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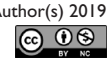
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From self-tracking to self-expertise: The production of self-related knowledge by doing personal science

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Abstract

This article explores the production and type of knowledge acquired in the course of specific digital self-tracking activities that resemble research and are common among followers of the Quantified Self movement. On the basis of interviews with self-trackers, it is shown that this knowledge can be characterised as a verified and practical self-knowledge, and that science in the form of scientific sources, methods and quality criteria plays a key role in its production. It is argued that this self-related knowledge can be conceptualised as self-expertise, and its production as personal science. The article then discusses the implications for the science-society relationship. In contrast to self-tracking data, so far self-knowledge has hardly caused any resonance in science, although science currently appears open to the insights from single subject (N-of-1) research. As a new mode of public engagement with science, personal science instead mainly leads to an individual self-expertisation.

Keywords

citizen science, knowledge production, lay expertise, public engagement, Quantified Self, self-tracking

1. Introduction

Digital self-tracking means the permanent gathering and evaluation of self-related data in one's daily life – be it the number of steps taken, calories burned, the heart rate, sleep patterns or mood – by using digital technologies (see for example, Lupton, 2016; Neff and Nafus, 2016; Selke, 2016). It has become a mass phenomenon through omnipresent smartphones, which increasingly feature the essential sensors and related apps to analyse, combine, evaluate and visualise the collected data. Especially in the health sector, the large app stores offer more and more apps to download, and wearables such as fitness tracking devices are prominently displayed in sports shops and consumer electronic stores.

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Prior to this entry into the mass market during the last couple of years (Research2Guidance, 2017), self-tracking was the preserve of relatively few individuals, who felt an affiliation to the Quantified Self (QS) movement that was founded in the United States' Silicon Valley in 2007. Following the slogan 'self knowledge through numbers' (QS, 2019), the movement's followers are united by the attempt to obtain insights into their own health or daily performance by collecting data about their bodies and lives. For this purpose, they use apps and other appliances such as activity and sleep sensors, scales or devices to measure blood pressure or blood sugar levels. The data are generated at least once a day and are analysed, plotted and evaluated automatically using statistics and graphics software. In addition, they are often uploaded to web platforms where they can be shared with others and discussed with regard to the possible consequences for the person's own (health-related) daily behaviour.

What is more, many QS followers, and especially those who have placed themselves at the head of the movement, are not satisfied with mere monitoring or optimisation goals like the recreational sportsman who monitors his daily jogging route in order to improve his performance. Instead or in addition, they develop personal *epistemic goals* and pursue these by specific self-tracking activities that resemble research. Sometimes, they even develop the necessary apps and software themselves, in case there are no satisfactory tools available (Heyen, 2016b).

In these self-tracking *research* activities, the goal is knowledge acquisition from which conclusions for daily life can be drawn. This usually concerns possible correlations of various parameters or variables, for example the influence of certain foods on sleep quality, the correlation of sleep quality and productivity, or that of productivity and mood. The main QS (2019) website is full of videos and blog articles in which self-trackers talk about such research activities. In principle, there are two possible approaches: a hypothesis-based one and an undirected one. The former formulates explicit and ex ante suppositions about the particular interrelation and designs the study accordingly. This also includes self-experiments in which a specific factor is deliberately altered in order to observe what impacts this has on a dependent variable. To give a completely random example, one self-tracker puts forward different hypotheses for his 'experiment' as he himself calls it, including 'if my calorie intake goes up, so does my weight' and 'if I cycle more, my weight will decrease' (Kalligas, 2014). The analysis of the self-tracking data he collected over a period of 3 months finally produces the results that the first assumption is (surprisingly) incorrect and the second is correct, and he goes on to further specify the type of correlations. The second approach, in contrast, starts from a certain data pool which is then examined from specific perspectives or generally searched for correlations in order to find out which variables are related to each other. An equally random example for this approach is a self-tracker who measured his physical activity, blood pressure and weight, among other things, every day for 2 years and then analysed these data without making any concrete assumptions beforehand, just with a general interest in discovering correlations and depicting them visually (Williams, 2014).

From the perspective of science (and technology) studies and public understanding of science, these self-tracking research practices are an interesting empirical phenomenon that deserves further scrutiny. It seems that, far away from institutional science, some lay people or citizens, at least no professional scientists, use methods and procedures known from science such as research design, data collection or data analysis in order to produce knowledge for self-use in their daily lives. How can the relationship between science and society, or science and the public (Bauer, 2009), be characterised here? Clearly, it is not about delivering information from science to the public in order to fill the latter's assumed 'deficit' of knowledge. Also, the common public understanding of science models of engaging the public (Brossard and Lewenstein, 2010) do not fit, since they presuppose some actors in science or science policy who intentionally address the public and involve citizens in concrete processes. The research activities of self-trackers do not seem to

be of any such form of 'invited' participation (Wehling, 2012; Wynne, 2007). Likewise, the appropriateness of the term 'dialogue' (Stilgoe et al., 2014) is doubtful because it is not clear to what extent there is a contact or exchange between professional scientists and self-trackers doing research at all.

The self-tracking research practices rather seem to be one of these growing 'informal engagement activities' that Stilgoe et al. (2014) call 'new spaces for [public] engagement with science and technology' (p. 9). Since they do not focus on learning or communicating about general scientific issues but on *knowledge production*, it is tempting to summarise them under the umbrella term 'citizen science' (Heyen, 2016b, 2017). Whereas it will be argued later to what extent self-tracking research can be called 'science', it is at least performed by citizens. However, given the two meanings of citizen science going back to Irwin (1995) and Bonney et al. (2009), respectively, and currently dominating the discourse (Cooper and Lewenstein, 2016; Strasser et al., 2019), self-tracking research as such neither seems to have the potential of democratising institutional science (Irwin, 1995) nor does it primarily aim at contributing data for professional scientific projects (Bonney et al., 2009). Again, and in contrast to the vast majority of citizen science projects, the self-tracking research practices take place aside from institutional science. However, it is increasingly acknowledged that there are 'many modes of citizen science' (Kasperowski and Kullenberg, 2019), coming along under terms such as 'grassroots' science, 'civic' science or 'community-based' research, and some of them are grounded, at least originally, outside institutional science. Even more fuzzy and difficult to grasp is the emerging science-related practices by citizens and users that have become known as maker movement, bio-hacking, do-it-yourself (DIY) biology or DIY science (Delfanti, 2010; Delgado and Callén, 2017; Ferretti, 2019). Self-tracking research adds to these diverse and complex science-related practices that challenge the familiar ways of conceptualising the science-society relationship.

Thus, this article aims to shed light on the knowledge production of self-tracking research and its relation to science. What type of knowledge is produced here? How is it produced, and what role does science play in its production? What is the resonance in science of that knowledge, if there is any at all? Might there even be something like a 'reverse' transfer of knowledge, not as usual from science to society but rather from the QS movement (society) to science?

2. Research design

Given these research questions focussing on knowledge and its social production, this study follows a sociology of knowledge approach and thereby adds to a long tradition of the sociology of knowledge and expertise within Science (and Technology) Studies (Collins and Evans, 2002). Generally speaking, if a person is attributed some kind of special knowledge, he or she is (socially) considered an expert. Also from a classical sociology of knowledge perspective, the two main aspects of the concept of *expertise* are already addressed in this ordinary consideration; first, expertise is ascribed socially and, second, it refers to a specific *special knowledge* (Hitzler et al., 1994; Schütz, 1946, for a very early reference). Collins and Evans (2002, 2007) in particular have drawn attention to the fact that in science and science policy contexts non-scientific people, normally deemed non-experts or laypersons, may also have some sort of relevant expertise. Since this kind of expertise is not certified or recognised by any academic or social institution, they call it 'non-certified expertise' in contrast to the 'certified' expertise of professional scientists (Collins and Evans, 2002). In health and medicine related fields (Epstein, 1995) and in the sociology of medicine (Prior, 2003), such a notion of lay knowledge or lay expertise has long been common, for instance, with regard to patients who have intensively dealt with a chronic disease for many years. For this study, the crucial point is to use 'expertise as an analysts' category' (expertise as special

knowledge) and not, as in other studies, as an 'actors' category' (expertise as socially ascribed), since the focus here is not 'on how the credibility of knowledge claims is negotiated and the status of expert awarded or withheld' (Collins et al., 2017: 771–772). Taking this analytical perspective, however, does not include the adoption of the normative implications of Collins and Evans (2002, 2007) approach and their basic classification of expertise. Rather, the aim here is to openly explore and reconstruct the kind of knowledge produced by self-trackers' research and, in a second step, to analyse to what extent this knowledge may be a special knowledge that analytically justifies describing it as expertise.

For that aim, a targeted multi-sited ethnography (Falzon, 2009) was conducted from October 2014 to June 2015, with a focus on the QS community in Germany, but including visits in Switzerland and the United States. On the one hand, this comprises participant observation at so-called meetups (local meetings) of the community at their 'hotspots' in Germany, two in Berlin, one in Munich, and one in Cologne. In addition, a meetup in Zurich and the 3-day global QS conference in San Francisco in June 2015 was attended and equally observed. On the other hand, qualitative in-depth interviews (usually between 1 and 2 hours of length) with self-trackers doing research were carried out. The interview guide (available online as supplemental material) focussed on the individual practice of self-tracking research: Why, how, and what is the respondent tracking? What are his or her conclusions? What role do scientific sources, methods and quality criteria play? What role do other self-trackers, the QS community or professional scientists play?

The interviewees were recruited successively, following a maximum variation sampling strategy. They were contacted (mostly) personally at one of the community gatherings or (rarely) through social media or email. The sample included both genders, self-tracker(s) from Germany and the United States, self-tracker(s) suffering from a chronic disease and doing their research for medical reasons as well as those who do it for everyday health or well-being reasons, self-tracker(s) having a leading role within the QS community as well as those who feel hardly affiliated with the QS movement, and self-tracker(s) having a professional job closely connected to digital self-tracking as well as those who get in touch with self-tracking only in their leisure time. The transcribed interviews were systematically analysed using the hermeneutic method of sequential analysis (Maiwald, 2005). This qualitative-interpretive method aims at the reconstruction of meaning structures beyond the subjectively intended meanings by the actors. By following the textual material sequence by sequence and applying some guiding principles of interpretation (available online as supplemental material), it allows for a grounded and intersubjectively checkable development of hypotheses on meaning or social structures, such as, in the given case, on specific modes of knowledge production. Since the analysis was done simultaneously to the successive sampling process, the latter was ended after seven interviews when saturation materialised.

To address the other part of the research questions asking about the resonance in science, an international literature review and analysis was conducted in September and October 2015 (searching the databases of PubMed, MedPilot and Greenpilot) aiming to identify life sciences, health or medical literature that refers to data or knowledge produced through QS activities. In addition, expert interviews were carried out in October and November 2015 with six German health scientists and medical experts on the quality, relevance and (potential) benefits of self-tracking data and knowledge for the respondents' medical or scientific practice. Recruited through email or personal contact, they were selected as leading experts in the fields of digital medical practice, medical informatics, mobile health, sports science, sleep research and epidemiology.

Given the focus on the knowledge produced by self-tracking research, this article primarily makes use of the self-trackers' interview data explicitly dealing with that issue. Accordingly, in the next section, several empirical examples of this type of knowledge and its production are presented and illustrated with interview excerpts. The self-tracking research practice is then conceptualised

by introducing the concepts of self-knowledge, self-expertise and personal science. Here, the other empirical material and results are incorporated, as well as in the subsequent section on the relevance of personal science between science and society.

3. Knowledge production through self-tracking research: Empirical examples

The starting point for the *first example* is a female self-tracker's monitoring activity of her menstrual cycle for the purpose of contraception. A random observation led to her wondering whether the sad moods that she had so far perceived as occurring randomly were in fact not more regular than supposed and could have something to do with her menstrual cycle. By referring to popular scientific literature on hormone fluctuations, she then followed this assumption – now in the sense of a research activity – and observed her cycle and her moods over a longer period of time (in order to control potential confounding factors) until a kind of validation of her findings appeared to take place:

> I also learned that I was – I would have a dip right after ovulation, too, which was about ten days before my period. I would get really sad and that was because my hormones were shifting but I never knew why. I just thought there were some days I was getting really sad.

The produced insight that a regularly occurring sad day was dependent on the menstrual cycle and hormone levels is then put to practical use by putting more thought into how to spend this day (e.g. not going to a party scheduled for this day) and by dealing with the corresponding emotions in a different way. In addition, the self-tracker began taking a multivitamin-multimineral supplement (Optivite PMT) to influence her hormone levels.

> Now that I've taken this supplement, I am like, maybe I won't get that sad anymore. But what I've done – I guess what I've done in the past knowing that I would be potentially sad within that period because I could see when it would be coming: I think I would just be nicer to myself. [. . .] If I am really upset, just having the awareness of like, okay, this is rooted in real issues but the severity of my emotions is probably hormonal and so you know just–it helps me NOT identify with them so much.

The *second example* is also based on a monitoring activity. The self-tracker here had a stroke so that, from a medical point of view, it is advisable for him to monitor his blood pressure and make sure it always remains below a certain upper limit. Measured almost daily for years, the blood pressure readings have yielded a dataset that the self-tracker now analyses on a regular basis, and relates to environmental and other factors. Over the course of this research activity, he made the following observations and gained the following insights (a–d, added by the author):

> [a] Blood pressure and weight: In phases when I weigh more, my blood pressure is higher. [. . .] [b] Then, I noticed that drinking coffee had basically no effect on my blood pressure – that was a flat line. [. . .] [c] For example, with me, it looks like my blood pressure rises over the course of a [working] week. [. . .] [d] If I am on a business trip for a week, I can see that my blood pressure tends to be higher.

The self-tracker, who travels a lot for work, discussed in particular the last point with his doctor and showed him the corresponding data and graphs – with consequences for his medication:

> We talked several times about travelling. [. . .] He gave me the clear recommendation that when I'm on a longer trip, that occurs every now and then, two to three times a year, [. . .] then I should for example take

> an extra pill or an extra half pill depending on my data, right? Those are clear recommendations for action from my general practitioner based on the experience of how it is for me – on my trips.

Also in another area, the analysis of self-tracking data, here the daily number of steps and own body perceptions, led to a self-related insight. The self-tracker found a correlation between daily exercise and physical pain, which he takes as the foundation and legitimation for a (desired) change of daily routines:

> The thing I noticed quite specifically, for example, is that if I don't walk a certain number of steps over days or weeks, then my knee problems get worse. I have meniscus problems and it is quite good if I move my knee, this kind of lubricates it, the joint, that is actually quite good for me. And I notice if I do less than seven thousand steps for several days in succession, then my knee hurts more. [. . .] The minimum target is ten thousand steps per day and my actual target is fifteen thousand steps. That would be great and that's what I am actually trying to achieve. And this is purely in my own self-interest, so that my knee doesn't hurt me or something and that I don't have to have another operation at some point. I try to do more than these seven thousand steps.

In the *third example*, the starting point is not a monitoring activity, but the insight gained from everyday life that sleep is a key factor influencing one's well-being. This directly triggered the self-tracker's research activity:

> I had a phase when I had a lot of stress at work and then I slept badly and I noticed that – or I found out myself, that stress influences how I sleep, and in turn that sleeping badly had a negative influence on my well-being. And so, I said, okay, take a look at this – what's the relationship?

He began by looking at the literature on the topic of sleep and then started 'different tests'. He took the point of time he went to sleep as kind of control variable, varied the length of time he slept, and related this, on the one hand, to the quality of sleep analysed using a self-tracking app, and, on the other hand, to his subjective feeling directly upon waking up and over the course of the day:

> And then I noticed, seven hours – this was over a few weeks – seven hours is best for me. Whether it is exactly seven hours, I didn't measure the precise number of minutes, but roughly seven hours, right? And then – due to the secondary constraint that I do a bit of exercise each morning – this resulted in a specific bedtime.

Based on this, the self-tracker 'carried on experimenting with this' and analysed the influence that alcohol (controlling, among other things, whether consumed while having dinner or not) or coffee (controlling, among other things, the time of consumption) has on his sleeping pattern. His insights here were the following:

> Up to one glass [of wine], I don't see any effect on how I sleep. And the more I drink, the more restless my sleep, the more the quality of sleep shifts to a light sleep. [. . .] And this matches my feeling [. . .] And I did the same with coffee. I tested all of that and my pseudoscientific finding on the topic of coffee is actually that coffee – that the caffeine itself has no effect, but that it does have the effect of enhancing the organism's existing disposition. So, if I am irritable or excited or nervous, then I become even more nervous. Or if I am quite calm, then it has no effect.

These self-related insights are taken into account by the self-tracker in his daily routines (e.g. do not drink more than one glass of wine if you have an important appointment the next day) and they contribute, according to his own perception, to his (improved) well-being.

The *fourth and final example* was triggered by the constant 'afternoon tiredness' of another self-tracker – something he had perceived as a problem. Sensitised by a misinformation of his health insurance company, which wrongly classified him as a diabetic, he asked himself whether his tiredness could have something to do with his blood sugar level and which factors influence this. He consulted scientific nutritional studies, self-help literature and blogs on this topic. Then he planned his research activity, measured his blood sugar level every (waking) hour for 5 days and collected other data each time of measurement – technically, not with a smartphone, but with an online questionnaire to himself. These other data included his current feeling of tiredness and, as potential influencing factors, his mood, activity, food intake and social contacts, among other things. His analysis of the resulting dataset in an Excel spreadsheet reached the following conclusion:

> [. . .] that if I have eaten a lot at lunchtime, mainly food rich in carbohydrates or something that your body transforms quickly into energy – into useful energy – that I had a peak in my blood sugar level and then, when the blood sugar level dropped again, regardless of how high or low it was, I had a phase of tiredness. And that was an insight for ME that I actually made use of, in that I now eat less for lunch, but eat five times a day. So, I have breakfast and in the morning when I first get hungry, I eat something – a bread roll or a small snack or I have some nuts or something like that on my desk – I then eat less at lunch, but eat something again in the afternoon. So, I keep myself constantly full – and then I don't experience this phase of tiredness.

The self-relatedness of the insight that his tiredness depends on the type and quantity of food eaten for lunch and on the resulting fluctuations in his blood sugar level is the decisive point for the self-tracker. He explicitly distinguishes general recommendations ('popular wisdom', 'proverbs'), which of course do exist regarding the number of meals taken over the course of a day, from his own 'individualised information':

> And to this extent, it has had a lasting effect on my behaviour, because instead of simply 'Walk ten thousand steps, that is good for you!' I had the information: 'If I take another ladle, then I know that I, personally, just for me, I know that I will then feel tired in the afternoon'. And that was the interesting thing for me and the lasting thing that came out of it all.

4. Self-knowledge, self-expertise and personal science

The self-trackers' insights presented in the empirical examples can be conceptualised as a form of knowledge that is characterised by three main aspects: First, the knowledge is self-related, that is related to the own body and/or life-world of the knowledge producer. Second, it is of practical use, that is relevant for managing the self-tracker's daily routines. Third, it is claimed to be verified, otherwise it could not be used by the self-tracker as the foundation and legitimation for behavioural changes. The knowledge obtained through self-tracking research can therefore be characterised as a *verified and practical self-knowledge*.[1]

Furthermore, the examples show that this self-knowledge is produced during the course of research activities, which are oriented towards *scientific* approaches in many respects. This primarily concerns the procedures and methods that are well-known from science: from setting up experiments as a research design through the measurement methods used (technical sensors, observation protocols, standardised surveys), descriptive statistics (automated through apps or manually calculated) up to more or less complex significance tests and correlation analyses. In addition, science not only serves as a role model for methodologies, also the scientific knowledge relevant for the respective subject – whether in the form of popular science or original journal articles – is in

demand by the self-trackers doing research and is used, for example, to generate hypotheses or to test their own conclusions.

Moreover, the classic scientific quality criteria of empirical research play a role, albeit often implicitly. Above all, importance is attached to the *reliability* and *validity* of measuring devices and operations. The relevant questions are addressed especially at the meetups observed: How reliable are the measurements? And to what extent do the devices actually measure what they are supposed to? In this context, it is not uncommon that self-trackers use different devices at the same time over a certain period of time in order to compare the data and results with each other.

Objectivity, in contrast, is only a topic to the extent that self-trackers usually claim their self-collected data were free of subjective influence – whether it is right to do so or not. In any case, objectivity in the sense of intersubjective verifiability or reproducibility of the measurement plays almost no role in the meetup discussions. And indeed, the self-tracker can only reproduce a research study *on himself or herself*, because here the researcher and the test subject are one and the same person. Correspondingly, the self-tracker doing research usually has no interest in repeating another person's study, unless on himself or herself which normally yields different results. In other words, in self-tracking research, not only '$n = 1$' applies but also '$n = $ me' (Swan, 2012: 108). Nevertheless, the knowledge production itself is intersubjectively traceable: in principle, because it is carried out in a methodically controlled manner; and often factually if the data, the approach taken and the outcomes are explained and presented to the public at meetups or through blogs.

The self-relatedness and practical relevance of the produced knowledge on the one hand, and the fact that it follows the production methods of scientific (verified) knowledge on the other hand seem to justify calling the research activities of self-trackers *personal science*. 'Science', because the attempt is made to produce verified knowledge using scientific methods and following scientific criteria; 'personal', not only because self-trackers are researchers and test subjects at the same time, but also because they conduct research for their own personal needs, that is for their own practical use.

The self-knowledge that is produced in a methodically controlled manner by doing personal science is simultaneously a *special knowledge* at the disposal of the self-tracker conducting the research. Taking the analytical perspective on the concept of expertise outlined earlier, the special knowledge of self-trackers doing research can be conceptualised as expertise. Like the special knowledge, this expertise is related to the self, one's own body and/or life-world, and therefore can be described as *self-expertise*. Since it is not certified or recognised by any social institution, it can be understood as a case of *non-certified expertise* (Collins and Evans, 2002).

Self-expertise should be clearly distinguished from the usual (self-related) knowledge based on experience that everyone automatically gains by coping with everyday life, because, in contrast to such an experience-based knowledge, the self-knowledge focused here is produced in a *methodically controlled* manner. This does not necessarily mean that – regardless of which evaluation criteria are used – self-knowledge is superior to experience-based knowledge, it can also be the other way around. Nor does it rule out the possibility that under certain circumstances (such as dealing with a chronic disease) experience-based knowledge may also represent a special knowledge that justifies calling it expertise (Epstein, 1995; Prior, 2003). Rather, the crucial point here is that the self-knowledge is produced and acquired in a different way than the experience-based knowledge, and thus represents a different type of knowledge. In this understanding of the term, therefore, not everyone is 'an expert on him/herself' only because he or she has self-related experience-based knowledge. Rather, someone (a self-tracker doing research) is a *self-expert* if she or he has a verified self-knowledge, meaning that it has been produced in a methodically controlled manner.

5. Personal science between science and society

One critical question that can be raised when looking at the empirical examples is whether the insights obtained by doing personal science are not somewhat trivial, and whether they do not, if they do anything at all, simply confirm general knowledge in the end. Indeed, 'an astonishing banality, expectability and triviality of the insights achieved by self-tracking' has been stated elsewhere (Duttweiler and Passoth, 2016: 28, own translation). However, it seems that false or exaggerated standards are applied here. Of course, the insights are usually not of the kind that will astonish the respective scientific community, but neither is that the aspiration here. Self-trackers doing research are striving for insights that are first self-related, and second of practical use. For them, it is therefore already a benefit if they prove that a statement generally held to be correct also applies to them. Nothing else is promised by the modern model of personalised or individualised medicine, and the self-tracker in the fourth example also argues along these lines. Besides, it is often the crux of general platitudes (such as, for example, coffee consumption influences sleep), that neither confirmation nor counter-evidence are perceived as surprising. In this respect, the guiding question of how or to what extent something affects oneself seems both legitimate and open, and therefore worthy of being studied in a methodically controlled manner. The answer does not have to be relevant for the general public or science.

However, it is certainly conceivable that the insights obtained through personal science are of interest to professional science. For instance, a self-tracker who presented his activities at the 2015 global QS conference discovered that his heart rate variability – an indicator of fitness and health or, if impaired, a risk factor for various diseases – correlates with the seasons, and he was wondering whether analysing this correlation might be a relevant task for professional research. In fact, this correlation is already known to science, as one of the expert interviewees confirmed – the seasons really do have an influence on heart rate variability through hormone levels. Nevertheless, several of the experts interviewed can well imagine that self-trackers' research could stumble across correlations that have not yet been addressed in science, and that this could spark professional research. One function of personal science for science could therefore be to generate hypotheses or to *stimulate professional research* (primarily in the fields of exercise, sleep and nutrition).

Of course, there are plenty of examples throughout the history of science, and especially of medicine, where scientists or physicians conducted experiments on themselves (Altman, 1987; Neuringer, 1981). In contrast to the research done by self-trackers, however, these persons usually were no lay people, but professionally engaged in their research, often being pioneers in their field. A professional scientist – the now deceased psychologist Seth Roberts, who was sympathetic to the QS movement – even published the results of his self-experimentation in a peer-reviewed journal under the current conditions of modern science (Roberts, 2004, 2010). In this context, it also fits that in the course of the growing importance of personalised or individualised medicine, so-called 'N-of-1 clinical trials', that is clinical studies of individuals, are being discussed as a methodological option (Bains, 2008; Lillie et al., 2011), even in renowned journals such as *Nature* (Schork, 2015). It therefore seems that science, in principle, is open to the insights from self-related research or research related to individual persons – not a bad precondition for personal science to attract more attention from professional science.

Given this background, it is somewhat astonishing to see what little resonance the research activities and insights of self-trackers have so far produced in science and medicine. There is nothing like a knowledge transfer from the QS movement to science and medicine, at least so far. The conducted literature review and analysis was unable to identify any life sciences or medical journal article that referred to knowledge produced through QS activities.[2] At least at the end of 2016,

some actors of the QS movement co-initiated the first relevant call for papers by a scientific journal, namely *Methods of Information in Medicine*, where it says,

> This focus theme of 'Methods of Information in Medicine' on single subject research encourages submission of original articles describing data processing and research methods using a 'N-of-1' design *where the questions and analysis are guided by the interests and participation of the subject*. (Drangsholt et al., 2016, emphasis by the author)

The issue was published at the end of 2017 (De Groot et al., 2017). In fact, it also contains 'personal science reports', but these and all other articles are written by professional scientists. According to a (personal) information by the editors, one-third of the submissions did come from non-professional (lay) self-trackers doing research. However and to the editors' regret, the attempt to bring some chosen contributions of self-trackers into a form according to the scientific standards of the journal was not successful.

Concerning the direct contact between the QS movement and professional science, the *Quantified Self Institute* founded in 2012 at the *Hanze University of Applied Sciences* in Groningen, the Netherlands, deserves special mention. It is explicitly committed to the QS movement and also involved in the above-mentioned call for papers. Of course, also the *Quantified Self Labs* in California play a role here, being the founding and coordinating body of the QS movement, for instance, by organising regular public health symposia with the participation of science and medicine. Overall, however, there are hardly any institutionalised formats (so far) for the exchange between self-trackers doing research, that is the personal scientists, and professional scientists. Although some meetups and the global QS conferences, which are held every 2 years in San Francisco or Amsterdam, are attended by some curious or interested professional scientists, so far any exchange seems to be rather random or sporadic. If it comes to such contacts, however, they seem to be open-minded, with mutual interest and respect, virtually at eye level.

In this context, it is noticeable that, so far, no knowledge accumulation can be observed in the QS movement, nor has a common stock of knowledge developed (yet). This is certainly also due to its rather loose form of networking. At best, there may be some initial signs of knowledge accumulation with regard to self-tracking methods and technical devices, but not concerning self-related knowledge. However, that would actually be quite conceivable. If more and more self-trackers research specific interrelations of exercise, sleep and nutrition on themselves, why should this not give rise to more generalisable insights beyond individual cases? Perhaps, these would then be of greater interest to science and medicine and would lead to more exchange between personal and professional scientists? However, the QS community shows hardly any signs of ambition in this direction, even if individual self-trackers in a small discussion group at the 2015 global QS conference stated that they were missing recognisable progress of the community as a whole, collective learning effects, a kind of meta-level as well as established standards of procedures. Instead of that, each self-tracker starts more or less from scratch, regardless of whether another self-tracker has already worked on exactly the same question and gained insights that could be built upon. Correspondingly, public presentations of self-tracking research at meetups or conferences make hardly any references to other self-trackers and their activities. In this respect as well, personal science is a very self-related affair.

Even if the stock of knowledge generated over the course of the QS movement in the future leads to more interest and resonance in science and medicine than has been the case so far, it still seems foreseeable that the focal point of interest will be – as is already the case today – the (body- and health-related) *data* produced by digital self-tracking. According to the expert interviews, medicine on the one hand expects these data to provide a better basis for diagnostics and the chance

to individualise therapies, because instead of only one measurement taken in an artificial clinical setting, potentially there will be a whole series of values measured daily and in the patients' familiar surroundings. Science, on the other hand, can tap into a new kind of data source that is related directly to the test persons' everyday behaviour, which represents a useful methodological supplement to laboratory studies or surveys in exercise, sleep and nutrition research (c.f. Heyen, 2016a, 2018). Science may do this in the classical way by issuing self-tracking technologies to test persons; or by less tried and tested ways such as using the data generated by digital self-tracking in non-controlled contexts, be it through data platforms of commercial providers of devices and apps like *Fitabase*, initiatives like Apple's *ResearchKit* (an open source framework for installing apps for research purposes on the iPhone) or health social networks such as *PatientsLikeMe*, where self-tracking data can also be gathered (Swan, 2009).

6. Conclusion

The empirical insights of this article add to an increasingly multifaceted picture of digital self-tracking practices in the literature (see for example, Abend and Fuchs, 2016; Lupton, 2016; Neff and Nafus, 2016; Ruckenstein and Schüll, 2017; Selke, 2016), where knowledge production so far has hardly received any attention. Here and in the mass media, a critical and seemingly obvious interpretation has long been dominant, namely that self-tracking was the new excess of a surveillance, disciplinary or performance society that led the individual to control and optimise himself with regard to social norms or targets and to even understand this as an expression of his free will (e.g. Sanders, 2017; Whitson, 2014). However, especially studies with an empirical base indicate that digital self-tracking and QS is a far more complex and heterogeneous phenomenon than critical ad hoc observers suggest. Sharon and Zandbergen (2017), for example, show using an ethnographic approach that self-trackers are not 'data fetishists' as they are often perceived. Instead, they attribute meaning to their data gathering practices insofar as these data 'may extend (rather than displace) one's senses, they may enable users to resist (rather than comply with) normalization and they may supplement (rather than solely constrain) what can be said' (Sharon and Zandbergen, 2017: 12). While many scholars counter the QS slogan 'self knowledge through numbers' by pointing (quite rightly) to the risks of data reductionism and an inappropriate belief in the objectivity of numbers (Sharon, 2017: 102–105), this article provides evidence that knowledge indeed is produced, however not just 'through numbers' as the slogan suggests but rather by specific, sophisticated self-tracking activities that can be referred to as personal science.

However, it has to be emphasised that, as the empirical examples illustrate, doing self-tracking research requires a personal epistemic goal and definitely some effort in terms of time, cognitive engagement and competences. Therefore, it is quite unlikely that all those involved in some sort of digital self-tracking are actively doing personal science. Especially the ordinary consumer of fitness tracking devices or other mass market products can be assumed to just pursue monitoring or optimisation goals without being engaged in any research activities. Personal science thus rather seems to be a niche phenomenon. However, how widespread it actually is, has to be investigated in further research.

Whereas, as indicated earlier, the masses of data collected by digital self-tracking will increasingly be used by professional science to produce scientific knowledge, in personal science, and that is what this article wanted to show, the data are used for the methodically controlled production of self-related knowledge and thus contribute to the self-tracker's *self-expertisation*. This self-expertisation can be interpreted as a further facet of an increasing scientification of society (Gibbons et al., 1994; Weingart, 1983). Moreover, it is the result of a new, namely very personal and self-related mode of public engagement with science (Stilgoe et al., 2014). The wider implications of

this engagement on both the individual and societal level have to be examined in future research. First, regarding health: To what extent does personal science affect the body and health awareness or the health behaviour of the individual? If it does it in a beneficial manner, may it even be used as a public health instrument? Second, regarding public understanding of science: How does this practice both depend on and influence the scientific literacy of the individual personal scientist? Can personal science, envisioned on a larger scale, even enhance public understanding of science, as has been argued with regard to citizen science (Bonney et al., 2016)? In any case, the lasting result that the self-expert seems to draw from his or her research efforts is (as the self-tracker from the fourth example put it):

> [. . .] that you know yourself what is good for you or what is not good for you.

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Supplemental material

Supplemental material for this article is available online.

Notes

1. From the sociology of knowledge perspective taken here, it is irrelevant for the definition of the term whether this self-knowledge would stand up to a professional scientific test or not. Likewise, it does not matter whether or not other self-trackers may have gained different insights or come to contrasting conclusions than the ones cited (both may be correct from a professional perspective, anyway). On a conceptual level, the structure and character of this type of knowledge remains the same.
2. This does not mean that QS and digital self-tracking are not a topic of interest in the life sciences and medical literature. However, they mainly crop up in discussion and commentary sections, whether in simple comments, reviews of the QS field, the discussion of impending regulation issues or drafts of research programmes. A genuine research subject are the (intended) effects of using QS technologies and users' experiences in their everyday lives and in clinical practice (e.g. by doing self-monitoring). In addition, one can observe the scientific use of QS data as well as the use of QS technologies and QS methods to collect data. Finally, there is a technical-scientific discourse about the development and quality checks of new sensors, systems, algorithms, platforms and apps in the QS field.

References

Abend P and Fuchs M (eds) (2016) Quantified selves and statistical bodies. *Digital Culture & Society* 2(1). Bielefeld: Transcript.

Altman LK (1987) *Who Goes First? The Story of Self-Experimentation in Medicine*. Berkeley, CA: University of California Press.

Bains W (2008) Truly personalised medicine: Self-experimentation in medical discovery. *Medical Hypotheses* 70(4): 714–718.

Bauer MW (2009) The evolution of public understanding of science – Discourse and comparative evidence. *Science, Technology and Society* 14(2): 221–240.

Bonney R, Ballard H, Jordan R, McCallie E, Phillips T, Shirk J, et al. (2009) *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education*. Washington, DC: Center for Advancement of Informal Science Education.

Bonney R, Phillips TB, Ballard HL and Enck JW (2016) Can citizen science enhance public understanding of science? *Public Understanding of Science* 25(1): 2–16.

Brossard D and Lewenstein BV (2010) A critical appraisal of models of public understanding of science. In: Kahlor LA and Stout PA (eds) *Communicating Science: New Agendas in Communication*. London; New York, NY: Routledge, pp. 11–39.

Collins HM and Evans R (2002) The third wave of science studies: Studies of expertise and experience. *Social Studies of Science* 32(2): 235–296.

Collins HM and Evans R (2007) *Rethinking Expertise*. Chicago, IL; London: The University of Chicago Press.

Collins HM, Evans R and Weinel M (2017) Interactional expertise. In: Felt U, Fouché R, Miller CA and Smith-Doerr L (eds) *The Handbook of Science and Technology Studies*. Cambridge, MA: MIT Press, pp. 765–792.

Cooper CB and Lewenstein BV (2016) Two meanings of citizen science. In: Cavalier D and Kennedy EB (eds) *The Rightful Place of Science: Citizen Science*. Tempe, AZ: Consortium for Science, Policy & Outcomes, pp. 51–61.

De Groot M, Drangsholt M, Martin-Sanchez FJ and Wolf G (2017) Single subject (N-of-1) research design, data processing, and personal science. *Methods of Information in Medicine* 56(6): 416–418.

Delfanti A (2010) Users and peers. From citizen science to P2P science. *Journal of Science Communication* 9(1): 42–56.

Delgado A and Callén B (2017) Do-it-yourself biology and electronic waste hacking: A politics of demonstration in precarious times. *Public Understanding of Science* 26(2): 179–194.

Drangsholt M, De Groot M, Martin-Sanchez F and Wolf G (2016) Call for papers: N-of-1. Available at: https://quantifiedself.com/wp-content/uploads/2016/11/N-of-1-Call-For-Papers.pdf (accessed 24 July 2019).

Duttweiler S and Passoth JH (2016) Self-Tracking als Optimierungsprojekt? [Self-tracking as an optimisation project?] In: Duttweiler S, Gugutzer R, Passoth JH and Strübing J (eds) *Leben nach Zahlen. Self-Tracking als Optimierungsprojekt?* [Living by numbers. Self-tracking as an optimisation project?] Bielefeld: Transcript, pp. 9–42.

Epstein S (1995) The construction of lay expertise: AIDS activism and the forging of credibility in the reform of clinical trials. *Science, Technology, & Human Values* 20(4): 408–437.

Falzon MA (ed.) (2009) *Multi-Sited Ethnography: Theory, Praxis and Locality in Contemporary Research*. Farnham: Ashgate.

Ferretti F (2019) Mapping do-it-yourself science. *Life Sciences, Society and Policy* 15(1): 1–23.

Gibbons M, Limoges C, Nowotny H, Schwartzman S, Scott P and Trow M (1994) *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*. London: SAGE.

Heyen NB (2016a) Digitale Selbstvermessung und Quantified Self. Potenziale, Risiken und Handlungsoptionen [Digital self-tracking and Quantified Self: Potentials, risks and options for action]. *Policy paper, Fraunhofer ISI, Karlsruhe*, December.

Heyen NB (2016b) Self-tracking as knowledge production: Quantified self between prosumption and citizen science. In: Selke S (ed.) *Lifelogging: Digital Self-Tracking and Lifelogging – Between Disruptive Technology and Cultural Transformation*. Wiesbaden: Springer, pp. 283–301.

Heyen NB (2017) Quantified self as personal (citizen) science. *Havard Bill of Health*, 11 May. Available at: http://blogs.harvard.edu/billofhealth/2017/05/11/quantified-self-as-personal-citizen-science/ (accessed 24 July 2019).

Heyen NB (2018) Mehr Gesundheit durch Quantified Self? Zu den Folgen der digitalen Selbstvermessung und möglichen Szenarien für 2030 [Better health through Quantified Self? Implications of digital

self-tracking and scenarios for 2030]. In: Decker M, Lindner R, Lingner S, Scherz C and Sotoudeh M (eds) *Grand Challenges meistern – der Beitrag der Technikfolgenabschätzung*. [Mastering Grand Challenges: The contribution of technology assessment] Berlin: Edition Sigma, pp. 259–270.

Hitzler R, Honer A and Maeder C (eds) (1994) *Expertenwissen: die institutionalisierte Kompetenz zur Konstruktion von Wirklichkeit*. [Expert knowledge: The institutionalised competence for the construction of reality] Opladen: Westdeutscher Verlag.

Irwin A (1995) *Citizen Science: A Study of People, Expertise and Sustainable Development*. London; New York, NY: Routledge.

Kalligas K (2014) Analyzing my weight and sleep [Video]. Available at: https://quantifiedself.com/show-and-tell/?project=15 (accessed 24 July 2019).

Kasperowski D and Kullenberg C (2019) The many modes of citizen science. *Science & Technology Studies* 32(2): 2–7.

Lillie EO, Patay B, Diamant J, Issell B, Topol EJ and Schork NJ(2011) The n-of-1 clinical trial: The ultimate strategy for individualizing medicine? *Personalized Medicine* 8(2): 161–173.

Lupton D (2016) *The Quantified Self: A Sociology of Self-Tracking*. Cambridge: Polity Press.

Maiwald KO (2005) Competence and praxis: Sequential analysis in German sociology. *Forum: Qualitative Social Research* 6(3): 31.

Neff G and Nafus D (2016) *Self-Tracking*. Cambridge: MIT Press.

Neuringer A (1981) Self-experimentation: A call for change. *Behaviorism* 9(1): 79–94.

Prior L (2003) Belief, knowledge and expertise: The emergence of the lay expert in medical sociology. *Sociology of Health & Illness* 25(3): 41–57.

Quantified Self (QS) (2019) Available at: https://quantifiedself.com/ (accessed 24 July 2019).

Research2Guidance (2017) *mHealth Economics 2017/2018: Current Status and Future Trends in Mobile Health*. Berlin: Research2Guidance.

Roberts S (2004) Self-experimentation as a source of new ideas: Ten examples about sleep, mood, health, and weight. *Behavioral and Brain Sciences* 27(2): 227–262.

Roberts S (2010) The unreasonable effectiveness of my self-experimentation. *Medical Hypotheses* 75(6): 482–489.

Ruckenstein M and Schüll ND (2017) The datafication of health. *Annual Review of Anthropology* 46(1): 261–278.

Sanders R (2017) Self-tracking in the digital era: Biopower, patriarchy, and the new biometric body projects. *Body & Society* 23(1): 36–63.

Schork NJ (2015) Time for one-person trials. *Nature* 520(7549): 609–611.

Schütz A (1946) The well-informed citizen: An essay on the social distribution of knowledge. *Social Research* 13(4): 463–478.

Selke S (ed.) (2016) *Lifelogging: Digital Self-Tracking and Lifelogging – Between Disruptive Technology and Cultural Transformation*. Wiesbaden: Springer.

Sharon T (2017) Self-tracking for health and the quantified self: Re-articulating autonomy, solidarity, and authenticity in an age of personalized healthcare. *Philosophy & Technology* 30(1): 93–121.

Sharon T and Zandbergen D (2017) From data fetishism to quantifying selves: Self-tracking practices and the other values of data. *New Media & Society* 19(11): 1695–1709.

Stilgoe J, Lock SJ and Wilsdon J (2014) Why should we promote public engagement with science? *Public Understanding of Science* 23(1): 4–15.

Strasser BJ, Baudry J, Mahr D, Sanchez G and Tancoigne E (2019) 'Citizen science'? Rethinking science and public participation. *Science & Technology Studies* 32(2): 52–76.

Swan M (2009) Emerging patient-driven health care models: An examination of health social networks, consumer personalized medicine and quantified self-tracking. *International Journal of Environmental Research and Public Health* 6(2): 492–525.

Swan M (2012) Health 2050: The realization of personalized medicine through crowdsourcing, the quantified self, and the participatory biocitizen. *Journal of Personalized Medicine* 2(3): 93–118.

Wehling P (2012) From invited to uninvited participation (and back?): Rethinking civil society engagement in technology assessment and development. *Poiesis & Praxis – International Journal of Ethics of Science and Technology Assessment* 9(1–2): 43–60.

Weingart P (1983) Verwissenschaftlichung der Gesellschaft – Politisierung der Wissenschaft. [Scientification of society – politisation of science] *Zeitschrift für Soziologie* 12(3): 225–241.

Whitson JR (2014) Foucault's fitbit: Governance and gamification. In: Walz SP and Deterding S (eds) *The Gameful World: Approaches, Issues, Applications*. Cambridge, MA; London: MIT Press, pp. 339–358.

Williams J (2014) Exploring my data [Video]. Available at: https://quantifiedself.com/blog/jamie-williams-exploring-data/ (accessed 24 July 2019).

Wynne B (2007) Public participation in science and technology: Performing and obscuring a political-conceptual category mistake. *East Asian Science, Technology and Society* 1(1): 99–110.

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