Co-Living as a Rental Home Experience: Smart Home Technologies and Autonomy

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Abstract. Smart home designs have an essential role in enabling new urban co-living services for the rental housing market. These services are appealing for their flexibility, ease of access and comfort, but they impact the autonomy of the residents. By utilising a protection-appreciation space model we explore how bundled co-living contracts, community as a service, and smart spaces redefine the relationship between the tenants and housing service providers in the smart city. We discuss the compromises tenants have to accept for the comfortable housing service. Our results are based on a thematic analysis of semi-structured interviews with residents in two co-living studio facilities in a major Nordic city. We conclude with a reflection on how the technologies used function to cushion the autonomy of the residents and identify policy development needs to respond to the new challenges presented by the application of smart home technologies in co-living.

Keywords: co-living, smart home technologies, autonomy, smart housing

1 Introduction

Smart cities are often concerned with building infrastructure enhanced with the Internet of Things (IoT) in order to address socio-economic, institutional, and environmental challenges [1]. As we design smart cities in pursuit of meeting these challenges, we may end up overlooking the complexities of smart housing. Through smart housing, where the smart city intersects with smart homes, we find new services and practices, such as housing on demand [2]. In this paper, we will explore how smart technologies facilitate the re-shaping of relationships between residents and landlords in a co-living space.

Smart home technologies typically refer to some form of automation, usually accomplished by digital technologies, such as heating, security, or entertainment systems. They promise various forms of efficiency, flexibility, or convenience. In the research presented here we study how these technologies intersect with housing when implemented in a co-living building and how this can affect the independence and agency of the residents. We tie the notion of the residents' independence to a need for design to consider their autonomy, which we consider to be "To have the ability to make informed choices about what should be done and how to go about doing it" [3], through the dimensions of protection and appreciation when introducing new

technologies, and explore how new technologies in residential spaces can both extend and restrict the independence of the residents.

The notion of a protection-appreciation space [32] (See Fig. 1) can be used to understand how a design ought to both protect the user from harm and appreciate the user's autonomy. A design that neither protects nor appreciates the user's agency becomes exploitative. Designs that appreciate the user's agency to explore and adapt may excite the user with new opportunities but place a significant burden on the users to be competent in acting in such a way to shield themselves from potential negative side-effects of the design. Designs in the lower right corner rely on the designers understanding of the users to shield them from negative consequences while not allowing them to explore, such as proprietary systems. However, should the user step outside of the designer's notions of use it can limit the autonomy of the user. In these cases, the autonomy of the users is negatively affected rather than a transparent approach that guides the users understanding while respecting individual preferences and thereby nurture their autonomy.

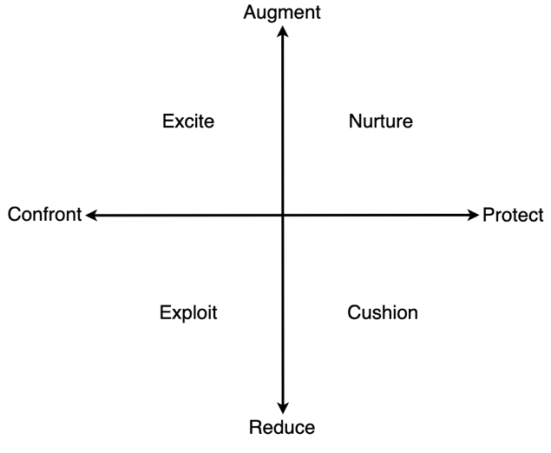

Fig. 1. Protection-Appreciation Space examining whether a design protects the user from harm or respects their autonomous agency. Source: Authors, adapted from Keinonen [32].

Access to housing is an issue in many major cities where rent increases significantly faster than income, leaving many to seek shared homes to keep the living cost down [4][5][6]. While shared housing exists on every continent, in Northern Europe it is particularly common among students, with the perception that it is a temporary phase while studying or leaving the parental home [7]. In many cases these shared apartments are referred to as co-housing, however they can be differentiated based on the economical and social arrangements as co-housing and co-living. Co-housing and co-living are two related concepts that are being presented as potential solutions to high costs of living in densely populated areas. While both co-housing and co-living imply shared communal spaces in some form, neither is strictly defined and there are many variations, some of which may appear difficult to separate from the other. In order to distinguish the two, we will differentiate them by considering co-housing to imply a

shared, bottom-up initiative from the residents, while co-living represents a more top-down approach, where the building or apartment is targeted towards shared housing. Another difference between co-housing and co-living is the ideological motivation, the arguments for co-housing are often based in feminist discourse such as making housekeeping services more visible, communal efforts of maintenance, and equality [8][9], while co-living is a market solution created by companies or landlords that may offer similar services. Previous iterations of co-living have historically aimed to provide a minimum standard of living for bachelors, students, or guest workers.

Residents of such housing setups described above typically have access to a small studio with various levels of included services such as electricity or food [10]. Commonly co-living facilities target young adults just out of their family homes but not yet fully independent or with a clear knowledge of where they will settle down. In recent years co-living has also been promoted as a niche type of living to non-students [11]. This shift has entailed not only offering the minimum standards of living but has instead been marketed as a more luxurious offer with modern design including the studios, restaurants, stylish communal areas, or facilities for working. These modern apartment hotels are differentiated from traditional boarding homes through targeting a more established working audience with higher disposable income and higher expectation in services. Smart technologies can enable easier facilitation of these services by embedding technologies such as smart locks, smart meters, surveillance cameras, lighting and music. At the same time, these technologies can also facilitate surveillance and shift the balance of power between landlords and tenants.

As smart technologies are introduced by more landlords, we believe it is important to consider how the autonomy of tenants is affected by these emerging technologies. Frichot and Runting's [12] comparison of the co-living studio to a prison cell is an evocative description, however in this article we are interested in how co-living affects, and perhaps compromises, the autonomy of the residents in more subtle ways. We therefore formulate the following research questions: How is smart housing affecting the relationship between tenants and housing service providers in a co-living housing model? How does this affect the autonomy of the residents?

This paper explores how technology, regulations, and residents interact in a co-living building in a major Nordic city. Our exploration reveals a techno-social system of human and non-human actors that together work to observe, maintain, and control the space through a holistic service offering. In section 2 we introduce related work on smart home technologies in shared households, the design of the smart home, and how it affects autonomy. In section 3 we present our methods and research approach of an exploratory case study and semi-structured interviews exploring the residents' relationships with the various systems in the building. In section 4 we present the results of the study, outlining how the design of contracts, community, and space affects the residents and the needs that the designs respond to. We continue by discussing and reflecting on the implications of the contracts, community, and space in section 5. We conclude in section 6 by noting how the holistic service offering of the smart home affects the autonomy of the residents.

2 Related Work

In this section we present related work regarding smart home technologies in shared households, the design of the smart home, and connecting the smart home to the notion of autonomy.

2.1 Smart Home Technologies in Shared Households

Significant research into smart homes has focused on private homes or family homes, often assuming middle class and a certain level of income and overlooking the political aspects of smart technologies in e.g. public housing [13]. In recent years there has been some research exploring other forms of housing such as shared housing [14], co-housing [15][16], as well as other less traditional forms of housing, including more nomadic lifestyles [17], opening up a wider understanding the home within HCI such as van-life, family structures beyond the nuclear family and other non-typical homes [18][19][20]. While the notion of home has grown more nuanced, the link between housing and smart cities has often been overlooked, suggesting that there is a need to explore new practices, such as the sharing economy and housing on demand enabled through smart housing [2]. Outside of the home, Fox et al [21] have created the concept of managerial visions, observing how, in the management of communal spaces such as bathrooms, smart devices are often tied up in cost reduction or exploitative regulatory techniques.

The implementation of smart technology in public housing can shift the boundaries between private and public domain, bringing attention to the values of the home and those who operate it [13]. Smart home technology also enables integration into policy for automated sustainability projects such as smart grids [2]. Kozubaev et al [13] notes that in low-income public housing there are a few concerns that should be addressed: privacy, shifting baselines (what it takes in terms of technology and knowledge to participate in public life), shifting expectations and responsibilities, and a concern for what the baseline for participation is.

Smart home technologies are also perceived as promising when considering supported service living for people with disabilities or the elderly [22] and a significant part of the research into these technologies focuses on these issues [23]. In the context of technologies for ageing or disabilities, the potential infringements on privacy or autonomy caused by technology can be motivated by the technologies allowing the residents to live in their own home rather than a care home, or otherwise easing their access to care. While smart technologies in private homes offer control and conveniences, they also redistribute power. The redistribution of power within the household is often based on one member installing and managing smart technologies that control lighting or entertainment systems while other members of the household adjust their behaviour accordingly [24].

The boundaries of the smart home are porous, rather than being bound by the walls, windows and doors that would otherwise mark the boundary of the home, the smart home extends beyond that [25][26]. Smart technologies are also modular, rather than a

single comprehensive system they consist of multiple systems and technologies, some of which may be interconnected. The possibility of reprogramming smart technologies as well as adding and removing technologies further contribute to the porous nature of the smart home. Smart Homes collect data through sensors which support automation in various forms, whether for security, utilities, or entertainment. These technologies are often focused on efficiency, convenience, and security with the aim of freeing up time for leisure [27]. Other definitions focused more on energy use see the smart home as a tool to provide services for residents and electricity system operators [26].

Prior research into smart homes focused on private homes or supported service living for disabled or elderly people [22][23][13] shows how other implications have often been overlooked thus far. With modern co-living solutions often depending on smart technologies for facilitation, understanding how smart home technologies affect these spaces fills an important research gap.

2.2 Designing the Smart Home

While smart home technology frequently refers to household products such as smart fridges or smart speakers, common smart technologies also involve controlling utilities such as heating, water, and power. Harper [28] asserts that what makes a home smart is the interactive technologies it contains, rather than how well it is built or how it uses space. However, Keinonen [29] argues that a more human-centered definition of a smart environment would be its capability to enable smart behaviour. We therefore take on Maalsen's [30] understanding of the smart home as a socio-technical assemblage, made up of social, economical, political, and technological apparatuses. As such, we consider the service offering to be a part of smart living spaces even though some services do not appear technological. By engaging with needs, meanings, and utilities that technologies respond to, one can create the desired improvements without engaging with novel but immature technologies. With this in mind, we consider a purely technology-driven definition of the smart home to be insufficient, without to some degree also considering the broader service system, business models, and contract practices that are part of shaping human behaviour in the smart home. This becomes even more apparent in shared housing situations such as co-living.

Co-living has been critiqued by Frichot and Runting [12] who argue that co-living, while providing housing, creates an infrastructure focused on productivity where intimacy is impossible. They draw attention to the similarities between the small apartments and prison cells. Design decisions materialize morality [31] and it is therefore pertinent to question both what and whose morality they materialize and how. Design is often said to respond to the needs of the users, some of which Keinonen [32] described as fundamental. Fundamental needs refer to an individual's unsatisfactory state of affairs where correcting the situation is deemed morally binding under the prevailing circumstances. While basic needs [33] are seen to define the bed rock reference for what is necessary for survival, fundamental needs are sensitive to the community's interpretation of satisfactory quality of life that is realistically attainable for all its members. Fundamental needs therefore remain somewhat elusive, but their

urgency can be defined by policy-makers, designers, or others who have the power to make decisions on behalf of others. Fundamental needs are further defined by 'protection' and 'appreciation', where protection implies protecting users from harm, while appreciation of the user considers how it appreciates the users' autonomy [32][3]. By exploring these dimensions, we can uncover implicit values that affect moral considerations in design.

In order to explore the implications of smart technologies on autonomy in the home there is a need to consider the meaning of the home. Després [34] argues that the home can be considered a place of security and control, a reflection of one's ideas and values, a material structure, an indicator of personal status, a centre of activities and relationships with friends and family. Gram-Hanssen and Darby [26] utilize Després' definition to identify four categories that are related to the smart home: security and control, activities, relationships and continuity, and identity and values. While Gram-Hanssen and Darby [26] refer to security and control in the sense of the residents being in control of the space, control can also refer to how the house is controlled. According to Wilson et al [35] there are three grand narratives of control in the smart home: functional, instrumental, and socio-technical. These can be broadly described as what can be done or connected, how we interact with it, and what the social implications of the technology are. Another literature review by Desjardins et al [36] articulates various genres of domestic research in HCI: social routines, ongoing practices, home as testing ground, smart homes and automation, contested values, home as a site for interpretation, and speculative visions of the home.

2.3 Autonomy in the Smart Home

The issues of autonomy in the smart home are complex. The residents' lives are shaped by the collection of data required to operate the smart technologies, as well as the social rules and regulations. The smart home can also make the boundaries between private and shared space more porous as data can be accessed and shared in new ways. The access to data can affect the relations between the residents and housing companies as their interests collide over issues on how to keep order or reduce resource use, while providing sufficient value for the residents. In Kozubaev et al's [13] study on public housing, the freedom to adopt smart technologies for the residents, as well as ownership of the data are highlighted. While it might be fair to assume that the data is used for public benefit in public housing, this shifts somewhat when a private company owns the data. Residents have little choice but to accept the use of their data or try to find a new home. Even so, choice of where to live can be limited in large cities and the compromises that co-living presents are not always clear.

The notion of autonomy in technology can also be examined through the perspective of persuasive technology. Persuasive technologies are often designed around the idea of reducing errors and to encourage positive behaviour [37], but it is important to ask whose notion of positive behaviour the technology encourages. Defining misuse of commons or defining acceptable use is a complicated process and there is a difference between actions that are undesirable by residents or by the housing company. By

looking beyond privacy, there are other ways in which the residents of smart homes are affected by the technology that can be revealed. Some of the ways that technology affects the structure of power within the home are by defining practices, the use of space and through observation [24].

3 Method

In this section we will introduce the exploratory case study [38] that was conducted through a series of on-location semi-structured interviews [39], along with reviewing publicly available material such as the case study organisation's website. The case study was conducted in two buildings with the same ownership. At the start of the study the buildings had been open for 6 months. The two buildings function as a form of commercial co-living or studio hotel. However, most of the residents can be considered long-term tenants. The participants in this study have the shortest stays planned at around nine and a half months, while others express that they aim to live there until they leave the city or move in with a partner.

As a resident, the first encounter with the building is via the website, which also functions to manage contract interactions. Residents book, similar to a hotel, a room based on availability. Upon arrival, a keycard is generated, which then functions as their key throughout the building. The booking automates the contract process, with minimal human contact as there is no need for visiting or speaking with anyone until you arrive at the building to move in. One feature of the flexible booking system is that several of the participants have tried out more than one studio, according to their preferences. If the studios are available, they can easily move within the building to another smaller or larger studio.

Each resident rents a studio (~20-40 m^2) as well as access to common spaces. The two buildings offer similar services and contracts, including all utilities, as well as access to a gym, bicycles, co-working spaces, communal kitchen, TV and game rooms, and terraces. The rent for a studio is comparable to a studio or a 1-bedroom apartment in the same area. While the participants in the study are long-term residents, from a legal perspective they are living in a hotel and therefore unable to register the studio as their permanent address. In this study we focus on long-term tenants in order to explore how co-living and smart housing may affect autonomy, but there are also other tenants who might stay for a shorter period, e.g. while their apartment is being renovated or while in the process of separating from their partner.

In the buildings there are also house managers that serve a number of roles, in part as receptionists and access points for the residents if they want to borrow bicycles, book a space, or have any issue they need resolved. They also keep track of common spaces as well as maintain relations with the residents. Aside from maintaining services they are also involved in creating social events. Most of the residents express that they have good relationships with the house managers. They describe the managers as primarily women in their mid to late 20s.

3.1 Participants

In this study we had 11 participants (5 male, 6 female) aged 18-45 in semi-structured interviews. The first participant was recruited through the researchers' contacts[1]. The rest of the study participants were recruited with the help of residents and participants in the study by requesting that they share an invitation to the study with other residents matching the criteria of aiming to live in the building for an extended stay of at least 6 months and preferably a year or more as well as having moved in shortly after the buildings opened (which had been open for 6 months at the start of the study). During the interviews the participants were asked how they felt about their current housing, their intended stay, how it compared to other places they lived, and what had brought them to this building. They were also asked about the technologies in the building, what compromises (if any) they felt they made to live there, and about the social life in the building.

The participants are residents at two co-living buildings (7 participants from one building, 4 from the other) in a Nordic capital. The two buildings are owned by the same company, have the same organisational structure and rules, albeit with different physical layouts. The majority of the participants are early to mid-career, with a few participants being students indicating a relatively high level of education with almost all having some kind of university degree or working towards one. The participants are all relatively economically privileged as the housing model does not target low-income people. At the behest of the participants, the interviews were held on location in the private co-working offices of the co-living building or in the participant's studio.

3.2 Analysis

Each interview was transcribed and analysed through thematic coding and analysis [39][40]. In the initial analysis we explored themes around motivation for living there, advantages, compromises, security, the role of technology, and how private and communal spaces were managed and maintained. The 11 interviews of between 24-60 minutes were used as primary data, while we also looked at the documentation on the website of the building and visited some studios as well as the common areas to use as secondary data. In the first coding we found 11 codes that, in various ways, affected autonomy and independence: surveillance, smart access, guests, defining the mood, cleaning services, personal space, communal space, smart utilities, house managers, community guidelines, and booking and contract. We then moved on to note the ways in which the technologies and services were used to either observe or regulate the behaviour of the residents. Once we completed the initial analysis, we invited two participants, one from each building, to review our analysis to ensure that they felt our description of the space and the technologies was fair. Both confirmed the interpretations. In the next step we then iteratively revisited our interpretations and refined the codes into three themes: contracts, community, and space.

[1] None of the authors are residents at the co-living building.

Table 1. Participants in the study: 1-7 in building 1 and 8-11 in building 2.

ID	Age	Gender	Planned Stay	Current Stay	Stated Motivation
N1	34	F	4 years on and off	8 months	Flexible contract, lightly furnished, no deposit
N2	25	M	About 1 year	6 months	Convenience, social life, included cleaning service
N3	18	F	9 months	6 months	Flexible contract, no queue, no deposit
N4	45	M	For the foreseeable future	7 months	Not owning stuff, simple billing
N5	19	M	9 months	6 months	Flexible contract, easy to rent
N6	24	F	About 2 years	6 months	Convenience, common areas, new
N7	33	F	For the foreseeable future	8 months	Location, common areas, amenities
N8	23	F	About 10 months	6 months	Social life, cost, location
N9	28	F	At least one year	5 months	Flexible, cost, no queue
N10	35	M	For the foreseeable future	9 months	Location, interest in housing model, easy to book, social life
N11	30	M	At least one year	5 months	Flexible contract

4 Results

In this section we will outline how the design of Contracts, Community, and Space function to shape the behaviour of the residents and how they work to do this, as well as what compromises are being made. They shape the behaviour either through observation or regulation, although many of the technologies and services serve to do both. Observation serves to ensure that the managers have information which they can act on, while regulation involves technologies and services that intentionally or unintentionally directly shape the behaviour of the residents. As the study does not involve the housing company, we do not wish to make claims as to their intentions, rather it can be assumed that it is business interests that drives the implementation of technology which facilitates the shaping of power relations between the residents and the housing company.

4.1 Contracts

The housing model in this case study presents several advantages for the residents, many of whom are uncertain about what their future will entail. While the age of the participants ranges from late teens to early 40s, one common feature is that they do not have families of their own yet, and while some have partners, none of them have settled

down with children. The lifestyle and arrangements at the co-living building respond to shared needs of flexible contracts and community.

The first advantage mentioned is usually the flexible contract. To get a regular rental apartment there are usually several limitations: for the most part there is a minimum length, usually at least 12 months, and in order to get the contract you are expected to go to viewings where you compete with several other potential tenants, making it a time-consuming venture for people unsure of their future, with a risk of ending up in a home they do not like for an extended period of time due to unexpected problems such as noise or difficult neighbours. You can simply book a room online, state how long you want it, and it is on a first come, first serve basis without a minimum of 12 months of stay. Participant N10 expresses "*that it was really easy to book in here, like normally you have to apply for apartments in [country] and there are several other applicants. And it's like a lottery if you get the apartment or not. And here I just have to book a room and that's it, and they don't ask for security deposit or anything.*" The ability to book online through an easily accessible web interface facilitates the flexible contracts. After making the online booking the residents are able to move in without dealing with any further hurdles that are associated with normal apartments, and if the neighbours are noisy they can swap the room for a different one if and when a room becomes available. While some of the participants in the study are planning to stay under a year, most are planning to stay long-term until their circumstances change, such as moving in with a new partner, or leaving the city. For these residents a flexible contract without a minimum stay and the ability to get out of the contract if their life changes, is a valuable benefit that extends their feeling of autonomy.

Although several tenants cite cost as a factor for choosing to live there, the rent is comparable to similarly sized studios in the same area, with the notable absence of a deposit (often 2-3 months of rent). An advantage, especially for foreign residents, is the inclusion of amenities in the bill. There are no separate contracts for water, power, or even the gym. Signing new contracts for each service can be imposing when moving to a new country, however locals also express that it is easier to just have one bill every month, instead of several separate contracts. Similarly, most of the rooms are also furnished and participant N4 expresses the important convenience of no longer being tied down by having a lot of things, saying that *"You can just move anywhere else, if you want to. If you don't have to buy this furniture which is not necessary anymore, I think."* After living abroad previously he found himself needing to sell most of his belongings, so not needing to concern himself with finding new furniture or getting rid of it if he moves makes his life easier. This indicates that while cost is a factor, the convenience and service offering may be a more important factor.

The contract regulates the behaviour of the residents. While the rules may not be out of the ordinary, the house being zoned as a hotel rather than an apartment complex changes the rights of the residents should they break the rules. Even though a tenant can book for a year, they are unable to register the house as their permanent address due to the buildings being zoned as commercial, rather than residential. Without registering the apartment hotel as a permanent address, they lack tenant rights that a normal contract would afford them and can therefore be evicted with a less arduous process. This precarity helps push the tenants to abide within the lifestyle that the

company targets for the house. The negative aspects of these contracts are subtly hidden. Participant N10 states that "*If you apply for certain benefits from the government you can't apply if you live here so in that sense it affects people. But myself I have a job, I am not unemployed so personally it has no effect on me or it might affect positively. Because there's not many students here and I wouldn't like this to be a student house, and I wouldn't like there to be many unemployed people here because that would create problems long-term*." The easy online contracts circumvent the time-consuming apartment-hunting of regular apartment contracts, at the same time they participate in turning the home into a commodity for rent. The negative aspects of signing away tenant rights are unlikely to become an issue for the resident unless other aspects of their life changes, such as unemployment. As the house is not registered as their permanent address, they are not eligible for social welfare systems such as housing allowance. In addition, having a different permanent address may affect the residents' ability to participate in public life, if they are registered elsewhere, they are unable to vote in local elections.

4.2 Community

A sense of community forms part of the services provided. While the residents benefit from the community, it is also in a sense commodified. The community is managed by the company, by means of setting the community guidelines and policies and while these are not technological apparatuses, they can be considered part of the assemblage that makes up the co-living housing solution. While the residents do organise their own activities, they are only able to do so within the framework (i.e. following community guidelines) the company has defined. It can also be interpreted as a direct benefit from the residency, as they will be phased out of the social activities facilitated and organised by the housing company if they move out of the building. The community within the co-living building is one of the most important aspects for many of the residents. The personal studio allows anyone to socialise as much or as little as they prefer, unlike sharing an apartment where one participant expresses that she felt obliged to socialise more than she wanted. By referring to the community as a service, we indicate that the community itself has little input in the rules within which it operates. While the residents can share their opinion or ask for changes, the decision lies with the managers and the company that owns the building, creating a top-down power structure. Several participants express that living alone is very demanding as socialising becomes difficult. Therefore having a house full of people at similar stages in their life with whom they can socialise is one of the greatest perks of living in the co-living building. Participant N5 expresses that *"I think it is the people that make it feel like a home and not like a hotel where you come and you know no-one*" and that "*this kind of feels like a giant living room basically, with all our friends coming here."*

The managers of the co-living building are also aware of the value of the community and regularly organise small events for the residents such as game nights, brunch, making sushi, or going to local events together. Some of the residents do organise their own activities together, but this is done within the company's framework of rules and

spatial design, where the design has been done with little input from the residents. As participant N11 puts it *"it's not born out of what the community who live here want, whoever designed the place and thought would be a good idea has thought they should be and implemented it without actually asking what the people need."* The house managers are present in most of the communication channels within the building, including unofficial group chats for the residents. Their presence in both events and groups indicate that they are not just managing the space, but also act as community managers. One participant expresses that they also enforce regulations, such as limiting access for all residents to certain spaces after perceived misconduct. There are various community guidelines that regulate the behaviour of the residents. As several of the residents point out, these guidelines are made by the company rather than the residents. Although the residents have ways of expressing what they would like to change or improve, the decision lies with the company. Although the residents express that the rules make sense for the most part, there is a sense of lacking independence, as participant N1 expresses: *"It is weird to be a grown person and have your own apartment somehow, but to have to be respondent to hosts [house managers] or to the building let's say. It's a bit weird."*

The regulation of guests in common spaces is another aspect which some of the participants highlight. While they are allowed to bring guests, there's an expectation that they let the landlord know in advance if they are more than 10 people gathering and that it should end as the staff leaves for the evening at 10pm. In addition, participant N1 informs us that they are not supposed to have friends over after 11 pm and that she had gotten a message from the housing managers about it stating *"So there are cameras filming us and I think they check on the video. Because some other day people were here, friends of mine. After 11 that's when there are no hosts in the building. They noticed, they told me something the next day."* While this does not appear to be strictly enforced as the other participants do not express similar experiences, it means that unlike a traditional rental agreement the residents do not have full control over granting access to their personal space. It is worth noting that as this study took place while there were ongoing regulations on how many could participate in public events due to the Covid-19 pandemic, the regulations within the building were significantly stricter than the ones instated by the local government. One of the participants contacted us after the interview, after letting the housing managers know that she'd have a few people over, they were informed that they were closing the building for outside guests, at a time when most of the local restrictions had been lifted. This type of restriction can be considered justifiable considering how care homes for elderly have experienced high levels of infection [41], however it is the housing company's ability to restrict guests that is notable here.

In the common areas there is music and automated lighting. While the music can be controlled by the residents, the lighting is automated to shift based on the time of the day, and especially to partially turn off at a certain time in the evening. Automated lights and music allow the housing managers to automate what kind of use the shared spaces are intended for. Louder music in the evening discourages work and indicates it is time for socialising. Dimming the lights first at 10 pm and then further at 12 pm signals that it is time to quiet down, and later to consider ending the evening. Although

there are no rules on using the space throughout the night, the lighting and music shape what kind of practices the space facilitates.

4.3 Space

Each resident has access to a personal studio, equipped with a small kitchen and bathroom. The studios range between 18-34 m². Although the studios can be rented both partly furnished and fully furnished, the residents are not allowed to modify the space, such as putting things on the walls. The studio could be compared to a private apartment however, several participants in the study mention that the studio, while personal, is not a private space. This becomes evident in a few ways through the technologies, designs for utilities, and access to the space. However, despite the infringements on privacy, several participants also express satisfaction at being able to have guests over without sharing all of their personal space. Treating the studio like a bedroom, participant N6 says about the co-living space *"…it changed completely the way I spend time with people from the outside so very easily you come here instead of going to a bar and spend hours there. This makes a space where you can host things way more and I really appreciate that."* Participant N6 continues *"There are very few people ever going into my room, like in my studio. Usually if I wanted to invite people it was always in my apartment because that was the only space I had."* Outside of the studios there are multiple communal spaces, such as offices for co-working, tv-rooms, saunas, a pool-table, a communal kitchen, and bicycles that can be accessed. These spaces and services are available at no additional cost whenever the residents want them, with no internal booking system with the exception of the bicycles (upon request to the staff). Designing housing inevitably affects the private lives of the residents. It is therefore not just the technology but rather that the technologies take part in facilitating how the housing design affects the residents, adding another layer of complexity to an already complex system. The co-living housing solution responds to the need among the residents for shorter and more flexible housing contracts. Co-living also responds to a need for community. With many people living alone, socialising can become more challenging. However, the introduction of smart technologies appears to change how the residents relate to both personal and shared spaces, which in turn affects their autonomy.

The building managers are available in the building from morning until evening. They offer support and help to the residents, but also to observe the residents, such as noting whether there are guests in the building, and how the space is used. They track usage of communal spaces and access to some of the amenities such as bicycles as residents need to ask the managers for a key in order to borrow the bicycles. As part of the co-working areas they are also in charge of utilities such as printing and one participant informed us that she'd been told she was printing too much, which shows they do not just influence how the residents live but also their work habits. Surveillance is not only done by people, in most of the common spaces there are surveillance cameras, with the exception of saunas and co-working offices. Several of the participants express discomfort with the cameras, and although some express that they

are uncertain as to whether the cameras function or not, or whether anyone ever looks at the recordings. Other participants express that when something has happened, they have received personal emails from the staff or other indications that the staff does check the cameras. Participant N9 states *"Once I was having my housewarming and a friend of mine had brought this dogbed for my dog. I had rented her place for a while. And we were several in my studio at the beginning, we were so many that I thought it would be a good idea to leave the bed outside my studio for a bit, but then I forgot it until the end of the night, this was around 2-3 am, they brought it around 10 pm. So we came back, brought it back in. And next morning I woke up to an email saying hey you can not leave stuff out."* Although some of the participants also express that their discomfort with the cameras has diminished over time as they have gotten used to them, the cameras ensure that you cannot be anonymous or do anything without the housing managers being able to find out.

Most of the doors within the building are controlled through smart locks, and each resident has a keycard for their studio which also functions as access card to the rest of the facilities, with the exception of the bicycles the building offers. While several of the participants express that it is convenient to have the cards, they also indicate that this allows the housing managers to track their movement throughout the building. The house managers are also able to observe who uses utilities such as the gym, when they go, when they use the terrace, and if something happens they can check who was there. Participant N4 also notes that unlike a hotel, they are charged when let back in saying *"if you get lost with it, or you left it in your room. They will charge you now."* While this is similar to a normal apartment it also indicates that the housing company treats the residents as hotel guests or as tenants, based on convenience.

Much like any other hotel, there's a bi-weekly cleaning service included. While the residents largely appreciate the service, participants also note that they are unable to opt out of the service. While all utilities are included in the bill, there is also a control panel that staff has access to, showing temperature and power usage in each home. During the interview two of the participants reflected on how this can be used to observe when they are home, and to some degree, what they are doing. The smart home technologies built into the utilities allow the housing managers to track the usage of the studios, both the heating and how much power they use through other utilities. One participant mentioned that when a fire-alarm goes off while cooking, she noted that the house managers can see whether or not she was using the kitchen fan on a dashboard for the building. She notes this dashboard as an example of how she feels the house managers have access to too much data about the personal lives of the residents, while at the same time she is unsure about exactly how much access they have. Smart metering has been a controversial issue. Cuijpers and Koops [42] argue that mandatory smart metering would be a breach of privacy that is not justifiable in a democratic society as it can provide deep insight into living patterns and relationships, as well as the risk of the data falling into the hands of third parties.

In this section we have explored the role of smart home technologies and how they compromise autonomy regarding three areas: *contracts*, where they remove protection associated with rental housing in return for flexibility, access to a *community* where the housing company takes ownership of the community and defines the use of communal

areas, and *space*, where the residents grant the housing company deep insight into their personal lives in return for ease of access and convenience.

5 Discussion

While we can distinguish between how some technologies function to observe or regulate behaviour, we can also note that many of the technologies do both. Technologies that serve to purely regulate often rely on some form of observation. Smart technologies can be understood as exercising disciplinary power, which requires both observation and judgement [24]. Technologies that exclusively observe are part of the same system of power that serves to control the lives of the residents. The reliance on management via technologies often leads to increased inequality [43]. While technology installed by the residents themselves may concentrate power within the household [44], the co-living space shifts the power in favour of the landlord, thereby affecting the autonomy of the residents.

However, the role of the housing managers is also reminiscent of the managerial visions of Fox et al [21], enforcing compliance and defining access to resources. At first glance, the direct implications of the co-living model appear positive. The residents, despite some misgivings, enjoy their homes, which affords them a desirable lifestyle, and provides the flexibility that their current life-situation requires. If they would prefer a different solution, it could easily be argued that they should find a normal apartment instead. However, that neglects the challenging process of finding an apartment with the ongoing housing shortage.

In the previous section we explored how *contracts*, *community*, and *space* are designed, and how technologies are applied to respond to needs such as flexibility, community, and well-located housing. These are real and important needs for the residents and in many ways the co-living buildings respond to them, providing relatively affordable modern housing at central locations. What we find important to question however, is how this affects the independence of the residents. The co-living housing model allows for outsourcing the residents' need to take care of and maintain their homes, to the point that rather than renting a home they are renting a home experience. Exploring these technologies from the protection-appreciation dimensions suggests that, in this kind of co-living setting, technology is used to cushion the residents rather than nurture them and thereby reduces their autonomy.

At first glance, *contracts* appear to be largely affected in a positive manner. The digital booking system allows for desired flexibility and convenient economics. At the same time the contracts and the regulation around the housing creates a certain precarity. The less permanent aspects of the flexible contract leaves the residents without the protection that regular rental contracts would afford them. The rental policy where the landlord takes advantage of being considered a hotel is seamlessly supported by online contracts which obscure the precarity. This precarity is something that more privileged and economically secure residents can more easily afford, while those with less secure employment are put in a difficult position. In this way the contract practices

can be positioned into the lower left of the protection-appreciation dimension (See Fig. 1) of exploiting the user. Long-term residents without the rights of ordinary tenants and residents in the municipality indicate that there may be a need for housing policy to reconsider the regulatory status of this kind of co-living solution.

Community is a central aspect of a shared living solution and most communities have rules or guidelines, whether by policy or praxis. In the case of co-living housing the rules of the community do not come from the community itself, but are imposed on it by the housing company similar to how Frichot and Runting [12] argue that the communities in co-living are co-created but not co-owned. Several of the residents express how they have less contact with outside friends since moving into the building. They also note that people who move out quickly fade from the community. As the community is tied to the co-living space, it becomes a part of the holistic service offering and at least in part a commodity, rather than something shared by the community members. The co-living community appears to cushion the residents, rather than nurture their future social relations and community. While it provides an initial network, it does not support the resident to generate social capital for their use beyond the sphere of the facility nor the period of staying, despite the community being one of the central motivations for living there as well as an important part of the housing company's service offering.

The holistic service offering affects both personal and shared *space*. While surveillance is problematic on its own, it also shapes the way that the residents relate to their personal spaces and to common spaces. The personal space, the studio, is not considered private. The lack of privacy where others can access the studio, whether physically (such as the cleaning service), or through sensors such as the dashboard of the housing managers, serves to regulate the behaviour of the residents. In the common area, the cameras might be easier to justify, as shared facilities are often difficult to maintain. However, they also reinforce that the residents are not in charge of their own living space and highlight the use of IoT as part of regulatory techniques that affect the autonomy of the residents. Much like the music and lighting function to set the mood and activities the space is used for, the surveillance ensures that they are always watched over, even in what they describe as an extended living room. While the residents express mixed feelings about the cameras, it once more indicates a lack of trust from the company about whether they will maintain the space without external motivation in the form of surveillance. Due to how the smart surveillance is designed, it supplants the residents' own feeling of belonging and taking care of the space, cushioning rather than nurturing the residents' connection to the space they live in. The service offering further commodifies the home in order to respond to the residents' need for flexibility, well-located housing, and community. The technologies implemented to manage the building intentionally or unintentionally shape the residents' behaviour and control over both personal and shared spaces, thereby undermining their autonomy.

5.1 Study Limitations

In this exploratory case study we have focused on the impacts of co-living on autonomy. We have not deepened the inquiry by studying the participants' societal activity and autonomy related attitudes and behaviours in other areas of life. Nor have we studied the co-living service providers' explicit or implicit intentions of controlling the life of the tenants. Acknowledging these shortcomings, the results are tentative and give an indication of developments requiring further attention. We see a need to address co-living spaces in policy as well as a need for further research such as comparative studies with regular rental apartments, which could provide useful insights in the particulars of the service offering.

6 Conclusions

In this paper we explore co-living in a Nordic city, the role of technology in facilitating the shifting relations between tenants and housing service providers, and how this may affect the autonomy of the residents. By analysing a series of interviews through a protection-appreciation dimension we identify signals of possibly unwanted developments in three areas where the private lives of the residents are affected by how smart and digital technologies interact with the holistic service offering. In the first area, *contracts*, we identify how they afford flexibility and ease of use, while circumventing tenant rights. In the second area, *community*, we find they cushion the residents' own ability to build community by outsourcing the community-building to the housing company who gains ownership over the local community. And in the third area, *space*, we identify various tools of surveillance that help circumvent community trust by automating the maintenance and care for the building within the community, as well as provide deep insight into the personal lives of the residents in a way that under most circumstances would be deeply questionable, even illegal. These technologies, while acting in apparent protection of the residents, fail to nurture the residents' personal growth and abilities to maintain their lives and build a community. While we find that the co-living space in its current form may hamper the residents' autonomy, we also recognise that it responds to central needs in the current housing market. Our findings therefore suggest that there is a need to adjust public policy in such a way to preserve those needs while also pushing the technologies to appreciate the independence and self-expression of the residents. The co-living buildings in this study currently exist in a grey area, where they officially and legally function as a hotel, while many residents consider it their permanent home. While this in itself is not new, the way that new technology allows insight and influence over the lives of the residents shifts the nature of this kind of co-living, creating a need for more up-to-date policy that considers the precarity that these houses currently create while also respecting the needs they respond to.

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