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ORIGINAL RESEARCH PAPER

The Pivotal Function of Non-human Actors in the Acceptability of the Body Technology, Actibelt®: a Reconstruction Based on Actor-Network-Theory

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Abstract This paper explores the question of how non-human actors contribute to the acceptability of technologies. Acceptance and acceptability of technologies were examined as network formation and not, as in conventional technology acceptance models, as adoption by individual human actors. Using the approach of translation sociology, the acceptance work necessary for network formation was examined. As a result, the (technical) actibelt®-Actor-Network and five modes of acceptance work by non-human actors and their effects on patients were identified. The different modes of acceptance work show that non-human actors, such as events, meetings, graphs, and socio-technical discourses, are not passive actors in the development of technology, but can enable, hinder, or condition acceptability. Therefore, non-human actors play a central and constitutive role in the translation process by performing acceptance work and contributing to the stabilisation and acceptability of the actibelt®-Actor-Network.

Keywords Actor-network-theory · Technology adoption · Technology use · Acceptance · Acceptability · Non-human actors

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Introduction

Digital wearables are small technologies that are worn on the human body, for example on the wrist, leg, ankle, or hip. While worn, they measure and record body data as you move through space and time. Wearables are intimate devices that are in constant physical contact with the human body when in use. Most wearables are used in health, wellness, sports, and fitness. They monitor steps, energy expended, distance traveled, body temperature, sleep patterns, heart rate, and stress levels. Some wearables have been developed for patients to use as part of home monitoring of chronic conditions such as hypertension, as well as for rehabilitation [1].

Digital body measurement is an example of the close entanglement and interdependence between human and non-human elements, new entities, and a development towards a "manufacturing of life" [2]. Through technologies, the body becomes the basis of body measurement by translating its everyday processes into graphs, tables, and images [3]. It thus becomes a digitally tangible, measurable, and objectified object [4]. People become "digital data subjects" [5, p. 339]. These human-technological encounters give rise to "digital data assemblages" that are configurations of discourses, practices, data, humans, and technologies [5, p. 336].

One such digital wearables is the actibelt® considered here. According to the vision of the protagonists, the actibelt is seen as a desirable future and the best solution to current problems [7]. Technicians describe the sociotechnical future vision of actibelt as a digital wearable in the shape of a belt. Inside it is an accelerometer that measures and records movement data. This data provides information about the type and intensity of human movements. Furthermore, the number, frequency, and amplitude of steps can be measured. These data can be used to make conclusions about gait quality [7]. The movement data of people with multiple sclerosis were recorded in order to create activity profiles and to make statements about movement quality. Physicians can use this data to adjust therapies for people with multiple sclerosis (MS), such as medications or physical therapy. People with multiple sclerosis appreciate the inconspicuous design of the actibelt and that their changed gait pattern can be "translated" into "objective" data and graphics.

However, many medical technologies are based on the scientific approach to disease and health and thus on the dominant biomedical model of disease [8]. This disease model assumes a strict distinction between body and mind and that the body should be treated much like a machine. The focus is not on the human being, but on the disease as a functional disorder that must be cured with the appropriate therapies or technologies. This understanding corresponds to a technological fix in which the patient is an object whose dysfunctions or problems can be solved (by technical devices). This way of thinking corresponds to the separation of technology, nature, and society, against which several scholars such as Merleau-Ponty, Spinoza, Deleuze and Guattari, and Latour argued and emphasizing the entanglement of humans and non-humans [1]. The poststructuralist emphasis on language, discourse, and symbolic representation is reinforced by a turn to the material: the embodied practices of humans and their interactions with objects, space, and place. The theoretical framework of new materialism is against human centrality and analyzes embodied, embedded, relational, and affective connections between humans and non-humans [9]. The Actor-Network-Theory (ANT) [10] also rejects this dualistic way of thinking and a priori dichotomies such as object/subject, technology/society, inside/outside, or micro/macro. The ANT understands the construction of knowledge and technology not as a singular and linear process but as a dynamic network of relationships, which only takes on concrete form through the relationships of the individual actors to each other. Thus, these networks are heterogeneous and diverse [11].

New perspectives are provided by recent work at the intersections of feminist techno-science studies and critical disability studies that challenge ableist and curative understandings of technology development. The Crip technoscience approach [12] understands disability, not as a deviation from the normal that needs to be fixed, cured, or eliminated. Accordingly, people with disabilities should be "experts and designers of everyday life" [12, p. 2] and should be an essential starting point for technoscience research: "Crip technoscience privileges disabled people as designers and world-builders, as knowing what will work best and developing the skills, capacities, and relationships to make something from our knowledge." [12, p. 7].

One way to incorporate the perspective of the Crip technoscience approach into technology development is through participatory Technology Assessment (pTA), because pTA understands potential users as "real" partners and involves them in the entire technology development process. Participatory Technology Assessment (pTA) is about reaching or negotiating consensus or compromise in technology conflicts with the participation of citizens and social groups. In these negotiation processes, potential users are involved by means of social discourses, scenario workshops, conferences, etc. In this way, their attitudes and behaviours and the cognitive and emotional dispositions behind them can be studied more closely [13]. The trend to involve experts and potential users early in the development of technology by means of interviews, special programmes, and questionnaires in the production of knowledge is referred to as the "participatory turn" [14]. Participatory methods of TA are also used to demonstrate the development of a technology from the direct viewpoint of the people and to include their opinions, attitudes and judgements in current debates and decision-making processes [13]. These procedures and instruments, which enable the participation of potential users and are used in the negotiation process, can be understood as "translation instruments" [15, p. 126]. These translation instruments are epistemic objects or non-human actors whose task is to mediate and bridge between heterogeneous social groups of actors, e.g., experts and citizens, and their specific orientations and knowledge bases. In this way, the wishes, fears, interests, and preferences of the technology developers and consumers of the new technologies can be made visible. Often, technology-related visions of the future are used for this purpose, in the form of mission statements, scenarios, and visions.

This paper was motivated by the intention to learn more about the role of non-humans and about the practices and impacts of human-nonhuman interrelations in the processes of negotiation and translation in the (re-)constructions in technology. For this purpose, we combined the pTA approach with ANT, which seems to be particularly suitable, because it understands science and technology as a result of the interaction between different actors, both non-humans and humans [16, 17]. From this perspective, technical objects are a result of the shaping of many interconnected and heterogeneous elements. For actor-networks to emerge, non-human and human actors need to connect. Translation is how different interests are translated before actors are enrolled in the network. This process is a key part of network building in ANT and is described as a translation process [18]. In ANT, the translation work is presented in a relatively undifferentiated way. ANT also makes it possible to understand non-human actors as active participants in social processes and to make their special importance for the development and stabilization of the actor network visible. In this way, the translation work of non-human actors can be made visible, which contributes to the development of a stable network.

The focus is on the "desirable technology" [6] of the actibelt. The aim of this article is to differentiate the translation work as acceptance work and to identify different modes of acceptance work of non-human actors. The following question is the focus of the analysis: *What acceptance work/effects do/do not non-human actors contribute and what impact do these have on people with MS?* This should help to achieve a better understanding of how technologies are developed, stabilized and acceptance gained, as well as to determine the roles that non-humans play.

For this purpose, a case study on actibelt® technology (www.actibelt.com) was conducted. The case study focused on the participation and contribution of non-human actors to technological development to achieve stability and, thus, acceptability of the technology.

The paper starts by describing the theoretical framework of the ANT, the approach of translation, and the understanding of acceptance and acceptability from the ANT perspective. Subsequently, an outline of the case study is presented, the methodology explained and the findings of the (technical) actibelt®-Actor-Network, and the different modes of acceptance work reported. Finally, the relevance of ANT and non-humans to the acceptability of technologies is reviewed in the discussion section.

Theoretical Framework

The Actor-network-theory

The Actor-Network-Theory (ANT) [10] first appeared in the field of Science and Technology Studies (STS) by Bruno Latour, Michel Callon, John Law, and many other colleagues. ANT declares that the world is full of hybrid entities containing both human and non-human elements and was developed to analyze situations where separation of these elements is difficult. According to the ANT, the term 'actor' is not restricted to social entities, since non-human actors are also viewed as agents [19]. The ANT describes the non-human actors, as those that offer the possibility of holding society together as a durable whole. Everything that changes a given situation by making a difference is an actor [20]. ANT does not conceptualize technology as something fixed and permanent but as something that must be reproduced repeatedly. Accordingly, technology is the moment at which social constellations are maintained by the grouping of actors. Society and technology are not two ontologically different units but phases of the same action [21]. "Accordingly, technical objects must be seen as a result of the shaping of many associated and heterogeneous elements. (…) Therefore, we cannot describe technical objects without describing the actor-worlds that shape them in all their diversity and scope" [19, p. 23]. A significant advantage of ANT in relation to alternative approaches to understanding the acceptability of technologies is that it treats both people and technological artefacts symmetrically and thus can expose relationships and contexts which are more difficult to detect using other approaches.

The Sociology of Translation

For actor networks to emerge from individual entities, the entities must connect with each other. In ANT, this process is conceptualised as translation. The term translation is a key approach in ANT and is understood as the translation of interests. The approach was theoretically developed by Callon [18], and he called this process “translation”. Using the sociology of translation, it is possible to look at the emergence and change of actor networks. For Callon [18, p. 18], “Translation is the mechanism by which the social and natural worlds progressively take form”. He understands translations as processes of displacement and transformations, e.g., of goals, interests, and devices [18, p. 18]. Thus, the translation process brings together different actors, who must share a common goal. Translations play a central role in the creation and stabilization of actor networks, creating actor worlds from individual actors. It is only through networking and integration into networks that the individual human and non-human actors become enabled to act. For a stabilized network of actors to form and temporarily stabilize, the translation processes must be constantly repeated.

Callon [18] has described the complex translation process in four phases. These phases, or moments, illustrate the structure, the problems, and the importance of translation processes for network formation for a temporary stabilization of actor networks. The phases of (1) problematization, (2) interessement, (3) enrolment, and (4) mobilization, as well as the optional phase of dissidence, can overlap.

1. Problematization is the first step in building a network and has the aim of creating a common awareness of the problem. For a common action to be possible, others must also perceive it as a problem, make it their problem, and be interested in a common solution. Common interpretations and definitions must be constructed. The translating actor formulates the problem in such a way that it is also accepted as a problem by others. The main actor then identifies other possible actors whom he wants to involve in the network and defines their identity. He tries to convince them that his proposed action program is the solution to the problem [18].
2. After a common awareness of the problem has been achieved, the aim of the interessement phase is to determine and stabilize the identities of the other actors defined in the first phase. In the interest phase, an entity attempts to impose and stabilize the identity of the other actors identified during problematization. To achieve this, different devices are used [18].
3. If the determining of interest is successful, the third phase of enrolment begins. In this phase, the alliance of the actors involved must transform from a hypothetical to an actual network. The actors must accept the roles assigned to them [18].
4. In the mobilization phase, the actors are mobilized. The previously immobile actors are mobilized and participate in an exchange with one another [18]. To maintain the stability of a network of actors, convergence and irreversibility must be present. Convergence, because the actors behave reciprocally in the way expected of each other, but also that they fit together despite their heterogeneity. In this context, convergence means the extent to which the translation process and its circulation of mediators lead to an agreement [18].

The connections between the actors and the network of actors are not permanently stable but exist only temporarily. They can be disputed at any time. If the common consensus and the established alliances are called into question, the translation becomes a betrayal [18]. This moment is called dissidence. For the associated actors to continue to adhere together and maintain a stabilized network of actors, the various moments or phases of the translation process must be performed repeatedly and successfully in an iterative process [18]. These phases of translation illustrate how actor networks are created by translation processes from heterogeneous actors and indicate the relevance of non-human actors. This is pertinent to this paper because it shows the importance of the acceptance work of non-human actors in the translation process and in the creation of the actor network–and therefore their contribution to the acceptability of technologies. According to the understanding of Callon [18], translation is a transformation from one element to another. But how exactly the translation work is done is still not known. Therefore, the aim of this article is to differentiate translation work from acceptance work and to identify the different modes of acceptance work of non-human actors. This should help to achieve a better understanding of how technologies are accepted by people with MS gained, as well as determining the roles that non-humans play.

Acceptability of Technology from the Perspective of the ANT

The concept of acceptability plays a central role in this work since whether, and to what extent, non-human actors contribute to the establishment of acceptability will be examined. For this purpose, it is useful to define the concept quite broadly. According to the ANT, acceptability is not seen as something fixed but as something fluid. Following the notion of translation, the participation of non-human actors is seen as a necessary condition for the mechanism of network formation. Accordingly, the mediation and translation work are conceptualized as *acceptance work*. The stability of the network of actors, characterized by convergence and irreversibility, is thus understood to be the *acceptability of the technology*.

Methods

The Case Study Actibelt®

Using a case study as an example to illustrate the involvement of non-human actors, the development history of a technology for body tracking was investigated. The research object was a body tracking technology called actibelt®. The actibelt® is a mobile, portable technology for tracking the physical activity of a user, using a belt with a buckle that contains a motion sensor. In the past, physical activity, somatic complaints, or well-being were assessed either by the people with MS themselves or by a health professional through examination and subsequent evaluation. Nowadays, technology can assume this task, tracking physical activity over several days [22, 23].

The first prototype version of the actibelt® was initially tested in a clinical study at a neurological clinic of a large hospital in Bavaria, Germany from May 2007 to December 2008. The clinic managed both the medical care of people with MS and the data collection in the study. The aim of the clinical study was to investigate the basic requirements for the application and applicability, safety, and handling of the actibelt® in volunteers. According to the crip technoscience approach, “disabled people are experts and designers of everyday life” [12, p. 2], the study included 20 people with MS.

Body tracking can be understood as a new kind of connection between technology and the body because it, “transforms the opaque and passive body of the pre-digital age into the informational self. Networking is the way in which order – personal, social, and ontological – is constructed in the digital age.” [24, p. 25]. Through the practices of body tracking, socio-technical actor networks are created. The body becomes a digitally tangible, measurable, and objectified self [4]. This suggests that technologies for body tracking, if they are considered only as isolated technical artefacts, are not adequately understood. They are the result of the design of many interconnected and heterogeneous actors [19], i.e., a complex network of actors, as described by body tracking, form an actor network that is a complex continuum overcoming the distinction between biology and psychological intentionality, subjective feelings and interpretations, and the distinction between physical and virtual reality. Through the practice of body tracking, the self is constructed as a hybrid, socio-technical network of actors within the framework of a “mixed reality” [4, p. 397]. According to the ANT, the relational nature of technology is emphasized and is understood as the result of continuously produced and reproducing activities. From the perspective of ANT, technologies such as actibelt® are not fixed and permanently existing but must be renegotiated and produced again and again.

Methods for Data Collection and Analysis

The actibelt® was chosen because it is a “non-stabilized technique” [25] meaning that its development work had not yet been completed. It is interesting because it allows for the possibility of finding mediators who act as links between the technology and the user [25]. These mediators are the developers and the users of the actibelt® included in the study. The mediators were interviewed by means of 38 expert interviews [26, 27]. The interviews were with the actibelt® “founder” (physicist) (4 interviews), a computer scientist (1 interview), and physicians (all neurologists) (3 interviews), a mathematician (1 interview), a communications scientist (1 interview), nurses (3 interviews), physiotherapists (2 interviews), and people with MS (23 interviews). In addition, three focus groups were conducted with people with MS who had worn the actibelt® in the clinical study; workshops and events presenting the actibelt® were attended; documents and other actibelt® material were analysed; and participating observations in a large hospital in Bavaria were made. The 38 expert interviews and three focus groups were transcribed with f4 according to the simple transcription rules [28] and evaluated, together with the other materials, using the analysis software Atlas.ti.

For the evaluation of the theory-generating expert interviews, we used the research style of Grounded Theory [29, 30]. The aim was to explore the experts' interpretive knowledge, i.e., to identify the principles, rules, and values that significantly determine the experts' thinking and interpretation. It is interesting to learn something about the experts' thinking and interpretation because we assume that the experts' actions can be explained by recourse to those meanings that are assigned to the respective things and values. The reason why it is interesting to learn something about the experts' thinking and interpretation is that we assume that the experts' actions can be explained by recourse to those meanings that are attributed to things and processes [27]. Grounded theory is not considered as a method or methodology but as a particular perspective, or approach, to the social world, or a particular research style [29] to approach and reflect on social reality. In doing so, it does not fall back on preconceived concepts or theory but stands for the greatest possible openness to different possibilities of interpretation [27].

The process of data analysis included the following steps [30]: data familiarization; generation of open, axial, and selective codes; writing of memos; and reporting of findings. These steps were not always followed linearly, but rather in an iterative process.

Results

The actor network of the actibelt® was reconstructed from the perspective of the ANT and the sociology of translation. Special focus was put on non-human actors and their acceptance work. The non-human actors were found to have created strong alliances and connections between the actors, merging their interests, wishes, and needs. Five different modes of work by non-human actors that led to acceptance were identified. The (technical) actibelt®-Actor-Network and the five modes of acceptance work are described below.

The (Technical) Actibelt®-actor-network

According to the ANT, the body technology actibelt® must be understood as a formation of Actor-Network and a permanent process that is never complete. Figure 1 illustrates the technical actibelt®-Actor-Network consisting of the socio-technical discourse, research and development, events, social science methods, and quantified data. This simplification should not hide the fact that each actor must in turn be a network, which in turn is a series of actors. For each actor assembles a cascade of other entities, which are represented under each actor. For example, actors such as *interviews*, *focus groups*, and *surveys* assemble behind the actor *social science instruments*, and *conferences*, *workshops,* and *forums* assemble behind the actor *events*.

Figure 1 presents the analysis of the actibelt®-Actor-Network of the state during the research period. This means that there are potentially other actors who, in the understanding of the approach of translation, can enter the actor world at any stage. These illustrate the empty fields.

Different Modes of Acceptance Work

According to the ANT and the approach of translation, translations are necessary to turn individual actors into actor worlds, whereby these translations can be understood as processes of displacement, dislocation, or transformation [17]. The assumption of the work is that the theoretical concepts of ANT and the sociology of translation cannot present the mediation and translation work in a sufficiently differentiated way. The aim of the following chapter is to take a closer look at mediation and translation work, here conceptualized as acceptance work, and to identify different modes (or patterns) of acceptance work by non-human actors. It will be examined which acceptance work (or effects) non-human actors do (and do not do) and their respective effects on people with

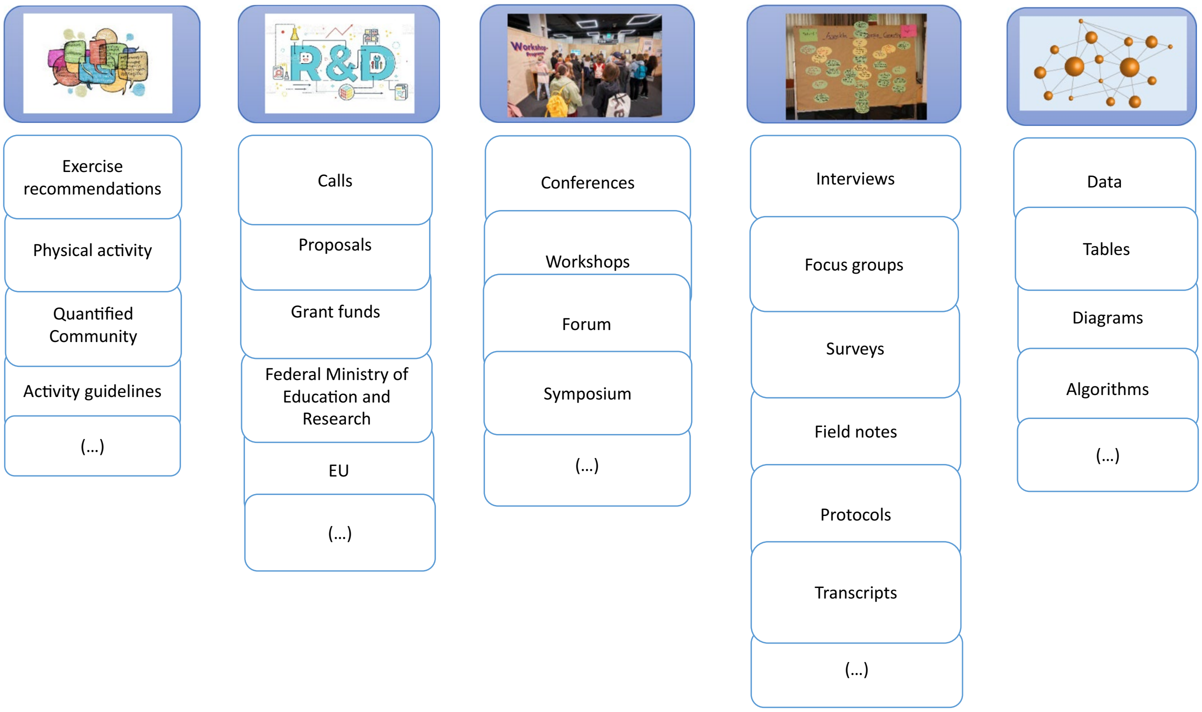

Fig. 1 The (technical) actibelt®-Actor-Network

MS will be considered. As a result, five different modes of acceptance work by non-human actors are identified, which are described below.

Mode 1: Acceptance Work Mediated by Events

The results showed that events, meetings, and workshops provided mediation opportunities for the development and stabilisation of the actibelt®-Actor-Network, thus, can contribute to acceptance: they brought together different groups of actors, defined the problems, generated interest, and conveyed information on the actibelt® action programme. Through these mediators, new actors were integrated into the network.

An example is a symposium that took place in the hospital where the clinical study on the actibelt® was performed. The symposium brought together different groups of actors, health professionals, people with MS, and their relatives. The people with MS showed a great deal of interest in this type of information gathering. They wanted to obtain information about their disease independently, "*I have mainly informed myself*" (D32: 13). They liked to attend events where they could increase their knowledge, "*I always go to the symposia (…) There was also an MS workshop in the afternoon, which I found quite interesting and when the symposium came on Saturday, it was clear to me that I would go there (…). You should listen to this*" (D 34:19). Both the symposium and the workshop for people with MS positively contributed to people with MS agreeing to participate in the clinical study on the actibelt® and, thus, integrating them into the network of actors. "*Then I said yes, I'll take part, why not. I can do well without being restricted.*" (D 34:19). Another person with MS reported that the symposium contributed to her decision to participate in the study: "*I had already looked at this before during the symposium and I thought, you could do that. After the episode, the Dr. [name of physician] asked me and I said to myself, 'Yes, you're doing that now'*" (D 16:6). The events and meetings contributed to stakeholders getting informed and sharing their interests and expectations with each other.

In contrast, meetings that did not occur contributed to a certain disappointment that, in turn, led to a weakening of the actor network. This was made clear in a statement by a person with MS in the study who was part of the actibelt®-Actor-Network. She had invested time and effort in driving to the clinic despite, "*a rather tight schedule*" (D34:10), in order to inform the physician about a defect battery and by driving there again to collect a new belt with a functioning battery. However, since the promised final discussion with the physician did not take place, she was very disappointed,

> *I had taken my time when I returned the belt, because he said that we would need half an hour for a final discussion. But then he had no time. In principle I gave the belt back and then I left again. It was a little unsatisfying because it was actually planned differently (D 34:10).*

The disappointment of not meeting the doctor contributed to the patient losing trust in the doctor-patient relationship and in the actibelt.

Mode 2: Acceptance Work Mediated by Medially/Graphically

Acceptance work can mediate by lectures and presentations at events and meetings, where flyers, leaflets, and information brochures were also available at market stands. These non-human actors helped to define problems, raise interest, translate the use of the actibelt® and, thus, integrate new actors into the actibelt®-Actor-Network. The following statement describes how the brochures raised interest in actibelt.

> *I have mainly informed myself. There was a stand with information on various illnesses, there was a leaflet on the belt, and I read through it. (Because) I always read the information about my illness. Then someone came to me and asked if I would like to participate in the study. I said, yes, why not, I've already read about it, I've already been informed by the brochure and I would like to participate. (D 32:13)*

It is shown that both events and brochures can motivate people with MS to participate in the study, "*Then someone came to me [at the symposium] and asked if I wanted to participate in the study*" (D32:13), especially since the use of the actibelt® seemed to have no disadvantages whatsoever, "*I said, yes, why not, I have already read it, I am already informed about the prospectus and I would participate without being greatly restricted*" (D34:19). The lectures, flyers, leaflets, and information brochures provided people with MS with knowledge about the clinical trial and the actibelt®. For example, one lecture informed a person with MS that physical activity is a good "therapy" for MS and that the actibelt® helped to analyse the movement. He also notes, however, that there was not enough information and that he would have liked to learn more in order to better understand the aim and purpose of the actibelt®,

> *I also told the gentleman from XX that he had misinterpreted his lecture. He had also briefly presented this actibelt®, but he did not really explain what the important aim is and what the purpose should really be (...) what it means to be active (...) what this then has, also for positive consequences for people with MS. I would have simply wanted more detailed information. It wasn't incomprehensible, I just didn't have enough. (D 33:8)*

The next example shows that non-human actors, such as flyers, can also inhibit acceptance work. A person with MS read on a flyer on the internet that the actibelt® is to be connected in the future to Google Earth via satellite and that it would be possible to create movement profiles. The flyer led to concerns and fears on the part of the person with MS that this function was already possible today, but that it had not yet been communicated. The person with MS formulated his fears as follows,

> *The fact is that it is possible via satellite, because the satellite has already been shot up. (…). Normally they can see your movements and, therefore, you via GPS. You walk around like a dot on the map. They can see you no matter what you do if you wear your belt. Imagine that. And that would bother me. I'm worried about that. Will I be totally supervised? (D 5:33)*

The fear of being monitored when wearing the actibelt® can lead to a loss of trust, scepticism, and, finally, to the rejection of the actibelt®, resulting in the destabilization of the actibelt®-Actor-Network as the person's statement shows, "*But for me personally now, I can't quite get used to it (…) these are just my concerns. I mean, this is only the initial phase. But the whole thing goes on" (D 5:37).* The person with MS continues, *"I am very sceptical about this*" (D

5:99). This shows that the person with MS had other expectations of the actibelt and these cannot be compatible with the actibelt.

Mode 3: Acceptance Work Mediated by Quantification of Data

The actibelt® action programme, represented by non-human actors, actively convinced several people with MS to participate in the study, resulting in their integration into the actibelt® network of actors. People with MS saw the actibelt® as, "*a great new opportunity to gain data about the course of the disease, which is otherwise not so easily accessible*" (D 4:4). Other people with MS were impressed by,

> *The more objective perception (of the actibelt®) when I notice I am not feeling well. If I then had such a belt (...) I would attach it to my own computer and get an evaluation where everything is explained. I can see that my subjective perception is confirmed by the diagnosis. (D 5:28)*

Others saw the actibelt® as, "*a good possibility as a supplement to a diagnostic method*» and as «*a diagnostic instrument that is very easy on people with MS*" (D 5:57).

The actibelt® was perceived as a body tracking technology that opened new possibilities for translating body data into figures, tables, and graphics and for receiving evaluations. "*Mr XX asked me if I would like to take part in it and, with the new diagnosis, I am interested in finding out as much as possible about myself. I then took part. Since this is a drug in quotation marks, which has no side effects, I was happy to participate*" (D 33:29). In addition, some people with MS associated the actibelt® with the hope that their subjective perception could be translated into objective figures,

> *Or even the more objective perception if I notice that I am not feeling well. If I then had a belt or a band like that, or something, connect it to my own computer and get an evaluation, where everything is explained on it. That's how I see how my subjective perception is confirmed by the diagnostics. That would be another positive aspect. (D 5:28)*

The quantification of data fulfilled two important functions in the actibelt®-Actor-Network. It contributed to making the physical condition of people with MS more objective.

> *This is important for me now because I have the impression that I walk less well. The physicians say, no, I'm going to walk right away - so it's still the same as before. The physician says I can't judge it, because I only have snapshots of how they are walking. It's important for me whether it's the same from walking or has got worse. (D 5:100)*

In addition, the quantification of body data strengthened the relationship between people with MS and physicians in the actibelt®-Actor-Network by increasing peoples' credibility with the physician. "*If it gets worse with walking and you have it in black and white, then you (the doctor) are more likely to believe it. The data is more objective*" (D 5:97).

However, the different expectations toward the data can destabilise and stabilise the actibelt®-Actor-Network. Data recording unsettled some people with MS and they saw no additional benefit to themselves. One person with MS even went as far as to see the actibelt® as a privacy restriction and felt controlled and monitored while wearing it. That was the reason that he rejected the belt and was sceptical about it,

> *For me this is the same as cameras everywhere. That is total control. I personally resist it. That's why I felt restricted in my movement somewhere by the belt in my privacy. Somehow the whole thing was uncomfortable for me. (...) Although I might get something positive later with the evaluation, I was at first completely negative. For me, the belt must bring me something positive first, where I say that's good for me. Then you can change my mind, but if I don't see anything positive, I am still sceptical of such new technologies. I don't know why, but it's true. (D 5:5)*

The evaluation and explanation of the data were shown to be important to the stability of the actibelt®-Actor-Network. The following person with MS example shows that an evaluation meeting that did not occur contributed to destabilisation.

> *This would also be very important to me. It has been quite a while now. First the symposium and then Dr. XX wanted to call and make an evaluation. But I don't know whether the whole*

> *thing has worked at all now. Personal feedback would be good. I would have liked that. I hope and think that it will come. But if I'm going to do something like this in the long run, I want to be involved. (D 5:25)*

Mode 4: Acceptance Work Mediated by Sociotechnical Discourses

The analysis showed that sociotechnical discourses such as "physical activity" and "exercise as therapy" played an important role in the translation process. They establish connections from the actibelt®‾Actor Network to other networks and increased the actor network. Sociotechnical discourses are addressed in lectures, discussions, and the symposium, thus raising peoples' interest in the actibelt®. If one's own ideas correspond to the discourse addressed, then this contributes to the integration of people with MS into the network. One person with MS reported,

> *(…) when I met the man (...) in April, he gave a short talk. (...) he also said that the most important thing for all of them is movement in this illness. Actually, exercise is a much better medicine than, in case of doubt, any pharmaceutical. (...). I don't have a washboard stomach and I am a normal person, but I have always been moderately active in sports. (...). That's why I also believe that sport in general can be a good medicine, and that actibelt® can perhaps help quite well. I found that quite interesting for me [and] it correlates with my well-being. (D 33:7)*

The person with MS also referred to the sociotechnical discourse and connects it with the actibelt®-Actor-Network,

> *The really important thing for people with MS is that research finds that movement is the important thing (...). I am now doubly motivated to go hiking this summer. Simply through this conversation, which I had at the symposium, I learned once again that movement is the most important thing. (D 33:30)*

Another person with MS referred to the sociotechnical discourse of "physical activity", both to people with multiple sclerosis and to herself. This indicates that discourses can contribute to role-taking and thus to enrolment in the actibelt®-Actor-Network.

> *Exercise and sport are even more important for people with MS than for the normal population. An American researcher once said that if a person with MS wants to achieve in everyday life what others do in everyday life, then they have to do as much as the ordinary citizen would have to do for the Olympic Games. I notice that even with me. As a person with MS, in order to have the same walking ability or performance, (...) you actually have to invest more. (D 27:7)*

Another person with MS also emphasized the socio-technical discourse and its contribution to involving people with MS in the actor network and strengthening the connections within the actor network, "*I really think it is very important that they do intensive advertising for this project, not only technically but also medically. (…) In my opinion, this would be the most important thing of all, because otherwise there will certainly be no acceptance by people with MS*. (D 33:17).

Mode 5: Acceptance Work Mediated by Scientific Methods

The results showed that also social science instruments fulfilled important functions as links in the translation process. The focus groups, interviews, and thought experiments translated peoples' experiences, opinions, and attitudes towards the actibelt®. They also encouraged people with MS integration into the actibelt®-Actor-Network. Thus, the social science instruments strengthened and stabilised the users' connections to the network of actors.

The contribution of focus group discussions is illustrated by the following examples. One person with MS said the following at the end of a focus group,

> *What I liked about the discussion round was that I was taken seriously as a person with MS. The concerns of the people with MS [...] that these are included. [...] But I feel good about it. I have the feeling that I am doing it, that I can express my concerns and that I feel somehow taken seriously. I find that pleasant. (D5:73)*

She emphasized that she felt taken seriously by the focus group because she was able to express her concerns about the actibelt®. The person with MS also noted that the focus group helped to change her rather negative opinion of the actibelt® into a positive one, "*I have slipped two points on the scale. In all the questionnaires, I always ticked off rather meaninglessly*" (D 5:72). Another person with MS noted that the focus group changed his opinion of the actibelt®. Thus, the focus group and the associated discussion and intensive examination of the topic that took place contributed to the fact that his sceptical opinion at the beginning changed to a positive one at the end, "*I also found it very good and positive that we initially placed the emphasis on scepticism. So, do I. And then we concluded that the company could serve us almost nothing better. Keep it up, keep it up, so that we can profit from it one day*" (D 4:7).

The examples show that the focus groups generated interest in actibelt® and thus created allies of the actibelt®-Actor-Network. The focus groups contributed to the integration of people with MS into the actibelt®-actor-network.

Another person with MS emphasised the pivotal importance of the focus group for the actibelt®-Actor-Network. To be taken seriously by the physicians on the one hand, but also by contributing to the development of new findings through her experience in handling the device. However, she was surprised and simultaneously disappointed that no physicians participated in the focus group because the people with MS also see themselves as part of the actibelt®-Actor-Network, "*one also works together with the physician*" (D 5:26). The absence of the physician was seen as a lack of appreciation of the people with MS and contributed to the weakening of the network,

> *So, I expected the medical part of the event to be there. That is missing a bit here, because it is also part of the study. You don't carry just any object, but a medical diagnostic device. So, I would like to see more people with MS research carried out. That was also a reason for me to participate in the study. That you have contact with the doctors here, that you can build up a relationship of trust. (D 5:73)*

In their opinion, the presence of the physician at the focus group in the form of a "*short introduction here and now*" (D 5:26) would contribute to strengthening the network. Furthermore, by including people with MS in the study, the trust relationship between people with MS and physicians can be enhanced.

Conclusion

The aim of the study was to illustrate the relevance of non-human actors to the technology development process using a "desirable technology" [5] as an example. Five different modes of acceptance work of non-humans can construct based on the actor-network theory (ANT). The analysis of the technical network of the actibelt from this perspective has shown that non-humans are an important element of the translation mechanism in different ways. The acceptance work of non-human actors can facilitate, inhibit, or even determine the stability of the actor-network. Acceptance work of non-humans is the work that is necessary for a heterogeneous network to be established at all. Through ANT and the approach of translation and the typology can be used to better understand how new technologies are developed and manufactured as a stable network. The ANT relational-material view of the acceptability of technologies makes it possible to take a symmetrical view of the topic and acceptability of technologies as shifts in networks. The study has shown that non-human actors are neither passive nor mere tools but have a mediating function in the emergence and maintenance of the acceptability of technologies by mediating between people and thus producing, disrupting, or shaping the acceptability of technologies. The case study is an example of a close entanglement of human and non-human entities and a trend towards a "manufacture of life" [2].

The non-dualistic perspective chosen for the study, and thus the theory and method of ANT combined with pTA, proved to be appropriate for the research interest in that it allowed for a change in perspective on the complex issue of technology acceptance. The use of the non-dualistic view of ANT was meaningful and useful in that it can capture aspects where things are "changing fast" and "where boundaries are so terribly fuzzy" [20, p. 142]. That is, wherever *new* topics [20], and relationships between humans and technology emerge. This perspective was worthwhile because it made visible the close entanglements and interactions between human and non-human entities of the technology actibelt. In this way, it was possible to understand the acceptability of technologies as actor-networks and network effects and not, as in conventional technology acceptance models, as appropriation by individual actors. Moreover, the elementary role and so far, invisible work of non-human actors in the production and (temporary) stabilization of technologies could be better understood.

For the network also includes human actors in addition to the non-human actors. This is because neither human nor non-human actors act alone, but only become capable of acting in a joint actor network. However, for a temporarily stable actor network to emerge, human actors are necessary in addition to non-human actors, and they must connect with each other. The contribution of non-human actors became visible, helping to include people with MS in the actor network and giving them a voice in technology development. The Crip technoscience approach [12] offers a good way to actively involve people with MS in the shaping of new technologies. The types of acceptance work could be used to structure the engagement of human actors to include people with MS as "*knowers and makers*" according to the Crip technoscience approach. The needs of people with MS could be the starting point of technology development rather than a problem solution or technology-driven idea. They would be involved in technology development as peer partners and experts on their own conditions.

The question arises to what extent the concept and the different patterns of acceptance work can also be found in other technology developments. The five patterns identified–acceptance work mediated by events, acceptance work mediated by media and graphics, acceptance work mediated by quantified data, acceptance work mediated by socio-technical discourses, and acceptance work mediated by socio-scientific tools–also apply to other technologies in the technology development process. Due to the conceptualisation of technology and acceptability, these patterns are not only typical for digital wearables. For technology was understood as an actor-network and not as an isolated object, and acceptability was not conceptualised as something fixed but as a network effect. In this respect, what has been described here as acceptance work is not limited to digital wearables but can also be valid for other technologies.

Furthermore, it should be investigated whether and to what extent the impact of the different modes of acceptance work can be differentiated. It would be exciting to look analytically at whether some types contribute more and others less to the successful alignment and synchronization of the actors' network.

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Declarations

Conflicts of Interest Not applicable.

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