework of introduced dynamics of the subject matter.

In order to improve the product-service systems, it is a requirement to study how digital technology is changing daily life. For doing so, an interdisciplinary approach will be used as in Science, Technology and Society (STS) studies. The user experience of self-tracking devices will be examined considering social, economical, political, psychological and lastly philosophical issues. The design disciplines will be integrated into a multidisciplinary stance for fully grasping the nature of such interactions. By doing so, the usability and the meaning for this specific product category are going to be discussed thoroughly.

INTRODUCTION

Technological advancements open up new possibilities for human beings. One of these advancements is the development of self-monitoring systems that enables users to track their activities throughout the day. With the feasible sensor and storage technologies, the human body and its daily practices are becoming the subject of self-surveillance systems. In the following chapters, the usability and the influences of self-tracking regarding the sense of self will be examined through studying the interactions between users and self-tracking devices. When this interaction is analysed, it can be seen that there are basically two processes involved in the interface of these products, namely physical embodiments and mental embodiments. The entanglement of the human body and the hardware resolves into a physical embodiment. The sensors embedded to the body operate as the physical contact points through which the human body is translated into a source of sensory input. Secondly, this physiological interaction is translated back to the organism through the interface, or the software. During this mental embodiment, a cognitive engagement occurs, in which the mediated output is reflected back to the cycle of data generation and retrieval for self-knowledge. Especially these mental interactions determine whether these products enrich the self-understanding for their users or not.

In Chapter One, firstly the definitions, the categories, and the examples of self-tracking products will be unfolded. Creating life-records are categorized into two main categories, namely lifelogging and personal informatics. While the former constitutes a continuous log for creating an artificial autobiographical memory, the latter is used as a means to regulate one's self. There are research projects and commercial products that exemplify both categories of self-tracking. The structural elements and the functioning mechanisms of these self-tracking products will be analysed through the product examples. Lastly, the reasons and consequences of the growing demand will be discussed from a socio-technical framework. Multiple aspects regarding self-documentation will be discussed from cultural, economical and political perspectives. The relationship between the various drives behind using self-tracking products will be reviewed.

In Chapter Two, the infusion of the feedback mechanisms for self-tracking into the neurological and the psychological circuits of the body and the mind will be examined with the help of psychology and design disciplines. Self-tracking products work as supplementary mental systems for self-observation and autobiographical memory. In order to understand the basic functions of self-tracking products, the biological counterparts of these digital systems will be analysed such as self-regulation and self-memory systems. Moreover, self-reflective functions of using these products will be discussed in order to understand the consequences of this mental engagement for self-knowledge. Concepts of self-regulation and autobiographical memory will be tied up with the notion of the self. Considering these psychological self-awareness mechanisms, design guidelines for self-tracking devices will be developed for improved usability.

The history regarding the hybridity of human organism and technology will be discussed within the specific context of self-monitoring systems in Chapter Three. Throughout history, human capacities were augmented by technological means; the machine and the human have been resolved into a cybernetic organism (i.e. cyborg) that lost and regained its identity by technical means. Such a hybridity has been brought to another level through digital self-tracking products. This phenomenon can be investigated within the framework of posthuman literature. The mediating and metaphysical qualities of this conjunction are worth questioning since not only certain physical or mental parts of the organism are undergoing a change, but also the organism as a whole is being transformed into another being. It is apparent that the sources of self-knowledge and the nature of human beings are being altered, extended, and augmented by using these devices. Thus, it is necessary to focus on how these tools are changing the perceptions, realities and the essential attributes of the self.

Technological progressions are occurring so fast that the processes and consequences of the users' interaction with certain products are rarely discussed in a critical manner. It has become more of a necessity and a professional responsibility to analyse the various aspects of the interaction between users and digital products. Understanding the consumption patterns, the usage scenarios and the design principles of these systems in regard to human psychology, may describe and offer new perspectives for the posthuman literature. The intention of this thesis is to investigate the relations between the self-surveillance systems and the self-concept to bring design

solutions to the existing problems in user experiences of these products and to examine how human beings are being evolved with the use of ubiquitous self-tracking devices.

CHAPTER 1

A BACKGROUND FOR DIGITAL SELF-TRACKING

1.1 Definitions of Self-Tracking

In 1945, Vannevar Bush envisioned a system called "Memex," i.e. Memory Extender, which could record and store all information of one's lifespan and function as a supplement to one's biological memory.[1] He designed a system including a walnut sized camera placed on the forehead and a machine for storing and retrieving data, similar to that of augmented reality glasses like Google Glass. The purpose of such a system was to provide an additional memory that would prevent memory loss and save room for other creative cognitive functions. Moreover it could enable men to assess his past, help examining and solving his current problems.[2] Thus, it could be inferred that Bush's vision was partially based on the purpose of self-understanding, self-reflection and self-improvement. Today, his prophecy is becoming a part of every individual's reality due to the feasible self-tracking systems.

There are mainly two categories for self-tracking product systems in literature: The first is called lifelogging; and the second branch falls under the category of personal informatics. The key difference between these two systems is that while the former constitutes a continuous log, the latter focuses on specific parameters and goals to collect and retrieve self-data. The main function of lifelogging devices is augmenting

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[1] Vannevar Bush, "As We May Think," *The Atlantic Monthly* 176, no. 1 (1945).

[2] Ibid.

memory, whereas personal informatics is mostly used for observing and enhancing bodily functions by tracking mostly physiological and psychological data. Both systems work separately for different purposes, however they both eventually become part of a personal digital archive.

1.1.1 Lifelogging

The process of creating an artificial memory through *passively* archiving individuals' life experiences in digital format by using total or situation-specific capture devices is known as lifelogging.[3] The benefit of such systems is mainly adding up a supplementary digital storage unit to the memory for contributing to its biological counterparts.

The methods of creating life logs fall under two sub-categories, namely CARPE (Continuous Archival and Retrieval of Personal Experiences) and PIM (Personal Information Management.) Both sorts of lifelogging methods include minimal user intervention. Personal digital repositories, mobile activity captures and domain specific captures are the types of lifelogging methods that exemplify both categories of lifelogging.[4] For instance, using portable mobile or wearable devices for the total capture of entire daily life is a form of CARPE. Creating organizational knowledge via selectively recording information during specific events such as meetings or lectures is an example of domain-specific CARPE. Lastly, managing heterogeneous collections of digital repositories including different forms and formats of data generated or encountered on any sort of digital platform stands as an example for PIM.

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[3] Abigail J. Sellen and Steve Whittaker, "Beyond Total Capture: A Constructive Critique of Lifelogging," *Communications of the ACM* 53, no. 5 (2010): 71.

[4] Steve Whittaker et al., "Socio-Technical Lifelogging: Deriving Design Principles for a Future Proof Digital Past," *Human--Computer Interaction* 27, no. 1-2 (2012): 5.

1.1.1.1 CARPE (Continuous Archival and Retrieval of Personal Experiences)

Continuous Archival and Retrieval of Personal Experiences (CARPE) is defined as a system, which aims to continuously monitor and keep track of daily activities in the forms of images, sounds, videos, and qualitative or quantitative written records.[5] The process of CARPE is dominated by a single product, or product-service system, that is intentionally used for recording daily data. The structure of such self-monitoring products is constituted of hardware components such as sensors and storage units; and software components that make up the interface. The sensors provide the incoming information, whereas the software presents the outcome by information visualizations.

The essential functions included in lifelogging consist of mainly two courses. The first one is recording data, and the second one is recalling the stored data. In order for self-tracking to function properly, indexing data and retrieving it systematically and semantically has vital importance. There are methods developed for creating a detailed index that could support semantic retrievals. Some of these methods include adding contextual clues such as time stamps, face recognition metadata and geo-tag logs attached to the gathered data. Without this focus on metadata, most of the recorded information becomes unreachable. The importance of index is that of creating a flawless system that would work in harmony with the neurological systems. The mental embodiment of lifelogging products is necessary and only possible through considering the consciousness and the working mechanisms of the human brain. Another challenge is integrating these systems into users' daily lives in a meaningful way. Both of these functions have been problematic in both research projects and commercial products that are built for lifelogging. Thus, the working mechanisms and the integration of self-tracking products into everyday lives become questionable for their users. The augmentation of memory and its reflection to self-understanding need a detailed examination. These two functions will be explored in depth in the next chapter.

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[5] Esmail Esaed Tahir Mohamed, "Designing and Evaluating a User Interface for Continous Embedded Lifelogging Based on Physical Context," (Newcastle University, 2013), 40.

1.1.1.2 PIM (Personal Information Management)

The second type of lifelogging is called Personal Information Management (PIM), which is defined as "processing and managing the distribution of information for everyday use."[6] In contrast to CARPE, PIM is not bound to specific products; instead it aims to organise, retrieve and control a larger, divergent data network where every digital footprint of an individual is collected. In the Digital Age, every action generates a digital record; gathered data about location, purchase patterns, social media behaviour builds up personal archives, mapping the individuals' lifestyles. Also, the sensors embedded in one's ecosystem generate personalized data streams from daily activities by tracking the personal environments. Therefore, not only certain wearable devices for self-tracking archive everyday activities, but also a combination of several applications, including accounts, private and public tools establish an extensive lifelogging system. Being wired into such systems is reducing the active participation of customers, offering a more passive role in which daily lives are automatically being documented.

What is remarkable about these digital archives is that the amount of information stored is increasing immensely. According to Moore's Law, the storage capacity for the digital products is doubled every 18 months.[7] In this respect, "big data" is a related concept in connection with PIM, which refers to large data sets that are added up to a collective global archive, whose size is "beyond the ability of typical database software tools to capture, store, manage and analyse."[8] This means, other than specific self-tracking products, every device linked to a digital storage or connected to the Internet contributes to the artificial memory of a person, and evolves into a massive collective memory of humanity, resembling the fictitious universe of Borges, imagined in the form of a library.[9]

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[6] Mark W. Lansdale, "The Psychology of Personal Information Management," *Applied Ergonomics* 19, no. 1 (1988): 61.

[7] Kieron O'Hara et al., "Memories for Life: A Review of the Science and Technology," *Journal of the Royal Society Interface* 3, no. 8 (2006): 354.

[8] James Manyika et al., "Big Data: The Next Frontier for Innovation, Competition, and Productivity," (2011): 1.

[9] Jorge Luis Borges, "The Library of Babel," *Labyrinths: Selected Stories and Other writings*, (1941).

1.1.2 Personal Informatics

Personal informatics is defined as the "activities where people collect and reflect on personal data to gain a better understanding for their own behaviour."[10] Collecting quantitative data such as physiological data and gathering qualitative data such as mood records are examples of these collected datasets.

The involvement in personal informatics activity can be user-driven, system-driven or a mix of these two approaches.[11] In the user-driven integration, data is collected manually. Such integrations might fail due to the burden of collecting data and the complexity of analysing this data. The problems in the user-driven self-observation processes can be overcome by using the automated system-driven approaches instead of using manual notation systems. Ubiquitous computing devices designed for self-tracking enable automated data capture for long periods of time in different contexts, recording data with high frequencies and visualizing gathered data that allow focusing on data analysis.[12]

Most of the self-tracking tools used within the context of personal informatics rely on bodily data. Health monitoring products that track exercise, posture and mood are involved in this category. Built in biosensors in these systems help to extract the physiological data. Through this usage process, users are encouraged to set goals, reminded of their objectives, rewarded with virtual medals and cups. "Gamification" is an important concept for personal informatics products, which frames the whole usage scenario into game conditions, in order to hook users into a course of actions for competing against their personal best, linking with friends or strangers for a challenge.[13]

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[10] Ian Li, Anind Dey, and Jodi Forlizzi, "Understanding My Data, Myself: Supporting Self-Reflection with Ubicomp Technologies," in *Proceedings of the 13th International Conference on Ubiquitous Computing* (2011), 406.

[11] Ian Li, Anind Dey, and Jodi Forlizzi, "A Stage-Based Model of Personal Informatics Systems," in *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (2010), 563.

[12] Ibid.

[13] Kai Huotari and Juho Hamari, "Defining Gamification: A Service Marketing Perspective," in *Proceeding of the 16th International Academic MindTrek Conference* (2012), 17.

There are two main differences between lifelogging and personal informatics systems. Firstly, in comparison to the passive involvement of lifelogging methods, personal informatics differs by requiring active participation for their users to be involved in the feedback mechanisms of the activity monitoring devices. Secondly, the total capture systems of lifelogging devices are replaced with the responsive, goal-oriented self-observation systems in personal informatics. Such systems aim not only to collect data, but also to assist the achievement of certain goals.

There are four hierarchical levels of goals involved in the personal informatics systems.[14] *System-concept goals* refer to the broad goals, which point to a sense of an idealized self. *Principal level goals* refer to the guiding principles for reaching an ideal. Lastly, *program level goals* are composed of specific activities that are divided into smaller steps called *sequence level goals*. Forlizzi et. al. defined a stage-based model for defining the working mechanisms of program level and sequence level goals. According to this analysis, collecting and reflecting on self-data are constituted of five steps.[15] Determining the types of tools for collecting information is called *preparation stage*, gathering information is called *collection stage*, transforming information for self-reflection is called *integration stage*, and understanding information is called *reflection stage*, while tailoring behaviours for reaching goals is called *action stage*. All of these stages reflect the working mechanisms for achieving an improved self.

Self-reported data of personal informatics can be used for the management, regulation, control and improvement of the self. Detecting problems about one's self and making changes in certain behaviours for fixing these problems are stated to be the two key ingredients for this five-stage process.[16] Critical keywords to be highlighted within this statement are "problem" and "change." Such kind of self-observation methodologies are bound to, and wouldn't function without finding defects about one's self, making progress on problems, and bringing a change of mind-set for performing corrective actions. In such systems the self is conceptualized as a problematic entity that

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[14] Li et al., "Understanding My Data, Myself: Supporting Self-Reflection with Ubicomp Technologies," 408.

[15] Li et al., "A Stage-Based Model of Personal Informatics Systems," 560-562.

[16] Li et al., "Understanding My Data, Myself: Supporting Self-Reflection with Ubicomp Technologies," 408.

needs to be fixed, or changed, in order to get "corrected." This mind-set imposed by self-tracking products targets reaching an idealized self; and needs further examination.

Self-tracking products are categorized within "positive technologies," which are defined as the technologies that are used for improving the quality of personal experiences through their structuring, augmentation and/or replacement of reality.[17] Especially, *eudaemonic systems* are stated as the structures designed especially for supporting individuals in reaching and engaging in self-actualizing experiences. Similarly, according to Ian et. al., personal informatics is stated to contribute to self-knowledge by offering new ways to monitor behaviours and to find patterns in behaviours; by doing so, it is argued to foster self-insight, increase self-control and promote positive behaviours.[18] It is emphasized that such systems help people understand one's self and enable insightful reflections for self-awareness. However such products are imposing users an ideal lifestyle by using self-reflection and self-awareness as operational functions. Self-understanding might have deeper mechanisms that aim for higher self-fulfilling purposes. Moreover, observing oneself can also be made possible without setting certain goals and without forcing oneself to adjust certain ideals. Thus, rather than jumping into positive or negative conclusions, the existence and the functioning of personal informatics systems need to be questioned on strategic and tactical levels before being developed and analysed on operational levels.

1.2 Product Examples

1.2.1 Research Projects

Two research projects have influenced today's lifelogging products and self-monitoring culture immensely. Creating an extended life record was firstly initiated by research projects parallel with the advancements in sensor technologies and enhanced

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[17] Cristina Botella et al., "The Present and Future of Positive Technologies," *CyberPsychology, Behavior, and Social Networking* 15, no. 2 (2012): 78.

[18] Ian Li, Jodi Forlizzi, and Anind Dey, "Know Thyself: Monitoring and Reflecting on Facets of One's Life," in *CHI'10 Extended Abstracts on Human Factors in Computing Systems* (2010), 4489.

storage capacities. These research projects mostly intended to record one's life entirely in full detail and enhance the human memory.

The pioneer of digital self-tracking products was Steve Mann, who began developing his wearable project "WearComp" in the 1970's in the purpose of building a personal photographic assistant.[19] Mann initially concentrated on creating a wearable computing assistant rather than designing a lifelogging product. However, as he invented a portable, easy-to-wear device with tailored sensors in it, he ended up developing a personal imaging system for life tracking. His vision for a wearable technical apparatus evolved into a self-watching system for memory augmentation due to the high levels of physical and mental embodiment he achieved.

Mann had three criteria for developing wearable computing devices.[20] First one was *eudaemonic criterion.* This criterion offered a wearable product to become a part of the user and to provide high mobility. Second one was *existential criterion*, which suggested that the controlled computational capacity should "behave as an extension of the user's mind and body." Thirdly *ephemeral criterion* proposed an immediacy principle that involved operational and interactional constancy, which means products should act as readily accessible computing devices with visible output channels at all times. He gathered up a set of sensors that could monitor his physiological parameters such as the stimulation of muscles, heart beat, walking pace; voice input and output systems, head mounted display and cameras; and lastly wireless communications. His design principle in building this personal imaging system was distributing components uniformly by spreading elements throughout a connective smart fabric, which was possible due to miniaturized computation.

Mann claimed, "Just as computers have come to serve as organizational and personal information repositories, computer clothing, when worn regularly, could become a 'visual memory prosthetic' and 'perception enhancer.'"[21] He aimed to reach a

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[19] Steve Mann, "A Historical Account of the 'Wearcomp' and 'Wearcam' Inventions Developed for Applications in 'Personal Imaging'," *Wearable Computers, 1997. Digest of Papers., First International Symposium*, (1997).

[20] Ibid.

[21] Steve Mann, "Wearable Computing: A First Step toward Personal Imaging," *Computer* 30, no. 2 (1997): 28.

visually undetected nature that could achieve personal documentary of day-to-day experience in real-time. What he declared as "life through a screen" initiated a computer-mediated reality by augmenting, diminishing and altering the everyday life. Mann referred to his wearable system as an assistant that could experience his point of view by becoming his "second skin", his "third eye" and more importantly his "second brain."[22] He argued that a constantly attentive computer could serve for situational awareness, perceptual intelligence, and assist day-to-day activities. Moreover, he stated, by such systems "it may be possible to 'remember' something or someone that one never saw."[23] His statements blurred the boundaries between seeing and viewing, between biological and artificial memories; and addressed the issue of agency, which will be discussed in the next sections.

Following Mann's project, the most extensive lifelogging project on self-monitoring has been "MyLifeBits," which was designed to fulfil the Memex Vision of Vannevar Bush in 1945.[24] The system consisted of wearable devices that created a database containing photos, audio, documents, web browsing history, sent and received messages, phone calls, location information representing an individual's life experiences. The goal of this project was exploring the possibilities and the challenges of passively collecting every detail of an individual's life. There were four principles in the design of MyLifeBits; replacing the hierarchical archiving system with an associative system for search and collection, supporting visualizations such as clustered-time view of photographic images for enabling easy retrieval, allowing annotations for their narrative value, and enabling an authorship through the hyperlinks formed within the digital archive.[25] This project had a great impact on commercial products by introducing hardware and software components as well as pointing out additional technical

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[22] Mann, "A Historical Account of the 'Wearcomp' and 'Wearcam' Inventions Developed for Applications in 'Personal Imaging'."

[23] Ibid.

[24] Jim Gemmell et al., "Passive Capture and Ensuing Issues for a Personal Lifetime Store," in *Proceedings of the 1st ACM Workshop on Continuous Archival and Retrieval of Personal Experiences* (2004), 48.

[25] Jim Gemmell et al., "Mylifebits: Fulfilling the Memex Vision," *Proceedings of the Tenth ACM International Conference on Multimedia*, (2002).

necessities such as face deduction, voice recognition, speech-to-text transcription, and search capabilities for classifying documents.[26]

1.2.2 Commercial Products

In this section, the main structure of commercial self-tracking products, their components and the types of data gathered by them will be described with examples. According to Swan, some of the widespread sensors used within certain self-monitoring devices and their functions can be named as the followings:[27]

- *Accelerometers* coordinate the amount of relative speed change felt by the users. They assist tracking movement and used in piezoelectric pedometers or step counters and in the monitoring devices for measuring walking, cycling or running speeds. Last generation MEMS-based (MicroElectroMechanical) accelerometers can also tell the 3d-axis position of an object where the sensor is attached. Lumo Lift is device that uses this technology for tracking the body posture.

- *GPS (Global Positioning System) sensors* calculate the location and time data of their users. They are used in cameras for geotagging the location of recorded documents and mapping the exercise routes as navigation systems.

- *ECG (Electrocardiography)* sensors measure the electrical activity of the heart. They are mostly involved in the professional sports equipments for measuring heart rates of their users during trainings of swimming, cycling and running. Polar wristwatches that are used with the chest straps and with the ECG sensors are examples in this category.

- *PPG (Photoplethysmogram)* is another sensor type for measuring pulse through optically determining the level of blood flow.

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[26] Gordon Bell and Jim Gemmell, "A Digital Life," *Scientific American* 296, no. 3 (2007): 63.

[27] Melanie Swan, "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0," *Journal of Sensor and Actuator Networks* 1, no. 3 (2012): 219.

- *EEG (Electroencephalography) sensors* are composed of multiple electrodes placed along the scalp for recording electrical activity in the brain. Cognitive responses such as attention performance and unconscious functions such as sleep quality levels are discovered and resolved through everyday products such as NeuroSky, or the Kickstarter funded project Emotiv.

- *GSR (Galvanic Skin Response) sensors* measure the increases in skin conductance by determining the degree of sweating, which is considered an indicator of the emotional state for displaying physical and psychological arousal. These sensors detect stress levels and provide feedback in case of anxiety and fear.[28] Empatica Embrace is a product that watches electrodermal activity of the skin in order to track the stress levels, thus detecting potential epileptic seizures and warn the users; it is a self-tracking device that claims to save lives.[29]

- *Temperature, moisture, sound* and *light sensors* are other instruments included in self-tracking devices. For instance, SenseWear armband, produced by BodyMedia measures the amount of burnt calories by detecting the bodily temperature and the heat loss of the body.

Most of these sensor types are combined in self-monitoring products and services for creating personal data dashboards that are unified through integrating the collected data. Recently, Apple has introduced a healthcare-tracking platform, named HealthKit, working as a medical tool due to its capacity to fuse and visualize data gathered from third-party devices and clinical applications.[30] Another important characteristic of this application is that it enables data exchange between the mobile device producers, the health providers or hospitals, which may possibly result in new healthcare models, promoting new commercial ventures between the health and the technology sectors. Thus, documenting biological data is becoming a part of the medical e-commerce.

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[28] Neil R. Carlson, *Physiology of Behavior 11th Edition* (New Jersey: Pearson Education Inc., 2012), 96.

[29] Liz Stinson, "A Next-Level Smartwatch That Predicts Seizures", @wired http://www.wired.com/2014/12/next-level-smartwatch-predicts-seizures/ (accessed December 02, 2014).

[30] Ryan Faas, "Get to Know Ios 8: Healthkit and Apple's New Health App", Macworld http://www.macworld.com/article/2691952/get-to-know-ios-8-healthkit-and-apple-s-new-health-app.html (accessed November 27, 2014).

There are other types of products that contain the sensors described above. Smart phones, wearable technologies such as smart watches, wristbands, patches, reality-augmenting glasses, head-mounted cameras, body metric textiles, and applications designed for the smart devices are among the range of portable means for life recording. Also, there are applications and websites that enable manually logging personal data. Some of the recognized first-generation quantified tracking devices and applications include Fitbit, myZeo, BodyMedia, MapMyRun, RunKeeper, MoodPanda, Nike Fuelband, Jawbone UP, The Eatery, MyFitnessPal, Luminosity's Brain Trainer, Neurosky and Emotiv brain-computer interfaces (BCI).[31] The Narrative Clip automatic camera is an example of commercial lifelogging products that continuously records the daily events in photographs and videos. In addition to these everyday products, there is also a more specialized commercial market segment that involves the professional health-monitoring devices. Blood glucose monitoring systems, wearable patches, systems attached on pills, that transmit data about the body's interaction with the medication, and dried blood spot testing patches by Sano Intelligence are examples of these applications.[32] Lastly, DIY (Do-It-Yourself) products have the potential to constitute a portion of the market for self-tracking products. RetroBand Activity Tracker is a result of Arduino Wearable Project initiated by one of the most renowned DIY communities online, the Instructables.[33] The structure of this product is very similar to that of professional products offered in the market, with its accelerometer for counting steps and its application developed for connecting the hardware to smart devices operating on Android.

The software platforms involved in self-tracking products are as important as these hardware components. The mediation of gathered data by sensors into human-readable script is a crucial part for the interface of self-tracking products. The main reason for the importance of mediation is to overcome the challenges of interpretation and making meaning of the accurate data. Thus, reading information and interpreting

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[31] Swan, "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0," 219-227.

[32] Ibid., 223.

[33] "Make Your Own Activity Tracker", @instructables http://www.instructables.com/id/Make-your-own-activity-tracker/ (accessed December 01, 2014).

this information are the two steps that need to be resolved for creating effective feedback mechanisms. The boundaries between the hardware and the programming components are not clearly separated from each other in self-tracking products. For instance, built-in sensors are hardware components that are not only used as instruments for recording data, but are also used as a part of the software and the interface by activating lifelogging devices to begin recording data. A recent project that uses EMG (Electromyography) sensors is measuring the electrical activity produced by skeletal muscles, and after detecting time intervals when the user is smiling, it activates full-documentation of that specific moment.[34] Similarly, MyLifeBits, a research project mentioned earlier, uses a similar approach for recording images. SenseCam's lighting sensor was programmed for initiating the recording process when it perceived changes in the setting by measuring the lighting conditions.[35] These working principles can also be used in the commercial products for preventing the ambiguity of total captures and for building up a context-specific database of life experiences.

All these commercial products are beginning to establish a change in the material culture by becoming a part of fashion, fusing into clothes, accessories and jewellery. They are built into users' ecosystems and natural territories, changing their wearing habits. Corporeal presences are inevitable, as the digital realm is becoming a greater fragment of everyday accessories. This is why the self-tracking instruments should be investigated from multiple perspectives in order to grasp their meanings for the human life.

1.3 A Socio-Technical Exploration of Commercial Self-Tracking Products

There are many dynamics that determine the rise of self-tracking products including ontological, psychological, economical, technological and political factors. All together, these drives trigger certain issues regarding the culture of self-tracking

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[34] Kurara Fukumoto, Tsutomu Terada, and Masahiko Tsukamoto, "A Smile/Laughter Recognition Mechanism for Smile-Based Life Logging," in *Proceedings of the 4th Augmented Human International Conference* (2013), 213.

[35] Gordon Bell and Jim Gemmell, *Total Recall: How the E-Memory Revolution Will Change Everything* (New York: Dutton, 2009), 31.

products. In this section these headlines are going to be described and discussed respectively.

1.3.1 Personal Dimensions Triggering the Growing Demand for Self-Tracking

Collecting and reflecting on personal information have personal motives such as the discovery of new tools, natural curiosity, interest in data, triggering events like health problems and lastly the desire to hear suggestions from another person.[36] Apart from these practical reasons, theories explaining the drives for keeping archives may shed light on broader personal incentives behind generating digital records of the everyday life. The impulse to create notations is a way of providing an organized protection against the decay of information. Through producing external impressions for internal memories, temporal events are being captured and materialized.[37] In this regard, archive is a shield for ephemerality, as an opportunity to seek timelessness. "Evidential value" of the archives brings a quality of truth, a proof of life to the documents for persisting in eternity.[38] "Mind uploading" is a concept manifested by futurists like Minsky and Kurzweil that suggests the transmission of the intellect that could bring immortality to humanity. Minsky claims that data transfer will make it possible to be alive anywhere and anytime in the future.[39] Likewise, for Kurzweil, men will be able to transform their lifelong experiences by fully uploading their brains by the end of 2030's.[40]

In contrast to these theories that are pointing out the truth and the immortality of archives, there is an opposite model suggesting that the will to create records is closely

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[36] Li et al., "A Stage-Based Model of Personal Informatics Systems," 560.

[37] Jacques Derrida, *Archive Fever: A Freudian Impression* (London: University of Chicago Press, 1996), 7.

[38] Theodore R. Schellenberg, *Modern Archives. Principles and Techniques* (Chicago: University of Chicago Press, 1956), 15.

[39] Marvin Minsky, *Why Computer Science Is the Most Important Thing That Has Happened to the Humanities in 5,000 Years* (Nara, Japan).

[40] Ray Kurzweil, *The Singularity Is Near: When Humans Transcend Biology* (New York: Viking Books, 2005), 166-169.

bound to the "death drive," which brings the impulse to destroy or to erase memory.[41] According to this standpoint, artificial memory is a tendency to prove a release from the burden of one's memoirs by burying them into an archive, which has a low probability of being visited again in a lifetime. Benjamin's definition of "aura" is in close relation to these opinions regarding the destructing role of archives. According to Benjamin, the unique presence of human life in time and space is shattered by the changes in the media of contemporary perception, such as reproduction. The representations of the daily experiences such as photographs, sounds and moving images lack the original attributes that take place in real life events. He named this lack of authenticity "decay of the aura."[42] Thus, the reproduction of memories through self-monitoring products causes decay in the life experiences and in the memories of those experiences. These two perspectives position life chronicles as a condition for vitality loss.

In another essay, Benjamin discussed the relationship between archives and ownership. He stated collection is more about the act of collecting rather than the collection itself.[43] Regardless of the content, the process by which items are brought together forms a property that is more important to the collector than what is being collected. In this sense, documenting human life is a motive towards giving materiality and ownership to the past experiences of one's self instead of accessing past memories for reflections on a future self.

1.3.2 Economical, Cultural, Social and Political Extents of Self-Tracking

Main benefits, potentials and constraints of the logging systems have more facades than these personal motives. The changing economical, social and political factors are important for adopting and transforming the habit of tracing one's life. A commentary on the economy of self-tracking systems is important in order to grasp the strategic and tactical goals behind the introduction and the spread of commercial lifelogging systems. As mentioned earlier, the boost in self-tracking products is due to

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[41] Derrida, 11.

[42] Walter Benjamin, *The Work of Art in the Age of Mechanical Reproduction* (London: Penguin Books Ltd., 2008), pt. 2- pt. 3.

[43] Walter Benjamin, *Illuminations* (New York: Schocken Books, 1968), 60-61.

the feasibility of high capacity storage and enhanced sensor technologies. The feasibility of such technologies has also led to an emerging market, which developed through the push strategies, i.e. making customers accept, adapt and consume certain products regardless of the demand and their true needs.[44]

"Technological determinism" has a significant role in the rise of self-tracking products by bringing the feasible technologies to the market and by imposing the industrial mind-sets to the users. According to technological determinism, technology is an agent for social change as an independent factor that is motivated by technological progress.[45] Accordingly the emergence of self-tracking products can be seen as a technological headway that infuses the industrial notions of progress, improvement and perfection to their users. The idea of change to reach a better self is rooted within the existence of quantified devices.

The emergence of the pervasive self-monitoring devices is also a result of social factors, in addition to these technological and economical factors. The initial push strategies for self-tracking products were reversed into the pull strategies by me-generation's interest in self-focus. The emergence and popularity of the English word "selfie" is an indicator for the cultural changes that favour self-documentation. The definition of this word is "a photograph that one has taken of oneself, typically one taken with a smartphone or webcam and shared via social media."[46] The appearance of this word referring to a new mode of self-documentation, points out to the synthesis of narcissism and technologies of the 21st Century. Wittgenstein stated that the words involved in a language are the reflections of everyday life; correspondingly, the word "selfie" is a symptom of the changes in technological actions that are transformed and reflected back to the language.[47] Another sign for the public interest in self-tracking devices is the online communities specialized in generating life documents. Quantified

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[44] Eckehard Steinbach et al., eds., *Advances in Media Technology* (Munich: Multimodal Information Processing Group, 2013), 20.

[45] Andrew Murphie and John Potts, *Culture and Technology* (New York: Palgrave Macmillan, 2003), 11-12.

[46] "Selfie: Definition of Selfie in Oxford Dictionary (British & World English)" http://www.oxforddictionaries.com/definition/english/selfie (accessed December 01, 2014).

[47] Ludwig Wittgenstein, *Philosophical Investigations*, trans., G. E. M. Anscombe (Oxford: Blackwell Publishers Ltd., 2010), 48.

Self Portal, with the slogan of "Self-Knowledge Through Numbers," is the largest online organization for sharing self-monitoring experiences on forums, presenting academic works on conferences with the subject of self-monitoring, and exchanging information and news about the self-tracking devices on online platforms or in their meet up groups.[48] Their slogan is based on the assumption that quantified self-monitoring leads to self-knowledge. The contradictory nature of this rhetoric will be unfolded in the following chapters.

The most concrete evidences for demand's suppression over supply in self-tracking devices are the projects supported in the crowd funding platforms. In 2012, with $3.34 million of backing in only five days, Pebble Smart Watch became the most crowdfunded project of Kickstarter.[49] By 2014, Emotiv, a commercial product with EEG sensors that was designed for tracing brain behaviour, became the 6th most funded project on the same website.[50] Another indication of the growing demand for these tools is the increase in DIY (Do-It-Yourself) open source electronics, which are fully initiated, programmed and customized by their users. For such commercial products, online stores like Adafruit Industries and Sparkfun Electronics are the platforms that includes learning forums for exchanging knowledge on developing such self-made products. Futurologist Toffler coined the term "prosumer" back in 1980, which stands for "proactive consumer," defining user groups who are not only customers, but also are transforming their roles by becoming a part of manufacturing process by improving and supporting the products' production stages.[51] The interest in self-tracking products in these crowdfunding platforms and the increase of DIY monitoring devices are signs of the support for this prosumer notion; and how users are becoming a part of tracing, recording, and discovering one's own daily experiences.

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[48] "About the Quantified Self" http://quantifiedself.com/about/ (accessed December 02, 2014).

[49] Alexandra Chang, "Pebble Smartwatch Breaks Kickstarter Record in Five Days | Wired", @wired http://www.wired.com/2012/04/pebble-smartwatch-breaks-kickstarter-record-in-five-days/ (accessed December 01, 2014).

[50] Edoardo Moreni, "The Most Successful Tech Projects on Kickstarter - Great Preneurs", @GreatPreneurs http://greatpreneurs.com/successful-tech-projects-kickstarter/ (accessed December 01, 2014).

[51] Alvin Toffler, Wally Longul, and Harry Forbes, *The Third Wave* (New York: Bantam Books 1981), 267.

Apart from these cultural conditions, there are also political factors concerning the rise of self-tracking products. Whether one intends to put an effort on capturing data or not, there is always a digital log of the physical life present in the form of a database or archive; and it is becoming more feasible to maintain such logs. Today, it is almost impossible to escape any kind of digital log. A main source for big data is the voluntary exposition of one's self through media technologies. Political scene benefits from voluntary self-watching functions as surveillance and control mechanisms. Governments are using the tracking of personal data for giving the impression of an open arrest in order to keep masses under control. Power groups in the market also have a ground for taking advantage of the self-watching technologies, by commercializing the information gathered from daily technologies used for online advertisement protocols or for market research. The two main reasons for questioning the willingly collected logs of life are the threat of self-tracking on the destruction of privacy and on the increased control over personal data by certain power groups.

"Sousveillance" is a term coined by Steve Mann to describe the voluntarily initiated self-watching situations, in which watching from "above" (or "sur"veillance) is replaced by watching from "below" ("sous"veillance.)[52] While revealing one's own neurological data through devices through the embedded EEG sensors sounds as an interesting mean for discovering the self, it may also be used for marketing strategies, in which biological data is used for promoting the sales of certain products according to the physiological and the psychological responses of the users. Another privacy issue regarding the sousveillance technologies is that an isolated watching of the self without recording the environment is hardly possible. Thus, the act of archiving one's own life might become a violation of others' privacy.

The pervasive watching systems are reminiscent of Foucault's Panopticism theory. He describes Bentham's layout of Panopticon Prisons with central observation towers, as a method for implying the power of gaze over each cell in the prison. The design of this arrangement is similar to the surveillance forces of governments by which the visibility of an individual is handed into automatic functioning of power, permanent

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[52] Steve Mann, Jason Nolan, and Barry Wellman, "Sousveillance: Inventing and Using Wearable Computing Devices for Data Collection in Surveillance Environments," *Surveillance & Society* 1, no. 3 (2002): 332.

pressure of imprisonment brought by being observed.[53] Recently, EU's Data Protection Reform made it possible for users to modify data flows that are stored within cloud computing and social media applications; and "to be digitally forgotten" has been defined as a human right according to this law.[54] This legal precaution towards tracking technologies might work as a barrier for exerting one's own control over the constant logging of lives, however voluntarily producing life records is likely to increase in the future as a part of digital culture and the outcome of this process will hardly be erased from the digital data repositories. Under these circumstances it is more important to evaluate the personal necessity, meaning, and value of these life logs.

[53] Michel Foucault, *Discipline and Punish: The Birth of the Prison*, trans., Alan Sheridan (New York: Random House Inc., 1977), 197-201.

[54] Steven C. Bennett, "Right to Be Forgotten: Reconciling Eu and Us Perspectives, The," *Berkeley J. Int'l L.* 30, (2012): 162.

CHAPTER 2

THE DESIGN OF DIGITAL SELF-OBSERVATION AND AUTOBIOGRAPHICAL MEMORY SYSTEMS

The relationship between computational self-tracking systems and biological self-knowledge mechanisms constitutes a design problem where the usability of self-tracking products as self-understanding tools depends on the complementary functioning of these two entities. The division between self-information and self-knowledge is mainly positioned at a duality between computational knowledge and personal knowledge of life. There might be ways to bring together these two forms of knowledge meaningfully within a computational system. Hayles claims that if the processing systems of the software and the brain can work complementarily within the course of making up knowledge, they can speak to each other in harmony.[55] In this chapter, the conditions of constituting this coherence between the two categories of knowledge for memory and self-observation are going to be discussed within the framework of usability.

For achieving a harmony between self-data and self-knowledge, the mental embodiment of self-tracking products is going to be discussed within a psychological framework. "In order to design more effective applications of persuasive, motivational and reflective technologies, we need to be wary of a simplistic notion of a rationale consistent self, and begin to inform our design with psychological research that reveals

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[55] N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999), 239.

the multitude of ways context, environment and subjective interpretation play a part."[56] For increasing the usability of self-tracking products as self-knowledge tools, the psychological dimensions for the functioning of this product category needs to be unfolded in relation to the self-concept. The natural functioning of the building blocks of the self, namely self-observation systems and autobiographical memory, are going to be examined in depth as a backbone for understanding the functioning of self-tracking technologies as sources of self-knowledge. The key points for improving the design of self-tracking products or the computational mechanisms for self-understanding, will be explained after investigating how human psychology functions in creating the self-concept.

2.1 An Overview of Self-Concept

Self-concept, broadly referring to "the total sum of beliefs that people have about themselves" is a multifaceted term that includes two procedures of making up the self.[57] The first one is assembling the *content of self-concept*, in which "self-as-known" holds the entire body of truths attributed to one's self. Some examples of these attributes include one's personality composed of roles, preferences and values; one's appearance or physical being; one's social features such as relationships; and lastly one's characteristic behaviours along with their goals, motives, rules and strategies for regulating their behaviours.[58] These aspects are constructed from the information contained in life experiences; and this construction brings us to the second phase of forming the *structure of self-concept*, in which "self-as-knower" maintains the processes of generating self-representations in the mind. Self-awareness is a related concept, which is regarded as the self-focused attention, selective processing and encoding of

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[56] Rafael A. Calvo and Dorian Peters, "The Irony and Re-Interpretation of Our Quantified Self," in *Proceedings of the 25th Australian Computer-Human Interaction Conference: Augmentation, Application, Innovation, Collaboration* (2013), 369.

[57] Saul Kassin, Steven Fein, and Hazel Rose Markus, *Social Psychology 7th Edition* (New York: Houghton Mifflin, 2008), 56.

[58] Hazel Markus, "Self-Knowledge: An Expanded View," *Journal of Personality* 51, no. 3 (1983): 543.

self-relevant information about the self.[59] The content and the structure of self-concepts depend on how individuals make sense of themselves with self-relevant information. Self-tracking products affect these mechanisms by providing new structural methods and new types of information regarding the records of life experiences.

According to Markus, "self-description" and "self-knowledge" have been used interchangeably in the literature of psychology.[60] Non-judgemental self-descriptions, building semantic ties between the self and its past experiences, form the foundation of self-knowledge and self-concept. However, according to Shavelson's model, self-concept is not only descriptive, but also evaluative.[61] Self-evaluation, depending on self-observation, determines the degree of self-esteem, i.e. satisfaction with an ideal or ought self; and the future goals, motives and desires, become part of self-knowledge by bridging the actual and the future selves. In this sense, one's past is tied to one's present through memories and the current self is tied to the future self through motives and evaluative aspects of an individual. It is important to note that some scholars hold a different opinion on the connection between self-evaluation and self-concept. They state that "self-evaluation," is only related to "self-esteem" rather than self-concept.[62] Their approach holds the view that the measurement, progress and growth of a person's attributes should be excluded from their self-knowledge. As a result, it might be inferred that self-concept, based on one's past, is the main component of self-knowledge though it is also organized in terms of conceptions of a possible future. Thus, by contributing to self-descriptions rather than self-evaluation, self-tracking devices that are building artificial memories have a larger impact on self-knowledge compared to the activity monitoring devices that are used for reaching and evaluating personal goals.

The roots and definitions of self-concept vary according to different psychological practices. "Biological perspective" defines the self as an outcome of physiological and

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[59] Charles S. Carver, "Self-Awareness," in *Handbook of Self and Identity*, ed. Mark R. Leary and June P. Tangney(New York: Guilford Press, 2003).

[60] Markus, "Self-Knowledge: An Expanded View," 551.

[61] Richard J. Shavelson, Judith J. Hubner, and George C. Stanton, "Self-Concept: Validation of Construct Interpretations," *Review of Educational Research*, (1976): 441.

[62] Dale A. Blyth and Carol Monroe Traeger, "The Self-Concept and Self-Esteem of Early Adolescents," *Theory Into Practice* 22, no. 2 (1983): 91.

genetic processes; "cognitive experimentalist perspective" underpins the conscious ways of processing personal information; "experiential perspective" puts emphasis on the existential conditions of subjective experiences; "social constructionist perspective" argues that social practices that involve interactions with others defines the self; and lastly "psychodynamic perspective" draws attention to the unconscious thought in making the self.[63] Hence, it can be inferred that the notions of the self result from several biological, cognitive, intuitive, social, and unconscious dynamics. None of these dynamics work in isolation from one another. They are integrated in the unity of the self and they work complementarily. For instance, the biological circuits are working in coherence with the cognitive intrapersonal means for creating the concept of the self. A recent study discovered that there is a specific physiological structure supporting this psychological mechanism in which a common neural network is responsible for the processes of building self-knowledge, such as autobiographical memory and self-projection.[64] Artificial memory and activity monitoring functions of the self-tracking products are directly integrated into these biological and cognitive self-making mechanisms.

For analysing the interaction between self-tracking products and users, the mental processes involved will be discussed within the framework of a cognitive experimentalist perspective. According to Stevens, cognitive experimentalist theorists declare the concept of self as a composition of three levels, namely interpersonal, societal and intrapersonal levels.[65] The "interpersonal level" considers social interactions as drives for creating the self-presentation, while "societal level" views self as a cultural construction. "Intrapersonal level," is crucial for discussing the design of self-tracking products since it involves cognitive processes such as memory, thinking and feeling, and motivational processes such as personal control and self-regulation for self-making. These informational processes are required for creating conceptions of the self and are directly related with the main functions of self-tracking devices.

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[63] Richard Stevens, *Understanding the Self* (Wiltshire: SAGE Publications, 1996), 30.

[64] R. Nathan Spreng, A. Raymond Mar, and S.N. Alice Kim, "The Common Neural Basis of Autobiographical Memory, Prospection, Navigation, Theory of Mind, and the Default Mode: A Quantitative Meta-Analysis," *Journal of Cognitive Neuroscience* 21, no. 3 (2009): 489.

[65] Stevens, 93.

One issue that needs to be considered regarding the improvement of self-tracking experiences is the developmental models of the self. Diverse notions of the self such as; "material self" that holds physical and possessive attributes for creating a self-image, "personal self" that forms identity, "adaptive self" that creates personal activities, "social self" that determines social attitudes and "self/non-self" that holds the distinction between self and others, are developed along the lifespan of an individual at different rates.[66] For instance, children's self-understanding and self-construction diverges from the self-reports of adolescents in that they put more emphasis on specific, concrete, factual behavioural and physical characteristics of the past events, whereas adults proceed to focus on the abstract and symbolic psychological characteristics.[67] Also, the evolution of memory across lifespan has a role in creating the developmental differences of the self. For instance, towards adulthood, the most critical skill individuals develop for building a self is becoming better at remembering specific traits and cognitively integrating these memories into a unified, meaningful, consistent, general conception of the self.[68] The concrete and objective approach of children on the self transforms into a more subjective and abstract understanding along lifespan. As a result of these changes in memory and cognition, for adults context-specific memories become more accessible for self-knowledge compared to the general self-relevant information. Hence, when made accessible and meaningful, any kind of documented detail that is captured by life logging devices might help creating self-knowledge in adults.

Another important developmental division between children and adults lies in the distinction between the private and the social self. Children tend to comprehend themselves more through intrinsic self-observations for building a private, context-independent self, while with adolescence social influence on making an identity increases with the growth of a social self and the increasing necessity to conform the

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[66] Thomas M. Brinthaupt and Richard P. Lipka, *The Self: Definitional and Methodological Issues* (Albany: State University of New York Press, 1992), 114.

[67] Raymond Montemayor and Marvin Eisen, "The Development of Self-Conceptions from Childhood to Adolescence," *Developmental Psychology* 13, no. 4 (1977): 314.

[68] Rebecca A. Eder, Suzanne G. Gerlach, and Marion Perlmutter, "In Search of Children's Selves: Development of the Specific and General Components of the Self-Concept," *Child Development*, (1987): 1049.

external demands.[69] Interpersonal relationships lead to a more flexible sense of self that helps one to adapt to the environment. The distinction between private and social selves is studied by personality psychologists and by social psychologists. The main question they are posing on this issue is whether the self-concept is a stable, fixed entity or whether it is a dynamic, changing one. The former perspective sees self as a construct with developmental continuity in which growth and progress are two concepts grounded in this self-construction. For this approach, the upward or forward movement of the self throughout a lifetime preserves orderliness and unity for self-consistency.[70] This view, parallel to the modernist perspectives, holds the idea of a linear life history. However the latter standpoint defines self as a dynamic entity, which experiences random developmental shifts within the flux of life for seeking self-discovery.[71] According to this approach, the self is not passive and stable, but it is the knower, the active agent of his life. In other words, the dynamic self is a fluid response to the changing social situations. Self-descriptions derived from the memories and the self-evaluations based on self-observations are related with the notions of the static and the changing selves.

These two standpoints on the stability and the changeability of the self place the truth and the accuracy of the self as relative concepts. For personal psychologists, self-deception is an adaptive defence mechanism that aims to provide continuity of a coherent self; and the distortion of self-perceptions or biased self-inferences are ways of protecting the unity of the self-understanding for maintaining the impression management.[72] On the other hand, for social psychologists, there is not one true self-concept, but multiple situation specific selves of a person, who activate a collection of different selves and identities according to the setting, the nature of situations, and lastly the motives or affective states.[73] The theories on self-narratives support this second perspective by defining the self as a product of interpretation, where fictitious identities

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[69] Brinthaupt and Lipka, 102.

[70] Ibid., 16.

[71] Markus, "Self-Knowledge: An Expanded View," 544.

[72] Shana Cole and Emily Balcetis, "Of Visions and Desires: Biased Perceptions of the Environment Can Serve Self-Protective Functions," in *Handbook of Self-Enhancement and Self-Protection*, ed. Mark D. Alicke and Constantine Sedikides(New York: Guilford Press, 2011), 166.

[73] Sheldon Stryker and Peter J. Burke, "The Past, Present, and Future of an Identity Theory," *Social Psychology Quarterly*, (2000): 289.

are woven into the stories of us. Accordingly, across a lifetime, memories with different significances and meanings are generated through the different life stories of the changing self.[74]

2.2 Self-Observation through Self-Tracking Devices

2.2.1 Self-Observation for the Improvement of the Self

The mechanisms of self-observation have a great impact on developing a sense of self since they are the very first steps for a child to know his/her own presence. As discussed earlier, for children the most frequently reported source of knowledge about the self is self-observation and this shows its importance for developmental psychology. The Rouge Test is a fundamental scientific experiment providing proof for the development of self-awareness in the infants.[75] In this experiment, the faces of the infants were marked with rouge and it was tested whether they could visually recognize themselves in the mirror, moreover act on it with self-directed behaviours. The experiment resulted in mark-directed behaviours of 15-18 months old infants; and directing their actions toward the marks on their faces rather than the mark in the mirror image proved the presence of self-awareness. The mirror is an important tool in observing one's self, because we do not have the ability to fully see ourselves. Thus, the spatial reflections of one's self through mirrors, presenting immediate, moving representations, help developing visual self-observations. Interestingly, "pictures" with non-immediate, static representations and "videotapes" with non-immediate, moving representations are also used for increasing the self-awareness of individuals.[76] Indeed, the reflections of the self in these representations are also referred with personal pronouns in daily life, with "I" and "we," blurring the boundaries between mediation

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[74] Brinthaupt and Lipka, 32.

[75] Michael Lewis and Jeanne Brooks-Gunn, *Social Cognition and the Acquisition of Self* (New York: Plenum Press, 1979), 218.

[76] Beulah Amsterdam and Lawrence M. Greenberg, "Self-Conscious Behavior of Infants: A Videotape Study," *Developmental Psychobiology* 10, no. 1 (1977): 1.

and immediacy. Thus, self-representations produced through visual media devices contribute to self-awareness just as mirrors do. Self-data is a way of seeing one's self.

As discussed earlier, self-knowledge can be developed through self-evaluation. The motives behind self-evaluation are self-enhancement (placing one's self in a positive position and protecting self from threats), self-assessment (creating accurate representations of the self), self-verification (maintaining consistency in self-perceptions) and self-improvement (expanding the self beyond its current boundaries or limits for identifying new avenues of self-expression).[77] One method of self-evaluation is self-regulation, or the overall process of behavioural control through self-observation, judgemental process, and self-response.[78]

Self-regulation is situated in the dynamics between self-other distinctions, private-social selves, actual-desired selves, and past-present-future selves.[79] Self-other distinction is one dynamic for developing self-regulation. Infants' awareness of their caregivers as instrumental entities apart from their own being is the first step in developing a sense of separation and individuation.[80] In the later phases of the lifespan, self/other distinctions progresses in a way to prove uniqueness of one's stable self-identity through the knowledge of others. The tension between private and social selves result in referential processing, where implicit and explicit motivations occur. The hypothetical self tends to perform socially desirable responses in certain situation specific contexts.[81] The risk of relying on the social comparisons when making self-observations is that the public judgements may lead to self-blame and may result in decreased motivational energy. The relationship between actual and desired selves

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[77] Michael J. Strube, "From "out There" to "in Here:" Implications of Self-Evaluation Motives for Self-Knowledge," in *Handbook of Self-Knowledge*, ed. Simine Vazire and Timothy D. Wilson(New York: Guilford Press, 2012), 398.

[78] Albert Bandura, "The Self System in Reciprocal Determinism," *American Psychologist* 33, no. 4 (1978): 349.

[79] Jay G. Hull, "Self Knowledge and Self-Regulation," in *Self and Motivation: Emerging Psychological Perspectives*, ed. Abraham E. Tesser, Diederik A. Stapel, and Joanne V. Wood(Washington D.C.: American Psychological Association, 2002), 190-193.

[80] Lewis and Brooks-Gunn, 14-15.

[81] Don S. Moskowitz, "Comparison of Self-Reports, Reports by Knowledgeable Informants, and Behavioral Observation Data," *Journal of Personality* 54, no. 1 (1986).

corresponds to the impulse to reach an "ideal self" where goals become a part of one's self-concept. According to Perceptual Control Theory (PCT) of William Powers, there is a hierarchical organization for goals in self-regulated behaviour where the higher level includes "goals to be", the middle level includes "goals to do" and the lower levels include motor level goals.[82] He states that all of these goals are processed simultaneously through parallel processing. Another key point to PCT is that behavioural outputs become more concrete as one moves from higher levels towards the lower levels of hierarchy.

The strategies for self-control and self-management are critical, because they tie the current actions to the more distant goals and outcomes. The connection between the past-present-future selves lies in the struggle between the want-self with current gratifications and the should-self with future gratifications. The regulatory scopes involving distant contexts involve abstract self-guides, whereas the near-future contexts closer to present selves involve concrete self-guides. "Construal level theory" suggests that the will to participate abstract goals are stronger since the personal value of distant ideals are higher for one's self.[83] However, the upper level goals including abstract principles for ideals and future selves require deliberate focus and attention to accomplish since the sub level goals are easier to handle. This dilemma needs to be solved with careful attention while designing self-tracking devices.

Apart from these dynamics of self-regulation, there are certain domains that determine the success in controlling behaviours. The changing emotions of the user, the levels of mental control they can attain, the behavioural guidance they possess, the attention controls they imply and lastly the success in overcoming incipient urges need to be taken into account when planning and realizing the self-regulation processes.[84] For instance, tasks with strong "ought to"s tend to repel people from preventing negative outcomes, whereas strong ideals promote positive outcomes. "Regulatory focus theory"

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[82] T. Powers William, "Behavior: The Control of Perception," *New York, NY: Hawthorne*, (1973): 254.

[83] Yaacov Trope and Nira Liberman, "Temporal Construal," *Psychological Review* 110, no. 3 (2003): 403.

[84] Kathleen D. Vohs and Brandon J. Schmeichel, "Self-Regulation: How and Why People Reach (and Fail to Reach) Their Goals," in *The Self*, ed. Constantine Sedikides and Steven J. Spencer(New York: Psychology Press, 2011), 144.

proved that promotion-oriented goals that present opportunities rather than obligations make people work harder for their goals.[85] Such factors need to be considered as designing self-regulatory systems.

The human mind engages in various informational processes when observing one's self and it is the subject of control theories for the organizational structures it attains during creating and maintaining certain behaviours. "Cybernetics" is the science of communication and control that studies abstract principles of organization in complex systems, where information, models and controlled actions steer towards purposes, while counteracting various disturbances.[86] Self-observation through self-tracking products lies in the heart of these control processes not only by monitoring and assessing progress, but also by being a part of defining goals, assessing progress, changing goals and promoting modified actions towards one's goals. Carver and Sheier applied cybernetic theory on self-regulation, where they defined the process of self-regulation as a feedback cycle, working on two information-processing procedures: Firstly defining goals or behavioural standards, and secondly regulating activity with respect to these standards.[87] The fundamental elements involved in these processes are; the "standards" or goals to be achieved, the "monitoring" of one's progress towards or away from those standards, and lastly the regulatory "operations" designed to reduce any lack of compatibility between one's current state and one's standards. These elements come together in a cybernetic construct called TOTE, which is the acronym for Test-Operate-Test-Exit. *Test* refers to the comparison of existing state and determined goal by a "comparator," *operate* refers to an action process where the existing state is altered, *test* continues to compare the existing and desired states until they reach the same level, and lastly *exit* ends the sequences according to the outcome of the loop. When this system is provided by a new reference value to the existing standards, and it is forced to track a moving target, the homeostatic mechanisms need to

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[85] Tory E. Higgins, "Beyond Pleasure and Pain," *American Psychologist* 52, no. 12 (1997): 1283.

[86] Francis Heylighen and Cliff Joslyn, "Cybernetics and Second Order Cybernetics," *Encyclopedia of Physical Science & Technology* 4, (2001): 156.

[87] Charles S. Carver and Michael F. Scheier, *Attention and Self-Regulation* (New York: Springer, 1981), 143.

respond in flexibility by forming a dynamic system.[88] However, the difference between the current standards and the desired standards needs to be taken into account since the increase in this difference may end up in breaking the cycle. According to the "self-awareness theory," the consciousness of the lack of compatibility between the present condition and the goals or standards results in reducing one's self-awareness.[89] Thus, an observer's awareness of a non-functioning feedback loops causes the breaking of the cycle. As exemplified, concerning the cybernetic perspectives on self-regulation, there is an additional factor that needs to be taken into account: The influence of the observer on the functioning of the observed system. In the next section, this issue will be discussed within the framework of second order cybernetics.

2.2.2 Second Order Cybernetics: "I Change as I Observe"

Self-observation includes feedback mechanisms in which one is included to the system both as the observer and as the observed. The inclusion of an observer to the processes of behaviour change has an impact on the working mechanisms of the feedback loops. This fact makes self-observation the subject of second-order cybernetics, or "cybernetics of cybernetics," which studies the role of the observer in the construction of models of systems and evaluates the observer as another cybernetic system within itself.[90] Accordingly, the observer is not considered to be neutral, detached and objective, but attached and relative to the system it is observing. "Our observations are determined by the assumptions we bring to the observation."[91] In a controlled environment the nature of the human being has the potential to be changed. The awareness of being watched alters one's consciousness of actions. As a result, there is the question of whether a human being can understand one's self when s/he is constantly involved in a control system. On the other hand, the presence of the observer is the first condition for having self-consciousness. "An artefact capable of receiving

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[88] Ibid., 16-27.

[89] Shelley Duval and Robert A. Wicklund, *A Theory of Objective Self Awareness* (Oxford: Academic Press, 1972), 11.

[90] Heylighen and Joslyn, "Cybernetics and Second Order Cybernetics," 156-158.

[91] Lewis and Brooks-Gunn, 1.

and acting on information about the state of its own body can begin to parallel many of the modes of activity we associate with self-consciousness."[92]

In the case of relating self-tracking devices to second order cybernetics, one distinct problem is analysing the changing roles of multiple observers. For self-tracking systems, the observer is a hybrid of the machine and the human, of the sensors and the cognition. For monitoring actions there are three key issues concerning the presence of multiple observers; *"what I perceive as the agent of my own experiences"*, *"what the computer reads from my experiences"*, and lastly *"what knowledge do I make of the computer-generated outputs regarding my experiences."*

Man is placed in the middle of the self-observation processes as an input/output device and watching one's own personal experiences results in direct opinions of one's self. *"What I perceive as the agent of my own experiences"* might be different from the representations of the self-tracking devices. Because, the first-hand knowledge of the world is claimed not to be a representation of the world out there, but an on-going process for bringing forth of a world through the process of living itself."[93] Accordingly, knowing is a way of doing and observing is a condition of experiencing. Maturana and Varela coined the concept "autopoiesis" for describing the autonomous biological systems, which respond to their environment in ways determined by their internal self-organization for producing and reproducing the organization that defines them as systems.[94] Consequently, the circular self-reflexive dynamic occurs within the activity of the nervous system, determined by the nervous system itself, and not by the external world. This process of "self-making" allows the observer to see only what its own systematic organization allows him to see. Thus the act of living is a process where knowledge of the world is generated through the intrinsic perceptions. According to Maturana, the essence of these perceptions does not consist of information. "Notions

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[92] D.M. MacKay, "Mindlike Behavior in Artefacts," in *Modeling of Mind; Computers and Intelligence*(Notre Dame: University of Notre Dame Press, 1963), 227.

[93] Humberto R. Maturana and Francisco J. Varela, *The Tree of Knowledge: The Biological Roots of Human Understanding* (Boston: Shambhala Publications, 1987), 242-248.

[94] Humberto R. Maturana and Francisco J. Varela, *Autopoiesis and Cognition: The Realization of the Living* (Dordrecht: D. Reidel Publishing, 1980), 79.

such as coding and transmission of information do not enter the realization of a concrete autopoietic system because they do not refer to actual processes in it."[95] As a result, the direct observations of one's self are described as cognitive actions rather than linguistic representations.

Though Maturana and Varela define signification as a separate entity from self-making, they claim that such abstractions help organisms explain what is seen; and they exist in the observer's domain of interactions to create self-consciousness through language.[96] Accordingly, the realities of self-consciousness and self-awareness are articulated together with abstract data. Therefore, the sensors of the self-tracking devices have an influence on articulated data for self-consciousness. *"What the computer reads from my actions"* is related with the sensors, which collect quantified data about the users automatically. At this point, the flexibility and versatility of data collection methods are necessary for self-observation. Reflecting on only one type of data regarding the actions of one's self would decrease the quality of self-evaluation compared to that of reflecting on rich sources of data. As mentioned earlier, there are certain dimensions to self-regulation such as emotions, current urges, attention and mental control levels. Without observing these diverse domains, understanding the monitored actions of users would be insufficient. Objectivity of the sensors for self-observation is another question regarding self-tracking products and their integration to self-consciousness. Though computerized methods for self-tracking are mostly perceived as objective means, they have a subjective characteristic for the fact that the relation between signifier and signified is being changed through the commands of the programmer.[97] The programmers and the designers predefine the mediation of signals and their interference changes the neutrality of data gathered through digital self-documentation.

Lastly, *"what knowledge do I make of the computer-generated outputs regarding my experiences,"* in other words, making sense of the self-referent data is an issue concerning the role of observers in self-regulating systems. The interaction between the message and the receiver, the integration between the computerized, articulated

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[95] Ibid., 90.

[96] Ibid., 35.

[97] Hayles, 46.

knowledge and the intrinsic, tacit knowledge is the ultimate result of such self-observation processes. This specific dimension of self-observation is critical, because the meanings rising from this conjunction is what is reflected back on self-concept. Piaget's theory of cognitive constructivism proposes that humans cannot be given information, instead, they need to actively construct their own knowledge through "schemas," or mental models based on their past-experiences.[98] Accordingly, these schemas are changed through two complimentary processes of building knowledge. One either incorporates new experiences into existing frameworks of knowledge through "assimilation," or s/he reframes the mental representations of the external world through "accommodation." The observer does not construct reality through passively perceiving data, but reflects on data depending on one's position. Parallel to this theory, Markus developed the concept of "self-schemas" to explain one's biased perceptions of everyday experiences for constructing a sense of self through monitoring processes. Self-schemas are defined as "the knowledge structures about the self that derive from past experience and that organize and guide the processing of the self-relevant information."[99] In other words, the self is the main construct for creating realities of one's self-concept by changing the processing of information about one's experiences.

As a summary, the presence of an observer changes what is being observed through activity monitoring devices since the meaning generated from self-directed data depends on what is understood by observers. Self-knowledge cannot be separated from the knower. In the case of self-tracking products, the nature of the observer is a human-machine hybrid where the mental constructs of the users; the programming of data representations and the relationship between the information and the user affect the outcome of the self-observation processes.

2.2.3 Design Directions for Personal Informatics Devices

In this section, by reflecting on current self-tracking products on the market, certain aspects of self-observation and self-knowledge will be tied to my personal

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[98] Jean Piaget, *The Origins of Intelligence in Children*, trans., Margaret Cook (New York: International Universities Press, 1952), 7.

[99] Markus, "Self-Knowledge: An Expanded View," 547.

experiences with the self-tracking products. The interaction with personal informatics systems are mainly going to be exemplified through products I have been using such as Misfit, a smart watch with an accelerometer that tracks movement and sleep, MyFitnessPal, a calorie counting application, To Do, a prospective aid for accomplishing tasks, and various mood trackers. I will briefly mention these products and applications in relation to certain design principles I want to point out.

The usability of artificial ways of self-observation depends on the success of the self-regulation processes. As discussed in the previous sections, the process of self-regulation is divided into three steps: Defining goals, monitoring behaviour and taking action for changes in the current states. When self-tracking systems are examined, all these functions need to be considered as a part of the self-observation processes.

The main function of the self-tracking devices lies not only in gathering and presenting data, but also guiding the users throughout short-term and long-term processes of self-control. The assistance of self-tracking devices on setting goals according to the current and desired selves, and then maintaining the actions for regulating behaviours of their users are the most crucial functions besides gathering data. During using MisFit, one of the problems I experienced was setting goals and maintaining them. As I began using the product, certain measures such as weight, height and age were entered through the interface, however no conclusions or suggestions were drawn relying on this data. As for setting goals, the accuracy and the relevance of the goals had no reference to the age or the weight conditions. Moreover, the assistance for testing one's self, acting upon it and if necessary changing goals, as mentioned in TOTE method for self-regulation systems, were not working properly in the interface of Misfit products. On the other hand, some products are successful in testing users in the early phases of gathering data, making suggestions for setting goals and promoting to take action on accomplishing these goals. For instance, FitBit measures sleeping duration and quality, analyses the data, develops self-tailored suggestions for improving the sleeping habits, and tests the progress of its users.

Another way of improving goal assistance for self-tracking devices might be advising on future-directed goals before beginning to promote short-term goals. The consideration of ideals and valuable targets may appeal to the users for achieving short-term goals and may increase their motivational energies. Setting general, symbolic life

goals and then developing them into the lower level hierarchical goals might increase the meaning of tasks that need to be accomplished. For instance becoming healthy might be a "to be goal", becoming fit might be a "to do goal" and devoting a certain amount of time and energy for working out might be a task for achieving these higher-level goals. A distinct problem with self-monitoring devices is their allowance of setting only one goal regarding the future actions. Defining one goal would not be enough for reaching higher-level goals. The application "To Do" is a good example for setting prospective goals and accomplishing them. It distinguishes between errands, short-term tasks and long-term goals; and it enables to assign a level of importance for each task one wishes to accomplish. However, the system works manually and monitoring behaviour might become a burden, causing one to exit the regulatory feedback mechanism. If it is used in connection with other applications and automated tracking mechanisms, it might be more useful as a long-term regulatory tool.

Another thread concerning the hierarchical system of goals is the necessity to act simultaneously on a number of sub-goals tied to higher-level goals. As introduced earlier in the PCT (perceptual control theory), high-level goals and sub-goals are processed simultaneously within human consciousness rather than being treated as a series of independent items. This issue brings us to another problem regarding self-tracking devices, which is the compatibility of various applications, working in co-ordination for tracking a set of goals. For instance the insufficiency of most of the mood trackers is due to their isolated functioning. For bipolar disorder there are a number of dynamics that need to be tracked including activity levels, sleep and mood for reaching an overall goal of preventing future episodes. Thus, all the applications necessary for measuring these dynamics need to be integrated into one application. They need to talk to one another in order to fulfil the necessities of tracking a patient. Some products are successful in creating integrated interfaces. For instance MyFitnessPal is an application tracking calorie intake and works with other applications that track calorie burning. The loss and gain of calories are tracked simultaneously through both applications so that the comparison and evaluation of gathered data becomes relatively easier.

An additional question regarding setting goals is the relevance of selected goals. One of the most popular reasons for tracking one's physiological data is improving health. However, what one understands of wellbeing might change from one individual to another. The popularity of counting steps is mostly driven by the existence of feasible

sensors, however the decision of taking action over one's wellbeing needs a more in depth consideration. The personal meaning for the activities to be monitored needs to be assessed before taking action. Considering the scope of self-tracking products, this choice is rather standard instead of personalized. Thus, a product-service system with a wide variety of activities to perform and monitor may work better in setting and taking action on self-relevant goals.

The ways of representing gathered data is a valid interaction design problem just as the relevance of setting and working in harmony with a number of goals. Common forms used for shaping this interaction are information visualizations such as statistics and tables of performance that are reported back to users in addition to the feedback information such as messages for motivation. These elements of the interface for self-tracking products are called "*procedural literacies*" in programming literature.[100] However, there is more to procedural literacies, especially for quantitative data. Wolfgang Iser coined the term "Lehrstelle" that described the action of reading as a creative process, a process of learning, in which a narrative is built from the mediated text in order to make sense of the story.[101] This means, representations of gathered data need to constitute a storyline for usability. According to Swan, the interface of self-tracking products can be improved by considering the fact that humans tend to think in terms of story narratives rather than statistics.[102] Generating accurate numbers might work for some of the users for the representation of collected data, whereas data regardless of the accurate amount, such as describing the exercise, might increase the motivation of other users. In this manner, Misfit is a successful example that offers an interface involving information visualizations with both analogue visual references, and the choice to view detailed quantified measures of daily performances. On the other hand, the language of this representation might be improved with the existence of the qualitative inferences regarding the daily or long-term performances, since the data

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[100] Michael Mateas, "Procedural Literacy: Educating the New Media Practitioner," *On The Horizon* 13, no. 2 (2005): 101.

[101] Wolfgang Iser, "The Reading Process: A Phenomenological Approach," *New literary history* 3, no. 2 (1972): 281.

[102] Swan, "Sensor Mania! The Internet of Things, Wearable Computing, Objective Metrics, and the Quantified Self 2.0," 237.

presented through narratives ease processing information for the users more than statistical or quantitative representations.

Regarding the same issue, the increased concreteness of goals causes them to be perceived more manageable by the users. Even though abstract goals are more compelling to accomplish for their personal values, if their representations become more defined and concrete, they would be easier to accomplish. Realistic future projections with descriptive goals can motivate the users to achieve goals. For instance, losing weight is among one of the most common reasons for the users to use activity-monitoring devices. If the monitoring devices help users to project themselves into the future, or enable them to compare their graphical representations in their actual and desired states, it might be an incentive for maintaining monitored tasks. Being aware of the progress through visual representations instead of quantified measures might help enduring regulatory processes.

The function of social comparisons is another issue that needs to be addressed. As mentioned earlier, referential processing might end in self-blame and cause the reduction of willingness to maintain self-regulatory behaviours. On the other hand, they might also work as positive reference groups, increasing motivation for self-awareness. A solution addressing this issue might be presenting users a social network, where they are not compared to each other through quantitative measures in a competitive way, but reminded of the presence of others who are working on a similar improvement path. For instance, the interface of Misfit is regularly sending notifications about the other users, regarding them as rivals and keeping users informed about the other users' daily scores. This may become a cause for stress and self-blame in the users for showing their inability to accomplish personal goals. Moreover, the developmental differences of different age groups need to be considered for defining the social dynamics involved in self-tracking products. For the adults, external comparisons pointing out to their social selves might work positively, however for the younger users, self-directed information may hold more significance compared to the data regarding their social connections.

Lastly, the most crucial characteristic of the sensor-driven self-observation systems is their inflexibility in collecting data. Quantified self-observation systems make it easy to keep a score of actions, but they are limited in terms of presenting flexible data. The flexibility of observation systems is important mainly because of the

individual differences between users and their promise of self-expansion. As stated earlier, self-improvement relies on self-seeking, where the developmental shifts and self-discovery are more important in comparison to the steady and linear developments in the self. The same built-in sensors, the same measures of data and the same progression paths do not work as tools for change. Instead, they might constitute barriers for the developmental shifts. Thus, there lies an inconsistency within the rhetoric involved in the marketing campaigns of self-tracking products with an emphasis on "self-discovery" and the actual meaning of self-expanding experiences. Products with an emphasis on possible future actions of the self might bring a new dimension to the market. Instead of retrospective tracking, products may promote prospective experiences that would allow users to observe themselves in new conditions of life. Such tracking devices would follow their users to their future actions instead of analysing their steady enhancements. Hence, they might work as mind-openers for fulfilling and witnessing the potentials of one's self.

2.3 Augmenting Autobiographical Memories through Lifelogging

2.3.1 A Description of Autobiographical Memory

As discussed earlier, the idea of a self is rooted in the meaningful descriptions built into autobiographical memories. Lifelogging devices and all the other actions contributing to building digital personal archives are integrated to this specific natural mechanism. In literature, one model explaining this particular interaction between the self and the memory is called "self-memory system" (SMS). It is a conceptual model that explains the dynamic processes involved within the autobiographical memories, which include interactions between the control systems of the working self and the long-term memory base that hold the information for self-knowledge.[103] The self-memory system is constructed from two main parts for accomplishing the main memory processes like storage, encoding and retrieval. The first part is the "autobiographical

[103] Martin A. Conway and Christopher W. Pleydell-Pearce, "The Construction of Autobiographical Memories in the Self-Memory System," *Psychological Review* 107, no. 2 (2000): 261-266.

knowledge base" that works as the biological storage unit where personal experiences are collected. The second one is the "working self" that is responsible for encoding and retrieving certain events as memories.

An autobiographical knowledge base provides the raw material for building memories that include permanent representations of the self. This unit can be examined according to its storage capacity and content. The mental storage capacity of the human working memory has several constraints for maintaining self-referent data to construct memories. Loss of information in biologically stored memories has several causes. Broadbent suggests that short-term forgetting is bound to "trace decay" where the memory traces fade with time; and long-term forgetting is due to the "interference" caused by the disruption of old and new memories.[104] For instance, during learning the brain might rewrite the existing memory cues or one might experience the fading effect where their older memories become unreachable.

The content of an autobiographical knowledge base includes different structures of memories and diverse types of information coming from the internal and external sources. Episodic and semantic memory systems are two types of memory structures that have their effect on a personal level.[105] Episodic memories stand for the personal experiences with specific events, people, objects, places and a sense of time. Information collected through the lifelogging devices is typical of episodic memories. These memories have a hierarchical structure with three types of memories that moves from bottom to up through sensory to thematic information. The thematic structures include the "lifetime periods" that are composed of events related to the particular personal phases whereas the "general events" are clustered around common themes.[106] Lastly the "event-specific knowledge" is constituted of the sensory copies for personal experiences that have no specific grouping quality. Semantic memories, on the other hand, are general recollections of memories with unspecific attributes. They hold the knowledge of life, as in knowing the general facts for constituting a self through

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[104] Donald E. Broadbent, "Flow of Information within the Organism," *Journal of Verbal Learning and Verbal Behavior* 2, no. 1 (1963): 38.

[105] Endel Tulving, "How Many Memory Systems Are There?," *American Psychologist* 40, no. 4 (1985): 387-388.

[106] Conway and Pleydell-Pearce, "The Construction of Autobiographical Memories in the Self-Memory System," 262-263.

personal experiences. The building blocks of semantic life stories are the episodic memories, especially the lifetime periods and the general events, but this structure stands together with the help of personal meaning.[107] This abstract, conceptual level is more about the factual knowledge of the events rather than the actual experiences. In this sense, semantic memories give meaning to life and they are more connected to the abstract levels of the self-concept.

For an autobiographical knowledge base, there are certain types of information stored in order to create memories. Episodic memories are composed of episodic information with the perceptual details like visual images and spatial elements; the sensory details like sounds, odour and taste; the affective components like feelings; and lastly the conceptual elements like verbal statements.[108] Accordingly, these inputs are categorized as the "visual-spatial traces" of objects and places, the "visual-temporal" information of events and actions, and the "semantic" data with verbal connections. An important point regarding the organization of episodic information is that the episodic inputs do not only include raw data, but also hold the information regarding the recorded data. These inputs are recorded associatively with specific attributes like their affective intensity and vividness, as well as their connection to the current enduring concerns or unresolved conflicts.[109]

Episodic memories are organized mostly in the form of visual mental images. There are studies showing that visual input is represented in the human memory as detailed sensory representations, as verbal descriptions and lastly as schematic representations that articulate objects and their spatial relations.[110] One of the most crucial characteristics for the encoded visual images in relation to these schematic representations is the changing vantage point of the recalled memories. Visual representations of evoked memories differ in the position of the observer and results in

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[107] Ibid., 272.

[108] William F. Brewer, "What Is Autobiographical Memory?," in *Autobiographical Memory*, ed. David Rubin(New York: Cambridge University Press, 1986), 29.

[109] Martin A. Conway and H. L. Williams, "Autobiographical Memory," in *Learning and Memory: A Comprehensive Reference*, ed. John H. Byrne et al.(Oxford: Elsevier, 2008), 901.

[110] W. A. Phillips, "On the Distinction between Sensory Storage and Short-Term Visual Memory," *Perception & Psychophysics* 16, no. 2 (1974): 283.

two different points of views.[111] First-person perspective, with an inside-out viewpoint is called a "field" perspective. It is a participatory point of view that enables the subject to remember himself as the attendant of the past events. Third-person perspective, with an outside-in viewpoint is named as an "observer" perspective. It positions the self as the spectator of personal experiences, detached from one's intrinsic state of being. These vantage points are not fixed in the human brain and every memory can be encoded and retrieved in changing perspectives. This transformation occurs according to certain moderators such as the emotionality dimension and the self-awareness factor.[112] Thus, the adaptability of one's perspectives in different memories functions as emotional coping mechanisms, and serves for the continuity of the self. For instance the observer view helps to cope with the negative emotions by distancing the subject from the actual event; and for positive emotions the field perspective is more common for supporting the self-esteem. This dynamic characteristic of viewpoints poses a serious challenge for the usability of lifelogging devices.

One issue regarding the content of the autobiographical knowledge base is the source of memories. The integration of inputs into the personal memories is affected by the recording source of the memories. To "remember" personal recollections and to "know" about specific personal experiences are two different perceptions regarding the autobiographical memories. The end result of this divergence may be a "source-monitoring error" where false memories occur.[113] According to this concept, one may judge that a memory belongs to them when the information is coming from an external source and construct memories that they have not actually experienced in life. The individual questions the original possessor of his memories, when externally recorded personal experiences are represented to him.

The processes of encoding and retrieving the autobiographical knowledge base are dynamic procedures that are guided by the working self. "Autobiographical knowledge is encoded through the goal structures of the working self, which also takes

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[111] Georgia Nigro and Ulric Neisser, "Point of View in Personal Memories," *Cognitive Psychology* 15, no. 4 (1983): 467-468.

[112] Ibid.

[113] Ira E. Hyman et al., "Manipulating Remember and Know Judgements of Autobiographical Memories: An Investigation of False Memory Creation," *Applied Cognitive Psychology* 12, no. 4 (1998): 374.

a major role in the construction of specific memories during remembering."[114] The dynamics involved in these mechanisms are tied to the filters of the working self that hold relations with a goal hierarchy, a conceptual self and various self-images. This specific mechanism serves mainly three functions: Providing guidelines for the future actions derived from the past experiences (directive function), developing and maintaining social bonds by sharing experiences (social function), and creating and maintaining a coherent sense of self (self function.)[115] For fulfilling these functions, the working self adapts to different situations in different contexts, constructing memories dynamically.

One function the working self executes is the process of encoding memories and regulating access to the autobiographical knowledge base. Being the control centre of the self-memory system, the working self decides on which information of the experiences are going to be used during recording and recalling memories. This selective process rejects to record and retrieve every detail of daily life. Instead it evaluates which details are worth remembering. According to Reiser et. al., activities that take place in a physical and social space for accomplishing certain goals are stored and recalled more easily compared to the general actions with no distinct goals.[116] Moreover, some memories are selectively emphasized and strengthened in the human mind for lasting longer, this process is called "memory consolidation."[117] There are certain variables that influence the strength and frequency of recalling such as the uniqueness, consequentiality, unexpectedness and emotion provoking aspects of the personal experiences.[118] These variables are significant on a personal level and they cause each memory to be treated differently in the biological retrieval memory systems.

According to SMS model, autobiographical memories have an associative

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[114] Conway and Pleydell-Pearce, "The Construction of Autobiographical Memories in the Self-Memory System," 597.

[115] Susan Bluck et al., "A Tale of Three Functions: The Self-Reported Uses of Autobiographical Memory," *Social Cognition* 23, no. 1 (2005): 93-94.

[116] Brian J. Reiser, John B. Black, and Robert P. Abelson, "Knowledge Structures in the Organization and Retrieval of Autobiographical Memories," *Cognitive Psychology* 17, no. 1 (1985): 89.

[117] James L. McGaugh, "Memory - a Century of Consolidation," *Science* 287, no. 5451 (2000): 248.

[118] Brewer, 44.

attribute, where they include interconnected representations of episodic information and these associations form the stable patterns of activation.[119] This means, different types of episodic information do not exist independent from each other, instead they are interrelated to one another by associative cues, which are recorded with the memories and are helping the retrieval processes. Some of these associative knowledge cues encoded into autobiographical memories are locations, goals, people, activities, feelings and evaluative knowledge of the experience being positive or negative.[120] The best retrieval cues are activities, followed by location and participants; and surprisingly exact time information is not routinely available in memory.[121] Accordingly, the reason for an activity cue to have superior value for memory retrieval is due to the fact that it embodies unique attributes and the distinctive meaning of the event. In this sense, the exact time of the event is not fundamentally necessary for remembering an event.

The construction of memories through the processes of retrieval happens in two ways, namely, generative and direct retrieval models.[122] The generative model is based on a retrieval system where certain cues are searched, used and evaluated according to the verification criteria that is defined by the task demands of the working self. This model is similar to the queries executed for reaching information in the personal archive interfaces. In direct retrieval, event-specific memories are activated spontaneously based on the instant triggers without a search phase. For the faster processing of the generative retrieval model, it is important to firstly reach memory cues of the goal-based activities and then to refine the content-frame with the performed actions.[123] Accordingly, another crucial factor is the presence of the concrete details of activities through situational cues like people, location, behaviours, feelings and perceptual features. Thus, the increased amount of added associations makes the system function better only if the supplementary cues provide concrete links to the description of

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[119] Conway and Williams, 896.

[120] Martin Conway, "Commentary Cognitive-Affective Mechanisms and Processes in Autobiographical Memory," *Memory* 11, no. 2 (2003): 220.

[121] Christopher Burt, Simon Kemp, and Martin Conway, "Memory for True and False Autobiographical Event Descriptions," *Memory* 12, no. 5 (2004): 546.

[122] Conway and Pleydell-Pearce, "The Construction of Autobiographical Memories in the Self-Memory System," 273-275.

[123] Reiser et al., "Knowledge Structures in the Organization and Retrieval of Autobiographical Memories," 121-123.

activities that are experienced.

As mentioned earlier, one personal dynamic that affects the functioning of the autobiographical memory is the coherence of the self. Remembering and reorganizing past life experiences through the filters of a desirable current self is one of the main functions of the autobiographical memory. Changing the levels of memory accuracy is among the strategies to maintain a consistent self-image. The Remembering Imagining System (RIS) suggests that there are two dimensions to the memories that define their accuracy: "correspondence" and "coherence."[124] Correspondence of a memory shows whether a memory is true to the event or not. Coherence of a memory defines if the memory is true to the self or not. All memories are to some degree false in nature for generating personal meanings that allow individuals to operate in the world adaptively. Memories that have the potential to create a discontinuity within one's self are enforced to be distanced from the self. For instance memories that are based on traumatic experiences often contain distortions and false coherences, whereas memories providing continuity for self-identity are more likely to involve accurate details for connecting and strengthening the relationship with the past self. Self-deception occurs for avoiding the negative emotions and negative self-images.[125] "Forgetting" is a similar function of the memory that works as an adaptive mechanism for preventing the recall of the negative events. "Cue avoidance" occurs when one inhibits the experiences that reflect an unwanted self and positions such memories in a difficult-to-access state.[126]

True and false memories differ in their visual and anecdotal qualities. True memories, which are the accurate copies of the sensory input, are well preserved with vivid details and often recalled from the first person field view.[127] On the other hand, fabricated false memories lack the vivid cues and they are remembered from the third person observer view. One distinct quality of false memories is their anecdotal quality

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[124] Martin A. Conway and Catherine Loveday, "Remembering, Imagining, False Memories & Personal Meanings," *Consciousness and Cognition*, (2015): 4.

[125] Ibid., 7.

[126] Amanda J. Barnier et al., "Directed Forgetting of Recently Recalled Autobiographical Memories," *Journal of Experimental Psychology: General* 136, no. 2 (2007): 316.

[127] Lucy V. Justice, Catriona M. Morrison, and Martin A. Conway, "True and Intentionally Fabricated Memories," *The Quarterly Journal of Experimental Psychology* 66, no. 6 (2013): 1196.

and this quality is studied under the name of "self-narratives." According to the narrative psychologists, autobiographical narrative is the cement that constructs the self from the raw material of the memories; and people engage continuously in the interpretation of the present and past experiences in the form of story telling to meet present objectives.[128] Without the interpretations provided by narrative telling, memories would not be much more than unconnected bits of information.[129] For narrative telling, the self plays the roles of both the actor and the narrator in the stories. People alter their concepts of themselves as their life narratives shift and new narratives regarding the self emerge. In addition to changing narratives, new experiences can also change the self, where multiple selves are formed instead of a unified conception of the self. For self-narratives to function properly, these new experiences must be interpreted in a way that narratively connects present self with the past self. Thus, one's self-narrative is adaptive both to one's changing narratives and to one's changing self-concepts. One of the purposes for the changing narratives is to convey one's identities to the others; and this social function causes the self-stories to be tailored for the audience.[130] To sum up, the self is an on going story that one tells to one's self and performs to the others in order to assure and adapt its changing presences; and one's memories gain an imaginary value with these stories.

2.3.2 Design Directions for the Augmentation of Autobiographical Memories

The self-memory system is based on the distinction between autobiographical knowledge base and the working self. This distinction is reminiscent of the hardware and the software components of the lifelogging devices. For instance the hardware parts such as hard disk and sensors supplement the storage and the perceptual mechanisms for creating the knowledge of the self, whereas the software components of the interface

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[128] William Hurst, "The Remembered Self in Amnesics," in *The Remembering Self: Construction and Accuracy in the Self-Narrative*, ed. Ulric Neisser and Robyn Fivush(New York: Cambridge University Press, 1994), 252-254.

[129] Ibid.

[130] Michael Ross and Roger Buehler, "Creative Remembering," in *The Remembering Self: Construction and Accuracy in the Self-Narrative*, ed. Ulric Neisser and Robyn Fivush(New York: Cambridge University Press, 1994), 213.

defined by programmers and designers work in connection with the working self during encoding and recalling information from the storage. The design directions for lifelogging devices are going to be pointed out respectively beginning from the content of artificial autobiographical memories and then followed by the functioning structures defined by the working self.

As mentioned above, biological memory systems have certain drawbacks concerning their limited capacities. Trace decays occurring with time passage and the interferences between the new and the old memory cues are certain failures in the biological memory of personal experiences. The failures regarding these issues can be overcome by using lifelogging devices with reliable, high-capacity storage units. Considering the capacity of the artificial autobiographical knowledge bases, physical presence of a non-decaying storage unit with no interference problems would be useful to prevent the problem of memory loss. However, there are other factors related with the information loss and the limited memory span such as the organization and the accessibility of memories. Information loss doesn't necessarily mean the physical absence of information; it is related more with losing the links that grant access to the stored information. Hence, the ability to reach necessary cues to recall memories also determines memory preservation. Thus, specific principles of the working memory should be mimicked for the compatible functioning of the biological and the artificial autobiographical memory systems.

These specific principles that make it possible to reach passively recorded logs can be categorized into three branches; the selective encoding of records, the organization of episodic information using memory attributes and memory cues, and lastly the selective retrieval of recorded information. For creating a successful interaction with the biological memory systems, the first principle that lifelogging devices should involve is the selective processing of information during the encoding of digital records. Selectively recording information instead of keeping a continuous record is the first challenge lifelogging devices should overcome during passively recording data. Regarding the selectivity principle, the first criterion that needs to be addressed is hierarchically separating activities and actions that take place in daily life. As mentioned earlier, the activities that are recorded with concrete details are prioritized in the human memory for their personal values and meanings. On the other hand, general actions that don't involve any goals or don't hold any significance can be of

secondary importance when recording the life events. For instance going to a dinner is an activity that might hold personal meaning whereas wearing clothes before going out to dinner is an action that doesn't need to be remembered. A second factor for selectively recording data is connected with memory consolidation. The uniqueness, consequentiality, unexpectedness and lastly the emotion-provoking aspects of certain memories cause them to be emphasized in human memory for later recall. Parallel to the previous example, going to a dinner might be both an ordinary activity, and a distinctive event that might hold surprising, emotional, unexpected elements for later recollection. Thus, it is more important to preserve the personal moments with high levels of exception, expectancy, emotion and important outcomes. Only then it would be possible to ignore trivial information and keep necessary accounts during the creation of passively recorded life archives.

One important factor for recording self-relevant information is to bear in mind that event-specific episodic memories do not only constitute of audio-visual information. Though lifelogging devices are capable of automatically recording audio-visual data, they fail to emphasize the affective states and semantic ties of the recorded events. In this sense, lifelogging devices can be said to be more effective on recording the episodic experiences visually and less effective on creating semantic links between the past events. However, the autobiographical knowledge base aims to preserve especially the meaningful memories. For instance the biological autobiographical system supplements the visual inputs through verbal data. Without the semantic dimensions describing the events, the recorded visual data would fail to hold the critical components for meaningful personal archives. Decoding the audio-data into verbal reports might be a solution for including semantic clues to the recorded audio-visual data. Also, recording affective information regarding the recorded data is important for recollection. Most of the digital archives gathered through lifelogging devices or through personal information management systems lack this detail on affective states. A solution for such a problem could be adding sensors that can measure emotional reactions during recording events. For instance electroencephalography (EEG) sensors might record emotional states in memories through measuring electrical activity in the brain. Similarly, galvanic skin response (GSR) sensors that detect sweat on the skin can be an emotional clue revealing the physical and psychological arousal or distress levels.

The second principle necessary for lifelogging devices is adding associative cues

to the recorded memories. The growing database of continuous recording needs to be constantly categorized and indexed for building an effective artificial autobiographical memory system. Associative cues are important to organize the recorded information for later retrieval processes. Inefficient indexing would result in memory loss due to cue loss. The links to the memories are important also for building semantic ties among the recorded information. As discussed before, activities provide the easiest cues for memory recall since they carry hints for generating meanings for the past events. This meaning begins to be created through contextual-situational cues such as the people involved, the behaviours of those people, the feelings associated, time information, location data, perceptual features, goals and lastly the evaluative knowledge of the experience. It is important to note that the time tags are not superior to the other cues and memories are not stored in a linear fashion in the human mind. The representation of memories in a date-based mode is demonstrative of the progress paradigm embedded into self-tracking devices. However, human life does not constitute a linear story. The associative presentation of life-data might be more in line with how memory works and how life experiences become meaningful. Thus, for effective retrievals, lifelogging devices should present recorded data with the tags and the filters rather than involving linear representations. Tags defined according to the emotions, the social environment, the intrinsic value and the meaning of the events, will provide a more realistic method for organizing self-relevant data compared to merely using time stamps.

A hyperlinked memory system with notations and annotations can make it possible to link the data into the mind-maps of the users. For instance Evernote is an application that uses tags to organize personal notes. Instead of using a folder-file hierarchy, personally defined tags are being used for building associative networks. The GPS sensors provide supplementary cues for recording the time and location metadata. One drawback of manually adding tags to records is the possibility of experiencing cue loss. When users have no limit or no guidance during adding the cues, they begin to increase in numbers and consequently function inefficiently. For preventing this dysfunction, users can be guided to manually add cues that are classified into categories that are scientifically proven for supporting easier recalls. Associative cues like; location, time, people, feelings, goals and lastly the evaluative data are some of these effective traces. Face detection can be an important supplementary function of the software. Recognizing the people in the visual data could help tagging participants in

the events. Providing additional information regarding the attributes of episodic information is also central for organizing episodic memories. Recording the affective intensity, the vividness and the conflicts involved in certain memories might help building stronger semantic ties within memories.

The third principle for the design of self-tracking memory tools is providing selective retrieval tools that enable strategic searching of the collected data. In lifelogging devices and other visual storages, the way to initiate remembering is by executing queries regarding the past records. Thus, the generative retrieval model and its working mechanisms have vital importance for optimizing this process. During memory search, offering various filter tags in the beginning of the recollection, revising the tags in line with search criteria along this process, and constantly refining search results is important for fulfilling the verification criteria of the generative retrieval mode. Moreover, creating an event hierarchy through separating the activities and the general actions is important since activities are the strongest ingredient for building and recalling one's memories. For retrieving activities, concrete memory cues are critical in that they help the users to describe their experiences in an abstract way. As mentioned before, situational cues like people, location, behaviours, feelings and perceptual features are the most significant associative information for retrieving the correct records. Thus, the geotags, time stamps, facial recognition tools and the annotative features that define the situational, the affective and the perceptual contexts are important.

The most important factor during preceding these memory principles is to fulfil the directive, the self and the social functions of the autobiographical memories. These functions need to be taken into account when developing devices that generate personal information archives. For accomplishing the directive function, memories should be encoded with causality and consequentiality relations regarding one's goals, one's self-image and the recorded memory. In order to function as the guidelines for the future, the meaning and the value of past memories need to be assessed. This requires the insight of the current self and a cognitive effort of the users to analyse past experiences. This requirement brings a barrier to the automatic information generation regarding one's past. The effortless recording processes may result in the demand of the effortful contributions of the users in order to fulfil the directive functions.

For fulfilling the self function and establishing a connection with the coherent self, one should be able to either forget the inconsistent past experiences or to create false memories to support their current identities. The digital memories should offer the flexibility to adapt to the low correspondence and the low coherence levels of the fabricated false memories. The representation of the negative memories with accurate, vivid, detailed, exact depictions might harm one's current self-image. Thus, the avoidance of certain memories and the space for creative manipulation of the past events constitute vital importance for the consistency of the self-concept. An adaptive function of the human memory is forgetting, which is an extension of remembering. For computing devices "memory loss" is seen more as a malfunctioning that results in fatal errors. During designing the lifelogging devices intentional memory loss should be considered as a design direction. Otherwise the human biology would fail to adapt to the lossless life data and lose the freedom to forget and to be forgotten.

For the usability of lifelogging devices, digital memories that reflect the unwanted selves need to be eliminated intentionally for not causing any discontinuity in one's sense of self. Negative evidences of the past selves not only limit the level of self-awareness, but also lower one's self-esteem. Avoiding the recollection of the negative true memories during the periods with negative moods are also important. Filtering the items when viewing the documents could be an important function for creating an artificial forgetting function. This principle can be named as "digital forgetting." Assigning certain filters to the specific associative cues and temporarily locking certain memories might be methods for digital forgetting. For filtering the memories, the users can determine specific tags that reflect an undesirable self, and the memories linked to these tags can be avoided during recall. By doing so, one can change the accessibility and the retrieval attributes of specific recorded memories. For instance if a memory is recorded with associative cues that involve negative emotions, they can either not be recalled or their retrieval qualities can be changed during recollection. The vividness or the visual details of the memories might need to be restricted when remembering the unwanted memories. In such cases, primarily recalling the verbal episodic information rather than the recollection of visual episodic input can be a solution for filtering the unwanted memories. Even the vividness level of the filtered visual representations can be decreased through specific visual effects like blurring or fading the colours of recorded images. A second method for digital forgetting can be associating a temporary

lock tag with certain memories that would place a temporary restriction for the long-term memories. Instead of using trash bins for permanent erasing, such restriction tags could be used for stopping access to the selected memories temporarily. The reason for replacing the action of deleting with such a lock system is preventing amnesia that would block the individuals to face past problems. In other words, putting temporary lock tags would create the option to analyse the past events from a distant standpoint in the later phases of one's life. For digitally forgetting memories, the hierarchical structure of episodic memories can be used. As mentioned earlier, the episodic memories are categorised into the lifetime periods at the higher levels, which are linked to the general events in the middle range and lastly the event-specific memories at the lower levels. Restricting access to the unwanted upper level episodic memories can bring automatic limitation to the related general events and event-specific memories that are linked to them.

Digitally recorded images and videos have a copy quality that ends up in building true memories. Life logs mostly reflect the exact information of the life experiences. If one wants to recall a positive event, exact digital records would be useful for supporting the recollection of the true memories that improve self-esteem. This truth quality can also be valuable during coping with the emotionally negative moods; it might help to recall the positive memories with vivid accurate details for overcoming the negative emotions. In such cases the recollection of positive instances can be encouraged through lifelogging devices.

However, the accuracy quality of the computationally collected data causes a challenge for the coherence of the self for creating only true memories by digital means. Creating biased self-inferences in memories is an important function for maintaining a coherent self, and the evidential feature of the digitally recorded memories is contradicting with some of the working structures of the autobiographical memories. Biased memories are the depictions or the mental constructions that are the products of imagination rather than the literal reconstructions of the actual experiences. In this sense autobiographical memories are not like videos, photographs, or like other recorded media, because they need to have a creative dimension within. Thus, the recorded data through lifelogging devices don't need to be represented with the exact same visual and verbal information. Instead, lifelogging devices should offer ways to visually edit and insert verbal descriptions for the anecdotal reflection. Providing organizational

structures that enable the addition of creative input is important. The collected information should be connected to each other and be presented with the descriptions of the events that allow building mental representations and expressing life stories for the user. Thus, the raw data of the memories should be open to users' imagination for generating narratives. Similar to digital forgetting, helping to create visual manipulations and to generate self-narratives with anecdotal qualities might bring flexibility to the digitally generated copies of true memories. However, specific qualities of the false memories and the self-narratives are hard to mimic. For instance the schematic organization of visual data enables one to recall traumatic events from a third person view instead of a first person view. This retrieval mode can be altered according to the changing personal meanings of the events. For lifelogging devices, this creative dimension is hard to mimic since a constant three-dimensional scanning of the settings would be necessary for creating such a field-observer perspective distinction. If such constructional details of the adaptive biological autobiographical memory systems cannot be mimicked, the accuracy of the computational data might be risky for creating personal memories that may not fulfil self function for creating a coherent self.

Lastly, the social function of the autobiographical memories should be considered for creating lifelogging devices that enable sharing life stories. Sharing is an important function of lifelogging devices that would make it possible to create and maintain social relationships. There is a social dimension to creating self-narratives. As mentioned earlier, in different social contexts the self-narratives are changing according to the listeners of the stories. Thus, creating and sharing life stories should be shaped according to the audience. Setting the levels of privacy and defining the levels of shared details of past experiences within different social circles is an important concern for defining the social dimensions of the artificial autobiographical memory systems.

There are two more issues that need to be addressed during discussing the usability of lifelogging devices as memory extensions. One issue regarding the design of lifelogging devices is the developmental aspect of autobiographical memories. Children and adults have different conceptions of themselves and their psychological mechanisms work differently. For designing lifelogging products, the interface can be planned flexibly for different age groups. The different developmental phases of the self-memory systems have different characteristics in creating a self-concept. As discussed earlier what is accessible for one's self-understanding may change with one's

age. Adults have the tendency to remember more specific self-relevant details and integrate them into a coherent self-concept whereas children tend to remember past events in a more general, objective, factual manner. Thus, lifelogging devices that record episodic memories might be more useful for the adults compared to the children. On the other hand for adults, autobiographical knowledge obtained through episodic information needs to reflect an abstract, subjective description of the self. Most of the lifelogging applications are designed primarily for collecting the data of the past experiences rather than building semantic associations. Recollections of the lifelogging memories can be improved through adding semantic links for the products that are targeting adults. The semantic qualities of the digitally generated self-information have vital importance for the usability of lifelogging devices.

One last issue that needs to be considered when designing artificial memory systems is the source-monitoring error. As mentioned in the first chapter and the previous section, lifelogging devices are seen as the "third eye" and the "second brain" of the individuals. However, the external memory sources can result in source-monitoring error in the users. By accepting self-tracking technologies as an extension of the biological counterparts, dilemmas may occur on the layers regarding the compatibility and the alienation to these devices. To resolve such dilemmas, the perception of lifelogging devices as external sources of memory can be altered. The head-mounted cameras might decrease the source-monitoring error by providing a first person perspective and preserving the original viewpoint of the users. However, passively recording events decreases the chance of seeing lifelogging devices as internal sources of memory. Without previously set intentional triggers for recording certain events, or without achieving selective encoding and retrieval, the users won't feel they are witnessing their own memories. Thus, they will have the information of the events that took place, but this information may not constitute their own personal memories if they do not work in line with the biological self-memory systems. In order to achieve a flawless mental embodiment, the personal meanings and the significance of the events need to be coded together with the gathered audio-visual data. Source-monitoring error is also related with the posthuman dimension of the self-tracking products. Such devices can be perceived as the extensions of biological counterparts, however users might also be alienated to such systems as external sources of information with no intrinsic witnessing value. This convergence will be addressed in the last chapter of this study.

2.4 Design Principles for Self-Tracking Devices that Contribute to Self-Knowledge

Understanding the self through making one's self visible to himself has countless possible modes. Self-tracking devices are one of them that are used for recording, observing and understanding one's personal nature. These products have certain advantages and limits in creating self-knowledge for their users. They might undergo certain improvements in order to result in more meaningful user experiences. The mental interaction between the users and the self-tracking products is mainly based on two functional elements: The content being tracked and the representational structures of the collected data.

Firstly, what is being tracked contributes to the content of the self-concept. All types of gathered data creates a base that defines what one believes to be true about one's self. The most crucial design principle in creating the content of self-tracking devices is recording and observing *self-relevant* information. If the information tracked is not self-defining and meaningful on a personal level, then both the personal informatics systems and the lifelogging devices would fail to function as sources of self-knowledge. For instance setting and maintaining certain goals for self-regulation would be impossible without the insightful self-diagnostics and the self-relevance of the collected information. Similarly, by discarding the self-revealing attributes of certain moments, the principle of selectively encoding memories would fail, which would also affect the preceding retrieval processes.

Moreover, regarding the content of the self-tracking devices, the perceptual, the social, and the unconscious dynamics of self-making should be used in integration for supplementing the information about one's self. For example tracking the sleep data reflects upon unconscious levels of one's being; and it is a valid input for self-knowledge from a psychodynamic perspective. Revealing such previously unknown details about one's self can be the most interesting contribution of the self-tracking devices to self-awareness, because this specific attribute positions these devices as self-discovery tools. As mentioned earlier, self-expansion is closely related with self-seeking and having new knowledge of different life experiences. The developers need to consider revealing the unknown, the hidden sides of the self to the users. Such information that enables one to see one's life from a different perspective is a way of reflecting on the unusual knowledge configurations of the self.

Secondly, the structures of collecting and representing data define the interface of the products that works co-ordinately with the organizations of the working self. Thus, the usability of self-tracking products not only depends on gathering self-relevant data, but also on the representations of the gathered data that define the user interactions. Since the mental embodiment between the mind and the self-tracking devices happen on a cognitive level, for revealing this interaction between the users and the products, the main focus should be on the cognitive experimentalist tradition, specifically the intrapersonal processes of the memory and the self-observation. The design principles of self-tracking should follow complex cognitive mechanisms of self-regulation and autobiographical memory systems. For instance the hierarchical level of goals, the feedback mechanisms of self-regulatory control systems that involve setting and changing the goals according to one's assessments and incentives that increase his motivation, and lastly the developmental differences should be considered during designing personal informatics systems. For augmenting the autobiographical memory there are mainly three biological principles to follow; selective encoding, associative organization of the collected information and lastly strategic reasoning for information retrieval. These three main design directions could improve the current lifelogging products. For designing artificial self-memory systems, the directive, the self and the social functions of the autobiographical memories are also crucial. Especially the key points regarding the coherence of the self during creating self-knowledge is important. Filtering the unwanted records through digital forgetting, and leaving room for the creative treatment of memories through visual manipulations or self-narratives are the necessary functions for these devices to generate life stories.

In my opinion the primary problem regarding the design of self-tracking products is a strategic issue rather than an operational one. Modelling the self as a linear, enduring entity is the main problem concerning these devices. When current self-tracking products are studied, it is apparent that these products promote self-growth and the linear depictions of lives. The stable, linear, and modernist vision of the self is inaccurate for the realities of the changing self. Especially for self-observation systems, the notion of progress is insufficient for self-expansion. Targeting the unity and the enhancement of a consistent self that is ideally projected into a future where it reaches perfection through stable enhancements is the underlying the philosophy of the current self-tracking systems. However, the self-seeking processes involve developmental shifts

that change the personal meanings and the significance of the past events. Therefore, self-information and self-knowledge should not be imprisoned in the ideas of progress and growth. Instead, they should be semantically linked to the multiplicity of the past, the current and the future selves when recording and representing the self-directed data.

CHAPTER 3

TOWARDS A MEDIATED SENSE OF SELF

3.1 Historical Perspectives on the Self and the Techniques for Self-Tracking

The history of identity and self-documentation frames the evolution of self-tracking systems culturally and technically. Analysing the meaning of identity, the motives and the methods for documenting the self throughout historical periods guides comprehending how the conceptions and representations of the self have changed over time. The dynamics between cultural context and technological advancements are apparent within each historical period, and they lead towards understanding today's conditions. According to my analysis, there are basically three factors that determine the reasons, the quality of outputs and the outcomes of self-tracking. First one is the *level of consciousness* regarding self-presence. Second one is the *cultural context* in relation to individualism. Third one is *the methods of self-documentation* by which self-observation is mediated. In other words, the level of self-awareness, the cultural motives for self-recognition and the technical tools for keeping records are the key variables capturing the essence of self-tracking behaviour in different periods of time.

3.1.1 Transformation of Self-Understanding Before Industrial Revolution

Self-documentation came into existence with the emergence of self-aware thinking. Neisser coined the term "conceptual self" to describe the meaningful model of

self-awareness that emerged with the cognitive abilities to understand one's self.[131] Before developing these abilities, self-recognition was only involved in the processes by which individuals were connected to their physical and social environments, expressed subjective private responses, and lastly prepared for specific plans considering their future selves. The cave drawings at Lascaux in 15,000–10,000 BCE exemplify a number of pictographs for the survival and the utilitarian purposes of the future self.[132] These depictions show the earliest scenes from daily lives and they were considered as the very basic forms of life-recordings that mimic life and represent plans for the future. However they lacked the sense of self as a separate, meaningful form of entity.

Building a conceptual self required more than these skills. It needed intellectual, semantic thinking. This was only possible due to the language, artistic, cultural and technological abilities that began being developed during Middle-Upper Palaeolithic transition period.[133] Accordingly, Homo Sapiens was the first species that moved beyond the limited experiences of life for its ability to think abstractly or symbolically about the self, moreover represent it semantically. The languages and the notation tools enhanced the ways of understanding and expressing the conceptual self. Gusdorf stated "the very first man who set out to speak and write his name inaugurated a new mode of human presence in the world."[134] As the pictographs evolved and merged with the symbolic abstract forms of representation, recording life abstractly became possible with the invention of writing. Meggs dates the earliest written records back to 3100 BCE, which were identified as the lists of commodities with pictographic drawings, in which objects were accompanied by numerals and the personal names were inscribed. These examples make up the first written examples of chronicles that show quantitative self-tracking. Later, the abstract forms of semantic representations or "ideograms" were used for semantic expressions. Trademarks of the owners, status symbols and personal

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[131] Ulric Neisser, "Five Kinds of Self-Knowledge," *Philosophical Psychology* 1, no. 1 (1988): 386.

[132] Philip B. Meggs and Alston W. Purvis, *Meggs' History of Graphic Design* (New Jersey: John Wiley & Sons, 2011), 7.

[133] Mark R. Leary and Nicole R. Buttermore, "The Evolution of the Human Self: Tracing the Natural History of Self-Awareness," *Journal for the Theory of Social Behaviour* 33, no. 4 (2003): 392-394.

[134] Georges Gusdorf, *Auto-Bio-Graphie* (Paris: Editions Odile Jacob, 1991), 11.

signatures became common forms of personal recordings.[135] According to Rettberg, noting down belongings of the self for proving ownership can be thought as an early form of the self.[136] However, by assuming so, the level of one's presence would only be restricted to the ownership and the status quo. Hence, such information may hardly be considered as self-documentation leading to a deep understanding of the self. Therefore, it is important to note that these early instances of logs and symbols referred to a limited notion of the conceptual self.

Following the Palaeolithic Period, as early as 3000 BC, Egyptians were known to be the first culture to keep records of daily life in the forms of writing (hieroglyphics) and figures for passing them to their afterlives.[137] According to their religious beliefs, it was culturally necessary for them to take along evidences from their current lives and to transfer them into their future presences. Logging their lives and saving them for the future brought a sense of power for reaching immortality.

In the Ancient Greece, self-consciousness gained a more philosophical stance. Instead of merely keeping quantitative and qualitative evidences of the past, the emphasis shifted towards understanding and knowing one's self. This attitude was present in the oral and the visual culture. For instance the ruins from antiquity illustrate the significance of self-awareness. One of the most renowned Delphic aphorisms "know thyself" was inscribed on the Temple of Apollo in 590 BC; and it was interpreted as "know your place in the world" or "know your true self."[138] For motivating introspective thinking about one's self, this aphorism was referred frequently during the Antiquity. By laying stress on this particular saying, Socrates' dialogues expressed that the wisdom of the soul was possible through occupying one's self about one's self.[139] Accordingly, there was a dichotomy, as the self was framed not as the body, but as the

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[135] Meggs and Purvis, 9.

[136] Jill Walker Rettberg, *Seeing Ourselves through Technology: How We Use Selfies, Blogs and Wearable Devices to See and Shape Ourselves* (New York: Palgrave Macmillan, 2014), 10.

[137] Katherine Hoffman, *Concepts of Identity: Historical and Contemporary Images and Portraits of Self and Family* (Westview Press, 1996), 13-14.

[138] Joseph Eddy Fontenrose, *The Delphic Oracle, Its Responses and Operations, with a Catalogue of Responses* (Univ of California Press, 1978), 294.

[139] Michel Foucault, *Technologies of the Self: A Seminar with Michel Foucault* (The University of Massachusetts Press, 1988), 20.

soul. The oral tradition of self-knowledge was apparent in Socrates' dialogues where he warns that the new technology of writing could undermine the power of memory: "This discovery of yours creates forgetfulness in the learners' souls, because they will not use their memories; they will trust to the external written characters and not remember of themselves. The specific which you have discovered is an aid not to memory, but to reminiscence, and you give your disciples not truth, but only the semblance of truth…"[140]

Before moving to the Hellenistic Period, another milestone for the conception of the self is worth mentioning. The myth of Narcissus is an example that points out the self-directed attention, appeared in the Greco-Roman Period. According to this myth, Narcissus saw his reflection in the water, whom being captivated by his beauty, could not realize that it was only a reflection. He was so drawn towards his charm that he drowned to his death in the end. This myth was re-interpreted by many scholars. One theory suggested the main theme of the myth was "duplicity" that exposed the gap between the self and the self-awareness.[141] McLuhan points out that parallel to the myth of Narcissus, any tool has been seen as an extension of men to reach self-reflection.[142] This comment points out how different techniques of self-observation are all connected to one another with a single concept: Of seeing one's self. Not so different from a mirror, any means of technology reflect back a self-image, which leads towards self-discovery and self-knowledge, or in some cases, only stays as a reflection for pure self-love.

During Hellenistic Period, the priority of passive self-thinking was replaced by the active concern for the self, which motivated taking good care of the self or searching wellbeing by practical means.[143] The oral tradition of antiquity was mostly replaced with the actions taken for wellbeing and the detailed depictions of the self. In visual arts, the attention to the body gained more importance in comparison to the Ancient Greek period with figures of the human body carved as a whole, instead of being sculpted

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[140] Charles L. Griswold, *Self-Knowledge in Plato's Phaedrus* (New Haven: Yale University Press, 1986).

[141] Lieve Spaas and Trista Selous, *Echoes of Narcissus* (New York: Berghahn Books, 2000), 3.

[142] Marshall McLuhan, *Understanding Media: The Extensions of Man* (Cambridge: MIT Press, 1994), 41.

[143] Foucault, *Technologies of the Self: A Seminar with Michel Foucault*, 21.

partially as busts. The first examples of diaries and letters described the details of the ordinary daily life, started a conversation with one's self privately and socially. Taking care of one's self was linked to the constant writing activity. For instance Seneca had a worry about his health and developed a self-understanding in which the essence of the self was connected with the nature. He stated, "Nature helps one in contact with oneself." The discipline for becoming one's own doctor, which is experienced with the health monitoring products today, was apparent in these writings, with the difference of his emphasis on the nature. The letters of Aurelius were also descriptive everyday-life essays about the body and the soul. All these detailed introspections had a connection to "vigilance" i.e. keeping a careful watch over oneself. Writing offered a new experience of the self. Seneca and Aurelius' letters are examples of this self-exercise in which the self was something to write about, a theme or an object for the writing activity.[144] Subject, became the object of writing; and this was similar to the duplicity theory mentioned above, which defined the self and the self-awareness as two separate entities.

The Middle Ages were more about self-examination and self-abandonment rather than understanding and depicting the self. In order to reach a fixed, idealized self defined by the Christian traditions, one had to achieve a certain self-image for God, the ultimate spectator.[145] Coping with the religious morality required high levels of self-control; this was possible through transforming self-knowledge into action. The Catholic traditions, requiring confessions to the monks were replaced with the total self-responsibility routines maintained with one's own devices during the Protestant Period, putting higher stress on self-control. Following the Christians' religious customs, "Confessions" by St. Augustine became the first example of autobiography.[146] This piece was composed of 13 books and was written during the author's transition to Christianity. It involved 4 stages through which the author improved himself for reaching a prospect of change through a retrospective self-examination.[147] These 4 stages were composed of "recognition" (realizing the self), "distanciation" (identifying one's problems), "articulation" (seeing past and projecting it into a future self) and

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[144] Ibid., 26-31.

[145] Mark Philip Freeman, *Rewriting the Self: History, Memory, Narrative* (London: Routledge, 1993), 25-43.

[146] Ibid., 44-49.

[147] Ibid.

"appropriation" (changing oneself). These steps resemble the stage-based model developed for analysing the personal informatics in self-tracking systems, which was constituted of the stages named preparation, collection, integration, reflection and action. This similarity in self-tracking between the Middle Ages and the Digital Age is meaningful in which the identity is examined and forced to change in order to reach a certain desired result. The nature of this desire has similar motivations in both cases. In Christianity, the fear of God and the obligation to confess caused the motivation for the inner-change. In the Digital Ages the fear of the society and the obligation to reach an ideal self-image as dictated by the cultural conventions might be the cause for motivating self-examination and self-control. In both situations, the ultimate goal is reaching self-affirmation for the spectator and converting the inner truth of one's self into an agreed appearance or self-image as a spectacle.[148]

During the years of humanism, man became the measure of life, in contrast to the secular communal tradition of the Middle Ages. In this respect, the Renaissance was a human-centred movement that gave rise to the individualization of the modern self, encouraged self-discovery and self-fulfilment. Returning to the Antiquity, humanists put stress on the phrase "know thyself" and they were concerned with self-knowledge extensively. Self-presentation, self-stylization and the impression of a unique personality became a part of the invention and the reconstruction of identity.[149] The genres of auto-portrait and autobiography were reinvented, enhancing the former models of self-expression. Parmigianino, Dürer, Michelangelo are some names who are known for their self-portraits. Status and personal expression of the artist were reconsidered; and putting signatures on the artworks became a common trait as a sign of individualization. Montaigne's writings were considered as the first personal literary essays examining one's own inner psyche.[150] He has seen the subjective expressions in autobiography as a way of self-portraiture. Along with these humanist developments, some other external factors also strengthened the universality of ego-documents such as diaries, journals, memoirs and letters. For instance, urbanization offered alternative ways of living and the concept of individual choice gained importance; travel offered

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[148] Guy Debord, *The Society of the Spectacle* (New York: Zone Books, 1994), 14.

[149] Roy Porter, *Rewriting the Self: Histories from the Renaissance to the Present* (London: Psychology Press, 1997), 17-57.

[150] Ibid.

new experiences that freed one from his past; print increased the works and the readability of personal written records. Each of these developments triggered tracking and expressing one's own life.

The self-centred thinking practices of the Renaissance reached its peak with the philosophy of Descartes. He brought thinking from a first person view as a method for arriving the knowledge of existence by his renown saying "*Cogito ergo sum*" or "I think therefore I am." [151] This thought, was born from the scepticism of the being. After criticizing the senses and the perceptions for becoming delusions, he put one's inner self-aware thinking mechanisms as the source of actuality. The ability for the mind to simply think was a source for reality. Another important point in Descartes' philosophy considering self-concept was that his Cartesian system presented two parallel but independent worlds, that of mind and that of matter, each of which can be studied without reference to the other.[152] This mind-body dichotomy presented soul and body as separate entities; thus drew attention to the division between the inner and the outer selves.

In the Age of Enlightenment, religious thinking was supressed by putting "reason" on top of all. Facts and observations became the sources of knowledge. Self-concept was defined by personal experiences; Locke and Bacon are thinkers who identified man as a self-made product of his own interactions in life.[153] Hume and Kant agreed that observation was the only valid method for perceiving one's self. According to this empirical perspective, in contrast to Descartes, man could only see himself through observing his experiences and interactions with others along his life. An isolated analysis of human interiority could never lead to self-knowledge.[154] This understanding contradicts with today's self-tracking systems, which mainly derive from and aim to make isolated intrinsic analysis.

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[151] Bertrand Russell, *History of Western Philosophy* (New York: Routledge, 2013), 493.

[152] Ibid., 567.

[153] Porter, 5.

[154] Hoffman, 37.

3.1.2 Self-Concept and Life Records in the Industrial and the Post-Industrial Periods

The turn of the 20th century witnessed a boost in the conceptions of the self and the techniques for documenting it. With industrialization, the tools became critical in self-tracking more than any period in history. The invention, then commercialization of photography made it a widespread method for recording one's life. Capturing the representations of daily life created a sense of control over time and also over the realities of life. It can be argued that photography is a means of augmenting the perceptions of time and representing the essence of the moment. Though this technique was more mechanic than any other depiction method in history, the realistic records attained through photography caused it to be perceived as a natural representational practice that reflected the reality in a natural way. In my opinion, this specific aspect was the significant reason for the adoption of this medium to the everyday lives for preserving past events, along with the innumerable economic, cultural, political factors. The popularity of these automated representations resulted in increasing the mediations for the self. The relationship between the original and the copy affected the realities of one's own presence up to a point where the representations of the self became truer than the reality itself. However, as mentioned earlier, the essence of reproduction was also seen as a way to kill the authenticity of the moment by destroying the "aura" of actuality.

By then, the increasing gap between dilemmas like original and copy, natural and mechanized raised new questions regarding the dehumanizing characteristics of technology. The reasons for these questions were partially due to the limits and the possibilities of the industrial tools that shaped the ways of thinking and expressing one's self. For instance writing is a form of expression and also a tool for creating new thoughts. Several academicians have stated that different tools of typing, such as a pen and a typewriter, caused different modes of thinking and expression.[155] It was claimed that typewriting, followed by the word processors has lead to a more mechanic way of thinking, and in this sense, the machine has begun changing the natural flow of thoughts.

The automated means of self-representation initiated a loss of inner perspective by causing a decrease in the individual voices and the interpretations of daily life. Partially

[155] Murphie and Potts, 157.

as a reaction to this aspect brought with Industrial Revolution, Romanticism aimed to reach an expressive language of the self for self-fulfilment rather than using objective self-analysis methods. According to the artists of the period, art was the only truth that could reveal the mysteries of the inner self.[156] The first person narratives, the emotional and creative treatments of self-documentation were supported within this movement.

During and after the Industrial Revolution, the definitions of the self altered immensely due to the changing conditions of life. "Taylorism" proposed a new working standard in which the labour was rationalized in reference to the working principles of the machine that were developed for increased efficiency.[157] Parallel to Taylorism, the modernist ways of living were characterized with the industrial and the mechanic notions such as control, speed, progress and automation. The pre-defined routines and the ways of self-control for an improved, ideal life have been criticized by the artworks such as Jacques Tati's renowned movie Mon Uncle.[158] The influence of industrialism on the daily life gave rise to the birth of an identity crisis that had links with the context of modernism. The alienation theory of Marx reveals different types of estrangement, where the labourer is alienated respectively to his work, to his act of production, to his own essence and to the people around him.[159] Accordingly, especially the third type of alienation concerning the essence of the species mentions an important breaking point in the relationship between man, technology and nature by defining a condition where man is separated from the nature that constitutes his body, his life, and his environment. As a result man can no longer recognize his presence as a part of the nature.

Within the transition to the Industrial Age, there were certain circumstances that the modern man had experienced. The speed of change, the burden of choice, being a part of stereotypical culture, and the loneliness were the conditions that led to a crisis of identity. As a result, new solutions were sought to make one's presence meaningful again. With existentialism, it was argued that in a constant chaos of identity, an

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[156] Hoffman, 50-53.

[157] Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper & Brothers, 1911), 7.

[158] Jacques Tati, "Mon Oncle," (France: 1958; reprint, The Criterion Collection, 2013).

[159] Karl Marx, *Economic and Philosophic Manuscripts of 1844* (Kent: Dover Publications, 2012), 74-80.

unexamined life would prevent man from becoming, from making himself.[160] Accordingly, one had to be responsible for himself and his actions through making certain life choices. Holding on to the good life experiences and the search for introspection in order to understand one's self from the inside were stated to be the needed acts for the modern self. Consequently, self-examination gained importance once again as a part of individualism brought by existentialism.

The analogue, mechanic media forms of self-observation and documentation were followed, and mostly meshed with the digital technologies by the end of the 20th century. During the transition from material culture to digital culture, the industrial product approaches have been transformed into the "product-service systems" where manufactured goods were combined with the intangible aspects of services. A Product-Service System (PSS) is identified as a structure in which the utilization rather than the ownership is qualified, and the differentiation in the market was attained through the combination of product and services that make a value in use.[161] With PSS, the immaterial qualities that created the usability of the service such as software and programming became essential to the hardware elements of the products. Smart devices are examples of these systems where the tactile product qualities and the immaterial service components are blended together. Through the interaction with the interface, meaningful user experiences are being created for the users. Product-Service Systems are not only characterized with the interface that unites the material and the immaterial for usability, but also with the output generated throughout the usage of the systems. During the Digital Era, data has become a reality in users' lives and the mediations of the self experienced a paradigm shift where the numbers, the computerized bits of information and the statistics have begun dominating the sources of self-understanding.

During post-modernity, parallel with these revolutions in the industrial products, the patterns of consumption have changed. The post-modernist consumer is characterized by his purpose of not "having" goods, but "being" through goods for

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[160] Rollo May, "Origins and Significance of Existential Psychology," in *The Discovery of Being: Writings in Existential Psychology* (New York: WW Norton & Company, 1994), 37-59.

[161] Tim S. Baines et al., "State-of-the-Art in Product-Service Systems," *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture* 221, no. 10 (2007): 1547.

living a meaningful life; as a result "such a transformation can not be coped with the idea of function primacy, but requires that of meaning fulfilment."[162] The digital has become the new mirror for self-awareness where the automated sensors became the new authors of the autobiographies and the auto-portraits. However, fulfilling the meaning search of the customers has been a challenge for the digital products. Especially with self-tracking, the concreteness of self-data wiped out the playground for imagination; and left users with pure evidential truths, replacing the creative scope of self-narrations. The gap between interpretation and accuracy was increased while the means of self-expression were reduced to the factual data of daily life. Making meaning through using such forms of information became more difficult than the previous historical periods.

To sum up, when the earlier historical perspectives and methods are compared to the industrial and the post-industrial self-tracking mechanisms, it can be seen that all three domains of self-tracking behaviour have been changed. In means of *cultural context*, individuals' attention towards themselves has become an approved, even popular act along time. The cultural reasons for this self-directed focus were changed throughout time according to the religions, the philosophies, and the lifestyles experienced in different historical periods. The technical *methods for self-documentation* have been altered, becoming more in favour of the mechanic, automated techniques with accurate outcomes and limited capacities for self-expression and self-narration. Lastly, though the cultural context and the methods for self-tracking have offered new opportunities to understand and know one's self, the *level of consciousness* constituting self-awareness has been kept in controversy. The social affirmation and the technical improvements for self-documentation were not enough for a deeper understanding of the self. Regarding this controversy, the most crucial difference apparently concerned the level of cognitive effort one had to put in order to understand himself and his presence. In the former periods, an intellectual effort was needed for observing the essence or the truth in life whether the source of self-reflectiveness is derived from the mind or the body, from the inner or the outer self, from the matter or the soul, from the facts or the expressions. Self-recording was only an act accompanying the cognitive processes for self-understanding. In today's conditions, the

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[162] Takatoshi Imada, "Self-Identity in a Post-Modern Age," in *Self and Future Generations: An Intercultural Conversation*, ed. Tae-Chang Kim and Ross Harrison(Isle of Harris: White Horse Press, 1998), 252.

case is reversed; the tools play the leading role, and elf-awareness is reflected as an act dependent upon such automated technologies. Self-tracking products influence the intellectual inner dialogue for reaching self-knowledge. They may even become a noise in this delicate connection within one's self. As a result, in the end of this process, self-tracking technologies transform the sources of self-knowledge into a medium, and the inferences regarding the self into an assembly of the mechanized outputs of self-data.

3.2 The Impact of Technology on the Changing Forms of Identity

3.2.1 Relating Self-Tracking to Posthumanism and Transhumanism

From the beginning of history, mankind has been differentiated from the other species by its superior ability to make and use advanced tools.[163] The relationship between the domain of tools and their creators is a symmetrical one: While humanity is shaping the tools, the tools are also shaping humanity. Technologies are causing a transcendence of human beings through augmenting the physical capabilities of the body and enhancing the mental capacities of the mind. Even the most basic technologies like clothing, wheels, and glasses are among the means that expand the limits of the human body. Intellectual tools like language and counting, notational tools like writing, and representational tools like photography are some of the examples that re-structured human mind by changing the ways of thinking, recording and perceiving the world. "Cyborg" (cybernetic organism) is a term that is used for explaining the result of this symbiotic interaction between man and the machine. It is defined as "a fictional or hypothetical person whose physical abilities are extended beyond normal human limitations by mechanical elements built into the body."[164] This term was first introduced in 1960 for defining a man-machine system in which organisms would be integrated with the artifacts that would extend the self-regulatory controls of man in

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[163] Steven J. Mithen, *The Prehistory of the Mind: The Cognitive Origins of Art, Religion and Science* (London: Thames and Hudson 1999), 132.

[164] "Cyborg: Definition of Cyborg in Oxford Dictionary (British & World English)" http://www.oxforddictionaries.com/definition/english/cyborg (accessed April 01, 2015).

order to enhance his adaptive mechanisms.[165] Accordingly, the eased ability to adapt different environmental conditions was claimed to set man free to explore, to create, to think and to feel. Self-tracking devices are examples of these integrated self-regulating systems where monitoring the human body, and remembering the daily life became automated; however the stated intention of freeing thought and enriching one's existence might be far from the current situation where the focus on self-data is overshadowing the knowledge and the experience of the world.

The term cyborg outlines a state of humanity that is augmented by the use of technology. However, the word "humanity" in this definition is not a fixed concept since the essence of human being is subjected to several changes, especially through technology. Posthuman and transhuman are concepts deriving from this change in the conditions of humanity. The first change brought by computational means to humanity is the altered capacities and qualities of the human thinking mechanisms. The etymological root of (Homo) Sapiens is to "be wise."[166] As the human mind is altered by computation, the abilities of consciousness concerning one's self are changing. It can be argued that technology augments the total capacity for human intelligence, but the human portion of this conjunction is probably shrinking as an independent facility of free thought. As Virilio suggests, the computer codes cause a loss of natural phenomena, which "disables any intelligent act of thought beneath the calculation of the machine."[167] In other words, with the presence of technology, the human mind might be becoming less capable in intellectual and cognitive means. The nature of human mind is changing not only in capacity, but also in the ways of handling information of the world. Digital ways for obtaining self-knowledge are examples to this change. Self-awareness is an act that comes with deep self-focused thinking, interpretation and evaluation. The older forms of thinking about the self are being changed, as the notational systems generating self-referent data become a larger source for self-understanding. The main problem in this transformation is the fact that self-tracking devices do not support all of

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[165] Manfred E. Clynes and Nathan S. Kline, "Cyborgs and Space," *Astronautics* 14, no. 9 (1960): 74, 75.

[166] "Homo Sapiens: Definition of Homo Sapiens in Online Etymology Dictionary" http://www.etymonline.com/index.php?term=Homo+sapiens (accessed April 04, 2015).

[167] Paul Virilio, *The Information Bomb* (London: Verso, 2005), 124.

the physiological, neurological and psychological processes involved in self-awareness. For instance, for autobiographical memory, lifelogging devices increase the capacity of memory storage, but trace decay problem leading to unwanted forgetting has not been resolved yet. Likewise, the ability to forget in order to maintain a consistent self-image is not being an option anymore with the constantly recorded lives. Hence, the augmentations brought by self-tracking devices have partial amplifications, and it is important for these devices to support the whole system of the natural brain functioning. In summary, computational forms of intelligence augmentation transforms the relationship between the knowledge and mankind; therefore the connection with technologies changes the human condition that has been referred as "being wise."

The second change in humanity caused by creating and using technologies is the integration of the living and the non-living entities. With the infusion of digital devices into daily life, a new type of subjecthood is being created in which the biological aspects of the human are blended with the non-biological counterparts of the technology. The level of this union is debated to reach such a point where the definitions of the human as we know today will no longer be present. This condition causing a new state of being that is beyond the capacities of human species is referred as "posthumanity;" Futurist Kurzweil coined the term "singularity" for stating a future condition where the human and the inhuman are going to be morphed into a singular entity in which technology and human can not be distinguished from one another anymore.[168] Singularity is a model of posthumanity where the distinction between the physical and the virtual will no longer be present. Thus, concerning the self-tracking products it can be argued that the articulated knowledge of the self through the computational representations will no longer be separated from the actual presence of the self, replacing the current state of humanity with a mediated one.

Posthumanity is a form of human transcendence that is argued to emerge through certain technological progressions. "Transhumanism" refers to the evolutionary transition stages towards posthumanity in which it is aimed to reach a superior human

[168] Kurzweil, 9.

model with the help of technology.[169] Accordingly, mankind is already at a stage where the transhuman condition is being experienced. This is due to the fact that the non-human is a part of the human life since the non-living is merged into the everyday lives. Implementing bionic body parts is not science fiction for today's conditions and using portable devices for augmenting capabilities of the human organism is a similar model of implementation. As McLuhan claims, technology is an extension of man that extends the physical and the mental boundaries of people.[170] Such an extension means that transhumanism is a reality for today.

Following Darwinist tradition, the roots of transhumanism go back to the theories of evolutionary biology and to the Eugenic purpose of rationally controlling the nature in order to improve and overcome the current state of the human organism.[171] Accordingly, human species is an object of evolution, a piece of an endless bettering of the present condition. Consequently it can be inferred that the ultimate goal of transhumanism is reaching an ideal self through technological developments. Parallel to Eugenic thought that supports the perfectionism of the species, sculpting one's self is argued to be an act for self-realization.[172] The enhanced race of the man-machine hybrid forms the fundamentals for the politics of the self. In a sense, self-control and surveillance functions involved in self-tracking products are bound to the underlying understandings of transhumanism.

The self-tracking devices and the fundamental principles of transhumanism can be linked in several ways. Firstly, the interest in control over the body and the self, which is becoming more of a fascination among people, is a sign of the will to improve the current human condition. "Being in control" of the self is reminiscent of the motivation to control the nature of humanity as mentioned in the Eugenic thought. Moreover this

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[169] Esfandiary Fereidoun M., "How Transhuman Are You? ," in *Are You a Transhuman? Monitoring and Stimulating Your Personal Rate of Growth in a Rapidly Changing World* (Clayton, Australia: Warner Books, 1989).

[170] McLuhan, 46.

[171] Nick Bostrom, "A History of Transhumanist Thought," *Journal of Evolution and Technology* 14, no. 1 (2005): 3.

[172] Karen-Sue Taussig, Rayna Rapp, and Deborah Heath, "Flexible Eugenics: Technologies of the Self in the Age of Genetics," in *Anthropologies of Modernity: Foucault, Governmentality, and Life Politics*, ed. Jonathan Xavier Inda(Carlton, Australia: John Wiley & Sons, 2005), 197-201.

behaviour means that the citizens are under constant self-surveillance or sousveillance where they exist within the pre-defined conformist boundaries, and obey the purpose to control the nature of humanity. Secondly, competition is a common theme for the self-tracking products where the users are constantly being compared to the other users through gamification or similar strategies. They are forced to interact with their rivals where the intended self-awareness becomes more about the awareness of the rivals. This virtual competition environment reminds of the "survival of the fittest" theory that is framed parallel to the natural selection principles of Darwin.[173] Thirdly, as mentioned in the literature of self-evaluation, having an ideal self is claimed to be mandatory for the self-regulation in order to change and correct the problematic self. Media platforms are channels for enforcing this ideal image to the masses. Susan Bordo claims, "The body that we experience and conceptualize is always *mediated* by constructs, associations, images of a cultural nature."[174] In this sense, self-tracking medium can be assumed to be a personal realm that is constructed politically which imposes the idea of reaching a desired state of being. The users are voluntarily monitoring their activities in order to match the codes of the ideals, in line with the transhumanist archetypes.

The essence of humanity is under continuous change where the categorical distinctions regarding the man and the machine are constantly being questioned. The dilemmas concerning the cyborg, the transhuman and the posthuman open up new philosophical debates. Separating the human and the machine by dualisms gives man a privileged status, handing an authority to declare the superiority of mankind over technology and to ignore the changing natures of humanity and artefacts. The reasons for describing and evaluating technological advancements with these distancing conceptions are partially due to the fear of a near future where machines may begin to control humanity. This situation in which the artificial takes over the natural is called "existential risk" by Bostrom; it is defined as the "threats that could cause our extinction or destroy the potential of Earth−originating intelligent life."[175] This condition has been

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[173] Herbert Spencer, *The Principles of Biology*, vol. 1 (New York: D. Appleton and Company, 1896), 444.

[174] Susan Bordo, *Unbearable Weight: Feminism, Western Culture, and the Body* (California: University of California Press, 2003), 35.

[175] Nick Bostrom, "Existential Risks: Analyzing Human Extinction Scenarios and Related Hazards," *Journal of Evolution and Technology* 9, no. 1 (2002): 1.

a theme for several science fiction books and dystopias concerning technology. An early example was Mary Shelley's *Frankenstein* that is stated to "channel society's fears and anxieties concerning rapid technological change," especially those with "transformative powers."[176] Frankenstein portrays a similar existential risk situation where the machine takes control over its creator. Another writer who similarly questions the boundaries between the man and the technologies is Asimov. He draws the line between the human and the machine according to his law that proposes "A robot may not harm humanity, or, by inaction, allow humanity to come to harm."[177] In a posthumanist condition where the robot and the human can no longer be separated clearly from each other, this law has the risk of being invaded. Thus, the fear of machines' taking control over humanity is also due to the indistinct definitions of the machine and the human intelligence that are coming closer to each other. The distinctions positioning man as the creator of artifacts might exist in the rhetorics, however it is becoming harder to classify what represents the self and what constitutes the other concerning the technological presences.

The discourses of transhumanity and posthumanity are not only focusing on the dualisms between the man and the machine, but also emphasizing the unities, the similarities and the blurring boundaries caused by the promising technological developments. Haraway, for instance, has a stance where she mentions technology as a form of fictional reality that makes it possible to redefine the limits of daily life and free the boundaries of the "historically constituted body" from the Western ideals.[178] Thus, the concept of technology does not need to be understood as a destructive force for humanity, but it can be seen as a new window for creating possible identities. In addition to these possibilities for the real life identities, virtual space "also made it possible for the individuals to assume multiple identities."[179] Accordingly, this *second self* cuts across real life distinctions of gender, race, class, and culture. Moreover,

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[176] Murphie and Potts, 96.

[177] Isaac Asimov, "Runaround," in *I, Robot*(New York: Doubleday, 1950; reprint, New York: Bantam Spectra, 2004), 25-45.

[178] Donna J. Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century," in *Simians, Cyborgs, and Women: The Reinvention of Nature*(Routledge, 2013), 157.

[179] Sherry Turkle, *The Second Self* (New York: Simon & Schuster, 1984), 288.

beyond bypassing the distinctions of the nature and the artefact, second self may also delete the boundaries constituting the distinctive presence of the self and reconstruct it. By being connected to the computational systems, one's identities might get decentralized through computers, and one can constitute a part of a bigger whole. In the Age of Digitalization, the self is beyond unity: "There is no 'me,' no 'I,' no unitary actor."[180] Decentralization of the self through the Net also changed the very definition of it. The self is claimed to have a distributed presence that is being spread over the entire web so that "no part can say, 'I am the I.'"[181]

3.2.2 Regarding the Mediation and the Essence of Quantified Selves

The devices used for self-tracking are increasing the digitalization of the self and bringing new definitions to the selfhood. These products transform their users in two distinct ways. First one is changing the *mediations of the self* where the automatically collected data defines the meanings, the representations, and the perceptions of the self-knowledge. The sources of the self-knowledge changes how one's self is revealed, how it is understood and learnt. Second one is the altered existence of the self where the materiality of the physical presences is being replaced by the immateriality of virtual information regarding the self, causing a new *essence* for the selfhood. Moreover another essential article that changes with self-data is the practices of living and the agency of the self with the communication technologies. The relationship between cognition, body and self-awareness are determined by both the mediation and the ontological qualities of self-data. These two aspects are offering a different model for humanity where the sources of the self-knowledge and the existence of human beings are transformed into a new human condition.

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[180] Ibid., 265.

[181] Kevin Kelly, *Out of Control: The New Biology of Machines, Social Systems, and the Economic World* (New York: Basic Books, 2009), 25.

3.2.2.1 Mediations of the Self: Self-Knowledge through Self-Data

The modifications caused in the *mediations of the self* are connected to three main facts; the semantics of information, the increasing data overload and the changing perceptions of representation. Firstly, the relationship between self-knowledge and self-data defines the semantics and epistemology of self-understanding. Secondly, the data overload is a condition that changes the meanings and the realities of self-knowledge. Lastly, the nature of replicated representations brings new conditions to the perceptions of self-understanding.

The reason why semantics of data has such a significant influence on subjecthood is that the human existence is based on and determined by its connection to the knowledge of life. In order to compare the meanings and realities of self-knowledge and self-information, the origins of the notions such as data, information and knowledge need to be examined. The word information is etymologically rooted in Latin *in-formare*, which means, to give form, shape, or character to something.[182] The philosophical origin of this word goes back to Greek philosopher Aristotle's empirical understanding of the form, where he describes in-formation as a *formative* process, a power of the mind on the sensations of actuality.[183] The knowledge for the essence of the world was defined in connection with the idea of information that symbolized the knowledge of forms. Thus, defining the sense of information by "form within," signified it as the empirical and the factual evidence of the world, emphasizing its referential, instructional and representational qualities.[184] This relationship has been transferred to the English language. The definition of information in Oxford Dictionary is: "Knowledge communicated concerning some particular fact, subject, or event."[185]

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[182] Luis M. Rocha and Santiago Schnell, *The Nature of Information* (Bloomington: Indiana University School of Informatics).

[183] Rafael Capurro, "Epistemology and Information Science" http://arizona.openrepository.com/arizona/html/10150/105705/ethikskript/trita.htm (accessed December 5, 2014).

[184] Francisco J. Varela, *Principles of Biological Autonomy* (New York: North Holland 1979), 266.

[185] "Information: Definition of Information in Oxford Dictionary (British & World English)", Historical Thesaurus

According to this definition, factual reality of the world is stated as a part of the realm of information.

The second notion of information resonances like an engineering term, constructing the modern conception of media as an independent entity of signalling, separated from the realm of materiality. According to this definition, information is involved in the processes of receiving and sending a message rather than constituting the content of it.[186] Hence, regarding this modern view, information has relationships within itself, rather than being connected to other entities. Subsequently, this sense information is more about gaining information, rather than information being about something. This definition terminates the semantic links of information, outlining it as a unit of transmission process, free from meaning. "Data," a sub-form of information, which can be defined as information that can be processed by computers, stands as an autonomous computational entity distinct from actuality and meaning.[187]

These ideas on information and data help to define the conditions of self-knowledge in the Digital Age. According to an epistemological perspective, there is a linear relationship between data, information and knowledge, in which data makes up information and information creates knowledge; and this sort of knowledge that can be articulated through such a process is called *explicit or codified knowledge*.[188] Arrangements of knowledge in mathematical expressions such as statistical reports, or in formal languages such as grammatical statements are ways for expressing such independent forms of data for constituting this codified knowledge.

The most important fact for the semantics of the self-tracking data is that there is no direct transformation from self-data to self-knowledge. Codified knowledge generated by sensors posits a computerized knowledge that lacks the comprehension of life shaped through one's experiences. The nature of collected bio-media regarding the

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http://www.oed.com/view/Entry/95568?redirectedFrom=information#eid (accessed December 05, 2014).

[186] Rafael Capurro and Birger Hjørland, "The Concept of Information," *Annual Review of Information Science and Technology* 37, no. 1 (2003): 343-411.

[187] Dick Stenmark, "Information Vs. Knowledge: The Role of Intranets in Knowledge Management," in *System Sciences, 2002. HICSS. Proceedings of the 35th Annual Hawaii International Conference on* (2002), 930.

[188] Ibid.

users has a different content structure compared to those of unmediated knowledge. For instance, the measurement of the heart rate only gives a clue on one's physiological condition. This information is a factual; it is a detached report, which only includes the numbers regarding the body. Such sort of sensor-based information has an articulated quality, in which the data does not aim to refer to the knowledge of the world. As computer signals, it functions more as a unit for digital communication that is free from content. On the other hand, comprehending the quality of one's breathing says something else about one's physiological and psychological condition. The latter is some kind of a self-understanding, because it requires an intrinsic exploration to reach a comprehension that is specific to an individual. This second kind of knowledge is called *tacit knowledge* that is derived from the learning procedures of personal experiences, which is intrinsically meaningful, bound to the knower and is beyond measurable limits of articulation.[189] This type of knowledge has an essence that cannot be communicated or represented by the means of computation. This category, standing for the knowledge of life, is created by inferring the meaning of the real world; and established through the cognitive filters that interpret the interactions or the experiences in life for a stabilized self.[190]

The quantified self faces a situation where the cyber figures are converting the sources of this tacit self-knowledge into the codified knowledge of self-information. The gap between the referrer and the referent increases in this new form of self-knowledge. This separation occurs because these entities are no longer in tact since the computational data is more of a signal without any content. In this sense the new models for self-knowledge involves no unity for giving a meaning to the self. For Mitchell, representations "mediate" our knowledge, but also obstruct, fragment, and negate that knowledge.[191] Therefore, just as the symbols of representation construct knowledge, the coded structure of communicated knowledge for the quantified selves can block, fragment and contradict with the intrinsic self-knowledge. According to

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[189] Michael Polanyi, *Personal Knowledge: Towards a Post-Critical Philosophy* (London: Routledge, 2012), 93-96.

[190] Robert D. Galliers and Sue Newell, "Back to the Future: From Knowledge Management to Data Management," (2001): 613.

[191] Thomas Mitchell, *Picture Theory: Essays on Verbal and Visual Representation* (Chicago: University of Chicago Press, 1995), 188.

Hayles, the destabilization of the self is articulated by the deconstructed presence of human life with no origins of meaning.[192] Lacking such semantic qualities, the knowledge of a computer and the knowledge of life may not work complementarily with each other.

Assigning meaning to the collected data can solve this crisis for the semantics of information. The ties between the codified knowledge of the world and the tacit knowledge of the life can restore the stabilization of the fragmented self. "Metadata," i.e. data of data, might constitute a bridge for the knowledge of life and the computational knowledge, because it gives a form to the collected data by defining it. "Metadata has been proposed as a mechanism for expressing the 'semantics' of information, as a means to facilitate information seeking, retrieval, understanding, and use."[193] The referential and associative quality of metadata causes the collected information to be included in the meaning maps of the human mind. Thus, it is a possible link between information, knowledge and meaning in the Digital Age.

Metadata has a reference quality regarding the collected data, however its essence is still codified, and it is an object of new media without a narrative quality. For Manovich, "many new media objects do not tell stories; they don't have beginning or end; in fact, they don't have any development, thematically, formally or otherwise which would organize their elements into a sequence."[194] The act of understanding happens only if the information constitutes a message, and the message is transmitted to the receiver within a specific context that can generate a specific meaning for the user.[195] Thus, meaning has a higher requirement that needs to involve a common ground between the data and the self. The essence of metadata is insufficient to provide such a context and to create a narrative for the self. Moreover, as mentioned earlier, the most commonly used category of metadata used in self-tracking devices in order to organise

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[192] Hayles, 285.

[193] Miguel-Angel Sicilia, "Metadata, Semantics, and Ontology: Providing Meaning to Information Resources," *International Journal of Metadata, Semantics and Ontologies* 1, no. 1 (2006): 84.

[194] Lev Manovich, *The Language of New Media* (Cambridge: MIT Press, 2001), 194.

[195] Tom Stonier, *Information and Meaning: An Evolutionary Perspective* (New York: Springer-Verlag Inc., 1997), 187.

self-data is the time stamps. However, self-narratives and autobiographical memory do not primarily depend on exact time indexes. The usage of metadata to construct narratives could work only if a variety of tags are used for generating stories. The overload of information is another layer that obstructs this common ground, by creating noise between self-data and self-knowledge.

The overload of information is the second fact for the changing the mediations of the self. The explosion of media technologies causes an increase in self-representations that result in excessive amounts of self-related media. The presence of media is dense due to the usage of pervasive computing devices. As mentioned earlier, the capacities of computational means have an exponential growth where they are doubling every 18 months. This growth means that excess self-data generation for the artificial self-observation, and the autobiographical memory systems will keep increasing through the digital means including self-tracking devices.

The first result of data overload for self-knowledge is that it causes certain semantic changes in readability. Finite information and infinite information result in different meaning generation processes. "Infinite quantities are at least inhibiting if not paralyzing in the handling of information and responding knowledgeably and appropriately to a situation."[196] Handling infinite information is harder not only because of the impossibilities connected with the quantitative amounts, but also due to the "redundancy" factor that codified knowledge lacks. Human communication is based on the "mutually supportive channels of communication, the verbal, the paralinguistic, and the non-verbal, including smell and touch. Gestures underline what we say and paralinguistic signs parallel intended meanings. This redundancy makes human interaction naturally resistant to noise and allows constant checking and testing of information."[197] Clues like gestures, facial expressions, and tonal changes make it possible to ignore certain information and focus attention on the important ones in face-to-face communication. However, for self-data this process of redundancy is not possible unless all the data is tagged according to the context and the levels of significance. Thus, data overload makes it harder to distinguish between the meaningful

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[196] Klaus Krippendorff, *On Communicating: Otherness, Meaning, and Information* (New York: Routledge, 2009), 298.

[197] Ibid., 260.

and the meaningless, the important and the irrelevant for the self. In this sense growing data storage might be causing overcrowded sources for self-knowledge. The unfiltered, complex informants make it hard to construct meaning for a sense of self. This situation sounds more like information pollution rather than insightful projections for the self. In order to prevent this burden of excess data, it is important to classify the collected data according to the personal importance and meanings. The design guidelines proposed in Chapter Two are pointing to some of these semantic problems.

Another consequence of the data traffic is connected to the perceptions and the realities of mediation. Paul Virilio argues that the overexposure to the visible causes a perceptual disorder, "a kind of paradoxical blindness," in which witnessing the world is replaced by an indirect witnessing of representations through the screen.[198] In this sense, overseeing representations is a form of blindness. Self-tracking has a similar effect on its users where intrinsic self-observations are replaced by the indirect knowledge obtained through the sensors. This traffic in self-data caused by the "motorization of appearances," also conditions the apprehension of reality.[199] Data pools are becoming common sources for self-interest with questionable value of self-relevance. In this regard, they are similar to the reflections in the water as cited in the myth of Narcissus. The increasing mass of signs is becoming infinite replications of the self with only a symbolic reference to self-interest. At this stage of over-simulation, the natural phenomena of the self is reduced to an optical illusion; and "the spectator's vision is totally clouded by signs, up to the threshold of disappearance" of the real life to the observer.[200]

While the gap between the referrer and the referent is being semantically and perceptually increased for the codified knowledge, the realities of information and its objects are getting closer to each other into an indistinguishable corporeality. The modern media technologies are creating a "crisis of representation" where objects and

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[198] Paul Virilio, *Open Sky* (London: Verso, 1997), 91.

[199] Ibid., 96, 130.

[200] Paul Virilio and Philip Beitchman, *The Aesthetics of Disappearance* (New York: Semiotext (e) 1991), 71.

infographic figures cannot be differentiated from each other.[201] The two layers of reality, namely the data and the self, collide into a realm where the actual and the virtual presences of the self become one. The information flood causes a loss off the materiality for its objects. Computer screen dispels all normative distinctions between the real and the simulated, thus a symptom of the immaterial becomes "de-realization."[202] These changes caused by the mediations of the self are defining the new realities and the essences for the self.

3.2.2.2 The Essence of the Mediated Sense of Self

With the outputs coming from the self-tracking products, the virtual representations of the self have become an actual part of one's *essence*. The conditions of the existence are changed into a new realm due to the progressive embodiment users are involved in. Progressive embodiment is a term coined by Biocca that is defined as "a steadily advancing immersion of sensorimotor channels to computer interfaces through a tighter and more pervasive coupling of the body to interface sensors and displays."[203] The progressive embodiment results in the rising representations of the self, the suppression of the actual by the virtual, the changing natures of the intrinsic self-observations and lastly the altering practices of living and controlling one's presence.

The first essential change in the mediated self is the altered realities concerning the increasing representations of one's self. Heidegger claims that the world in its essence has become a "world picture" in which the existence is conceived and grasped as a picture; man depends upon himself by his capability to measure and execute this world picture.[204] Creating "the memory of a body" establishes a sense of control over the world and a kind of sameness between the media of the body and the physical

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[201] Paul Virilio and Daniel Moshenberg, *The Lost Dimension* (New York: Semiotext (e) 1991), 108-112.

[202] Ibid.

[203] Frank Biocca, "The Cyborg's Dilemma: Progressive Embodiment in Virtual Environments " *Journal of Computer-Mediated Communication* 3, no. 2 (1997): 14.

[204] Martin Heidegger, *The Question Concerning Technology, and Other Essays*, trans., William Lovitt (New York: Harper Torchbooks, 1977), 129-132.

realms of the body. By the expansion of self-referent data, the codified representations of the self are holding an equivalent position as the self. The truth of the self is becoming more related with the media of it. At this stage, digital representation forms like photography begins to replace actuality with a sort of an *absence-as-presence*.[205] The absence of the actual is due to the dominance of information over the reference of the information. The "reality itself gets ever more deeply buried under all the information we have about it."[206] The absented presences built by lifelogs means that the subjects of life records are becoming non-existent within the representations of the selves. Where the outputs of the sensors become more important than the observed, self-data becomes its own source of knowledge. "Behind the virtual self-representations there are no real persons left to be acknowledged."[207] The signs are replacing the actuality of the human life by increasing the representations of it.

The virtual aspect of self-representations is the second influence of the self-tracking devices on the essence of human life. With the dominance of technologies in daily lives, the virtuality of information began having a central place in the domain of reality. The nature of these representations is different from those of the analogue means for self-documentation. Pointing to the analogue/digital distinction, Borgmann classified three layers of information as; "natural information" that is *about* reality, "cultural information" that is *for* shaping the reality and lastly technological information *as* reality.[208] Accordingly, the technological devices, as a carrier an electronic stream of bits, are producing the immaterial information and this immateriality has a reality of its own. One result of the interplay between the virtuality of technological information and the progressive embodiment is suppressing the physicality and the immediacy of the human presence through the intrusion of data into the body-mind relationship. At this stage, the equality between the actual and the virtual are brought to another level with the suppression of self-data over the self. This situation points to a fluctuating self that

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[205] Roland Barthes, *Camera Lucida: Reflections on Photography* (New York: Hill and Wang, 1981), 106.

[206] Albert Borgmann, *Holding on to Reality: The Nature of Information at the Turn of the Millennium* (Chicago: University of Chicago Press, 1999), 218.

[207] Ibid., 218, 219.

[208] Ibid., 2, 57.

is lost to its representations and simulations. In other words, the realities of the actual presence are being dominated by the data capsulated in the virtual.

The stage where the simulations of reality constitute an irreference quality and signify only to themselves instead of referring to the world is referred as "simulacrum."[209] Accordingly, simulacrum indicates a hyperreal condition in which the virtual attains more truth than the reproductions of the actual, causing a higher level of the crisis of representation. With hyperreality, data becomes one's reality up to a point where it becomes truer than the truth of self. Within this simulacra condition, the virtual representations of the self dominate the presence of the self and even become the essential element for the self. In other words the informatics of the self becomes superior to the actual presence of the self and self-referent data turn out to be more real than the reality of the self. For instance the images or the measurements of the users are replacing the actual presences of them. The conversations with the social environment are becoming more based on the data regarding the self. The bodily data tells the scientific truth about the activities concerning the body. This is a point where self-data erases self-knowledge and rewrites what the sensors read from a person based on a program. The virtual representations are eliminating the actual phenomena by saturating the self with bio-media. The virtual expressions of individuals become more real than the actual model: Selfie substitutes the self.

A related consequence of the replacement of the actual self by the virtual self is disconnecting it from its natural inner realms. Biocca states that in this condition where the virtual is more real than the actual, "cyborg's dilemma" occurs: The more natural or transparent the embodiment feels, the further users fall away from their own nature.[210] Parallel to this notion, the data of the self feels real and thus becomes necessary for one's existence. As a result, the users begin discarding their own realities in order to be connected to their virtual selves. Self-tracking devices are changing the ways of self-actualization in which the individuals are experiencing self-fulfillment only if they are wired to a matrix with their self-referent representations. The tendency towards

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[209] Jean Baudrillard, *Simulacra and Simulation*, trans., Sheila Faria Glaser (Ann Arbor: University of Michigan Press, 1994), 3-7.

[210] Biocca, "The Cyborg's Dilemma: Progressive Embodiment in Virtual Environments ": 12.

transforming the life into the measurable forms of experiences increases the quantitative or qualitative virtual traces left in the cyberspace. The natural tendency to search for meaning within the inner self is replaced by the search for the scientific data regarding the self. In this sense, the existence of human nature is being transformed into a source for media, as a means for gathering information.

Heidegger coined two terms regarding this relationship between the human, the nature and the technology. Accordingly, the "standing-reserve" refers to a situation where the nature becomes the resource of the technology, for fulfilling man's utility purposes.[211] He claims this standing-reserve is the raw material for technology, however humanity does not have the ability to fully control the condition where technologies are revealed through framing the natural resources. As a result, due to the essence of technology, mankind becomes the object of his objects: Through "enframing," man constitutes a standing reserve for his technologies.[212] When self-tracking devices are evaluated in this framework, it is seen that human life is becoming a source for self-monitoring. The human body and mind are becoming the natural resources to build these technologies on; and as a source of data, they are becoming downgraded to the level where they are not more than the object of these technologies. As the position of mankind in human-technology relationship is being reduced to constituting the raw material for existing technologies, the self is becoming the object of its own science.

The theme of self-awareness with self-tracking products is a subject that is also rooted in media and agency. The stated progressive embodiment can change the realities of the users only if the individuals accept and involve these interactions into the realm of their lives. So, besides these changes in the realities and the natures of the self, another determiner that changes the essence of it is the actions of the individuals, and their decisions on making the habit of self-tracking. According to Certeau, the concepts of usage and consumption are linked with the idea of "cultural products" in which the routines performed on products frames the appropriation of the technologies through the ordinary acts of consumption.[213] The preference of using certain products and the ways

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[211] Heidegger, 17.

[212] Ibid., 20.

[213] Michel De Certeau, *The Practice of Everyday Life*, trans., Steven Rendall (Los Angeles: University of California Press, 1998), 31-49.

of using these products shape the practices of everyday life. Spending less time with the nature of one's self, and keeping life records by converting one's world into the data of the cyberspace are decisions that come with the attachment to certain technologies. In this regard, self-tracking routines appear as a way of choice for living one's life under surveillance. The deliberate act for watching one's self asserts its own agency to the users' lives.

New media and the emerging technologies can change the conditions for subjecthood by altering the ways by which people learn and control their own existence. The issue of control is important for the discussion of self-tracking products, because being in control of one's life is one of the main themes for lifelogging and activity monitoring devices. Whereas self-tracking products give the impression that the users are in control of their data, it is debatable that the users are under the control of the will to use the computational means. The paradoxical aspect of using self-tracking products as self-control tools is that the ways of using technology seems as an act of agency, however the nature of this consumption "shows itself not in its own products, but in an art of using those imposed on it."[214] Therefore, using self-tracking products brings the invisible obligation to obey the built-in mindset underlying these products.

In this sense, individuals are "free" to live a controlled life; a life rationalized by one's self, but more importantly rationalized by the politics of the self. The states of authority derived from the agency of technology can be used for establishing a rationalized and controlled society. Foucault poses questions on the relationship between subjectivity, agency and power. He claims, while the human subject is objectified through the production of signification, s/he is equally placed in power relations.[215] This form of power applies itself to the immediate everyday life; which categorizes the individual, marks him by his own individuality, attaches him to his own identity, imposes a law of truth on him, which he must recognize and which others have to recognize in him.[216] According to this theory, these forms of power are shaping self-knowledge; and as the power of agency is becoming more of a territory for the digital

[214] Ibid., 31.

[215] Michel Foucault, "The Subject and Power," *Critical inquiry*, (1982): 779-782.

[216] Ibid.

devices, the technological actions defined by the producers matter more than the actions of individuals.

Agency, or the conditions of taking action over one's life, is bound to the mediations of the self. With the notation systems of self-tracking products based on the sensors, the positions of authorship for autobiographies are blurred. By reducing self-expression to a minimal level, sensors become the new authors of automated personal stories, transforming autobiographies into "auto"biographies. Sensors are controlling this autonomous production process, separating users from their own realities and their own skills of authorship. In this sense, by muting self-expression, the agency of sensors brings a sort of censorship to self-documents. The automated data generation is also repressing the roles of the users. Baudrillard claims that with minimal autonomous activity on the part of spectator, the reader is left with the poor freedom either to accept or discard the text instead of gaining access to writing. Thus, we live in the era of non-response.[217] The passive condition/role derived from automatic capturing is leading users into an inactive state, in which the cognitive effort to understand and reflect upon one's inner self has become reluctant to perform.

As technology is becoming a dominant form of agency for one's life, the selfhood is pushed to be a secondary mechanism for taking action over one's presence. McLuhan supports this idea by arguing that one of the dangers of new media is to blind us to the ways that media affect our conditions of existence, which are the conditions of possibility for effective action.[218] The control over new media and our bodies are more likely to be handed to the agency of technology in the digital age. As a result, the connection of the mechanical and the lifelike causes "artifacts to behave more lifelike and in return, life is becoming more engineered."[219] Record keeping is a self-analytic activity in which performance, targets and numerical values are superior to the meanings of the self. Especially for the activity monitoring devices, the self becomes a programmed, coded entity. Bodies in code might be more efficient, but they are also less human.

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[217] Jean Baudrillard, *For a Critique of the Political Economy of the Sign* (New York: Telos Press Publishing, 1981), 170.

[218] McLuhan, 9.

[219] Kelly, 97.

Through self-tracking devices, the ways of understanding the personal experiences is happening throughout a computer language. The knowledge of the life becomes the data of life, self-understanding becomes self-processing, memory becomes storing the information of the past, and taking a walk becomes the equal of counting steps. The transformation from the human layer to the computer layer is connected to a notion called "transcoding" that means the "re-conceptualization of the cultural categories and concepts on the level of meaning and/or the language, by new ones which derive from computer's ontology, epistemology, and pragmatics."[220] Besides the changes in the language for understanding the self, self-tracking devices also brings other qualities of technologies to human life. The accurate processing of routine activities is the nature of the computing. Similarly, the habit of tracking one's self causes positioning the essence of the human in the routines of informatics. The numerical routines created by self-tracking are the processes by which the computer is anthropomorphised and the human is computerised. The habit of retrieving automatically generated data has no direct relationship with self-consciousness. The repeating transferring of self-data terminates one's responsibility for knowing one's self. Therefore, this automated habit threatens one's intrinsic self-observations. "When routine is disturbed: that it will cause a change from 'mechanical' to 'mindful' behaviour."[221] The self-tracking behaviour should exceed the habitual routines of gathering automated data in order to contribute to the processes of self-consciousness, self-evaluation and self-reflectiveness.

The routine of relying on self-data for self-knowledge should be disturbed not only for breaking the mechanic cycle of encoding and retrieving self-data, but also for breaking the constant awareness towards self-media. The constant focus on self-data constitutes a paradox where the fascination with being self-aware obstructs the circumstances for being self-aware. Being self-aware is a condition that requires one to be unaware of the whole process of awareness. In other words, if one is experiencing a moment of mindfulness, this means one is not conscious of the situation in which he/she is experiencing such a moment. Thus, continuously being focused on self-data is a contradiction for the human interiority. Archiving self-data is a continuous awareness

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[220] Manovich, 64.

[221] Arthur Koestler, in *The Ghost in the Machine*(New York: Macmillen, 1968), 207.

situation where one is becoming blinded to one's life experiences by focusing on gathering data. The source of self-consciousness is not self-consciousness itself. It is the ability to think freely about one's self with a perspective. Therefore, disturbing the routines of self-tracking is important for preventing the contradictions and obstructions derived from constantly being self-aware.

The discussions concerning the essence of the mediated self is closely related with the practices of design. "With the emergence of technologies that extend, simulate, and replace faculties that were uniquely human, one witnesses the emergence of a new image of what human beings are, an image to which design will have to respond well."[222] As a result, design practices should consider the changes brought by technology and become a part of reconstructing human essence by influencing everyday practices. Technology can be a threat for self-knowledge by losing the sources, structures and meanings of life; fluctuating, dematerializing, blinding the human mind and body to its own realities, and lastly by decaying the capacities for taking action over one's knowledge of life through mechanizing the routines of gathering self-information. The essential qualities of the quantified self are being defined by a hyperreality condition where the numbers and representations regarding the self are more real than the actual selves and the virtual substitutions constitute the simulacrum of the self with no reference to the actual identities. These changes resulting from self-tracking devices do not mean there is a need for withdrawal from the digital technologies for the self. On the contrary, the inevitable advancements in the digital technologies can be seen as opportunities to reconstruct the self through the interaction between the computerized and the human. As Heim claims, "interactivity signals a process of reconstruction" where designing unities for human habitation is more important than patching fragments of information.[223] Reconstructing self-knowledge mechanisms rely on the interactions between the self-tracking devices and the human mind in which self-data should be brought together as a holistic knowledge of the self-concept. For this reconstruction, interaction of self-tracking devices should be built upon the context of

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[222] Klaus Krippendorff, *The Semantic Turn: A New Foundation for Design* (Boca Raton: CRC Press, 2005), 20.

[223] Michael Heim, *Virtual Realism* (New York: Oxford University Press, 1998), 75,76.

the self and the act of self-understanding. These two contexts define the usage and the values of lifelogging devices as a reference for the design processes.

CONCLUSION

Monitoring one's life and creating documents for archiving daily activities have been old practices with historical roots. Throughout history, the cognitive effort to understand one's self has been supported by the intellectual means like language and counting, as well as the depiction tools like writing and drawing. Self-documentation functioned as a medium for seeing one's self through revealing the unknown information regarding one's life. With the introduction of self-tracking devices, this behaviour has been extended by the automated mechanisms of recording and representing one's life. However, during the transformation from analogue to digital, the cognitive qualities regarding the self-documents became limited to the capabilities of the devices. Today's attitude towards self-documentation has been more technology-oriented rather than self-oriented, which is likely to cause failures in self-insight and trigger problems for self-awareness. This remark has been the underlying motivation for re-assessing the qualities of the digital self-tracking products in relation to one's self-understandings.

This thesis aimed to cover the socio-technical issues related with the user experiences, the meanings and the metaphysical qualities derived from the self-tracking products. After introducing the definitions, the examples and the functional mechanisms of self-tracking devices, the personal, economical, cultural, social and political dimensions regarding these products were investigated in Chapter One. The factors such as technological determinism, surveillance politics, and the popularity of self-interest were identified as the fundamental drives for tracking one's self.

The mental embodiments involved in the functioning of these technologies were related to the usability dynamics in Chapter Two. The user experiences of lifelogging and activity monitoring devices were investigated in connection with the human psychology. The functions of these products were related with the content and the structures of the biological mechanisms like self-observation and autobiographical memory that were stated to be responsible for creating and maintaining a coherent self-concept. Self-evaluation and self-memory systems were linked to the interactions with the life recording devices. Lastly, design guidelines were drawn with the principles

concerning selectively recording and retrieving self-referent data associated with personal meanings and a coherent sense of self for an enhanced usability. Moreover, the perspectives on the self as an expanding entity capable of self-discovery were emphasized, criticizing the linear personal informatics models suggesting self as a problematic entity that needs to reach perfection through repetitive progressive actions. The significance of the creative inputs in autobiographical memory such as self-narratives for writing the stories of one's self were underlined.

In Chapter Three, the hybridity of the computational self-tracking tools and the self were discussed within the framework of posthumanity after analysing the meanings of the self and the means of self-documentation throughout history. The computational means for watching, quantifying, representing and controlling the human life were stated to shadow the perceptions of the self and the actuality of the inner realm. The accuracy of self-data, and the increasing virtual representations of the self were stated as the factors that might diminish the cognitive efforts for understanding one's life. The hybridity between the computers and man was stated to increase the mediations and to alter the metaphysical qualities of the self. In means of the mediations of the self, the semantic differences between self-data and self-knowledge were assessed, the problem of data overload was addressed and the blinded perceptions of the self were pointed out. In terms of the essence of the mediated self, it was emphasised that the self was positioned at a transhuman stage where its realities were being dissolved into the hyperreal conditions of virtuality. Moreover, the agencies of the self on taking action over one's life and his knowledge of the world were related and contrasted with the routines of the automated data generation and retrieval included in human life.

As a conclusion, reconstructing the self through the design practices by improving the experiences of self-tracking products was suggested as the only possibility for overcoming the existential risks deriving from the defragmented meanings of the self and the de-realized essences disconnected from one's inner realm. The design guidelines regarding the self-tracking products were stated to restructure the self through blending the codified knowledge and the tacit knowledge of one's life by positioning the biological mechanisms of self-making and self-awareness as the primary starting points.

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