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Spacetimematter of aging – The material temporalities of later life

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ABSTRACT

Material gerontology poses the question of *how* aging processes are co-constituted in relation to different forms of (human and non-human) materiality. This paper makes a novel contribution by asking *when* aging processes are co-constituted and how these temporalities of aging are entangled with different forms of materiality. In this paper, we explore the entanglements of temporality and materiality in shaping later life by framing them as *spacetimematters* (Barad, 2013). By drawing on empirical examples from data from a qualitative case study in a long-term care (LTC) facility, we ask how the entanglement of materiality and temporality of a fall-detection sensor co-constitutes aging. We focus on two types of material temporality that came to matter in age-boundary-making practices at this site: the material temporality of a technology-in-training and the material temporality of (false) alarms. Both are interwoven, produced and reproduced through spacetimematterings that established age-boundaries. Against the backdrop of these findings, we propose to understand age(ing) as a situated, distributed, more-than-human process of practices: It emerges in an assemblage of technological innovation discourses, problematizations of demographic change, digitized and analog practices of care and caring, bodily functioning, daily routines, institutionalized spaces and much more. Finally, we discuss the role power plays in those spacetimematterings of aging and conclude with a research outlook for material gerontology.

Introduction

"At the heart of temporalities… are questions of being/becoming" (Barad, 2013, p. 17)

Time is essential in aging research. Many scholars in gerontology and age studies have noted that the social construction of age(ing) depends at its core on different notions of time. Most obviously, calendar age is determined by the amount of time passed since our birth, and one's position in the life-course – may it be at its beginning or at its end – is constructed and stabilized through institutions like school, work, and retirement (Kohli, 2007) and their related temporal norms on when to transition from one life stage to another (Freeman, 2010; Riach, Rumens, & Tyler, 2014). While calendrical and life-course time – represented in calendar age and the life stage of later life – illustrate one-dimensional, linear notions of time, researchers have also acknowledged the multi-dimensionality of time of later life, highlighting how aging is constructed in relation to not just one, but multiple forms of time (Kottmann, 2008; Segal, 2014).

Taking these multiple temporalities of later life as a starting point, researchers in the field of material gerontology (Höppner & Urban, 2018; Manchester & Jarke, 2022; Sultan, 2022; Wanka & Gallistl, 2018) have increasingly questioned how aging processes and their multiple temporalities are co-constituted in relation to different forms of (human and non-human) materiality. Drawing on Rosi Braidotti's concept of the "nomadic subject" (Braidotti, 2002), Höppner (2021) puts forward the idea of a temporally and materially mobile and non-linear aging process, which materializes in different levels of temporality. Building on the idea of "distributed aging" (ibid., p. 217), material gerontology, therefore, situates aging as a multi-faceted phenomenon that materializes in multiple ways and, at the same time, "temporalizes, as it produces diverse (and sometimes conflicting) temporalities" (Wanka & Gallistl, 2018, p. 122).

In this article, we aim to further explore these entanglements of temporality and materiality in shaping later life. Framing these entanglements between materiality and temporality in later life as *spacetimematters* (Barad, 2013) of aging, we ask what can be gained for age studies when we view the temporalities and materialities of aging not as separate from each other but as formed through processes of entangled

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becoming.

To do so, this article takes three steps: First, we introduce Barad (2013) concept of spacetimematter as one way to conceptualize the relational terrain between the materialities and temporalities of aging which highlights how time can never be separated from space or matter (ing) and is thus seen as contingent and non-linear. Second, we explore these spacetimematters of aging at one particular empirical site: an LTC facility that introduced algorithmic fall-detection sensors in the rooms of its older residents. Drawing on data from a qualitative case study that explored the experiences of older care home residents, care staff and technology designers with algorithmic technology in LTC, we ask how one particular materiality – a fall-detection sensor – temporalizes in the lives of older care home residents and hence, co-constitutes aging through entangling materialities and temporalities. Third, we end this article by discussing the relevance of the empirical findings for material gerontological perspectives on age and aging and outline questions for future research.

Theoretical framework: Aging as spacetimematter

Applying a material gerontological perspective to the temporalities of later life, first and foremost, highlights the role of the diverse (human and non-human) material actors in shaping the temporalities of aging, such as clocks that structure everyday life into day and night, animals that demand to be fed at certain times, or retirement gifts, as materialized rites of passage from one stage of life to another. In his classical work, Zerubavel (1981) frames these things through which temporalities materialize and which, in turn, structure time through their materiality "*Zeitgeber*". More recent work has taken up ideas around material *Zeitgeber* and applied the concept to technological artifacts, including algorithmic technologies (e.g., Buongiorno, 2022; Sareen, Remme, Wågsæther, & Haarstad, 2021;). At their core, such accounts of material temporality ask which temporal order is set into practice through technologies, highlighting the temporal flows and rhythms that technologies add to a particular situation. While these engagements with technological temporalities are important to highlight the way temporal orders change in digitized societies, they have so far been hardly connected to the temporalities of aging and later life.

To conceptualize the entanglements between the materialities and temporalities of later life, we draw upon a material gerontological framework (Höppner, 2021; Wanka & Gallistl, 2018), as well as the works of Karen Barad (2007, 2013), who argued to view temporalities and materialities not as separate or exterior to each other, but instead focus on the relational and connected becoming of time and materiality. From her perspective, time does not govern matter and matter does not structure time. Instead, "space, time, and matter are mutually constituted through the dynamics of iterative intra-activity. The spacetime manifold is iteratively reconfigured in terms of how material-discursive practices come to matter." (Barad, 2007, p. 181–182). Hence, Barad frames space, time, and matter as essentially inseparable, as *spacetimematter*. As such, time can never be separated from space or matter (ing) and is thus seen as contingent and non-linear (Kuby & Christ, 2018).

The contingent and non-linear nature of entangled becoming also informs Barad (2013) perspective on materialities, as they are "the materialization of time. Matter doesn't move in time. Matter doesn't evolve in time. Matter does time. Matter materializes and enfolds different temporalities" (Barad, 2013, p. 17). This relationship between space, time, and matter that Barad (2013) refers to as spacetimematter is hence reconfigured by intra-actions – the processes of mutual and co-constitutive becoming – and material-discursive practices that make agential cuts to form certain phenomena as seemingly distinct from others and establish boundaries between them. These agential cuts might be, for example, relevant in separating what is perceived as "old" from what is perceived as "young"; it might, however, also be relevant in practically separating "mundane" materialities from "technological" materialities.

How can the concept of spacetimematter be productive for age studies? We argue that, firstly, through and with Barad (2007, 2013), aging itself can be conceptualized as a phenomenon that is made through *age-boundaries* that are established through agential cuts – as aging relies, at its core, on differentiating what is old from what is not-old. Secondly, reflecting on these boundary-making practices from a material gerontological perspective highlights the ways in which age-boundaries are established through *spacetimematter*. This might refer to how later life is made distinct from other stages of life, such as through temporal codes (being perceived as older or younger than someone else), materialities (using particular age-coded materialities such as walking aids or alarm bracelets), and their relationships; or how older adults are assigned distinct needs and preferences through temporality and materiality (e.g., through the transition to age-coded housing arrangements in later life such as long-term care facilities).

For the purposes of this paper, we therefore put forward the suggestion to view age as a phenomenon that is established through age-boundaries, and that this boundary-making happens through spacetimematter. In the following empirical example, we aim to showcase the fruitfulness of such a conceptual framing of aging, through reconstructing the spacetimematterings of aging in an LTC facility that uses an algorithmic fall-detection system in the rooms of its older residents. We aim to identify the central practices, situations, and artifacts within these spacetimematterings, as well as the processes of intra-actions that reconfigure them. We aim to question how the materiality of a fall-detection sensor, and its related algorithmic temporality, contributes to drawing age-boundaries and, therefore, contributes to the relational becoming of aging, materiality, and temporality.

Material and methods

The case of algorithmic fall-detection systems in long-term care (LTC)

To explore this entanglement between the materialities and temporalities of aging, we draw on a multiple-perspective qualitative interview study (Vogl, Zartler, Schmidt, & Rieder, 2018) that was conducted in a long-term care facility in Austria that uses algorithmic fall-detection sensors to detect, and alarm, care staff about falls that happen to older adults living there. Being used as remote monitoring systems, algorithmic fall-detection software is one of the biggest areas of development in the field of algorithmic and automated decision-making systems for older adults (O'Connor, 2022). One well-documented challenge of such systems that continuously monitor older adults' behavior is a high false alarm rate (Kangas, Korpelainen, Vikman, Nyberg, & Jämsä, 2015; Rantz et al., 2015). Privacy, data security, and data protection are also issues that are frequently discussed in research on monitoring technologies for older adults (Pol et al., 2016).

In the case analyzed here, the algorithm of the automated fall-detection system had initially been trained to detect falls, but as technological development moved forward, the system was increasingly used for several purposes. Most prominently, the monitoring system was also being used as a fall prevention system, and the algorithm hence aimed at not only detecting falls after they have happened but also at identifying behavior that was seen as being associated with a high risk of falling down, such as raising and sitting in bed, sitting sideways in bed or getting out of bed. The system also had a setting that could be activated to sound an alarm if a person did not return to their room for a certain period of time. The sensitivity of the algorithm, as well as the specific settings, could be adjusted by care staff and care management through a web-portal, while older care home residents had no possibility to change the system and its settings.

The algorithm used in this system is trained through 3D depth data, which is gathered through sensors which – unlike visual data from cameras – make it difficult to identify persons that were being monitored. The depth data taken by the sensor was perceived by the developers to be more abstract, as only shapes of people, furniture, and rooms were identifiable through this data. One central challenge of an algorithmic fall-detection system as used in our example is that training data is hardly available, which meant that developers had to find creative ways of building and gathering "ground truth data" to train the system. For this, they would use (abstract) image data on body movements from existing data banks, gather at least some "real world data" in hospitals, and then also expand this real-world data with synthetically created data. To synthetically create data, developers would (among other things) use motion capture suits to create data about different movements and types of falls. This meant that the algorithm used needed some time to adapt to the specificities of LTC, as training data was mostly gathered in other contexts, such as hospitals, or synthetically created by software developers.

Data collection and analysis

The empirical work for this interview study was set in a long-term care facility in Austria. The facility hosts around 150 older adults in need of differing levels of care, both for long- and short-term care. The care provider company that runs this facility has purchased several algorithmic fall-detection systems; 51 of them were running in the care facility under study. These systems monitored the behavior of residents through 3D sensors that produced depth images that – different from traditional video surveillance through cameras – contained information relating to distances of surfaces in a room. Based on this data, the system calculated a confidence interval of a fall happening in a particular room, and, based on automated decision-making processes through algorithms, alerted the care staff if a fall was observed. Care staff received notifications of these alarms on mobile phones, while older residents had no possibility to actively engage with the sensor.

Fieldwork was conducted during August–October 2021, initially to examine the implementation of an algorithmic fall-detection system for long-term care. Data collection took multiple perspectives and sites of research into account: The study began with six interviews conducted with programmers, coders, and technicians at the company that produces the algorithmic fall-detection system for long-term care settings. The research team also held one half-day workshop with a researcher at this company to gain insight into how the algorithm functions and how data to train the algorithmic models is produced and collected. After this, the research team conducted seven interviews with care staff in stations where the fall-detection system was in use and five interviews with older care home residents who lived in rooms where the fall-detection system was stationed. Besides the twelve interviews, two researchers conducted about 60 h of participant observation in the care facility, mostly on the floors where a considerable amount of fall-detection software was in use. Lastly, data collection was conducted in the office spaces of an interest group that represents the rights of people in institutional living across the life-course. We conducted two interviews with professionals from the organization. All interviews were transcribed in German verbatim. Field notes were taken in German by two researchers throughout the research process.

Data analysis was conducted using situation analysis (Clarke, Friese, & Washburn, 2016), which is a qualitative analysis method based in grounded theory. The aim of situational analysis, as applied in this project, was to identify relevant actors and their relationships in the situations that were encountered during data collection. In combining Barad's theoretical approach with this kind of analysis, we refrained from deploying the classification scheme that Adele Clarke and colleagues proposed for categorizing elements that run the risk of the reification of boundaries that we want to overcome. Instead, we mapped elements that we found in empirical research without grouping them into categories and focused on the dynamic relations between them. Particularly, we asked which human and non-human actors shape the everyday practices of engaging with algorithmic fall-detection software in long-term care facilities and what the relationships between these actors were. In the first step, interviews and observation protocols were openly coded using MAXQDA2022. In the second step, four researchers produced four situational maps, detailing the codes from a) care staff interviews, b) residents' interviews, c) interest group interviews, and d) software designer interviews in group sessions. In a final step, we produced positional maps for which all interviews were analyzed together. We acknowledge that these maps only represent "snapshots" of the inherently dynamic situation, and thus used them not primarily as results, but as tools for analysis and discussion of the ever-shifting intra-actions through which boundaries are drawn and reconfigured.

Findings: The spacetimematterings of aging

In the following, we illustrate how age-boundaries are established through spacetimematter in the particular case of algorithmic-supported long term care. To do so, we explore two different material temporalities that were found in our data and discuss the age-boundaries that are established through these spacetimematterings: a) the material temporality of a technology-in-training, and b) the material temporality of (false) alarms.

The material temporality of a technology-in-training

The first type of material temporality that emerged through the data analysis that highlighted the entanglement of materiality and temporality in the present case was framed as "life-course time" by diverse actors in our interviews. Here, our empirical material shed light on the idea that not only older adults, but also the materiality of the fall-detection software was situated in life-course time, meaning that, much like humans, the functionality, development and application of the fall-detection software was temporally structured through the idea of a life span. This life-course temporality materialized in both older adults and the algorithmic fall-detection system.

This life-course time then also had consequences for the ways in which different actors would act with and relate to each other. This became most visible when designers explained the functionality of the fall-detection system by drawing attention to the fact that the technology was producing a considerable number of false alarms (something that was also highlighted as a frequent issue with this technology by care staff (CS[1]12, CS4) and older care home residents (R10, R6) several times during the interviews). For software designers, this was because the fall-detection system, like all automated decision-making systems, was a technology-in-training that was projected to perform better in the future, as the database for algorithmic decision-making would grow (D15). The system had to be continuously "trained" (D15, Pos[2]62), to improve its functionality as it matured:

> So, we're constantly retraining, like every two months or so. And we also use data from all the new installations for this. The more installations of our sensors we have, the more diversified it is, and in my opinion, the smaller the chance that a type of person comes along who is not in the data at all and where it then performs poorly.
>
> (D14, Pos52)

This type of material temporality was hence connected to the basic structure of the development of algorithmic technologies, which needed intensive "ground truthing" (D15, Pos38), and "training data" (D15, Pos56) to be able to learn to make good decisions (D15). This temporal structure of the algorithmic learning process, however, also meant that care staff as well as older adults living in the care home facility had to deal with a considerable number of false alarms until the algorithm

[1] Abbreviations for interview type (CS = Care Staff, R = Resident, IG = Interest group, D = Designer) followed by interview number

[2] Pos = Position in the transcription text which indicates the beginning of the quote

would mature when it was better trained in a distant point in the future. One caregiver explains in his interview:

> It has already improved a lot. In the beginning it was quite terrible when it rang for every little thing. Because we also didn't know how to set it right, the sensitivity. The AI [algorithm] was also not yet so well trained. I think by now it's a bit better, but there's still room for improvement
>
> (D13, Pos29)

The life-course time of algorithms was hence used to legitimize a certain amount of misbehavior of the technology in practice because it was expected to mature and grow into a technology that would perform better in the future. The care staff highlighted at several points of the interview how the system was perceived as a child, which came with certain "teething problems" (D4, Pos99[3]), that needed to be accepted by the care staff and older residents alike:

> There were teething problems at the beginning, which were extremely exhausting at the beginning, which I also heard from my colleagues. For example, if the bell rings 15 times on the ground floor, but the resident is upstairs [not in the room] or so, those were teething problems.
>
> (D4, Pos99)

How did this materialized temporality contribute to the establishment of age-boundaries? Which spacetimematters of aging was it connected with? In contrast to the algorithmic fall-detection software that was positioned as a technology at the beginning of its life-course, with child-like characteristics (like having teething problems), which made wrong (at times annoying) decisions and produced a considerable number of false alarms, older care home residents were positioned at the end of their life during the interviews with software developers and care staff, and perceived as having only little interest (or the cognitive capabilities) to understand what the fall-detection software was doing in their rooms. Care staff highlighted several times that older care home residents would not "actively" (CS4, Pos281) engage with the technology or were not able to do so because of their declining health status:

> First of all because they don't know, they don't question it either. I think just because of their, their cognitive state. And I think when they come to us, they don't know that it exists, so it doesn't exist for them, right?
>
> (CS8, Pos271)

As a consequence of this prejudicial view of older care home residents as too frail to understand or engage with technologies, the interviews showed no mention of teaching or learning practices that would enable older care home residents to understand the nature, effects, and functionality of algorithmic fall-detection systems. On the contrary – care home residents were depicted as a rather indifferent user group who, because of their age, would not have the capabilities or interest to understand such technologies and therefore needed to accept the mistakes a technology-in-training was making. While the sensor technology was positioned as an entity capable of learning, older adults were perceived as either being indifferent or silently accepting the presence of monitoring technologies in their rooms: "I think they just accept it. Above all, if they have questions then we can explain it to them." (CS4, Pos277).

While the algorithmic system was hence positioned as a technology-in-training, with plenty of time to grow and mature over its life-course, older adults were framed as being in a life stage of decline which made it difficult or even impossible to learn about and engage with innovative technologies in their lives. This (problematic and, at times, ageist) framing of older adults as too incompetent or uninterested to learn about new technologies was also created by giving them little information about how the system worked or why it was being used. Often, residents would only have a vague idea about how the sensor worked but were not entirely sure if the system was even running or not:

> It lights up and then (…) when you're lying there at night, I don't know how that works, then it rings outside and upstairs it rings somewhere and then they come (…) but how that works, I don't know. (…) In the night it blinks red without any reason (…) And now? It's, well (…) maybe that's turned off completely? I don't know
>
> (R10, Pos124)

In the interviews, residents also shared how the monitor system was either in the room when they moved in, or that they were only informed about the system because they were accidentally in the room when it was installed: "I basically only know (note by authors: about the sensor) because I was there, was here in the room, how they installed it. And that's actually why I know." (R6, Pos146).

The interviews also highlighted that older care home residents were in fact interested and eager to learn about the system that was running in their rooms, wondered about how it worked, however, they seemed to lose interest as the system would not interact with them:

> In the beginning you keep looking because it's new and then you keep thinking, 'Will it go off? Will it ever start?' and it never does. But by now I don't think that it will, because it never started, so it never will.
>
> (R6, Pos137)

This example highlights how through the entanglement of different materialities, that is, algorithmic technologies and aging bodies, and their related temporalities (i.e., being in the beginning or towards the end of the life-course), an age-boundary was established that differentiated older care home residents from other entities: older adults were situated as the (silent) bodies being monitored and in a life stage of (inevitable) decline, while all other actors in this example were perceived as being capable of, and interested in, engaging with and shaping the fall-detection sensor. This, however, was not in line with the perspectives older adults', who described themselves to be both interested and willing to learn about the fall-detection system. However, organizational practices of both the LTC facility and technology development did not leave much space for older adults to explore, learn and experience the technology they were living with.

The material temporality of (false) alarms

The second type of material temporality that emerged during data analysis was connected to the basic functionality of the fall-detection system: its capacity to sound alarms and through this, interrupt the everyday routines of care staff and residents alike. Disruptions through alarms of the mundane, everyday temporalities were described by both the care staff and the residents as a central aspect of everyday life with the fall-detection system. This extraordinary time, established through (false) alarms, stood in contrast to the routine temporality of everyday life in the facility and also established age-boundaries between those whose behavior could potentially trigger an alarm (older residents), and those who had to react to it immediately (care staff).

Both care staff and residents described their day-to-day life in the long-term care facility as being strongly structured by routines, highlighting well-known patterns of everyday practices that happened every day in a similar order. Residents temporally structured their days around routine tasks, such as eating at particular times, going to or getting out of bed, or taking naps throughout the day:

> So, in the morning, first of all I get up all by myself. (…) Then I go to the bathroom and if I somehow can't fasten my bra when I'm getting dressed (laughs), then the nurse has to help me. And then I go to eat breakfast. So that's breakfast. Then you always hope that there are

[3] Literal translation: Childhood diseases (Kinderkrankheiten)

> some events after breakfast, so that the day doesn't get too long. (…) Yes, then I go for lunch. With (..) / with (..) / with more or less desire to eat, which is not always very good (laughs). Yes, then I lie down, half an hour, three quarters of an hour I lie in bed and then I go for a walk in the afternoon (…) and then the day is actually already over. Then I go out for dinner. No, in between I have a snack. There is a snack. And after the snack, yes, then I don't do much. And then there's dinner and then it's / either a little TV or bed
>
> (R6, Pos2)

This routinized temporality of everyday life in long-term care was also mirrored in the interviews with care staff, who also described their work in relation to standardized work routines:

> Everyday care is: handover of duties in the morning. (…) And then it starts with body care. The positioning in between, who lies down longer, and yes, body care, so mobilizing the persons out and then feeding if necessary … So eating, drinking. Then somehow see that one accommodates everything that one would like to do or what would have to be done. (…) so that one also deals with the residents and not just sits around somewhere or so. (…) the documentation then often eats up a lot of time or it is lost that it is not documented what one has done. Yes, and in the evening then back to bed
>
> (R4, Pos3)

In these routine everyday temporal patterns of long-term care, alarms, and their related temporality of having to act immediately, were well known (and referred to as ringing "the bell" (I2, Pos44)). Alarms were either set off actively by older residents pressing a button, or automatically by the fall-detection sensor. Reacting to said "bells", which interrupt the more routine care work (doing "rounds" to check up on every care home resident in their room) was, therefore, a well-known aspect of everyday life in long-term care: "In between there's of course the bells. The first round there are always many bells." (CS2, Pos43).

While the first type of alarm ("bells" being set off by older care home residents) was perceived as a mode of communication between care staff and residents, the second type of alarm (being set off by automated fall-detection software) was mainly described as annoying, as many of them were false alarms. On the one hand, this meant that care staff had to react immediately to the alarm and were interrupted in their care routines, and on the other hand, older care home residents were often interrupted in their everyday routines. As one care assistant shares in his interview:

> Yes, it's actually just mostly the false alarms, I would say. (…) And then you run to the end of the corridor, because we have such a long house. When you get to the end, only to find that a false alarm.
>
> (CS13, Pos33)

This was also mirrored in the interviews with older residents, who also described being interrupted in their everyday routines through the false alarms of the fall-detection software:

> And I'm lying in bed and I've got the rollator next to me and then they come in too, 'Mrs. Bee,[4] has something happened?' I say 'No, I'm asleep.' 'Well, because something set off the thing.' Then she asks me if I need anything, I say 'No thanks, I don't need anything, I want to sleep. Good night.' (…) Well, it shows when you fall. Then it flashes like crazy. Sometimes I'm sitting watching TV and they rush in 'Mrs. Bee, did something happen?' I say no, I'm sitting there watching TV. 'Yes, it was triggered again'
>
> (R11, Pos80)

These false alarms were hence omnipresent in the lives of older care home residents. Older residents, however, also described instances where they would deliberately play or tinker with the sensor – thinking about, for example, throwing a ball at it to make it sound a false alarm on purpose:

> Maybe, I should throw a ball at it or something (laughs). No, one should not be that mean. I should be thankful that I am being looked after. (…) Yes, just so I know if it works. Just whether it works or not
>
> (R6, Pos155)

This example highlights that through the fall-detection system, a particular type of temporality – the temporality of alarms – materialized in the lives of care staff and older care home residents, and could then be used to communicate, be tinkered with, or played with by all social actors involved.

In its essence, this material temporality was built upon (and at the same time established) a clear agential cut between those humans that were being cared for (older care home residents) and those who would do the caring (care staff). Challenging this agential cut would then contribute to sounding false alarms, as one caregiver explains during her interview: moving too close to an older resident who was being monitored would sound an alarm, as the system could no longer differentiate between the older person lying in bed and the caregiver sitting next to them:

> Did you see that I talked to her standing in front of her bed? Once, I didn't talk to her standing, but kneeled down right beside her bed. Because I wanted to talk more intimately. But I was too close to the floor and the alarm went off
>
> (Night shift observation protocol 1, Pos 105)

How did this type of material temporality of the fall-detection system contribute to the establishment of age-boundaries? First and foremost, this temporality established a clear differentiation between two types of human actors in long-term care: those who were being monitored in their behavior (older residents) and those who had to react to alarms (care staff). Further, the automated analysis of behavior monitoring that was done through the algorithmic fall-detection system also established normative boundaries between risky behavior of older care home residents (which would set off an alarm) and not-risky behavior (which was still monitored but did not sound an alarm). For software designers, this boundary was synonymous with the line between falling down and not falling down, as the sensor was being trained to detect falls as early as possible (D15). In practice, however, this boundary was significantly more blurred. Care home residents and staff described how an alarm was set off when they were falling, however, they also noted that an alarm would ring when they picked up things that were lying on the floor or when they would move around their rooms with their walking aid during the night (R11, R12, R4, R13). The material temporality of (false) alarms which was established in the everyday lives of older care home residents hence communicated a boundary that was established between "risky" and "safe" behavior in later life.

These boundaries between risky and non-risky behavior were then also reinforced by care staff who, due to a high workload, asked residents to behave in a way that did not cause (false) alarms. As one resident explains, she was asked not to use her walking aid at night, as care staff were hoping that this would reduce the number of false alarms:

> Yes, I've already been told that I'm not allowed to move the rollator, because when I go to the toilet at night I have to go with the rollator. Then it [the sensor] flashes all over the place, like crazy. And then I lie down in bed again, then it goes quiet again so I can have some peace. (…) Nothing has happened, but it started going off, because I could have fallen
>
> (R11, Pos86)

Discussion

In the findings above we illustrated how different material

[4] Name changed for anonymization

temporalities entangled in bodies, spaces, and things – and in particular, in an algorithm-based fall-detection sensor – come to matter in a long-term care facility, establish age-boundaries and through this, constitute aging.

The empirical data highlighted different types of material temporality that came to matter in such age-boundary-making practices, from which we focus on two for this article: first, an everyday and routine temporality of care, in which routinized practices of staff and care-home residents were interrupted and redeveloped through false alarms; and second, a non-human life-course temporality that situated the technology in infancy and framed it as a technology-in-training which needed to be nurtured and redeveloped to be improved for an anticipated future. Both these (life-course and everyday) temporalities as well as the respective materialities of bodies, spaces, and technologies, are interwoven, produced, and reproduced through spacetimematterings that ultimately established age-boundaries in the analyzed case, as they facilitated establishing who was perceived as an older care home resident, and who was perceived as a member of care staff, a technology designer, or another (human) actor.

Whereas we can find multiple boundary-making practices in this setting – producing and enacting, for example, the difference between care home staff and older care home residents, between technologies and (other) mundane materialities, between human and non-human actors, or between risky and non-risky behavior – we choose to focus on those spacetimematterings that establish age and aging. The material temporalities that we found, we argue, established age-boundaries that separated older adults as a particular group, different from both care staff and technology designers in their needs, capabilities, and routines, and also established a particular position for them: being positioned as the ones under surveillance, who had little interest to engage with innovative technology. This case presents another example of how in relation to innovative technologies, old age is mainly framed in terms of vulnerability and technological incompetence (Köttl, Tatzer, & Ayalon, 2022; Neven & Peine, 2017).

Did our proposition to understand age-boundaries as spacetimematter enable us to gain a deeper understanding of how age is constituted and established? Against the backdrop of the findings we presented, we can understand age(ing) as a situated, distributed process of practices (Höppner, 2021). We propose to understand age not as an attribute and aging not a development exclusive to human individuals, but as a material-discursive phenomenon emerging in an assemblage of – in our case – age-coded practices, spaces, things, and temporalities of care and caring (Krekula, Arvidson, Heikkinen, Henriksson, & Olsson, 2017; Nettleton, Buse, & Martin, 2018). Framing aging, however, not only as materially diverse but also temporally diverse, as we have done with our suggestion of spacetimematter, expands this material-gerontological body of literature as it highlights that aging emerges not only as an assemblage of different materialities but also as an assemblage of related temporalities. The temporalities of aging, we argue, therefore go beyond an aging body, a human life-course, or generational time, but also include temporalities of digital technologies, socio-technical innovation processes, or temporalities of algorithmic and automated decision-making. Our contribution, hence, is to view aging as both materially and temporally distributed between different actors and take human as well as non-human materiality and temporality into account when doing so.

Such a perspective, moreover, shows how age is much more than human: first, it explicates how technologies play a role in the drawing of age-boundaries. Medical decisions are based on assessments of risk (Kaufman, 2010), and therefore boundary-making practices between risky and safe. Fall detection systems allow for a re-definition of this risk (Wigg, 2010) and increasingly base its assessment, as our case illustrates, on algorithms. Algorithmic aging, that is, the production of age-boundaries through the collection and analysis of data and its use for automated decision-making processes, can and will likely become another dimension of the phenomenon of aging (next to calendrical, subjective, social aging). Risk, as a major component of algorithmic aging, thereby refers to the prospective possibility of (in our case physical, health-related) damage, and thus points to another dimension of temporality interwoven in age constructions that is often overlooked in gerontology: the future.

Second, it emphasized that age(ing) is attributed not only to human individuals but also to non-humans, like technologies and things. Hence, they can not only be rendered new, but they can also be framed as young – and thereby framed as developing and treated with indulgence in hopes of improvement in the future – as well as old, obsolete, and/or in need of repair, respectively (Cozza, 2021). For a prospective research agenda of material gerontology, we can thus apply aging as a material-discursive and temporal phenomenon not only to humans but “scale it up” to places, things, ideas, technologies, infrastructures, societal innovation processes, and so on.

This scale-ability becomes particularly striking when we trace how the algorithm-based fall-detection system relates discourses of socio-technical innovation and “newness” to problematizations of aging populations and increasing demands for care on a societal level. Similar processes have been described in the research field of socio-gerontechnology as co-constitution of aging and technologies (Peine & Neven, 2019). However, this phrasing, we argue, still presumes two entities – aging individuals and non-human technologies – that co-constitute each other. Drawing on Barad’s notion of spacetimematterings, age(ing), however, appears as much more relational, emerging in an assemblage of those innovation discourses, problematizations of demographic change, digitized and analog practices of care and caring, bodily functioning, daily routines, institutionalized spaces, etc.

What proved to be particularly striking in our material was the way seemingly conflicting and colliding temporalities were harmonized through these practices of spacetimematterings. With its repeating false alarms, the fall-detection software system significantly disturbed the temporal routines of the care home, for example when care staff were supposed to visit or when residents were supposed to sleep. However, these disturbances were accepted and integrated into care practices as the technology was granted an “infant status” as a technology-in-training that needed to learn to grow better in its assessments, eventually resulting in new nursing home routines. This demonstrates the role that power plays in and through spacetimematterings: Whose routines can be disturbed? Would the same number of false alarms be tolerable, for example, in a school or a workplace? Who and what is framed as help and protection, who and what are to be helped and protected? Who and what is surveilled, who and what is surveilling? Who and what is able to tinker with temporalities, is knowledgeable about temporal regimes, and educated and trained in the use of the technology? How can it be switched off? All these questions point to temporal power that is redistributed in spacetimematterings, and the materiality of epistemic violence resulting from it in a care home setting. Speaking to Sharma (2014), the “power-chronography” of this setting links material and temporal power to draw age differences.

Lastly, there are considerable limitations to the study at hand. As we focused on the making of age-boundaries, we deliberately neglected other boundaries that intersect and cross those age-boundaries, like those around gender, health, autonomy, knowledge, or personhood. For a material gerontology, the findings and shortcomings of this paper imply a variety of future research pathways. Mainly, this concerns the boundary-making practices of gerontology itself: In our case, age-boundaries were not only created in the lives of older adults – they were created through multiple human actors, (e.g., technology designers, care staff, older care home residents) non-human actors (e.g., alarms, algorithms, furniture, objects) and much more. From a material-gerontological perspective, this also implies that we can study aging not only in the lives of older adults but also in technology development teams, in architectural firms that plan and build long-term care facilities, in technology user manuals, or in schedules of professional care staff.

However, while some of these aspects are more closely studied in gerontology already, others have not been on the gerontological research agenda. A material gerontological perspective on aging as spacetimematter hence significantly expands the scope of gerontological research – and critically questions how gerontology creates its own age-boundaries through the boundary between what is "in-scope" of gerontological research and what is outside of it. We hope that such insights can guide the further development of (material) gerontology, to reflect upon not only its strengths, but also its own practices of drawing the boundaries of age and aging.

Declaration of Competing Interest

None.

Data availability

Data will be made available on request.

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