QUANTIFIED SELF: A LITERATURE REVIEW BASED ON THE FUNNEL PARADIGM

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Abstract

Over the last decade, increasing scholarly interest has been demonstrated by the exponential growth of published studies on the topic of Quantified-Self (QS). After 10 years of existence, it seems important to review the knowledge accumulated on QS in order to identify potential gaps and avenues for future research, especially in the IS field. We rely on a systematic literature review in the field of Information Systems with the approach recommended by Okoli and Schabram (2010). In addition, we use the paradigm funnel (Berthon et al., 2003) to structure our analysis. We find that the literature on QS covers three main domains. The technological domain has studied data mining, visualization and user behaviour. The medical domain has focused on the benefits of QS especially for health management and the social domain is more critical about the implications of QS in people’s life. Also, our analysis of the literature reveals a concentration of empirical and critical articles and few theoretical and methodological papers. Future research should fill in these gaps.

Keywords: Quantified self, self-quantifying, literature review, funnel paradigm.

1 Introduction

According to a study conducted by the Pew Research Center, “seven in ten American adults track a health indicator for themselves or for a loved one” (Fox and Duggan, 2013). This practice is reinforced for people suffering from chronic diseases or having health concerns as they increasingly use trackers to improve their health condition and change their behaviour. Tracking one’s indicator is related to the movement called Quantified-Self (QS), a concept introduced for the first time in 2007 by Wired editors Gary Wolf and Kevin Kelly. They opened a web site in 2008 to gather people who share concerns for the improvement of health quality of life. “Quantified-Self refer to the practice of gathering data about oneself on a regular basis and then recording and analyzing the data to produce statistics and other data (such as images) relating to one’s bodily functions and everyday habits” (Lupton, 2013b, p.25)

The exponential growth of smartphones, nowadays used by 72% of citizens in the USA, 58% in China, 49% in France and 60% in Germany (Poushter, 2016), has facilitated the tracking of body indicators. For instance, mobile applications offer functionalities to monitor sport exercises performance and the evolution of weight. In 2015, 165 000 mobile health apps were available on the market and nearly two third were dedicated to wellness and fitness, lifestyle and stress (IMS Institute, 2015). In the same vein, connected objects provide great opportunities for Self-Quantifiers (QSers). As an illustration, connected watches can analyse calories,
numbers of steps, heart rate or blood pressure. Similarly, clothes equipped with “wearables”, meaning clothes having electronic components, support the Quantified-Self movement.

Over the last decade, increasing scholarly interest has been demonstrated by the exponential growth of published studies on the topic of QS. The results of the database request used to build our literature review returned articles dealing with QS in different disciplines including medicine, sociology, information systems and computer science. Computer science research has discussed some technical aspects concerning the normalisation of QS platforms because of the profusion of brands with proprietary technologies (Li and Guo, 2016). Information systems research has studied the adoption of QS technologies (Kim, 2014b; Pfeiffer et al., 2016; Mamykina et al., 2015). Medicine has pointed out the benefits to self-quantify, particularly in the field of healthcare (Majmudar et al., 2015; Barrett et al., 2013). The promise of self-quantification in conjunction with big data offer the potential to prevent chronic disease (Barrett et al., 2013), and to save billions of dollars in healthcare by engaging patients to manage their chronic conditions (Swan, 2009). But this vision is criticised by sociologists who see in the practice of QS some risks pertaining to privacy (Lupton, 2016) and the control of our life imposed by the machine (Williamson, 2015), plus the risk of disclosing our own physiological data to the wrong person.

However, these developments don’t provide a complete picture of the QS phenomenon. After 10 years of existence, it seems important to review the knowledge accumulated on QS in order to identify potential gaps and avenues for future research, especially in the IS field. QS has been addressed in different disciplines so this paper also aims at highlighting this heterogeneity by classifying the literature on QS. Thus, a systematic literature review is needed to define the boundaries of current research state, to evaluate the dynamics of knowledge in QS, and to guide future investigations. Therefore, our research question is the following: “What is the state of knowledge on QS after 10 years of existence?”

To answer that question, we rely on a systematic literature review in the field of Information Systems with the approach recommended by Okoli and Schabram (2010). In addition, we use the paradigm funnel (Berthon and al., 2003) to structure our analysis.

The reminder of this paper is structured as follows. In the next section, we provide a definition for QS. Next, the methodology of the literature review, based on a systematic approach will be presented. And finally, the results of our research and classification according to the funnel paradigm will be exposed. The paper will end with a discussion and opening new avenues of research.

2 Definition of Quantified Self

QS has been first presented as the concretization of a community of practice whose motto is "self-knowledge through numbers" (Rivera-Pelayo et al., 2012, p.1). At its creation in 2009, Wolf defines the outlines of this movement as a "collaboration of users and toolmakers who share an interest in self-knowledge through self-tracking" (http://quantifiedself.com/aboutqslabs/). Indeed, QS attracts personalities with very different profiles, ranging from artists to researchers. The QS community makes “show-and-tell” meetings to share experiences of self-tracking and presents projects answering three questions: “What did you do ?”, How did you do it ?” and “What did you learn ?”.

With the emergence of businesses and start-ups specialized in the creation of wearables like Fitbit, or Jawbone, QS has been popularised with the search for personal improvement: "QS is a concept in which individuals deploy sensors and monitoring devices to measure and improve their own health and behavior" (Barrett et al., 2013, p.168). Improvement is part other characteristics frequently use in the literature to define QS. All of them are summarized by
Kim’s definition: “The philosophy behind the QS movement is that by using quantifiable data, which can be collected relatively easily through readily available technology, one can significantly improve the understanding of one’s health and gain deeper insights into different approaches to improving health” (Kim, 2014b, p.552). These digital technologies generally all offer the feature of tracking. Their prices have decreased and we can find nowadays affordable wrist bands sold by the Chinese brand Xiamo for 15$.

“Self-knowledge” is another characteristic of QS, especially developed in the field of medicine, to understand people with chronic conditions. QS can help patients managing their illness and improve their life. Martin et al. (2006) followed 3268 patients between 1995 and 2003 and found that self-measurement of blood glucose for at least one year was associated with decreased diabetes-related morbidity and was associated with a healthier lifestyle. As such, self-knowledge is often associated with improvement. This is the case for QSers who practice a sport.

Nowadays, the term QS has little to do with the movement initially introduced by Wolf (Pharabod et al., 2013). Pharabod et al. (2013) conducted forty semi-structured interviews with different people, including QS members to better understand the practices of self-quantification (with or without technology). Their findings show very few practices of self-knowledge as promoted by the seminal movement, even in the community of QS. Rather, the main practices are surveillance, routine, and performance. So, QS has gradually evolved into “quantified-self” (in lowercase) with no relation to QS community (Boesel, 2013). Boesel argues that the QS movement is not the initiator of self-tracking but it has contributed to make it popular and make it more visible. Consequently, QS has lost its link to “self-knowledge through number” and has become synonym of “self-tracking” through sensor devices (Smarr, 2012; Swan, 2012).

Beyond the QS movement, QS is also a consequence of IoT that takes advantages of wearables to facilitate automated self-tracking. “It provides an accessible domain for experimenting with IoT problems; and experience with QS sensor analysis should provide insights into IoT issues” (Fawcett, 2015, p.250). However, tracking biological dimensions amplifies some issues such as privacy.

As a summary and in conjunction with Kim’s definition, we note three main points in relation with QS: 1) the role of technologies to capture data and facilitate self-quantification, 2) the cognitive impact of QS especially by allowing self-knowledge or self-reflection and 3) its behavioural impact on individual well-being or self-improvement.

In the next section, we present our methodology and investigate in depth how papers dealing with QS have examined this phenomenon.

3 Methodology

3.1 The search approach

This research adopts the systematic literature review approach to review the concept of QS. Fink (2013, p.3), defines a systematic literature review as “a systematic, explicit, and reproducible method for identifying, evaluating, and synthesizing the existing body of completed and recorded work produced by researchers, scholars, and practitioners.” This method is well known in the medical field but rather new in the IS field (Levy and Ellis, 2006). Okoli and Schabram (2010) provided an overview on several methodologies of literature reviews used in the IS field. This led to the development of a guide that includes eight steps to follow in order to conduct a systematic review in the IS field, which are: identifying the purpose, draft-
ing protocol and training the team, searching for literature, applying practical screen, extracting data, appraising quality, synthesizing studies, and writing the review. This guide has the advantage to take into account both qualitative and quantitative methods, as both co-exist in the IS domain that stems from social science, business and computing science (Okoli and Schabram, 2010). Therefore, we retained this methodology in our research and followed the eight steps recommended.

In order to conduct this literature review, we selected four main online academic databases: Web Of Science (WOS), EBSCO, Science Direct and IIIExplore. We also selected the following options for our searches: “all databases” option for our search in EBSCO and WOS, “all sciences” in Science Direct and “all results” for IIIExplore.

We used several keywords for our search: “quantified self”, “self-tracking”, “personal informatics”, “self-quantification”, “auto-analytics”, “body-hacking”. We decided to exclude “self-monitoring” because this term lead to many results, which were often far from our subject.

We used keywords between quotes, the search was carried out only for academic articles, excluding book and magazines. Since QS has been popularized from 2007, our search was confined between 2007 and 2016. We decided to keep only peer reviewed articles written in English and French, which dismissed two articles, one written in German and one in Italian. Also, 32 articles were excluded because they did not correspond to peer reviewed articles, despite our filtering (17 articles were from magazines, 11 communications, and 4 came from academic journals but were editorials).

We then filtered by reading the titles and abstracts of each article in order to determine the relevance of the article with the topic of QS. As such, 324 articles were excluded.

The remaining 123 articles were assessed by a full reading. Among them, 18 articles were not available to us. Our 105 remaining articles were assessed according to the three criteria introduced in the previous section (IT usage, cognitive impact and behavioural impact).

For each of the 105 articles, we verified that the main topic of the articles contained at least two of the three criteria. In total, 43 articles met at least two of the criteria of the QS. Further, we recovered ISI impact factor of the 43 articles. Seven references had no impact factor in WOS. The list presents value from 0.276 to 9. Among the 31 remaining papers with an impact factor, 21 had an index below 2.

### 3.2 The Funnel Paradigm

We analysed our literature with the Funnel Paradigm, which is a conceptual tool for literature analysis (Berthon et al., 2003). This tool is especially recommended when researchers examine heterogeneous literatures, which is our case. Berthon et al. (2003) suggest classifying articles in four categories representing each a level of understanding of the subject: beginning with the observable and explicit facts that emanate from empirical observations and finishing with the implicit and unobservable. This approach also allows to represent the dynamics of knowledge by analysing the transitions between the four categories. We introduce in more details each of these four levels in Table 1.

<table>
<thead>
<tr>
<th>Levels</th>
<th>Explanations</th>
<th>Questions</th>
<th>Process of search</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>Combines articles whose main subject is empirical observations of the phenomenon.</td>
<td>What is observed in nature?</td>
<td>Generated by data</td>
</tr>
<tr>
<td>Level 2</td>
<td>Includes articles that have a methodological analysis</td>
<td>Are the mechanisms by which data is mapped to</td>
<td>Ordering, structuring and manipulation of data.</td>
</tr>
</tbody>
</table>
We made some adaptations of the funnel paradigm because the four categories did not cover all of our identified articles. More precisely, we added a preliminary level, placed before Level 1 and named it “overview”. This level corresponds to the articles that present the topic of QS without empirical observation. We created another level called “critical” to replace Level 4 because in our selection none of the articles discusses the theories developed at Level 3. But several critical articles address QS with the perspective of sociological theories. So, it seemed logical to place this level at the end of the funnel. In Figure 1 at the end of the paper, we present our application of the funnel paradigm to our set of 43 articles. This figure shows the distribution of our selected articles/references at each level of the funnel paradigm.

### 4 Findings related to the 4 levels of the Funnel Paradigm

#### 4.1 Level 1: Empirical observation

At level 1, we examined the articles that study QS with empirical observations (16 articles out of 43). Three main topics are addressed in this category: individual perceptions of QS, design issues of QS systems and the impacts of QS on relationships.

First, research points out individuals’ perceptions of QS. For instance, Rapp and Cena (2016) gathered the feelings of people who have never practiced digital self-tracking. Their study highlights how difficult it is for people to manage this type of data and the improvement needed in terms of data visualization to better match user feelings. The same conclusion arises from Verdezoto et al. (2016) who focused on elderly and the usage of QS for blood pressure monitoring. They found that participants were not comfortable with data interpretation and didn’t understand the medical implications of these measures.

Second, the literature offers several empirical research on design issues. Almalki et al. (2015a) examined the limitations of QS systems and found that: a) they don’t provide accurate answers on health status and b) there are too many tools available for quantified users (QSers). Therefore, Almalki et al. (2015b) had the idea to study the time spent by QSers in managing their tasks. They found two main phases that succeed in the process of QS: “data management activities” and “health management activities”. But due to time loss during these phases, people often focuses only on one of them. The problem of accurate QS system and health status have also been studied by Li and Guo (2016) who propose a new data analysis platform named WikiHealth, based on adaptive learning approaches. It allows the storage of structured, semi-structured and unstructured data. Regarding the treatment of data, Choe et al. (2015) studied video presentation during QSers meeting to understand how to improve data analysis and data visualization, while Fawcett (2015) exploited data mining technics to provide understandable analysis to non-scientists. His solutions are based on descriptive data mining, visualizing patterns, experiment, and supervised analysis. The design difficulties of
effective analytical systems tend to be linked to the lack of consideration of the context in which the data is collected. For instance, to date, a body scale doesn’t make any difference between a pregnant woman and someone with excess weight (Bietz et al., 2016). Therefore, Li et al. (2012) recommend taking into consideration context when doing QS research. Mueller et al. (2015), relying on Reflective Learning Theory, developed an approach to assess the role played by context by recording professional practices in the workplace. They were able to gain better knowledge and insights on working behaviour changes.

Third, QS research has also paid attention to its impact on actors’ relationships. According to Nelson et al. (2016), QS can also be extended to Quantified-Other. The authors studied the influence of quantification on pets’ activity and people’s relationship with their pets. This study revealed the type of relationship owners have with their pets. This understanding strengthened owners’ ties with their pets. QS can also modify relationships people have with others. Indeed, Crawford et al. (2015) showed the normalisation role that the weight scale has played from the 20th century until nowadays. But today the notion of “what is normal” is hidden in the device that often lacks transparency. En and Pöll’s (2016) exploratory research based on several dozen individual accounts shows the risk of normativity in self-tracking. As a matter of fact, normativity should unveil the diversity of existing personalities rather than creating a homogenous world.

4.2 Level 2: Methodological analysis

At Level 2, researchers should gather articles that provide insights into methodologies. Therefore, we gathered the articles that deal with the methodology to be used to study the phenomenon of QS. Only 3 articles correspond to this level, which also highlights a gap in research. Ruckenstein’s (2015) article insists on the use of ethnographic approach to analyse QS phenomenon. The paper demonstrates how an ethnographic research based on the self-tracking can be used to understand the commitment to technology and human-machine relationships in health informatics. To demonstrate his approach, Ruckenstein studied the tracking tool Meal-Logger and identified the issues that emerge when health professionals have to manage data that details people’s daily eating habits.

The two others articles address the use of QS as a research methodology. Experimentations with QS should gain legitimacy because they offer the opportunity to study large cohort what would not be possible in a clinical context due to time or money constraints. Conversely, researchers should also develop a protocol for single subject research (Gimbert and Lapointe, 2015), which is the core of QS movement. This type of research has proven to be effective but is not well recognised (Roberts, 2012). Gimbert and Lapointe cite the treatment of "Clostridium difficile" that was developed from the analysis of only two subjects.

Jain and Jalali (2014) argue that QS could be used as a possible method of experimentation to achieve higher scientific rigor because QS systems are quite advanced systems and they provide precise data. Nowadays, we can access / observe the data of a human being continuously. As such, QS represents a new scientific protocol that could replace laboratory studies and allow observation of human beings in their social, physical and intellectual environment.

4.3 Level 3: Leveraged Theories

Level 3 corresponds to the articles using different theories to understand the phenomenon of QS. Eight articles out of the 43 belong to this category. Some of these articles rely on theories to explain the sharing motives. Other papers use theories from the IS field, especially to study the acceptance of QS systems and self-tracking technologies. Last, one article relies on sociological theories to explain new control systems that can appear with QS.
First, research has pointed out the role of QS in communities and its influence on sharing behaviour. By studying different channels such as meetups, video presentation and specialised online forums, Barta and Neff (2016) observe that sharing increases social capital and generates bridging and bonding capital. The second article (Stragier et al., 2015) examines the benefit of sharing physical activity. Relying on a literature review, the authors identify several sharing motivations divided into extrinsic and intrinsic motivations based on self-determination theory. Their results show that people share information on Facebook about their physical activity because of altruism, information sharing motivation and self-monitoring motivation, while sharing on Twitter is only related to information sharing motives.

Second, the literature at this level has focused on user acceptance of self-tracking technologies. Kim (2014a, 2014b) applies the Health Information Technology Acceptance Model (Kim and Park, 2012) to describe consumer intention of using health information technology. In his first article, Kim (2014b) assessed his model quantitatively. The results confirm the relevance of the model, and especially of the following variables: perceived usefulness, ease of use, attitude, and behavioural intention. In his second article Kim (2014a) initiated a qualitative approach to understand self-tracking usage and to extend the HITAM (Health Information Technology Acceptance Model). Mamykina and al. (2015) proposed another theory to explain user acceptance of self-tracking. Their model is based on the theory of sense-making to understand how individuals give meaning to the observed data and how this guides their action. Their framework should facilitate chronic disease management. Finally, Almalki et al. (2016) identify the different activities of self-quantifiers by applying the activity theory to a literature review. These activities are characterized according to six constructions: users, tracking tools, objective health, division of work, community, and map and rules. In supplement to these themes from theory, they identify two other inductive activities. The first is the “work on data” that users carry out to manage their Health QS data. The second is “the work with data” as the basis for actively managing their health status.

Last, research has also addressed the tensions that arise between the emancipatory potential of QS and the governmental control of the self with QS (Ouellet et al., 2015). This topic has been examined especially with theories of the Frankfurt School and of the French philosopher Foucault (with his concept of governmentality). This research stream argues that individuals can become entrepreneurs of themselves by regulating their activities in a productive optimization goal as illustrated by Hammerfelt et al. (2016) with academic research quantification. In this environment, only people’s data matter, monitoring and control are made trivial.

4.4 Level 4: Critical QS

In the funnel paradigm, Level 4 includes articles confronting suppositions that have been made in the upper level about the topic of QS. In our set of articles, we didn’t find research matching this description. However, a number of articles operates a critical analysis of the QS movement. So we decided to gather them in a category entitled "critical QS" in preference to "core assumption" as suggested by the funnel paradigm. Three main topics are addressed in this category: QS in a neoliberalism age, privacy consideration, and health issues.

First, QS can be perceived as a neoliberal practice of self-management and self-surveillance of the body. Hammarfelt et al. (2016) use the example of ResearchGate, the academic social network that helps in quantifying one’s research. Authors consider ResearchGate as a form of neoliberal self-entrepreneurship. Lupton (2015) gives another illustration when examining the quantifying of sexual activity to monitor people performance and control their addiction. Williams et al. (2015) pinpoint that QS allows us to quantify sleep, a practice reserved to the
medical field but now in our control. It is a form of submission, but also a form of resistance (Nafus and Sherman, 2014). Nafus and Sherman (2014) consider QS as a "soft resistance" because every use of data comes from unique QS experience and is part of a context not aggregate-able by a commercial party. This contextualisation leading to a soft-resistance becomes a real problem for medicine. Thornquist and Kirkengen (2015) give the example of patients who can be prompt to argue with their doctors based on the data generated by the QS tool. However, symptoms measured by QS and taken separately cannot help to discover a disease.

Second, the literature discusses privacy consideration. Self-tracking redefines the boundaries that exist between what is constrained (the public domain surveillance like CCTV cameras), and chosen (private security such as self-tracking) (Lupton, 2016). Lupton identifies five self-tracking modes that can serve as a heuristic. The first mode is a “private self tracking”: it is a voluntary self-tracking done for personal purposes. The second mode is “pushed QS” and done by a third-party to encourage people to do self-tracking. The third mode is the “communal mode”: self-tracking for sharing with a community. The fourth mode is called “imposed self-tracking”, which is when people have little freedom to refuse the tracking. The fifth mode is “exploited” by organizations for their own needs. Exploited personal data by third parties is not only seen as a violation of privacy, but also as a loss of autonomy (Lanzing, 2016). Lanzing (2016) argues that self-tracking has changed our point of view on disclosing health information. Indeed, this information has been shared historically with a very limited audience such as doctors, but with the development of IoT, it is no longer clear who will have access to personal information. According to Lanzing (2016), disclosure is increased by new self-tracking practices. A disclosure of data in an inappropriate context can have serious consequences, for instance providing access to medical condition to an employer. As such, self-tracking creates a dilemma between a better self-control and a loss of autonomy / privacy.

Third, QS is criticised for its influence on users’ health. Lupton (2013a) explored self-tracking in a techno-utopia vision. This techno-utopia focuses on a detailed knowledge of the body by which illness and disease may be prevented. Such idea comes from the healthism movement that has emerged since 1970s and considers that the ideal citizen is one who takes care of his health. According to Andrieu (2015), QS nurtures an illusion of a bio-control of the self.

4.5 Unclassified articles

The seven remaining articles don’t fit any of the funnel levels. Three articles pertain to the medical field. For instance, Gimbert and Lapointe (2015) present the self-tracking opportunities to assess human beings’ microbiome, namely the totality of micro-organism present in human bodies. Barrett and al. (2013) present two cases of QS use: the first to increase physical activity and the second to manage asthma prevention. Majmudar and al. (2015) introduce the different opportunities of using QS techniques for patients, doctors and researchers. QS can also characterize a new service offered by health and social digital networks to connect people sharing the same medical conditions (Swan 2009). For Swan (2009), these networks represent a new opportunity for the treatment of patients.

The last three articles expose QS in a general manner. Swan (2013) discusses different aspects of QS: tools, data management and analysis, as well as user motivation and it concludes with a vision of the augmented human being through exo-senses, which are human augmented senses provided by technology (haptics, wearable electronic senses). Hoy (2016) deals with activity trackers, describing their usage and the capabilities offered to users. Lupton (2013b) returns to the beginning of the QS movement, and consider it as an extension of the body. His
presentation also outlines privacy issues and it explains self-responsibility of the body in a neo-liberal society.

5 Synthesis of the literature review analysis

In this section, we take a look at the different disciplines dealing with QS. Table 2 shows a classification of the reviewed articles based on their category and discipline. The categories are the ones offered by ISI Web of Science, while the disciplines were created by merging some categories. The disciplines correspond to technic, medical and social sciences.

5.1 Distribution by subject

We combined communication, computer science, engineering and information science in one domain called Technic. This domain is the most represented and takes 50% of total articles. The medical domain is composed of healthcare sciences, medical informatics, medicine, microbiology, psychiatry, and sport science. It represents 30% of all our articles. For the social domain, we merged business, cultural studies, environmental sciences, psychology and social sciences. This discipline reflects 30% of our reviewed articles.

<table>
<thead>
<tr>
<th>Number</th>
<th>Category</th>
<th>Discipline</th>
<th>Article</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>COMMUNICATION</td>
<td></td>
<td>(Nafus et al., 2014), (Ouellet et al., 2015), (Stragier et al., 2015), (Barta et al., 2016)</td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>COMPUTER SCIENCE</td>
<td></td>
<td>(Li et al., 2012), (Barrett et al., 2013), (Swan, 2013), (R. Jain and L. Jalali, 2014), (Almalki et al., 2015), (Choe et al., 2015), (Fawcett Tom, 2015), (Li, Yang and Guo, Yike, 2015), (Mamykina et al., 2015), (Mueller et al., 2015), (Bietz et al., 2016), (Nelson et al., 2016), (Rapp, Amon and Cena, Federica, 2016)</td>
<td></td>
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<tr>
<td>2</td>
<td>ENGINEERING</td>
<td></td>
<td>(Lupton Deborah, 2013), (Verdezoto, Nervo and Gronvall, Erik, 2016)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>INFORMATION SCIENCE</td>
<td></td>
<td>(Hammarfelt et al., 2016), (Lanzing, 2016)</td>
<td></td>
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<tr>
<td>1</td>
<td>HEALTH CARE SCIENCES</td>
<td></td>
<td>(Kim, 2014)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>MEDICAL INFORMATICS</td>
<td></td>
<td>(Kim, 2014), (Ruckenstein, 2015), (Almalki et al., 2015), (Almalki et al., 2016)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>MEDICINE</td>
<td></td>
<td>(Majmudar et al., 2015), (Thornquist and Kirkengen, 2015), (Hoy, 2016)</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>MICROBIOLOGY</td>
<td></td>
<td>(Gimbert and Lapointe, 2015)</td>
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<tr>
<td>1</td>
<td>PSYCHIATRY</td>
<td></td>
<td>(Andreiu, 2016)</td>
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<tr>
<td>1</td>
<td>SPORT SCIENCES</td>
<td></td>
<td>(Williamson, 2015)</td>
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<tr>
<td>1</td>
<td>BUSINESS</td>
<td></td>
<td>(Roberts, 2011)</td>
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<tr>
<td>1</td>
<td>CULTURAL STUDIES</td>
<td></td>
<td>(Crawford et al., 2015)</td>
<td></td>
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<tr>
<td>1</td>
<td>ENVIRONMENTAL SCIENCES</td>
<td></td>
<td>(Swan, 2009)</td>
<td></td>
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<tr>
<td>2</td>
<td>PSYCHOLOGY</td>
<td></td>
<td>(Hermsen et al., 2016), (Stragier et al., 2016)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>SOCIAL SCIENCES</td>
<td></td>
<td>(Lupton, 2013), (Reigeluth, 2014), (Williams et al., 2015), (Lupton, 2015), (En and Pöll, 2016), (Lupton, 2016)</td>
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</table>

Table 2. The distribution of the articles according to their category and their discipline

The technic domain has published papers that cover the four levels of the funnel paradigm. However, most of these papers belong to Level 2. Therefore, researchers need to take into account the role of context to improve the understanding of QS. The technics domain reveals poor adapted tools for QS users. Whether with expert or beginners QSers, data management is still difficulty, devices seem to be unsuitable to everyday usage and difficult to manage in the social sphere. Consequently, researchers can work on new solutions that could simplify data management. Level 3 doesn’t give answers to questions on empirical observation. This level is only concerned with the possibilities brought by new QS research methodologies. At Level 3, only one article develops a theory, based on sense-making to facilitate QS usage. The remaining articles question data sharing between QSers, the problems of governance and QS surveillance. The critical funnel level is centered on data privacy, openness to neoliberalism, or resistance of vision related to the single use of data.
All the funnel levels are represented in the medical domain. The empirical papers examine the management of QS tools and the impact of algorithms in the physical education of children at school. Technology is also a topic developed in the Medical discipline: four articles deal with medical informatics. The analytical level offers an ethnographic approach to study QS. At the theoretical level, Kim (2014b) the HITAM model and Almalki et al. (2016) developed a framework to conceptualize QSers activities. At the critical level, questions such as the role of data on the consciousness of self-health and the consequences of excessive and fragmented quantification on the assessment of disease are discussed.

The social domain has developed a critical stance when discussing QS by examining the relationships between QS, the body, privacy and new forms of surveillance. For instance, an empirical study showed that QS leads to a normative social structure because the algorithms embedded in wearables compare user data to a norm (En and Pöll 2016). Hermsen et al. (2016) showed that QS leads to behavioural change and sustainable habits. Level 3 is illustrated by research dealing with the potential impact of self-experimentation. At the theoretical level, Stragier et al. (2016) use the self-determination model to understand the determinants of the use of community platform of fitness. The critical level (Level 4) better represented in the social discipline than in the technical and medical disciplines, especially with the work of Deborah Lupton (2013a, 2015, 2016). Foucault is often cited in particular for his contribution to the bio-politics: a new way of governing, not centred on territory but on individuals.

6 Discussion of the findings and future research directions

The systematic literature review presented in this research reveals QS as an immature domain of research. The paradigm funnel suggests that a scientific domain should begin with many empirical articles and go to few critical articles. Our systematic literature review identified some empirical articles, but too few theoretical and methodological papers. Regarding the three domains covered by our study (technic, social and medical domains), different results were also reported. The technical domain tends to focus on data analysis approach, while social sciences tend to criticize QS practices. Medicine has been concerned with the influence of QS on health management and wellbeing.

Empirical research on QS practices notes that QS tools are time-consuming and difficult to interpret (Almalki et al., 2015a; Rapp and Cena, 2016; Verdezoto et al., 2016) because of the heterogeneity of the platforms and their lack of inter-operability. Therefore, users have to juggle between several different applications and data. In addition, not all data are collected automatically, so users have to enter the information manually, which is time-consuming. Last, the over simplicity of graphs and charts offered by some QS tools can also reduce the added value for users. Consequently, designers of QS tools should think of XML approach to facilitate interoperability between applications.

The complexity of QS also requires original methodology such as ethnography, which represents a good alternative method to observe complex phenomena (Ruckenstein, 2015). Furthermore, the tools used for self-quantification could also be used by researchers to collect more precise and objective data. Hence, new mix method combining interview and QS data could bring more reliable and rigorous results (Kim, 2014b). Jain and Jalali (2014) also argue that QS could be used as a possible method of experimentation to achieve higher scientific rigor because QS systems are quite advanced systems and they provide precise data. We can access and observe data of human beings’ activity continuously. As such, QS represents a new scientific protocol that could replace laboratory studies and allow observation of human
beings in their social and physical environment. Some QS manufacturers have already conducted partnership with research labs to analyze large sample of data. (http://health.withings.com).

Regarding the theories used to examine QS, the literature reveals quite a diversity of conceptual backgrounds. Some articles aim at understanding why self-trackers share their data on social networking platforms (Stragier et al., 2015). Other studies focused on the acceptance models (Kim, 2014a; Kim 2014b), while some papers examined the activities of self-trackers (Almalki et al. 2016). Also, some articles adopt sociological theories to better understand the questions of emancipation and control related to QS (Ouellet et al., 2015). Sociological theories used in combination with QS have also paid attention to increased surveillance, return to individualism, self-reflexivity and loss of privacy. Individual feel forced to monitor their own attitudes in order to improve their performance and their life (Hammarfelt et al., 2016). The society tends to impose this unattainable goal of a perfect being, master of the self, and his health, having such knowledge of his body that he could prevent any disease (Lupton, 2015; Williams et al., 2015). QS nurtures even more this illusion of a bio-control of self (Andrieu, 2015). However, some optimists see QS as a form of resistance, because the data generated belong to us and they are so contextualized that they become difficult to exploit by third parties (Nafus and Sherman, 2014). This massive exploitation of data, desired by third parties to get a closer look at their consumers, redefines the limits of privacy and public life (Lupton, 2016). This raises the question of the unapproved disclosure of our data to third parties, endangering the integrity of our being, and by the same of our freedom (Lanzing, 2016).

These various articles reflect a vision of the QS nourished by the thoughts of Michel Foucault. This French philosopher is known in information system for his theory of the techniques of power that he calls “gouvernementality” and which gave rise to a very prolific disciplinary field called governmentality studies. His neoliberal vision of surveillance with the panopticons has been frequently cited in IS studies (Leclercq-Vandelannoitte, 2010). The goal of the panopticon is to define architectures allowing to see without being seen and to monitor without the others knowing it. QS tools tend to reproduce this panopticon view by collecting data on individuals in an invisible way. Future research can investigate further these topics, but they can also expand the field and add new theories such as the affordance theory to understand usage of QS. The problems linked to neoliberalism, normativity and governmentality could also be operationalized and tested.

In Figure 1, we present an overview of our literature review by taking into account the four levels of the Funnel Paradigm. We grouped the articles by theme and the color represents the disciplines (white = social; green =medical; grey = technic). The same themes are connected with lines. This figure highlights the lack of homogeneity in the study of QS. Only the topic of QS experience was found in three different levels (empirical observation, specific theory, and critical studies).

Our research also presents some limitations. First, we decided to filter the articles with at least two criteria (out of the three criteria we have defined) in order to have more relevant articles dealing with QS. However, the initial movement of the Quantified Self that corresponds to a community of early adopter is gradually turning into "quantified self" synonym of "self-tracking" in common language (Boesel 2013). Consequently, to add knowledge about QS it would be useful to study other areas such as e-health, m-health, mobile use, IoT and wearable. We can cite as an example the special issue of IEEE Journal of Biomedical and health Informatics published in September 2015 dedicated to "Sensor Informatics and quantified self".
In conclusion, our literature review shows that the QS research stream is young and deserves further attention. We observe a lack of methodologies developed and used to test QS. Researchers tend to use conventional methodologies based upon survey, case study or ethnography to study this phenomenon. But we encourage new methods that exploit the objectivity of the measurement provided by the trackers. The theories of governmentality and normativity will also benefit from being tested qualitatively to fill the empirical and theoretical level of the funnel and thus respond to the critical level.
Figure 1. Synthesis of our literature review according to the funnel paradigm
References


