



Residents' views on adaptable housing: a virtual reality-based study

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RESEARCH

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ABSTRACT

Housing adaptability is often said to be a characteristic that benefits the residents. But is there an actual demand from residents? This study asks whether and what kind of value residents place on adaptable housing. The research, situated in Finland, combines interviews involving seven varied households together with their experiences of adaptable flats in a 3D CAVE immersive virtual reality environment. The participants were first interviewed about their current life, housing situations and expected future changes in household composition or housing needs. For the virtual viewings, flats with systematically transformable floor plans were designed to anticipate situations that could occur during people's housing careers (e.g. the birth of a child, working from home, a child leaving home, additional healthcare, etc.). The participants walked through virtual flats selected for them based on the first interview. Afterwards, they were re-interviewed, focusing on the value they place on the presented adaptability. All households identified functional benefits for their current or anticipated situation, and many expressed a willingness to buy a home with the demonstrated adaptability characteristics. Most also described economic security that adaptability provides (e.g. renting or selling a part of the flat separately) and the benefits of remaining long term in a flat.

PRACTICE RELEVANCE

In the adaptability discourse, residents' opinions have been heard to a very limited degree. More typically, adaptability researchers or architects make the case for adaptability on the residents' behalf. According to recent research, some architects assume developers are disinterested in building more adaptable flats partly because no real market demand by inhabitants is believed to exist. The findings of the current study demonstrate that residents need to be properly informed about the benefits of adaptability by the housing provider. Virtual reality can be a useful tool for demonstrating adaptability characteristics. When sufficiently informed, the participants of the current study considered adaptability as functionally beneficial for the family and a desirable feature that would increase their willingness to buy and pay a premium. To demonstrate a potential market or its absence in a given context, residents' views should be sought more widely and more often.

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1. INTRODUCTION AND BACKGROUND

Adaptability is often seen as a focal feature for socially, economically and environmentally sustainable housing (e.g. ISO 2011). It can contribute to a long building life (e.g. Heidrich *et al.* 2017) and enable residents to customise housing to suit their lifestyles and needs (e.g. Loch 2011) throughout their housing careers,¹ where the household and its spatial needs may grow as, for example, children are born, and shrink again as they leave home, or as family members work temporarily or permanently from home. In areas where the housing stock offers a limited selection of dwellings, adaptability may reduce people's need to move and rebuild location-based social networks in the face of these kinds of changes (e.g. Huuhka & Saarimaa 2018; Braide 2019), which can contribute to preserving social capital and a higher level of wellbeing (e.g. Gilbert 2009).

Adaptability can be understood and approached in many ways. In this paper, 'adaptability' is used as a general term and in a broad sense, referring to a building's physical potential to change to different uses. It is the term applied in this meaning in a recent standard ISO 20887 (ISO 2020) and by several authors in present-day research (e.g. Schmidt & Austin 2016; Femenias & Geromel 2019; Saarimaa & Pelsmakers 2020).

Many theorists (e.g. Groák 1992; Schneider & Till 2007; Krokfors 2017) recognise two main principles for producing adaptability: first, spatial strategies that enable variable uses with no transformations to space; and second, those that call for modifying the space to accommodate an alternative function. The former principle can be called 'multifunctionality' and the latter 'transformability', although various other terms have also been used. Some theorists content themselves with this fundamental categorisation, but most scholars classify the adaptable solutions further. Transformable solutions are often divided into two subcategories: those that operate within a building without affecting its perimeter or facades, and those that extend beyond the building's current envelope and volume. The former can be called 'internal transformability', and the latter 'external transformability'. **Table 1** gives an example of the various classifications and terms used by different authors in relation to these general categories.

These and other classifications (for more extensive reviews, see, e.g., Loch 2011; Tarpio 2015; Schmidt & Austin 2016) show there are diverse ways and means to produce adaptability in housing. Many have been known since the 1960s, and various academics and practitioners in several countries have argued in favour of adaptability based on the benefit for the resident. One well-known approach is the so-called 'open building' movement, stemming from the ideas of Habraken (1972) which were later developed by him and others (e.g. Habraken *et al.* 1976; Vreedenburgh *et al.* 1990; van der Werf 1993; Geraedts 2006). To give residents substantial decision-making power, open building suggests the building be divided into durable parts which the resident community decides upon together (the 'support'), and changeable parts that each household can decide on individually (the 'infill'). Housing projects that recognise these two levels, which can produce both internal and external transformability, have been built in several countries (Kendall & Teicher 2000; *OpenBuilding.co* 2020). In addition to the open building approach, there are other means to provide adaptability to housing (e.g., for various cases, see Schneider & Till 2007). However, in the context of whole housing stocks, the number of adaptable dwellings, implemented by any means, remains negligible.

Despite the suggested benefits for residents, adaptability has not become a common feature in housing construction. Many authors arguing for adaptability have also identified obstacles to its wider implementation. Compared with regular housing construction, where design is optimised to meet the present demand (e.g. Schneider & Till 2007; Krokfors 2017; Tarpio *et al.* 2021), multifunctional or transformable solutions may require overprovision of space, structural capacity or building services (Rabeneck *et al.* 1974; see also Rabeneck 2021). Unsurprisingly, most factors beneficial to adaptability also increase investment costs, while it remains obscure whether these provisions will ever be capitalised on (Geraedts *et al.* 2017). Consequently, developers have been hesitant to invest on them (Geraedts *et al.* 2017; Tarpio *et al.* 2021). One additional reason for this may be that despite the academic discourse on benefits for residents, some practitioners believe that no substantial market demand truly exists (Tarpio *et al.* 2021). It has also been recently proposed that the market should identify and understand people's needs for adaptability better (Femenias & Geromel 2019).

	LEUPEN (2006)	BRAIDE (2019)	VAN ELDONK & FASSBINDER (1990) EXEMPLARY CONCEPTS	JIA (1994) DESIGN STRATEGIES	SCHNEIDER & TILL (2007) DESIGN STRATEGIES AND TACTICS
					[Extra area in] internal circulation
				Multifunctional entrance space	[Extra area in] external circulation
			Movable wall units and house appliances	Multiple relationships between rooms	Permeable circulation
MULTIFUNCTIONALITY	Polyvalence	Generality	Purpose-neutral and multifunctional rooms	Use-adaptability of rooms	Rooms without labels
			Sliding and revolving walls	Living on the roof (multifunctional roof space)	Sliding and folding
			Fold-up furniture	Balcony as an outdoor living room	Moving wall
					Room as furniture
				Ground floor is the most usable floor	
				Combinable flats	Joining together
				Exchangeable rooms between the flats	Switching it
		Flexibility	Building or moving partitioning walls	Moveable wall division	Moving in
INTERNAL TRANSFORMABILITY	Alterability			Adaptable kitchen	Dividing up
		Elasticity		Adaptable bathroom	Raw space
			Breaking away	Free-size apartment plan	Excess space
				Fixed installation combined with a free plan	Indeterminate building
				Simple outline of the apartment unit	
			Altered finish	Living on the roof (adding on the roof)	Adding-on
EXTERNAL TRANSFORMABILITY	Extendability		Interior and exterior expansions	Flats which can grow	Expanding within
			Adaptation of facade layout	Design of the structure	Slack space

The current research was devised to learn about residents' appreciation of adaptability. Knowledge of it is scarce, even though some studies on residents' views or adaptation behaviours exist (e.g. Aziz *et al.* 2020 in Iraq; Benrachi & Lezzar 2014 in Algeria; Bettaieb & Alsabban 2020 in Saudi Arabia; Braide 2019 and Femenias & Geromel 2019 in Sweden; Carrasco *et al.* 2016 in the Philippines; Jia 1995 in Switzerland; and Minami 2007 in Japan). The current research is located in Finland: its purpose is to create an in-depth understanding of residents' thoughts and views on adaptability by exploring the following research questions:

Table 1: Approaches to adaptability: examples of general and more detailed classifications.

- Do residents understand what housing adaptability is?
- Do they identify the benefits adaptability might bring for their households?
- Do they consider adaptable housing is worth buying and paying for?
- Is virtual reality a useful tool in communicating adaptability features?

The scope of this research is limited to flats. Flats comprise the most of new residential construction in Finland: 72% of the newly built dwellings in 2020 were flats (Statistics Finland 2021). The research focuses on mid-size and large flats, which are suitable for family use and can be divided into smaller units (see Section 2.3 for details). Hence, the study’s scope is limited to the internal transformability of flats. The adaptation options that require external transformability are excluded. Besides internal transformability, the issue of multifunctionality arose to a limited extent to allow variation in the furniture configurations in bedrooms and the possibility to use bedrooms in various ways.

2. MATERIAL AND METHODS

People in varied life situations were recruited as participants for a virtual reality-aided semi-structured interview study (cf. Galletta 2013). The research consisted of pre-interviews, viewings of internally transformable flats in a 3D CAVE immersive virtual reality environment, and post-interviews. Volunteers were recruited mainly via an online call in which people who fulfilled the criteria presented in **Table 2** were asked to enrol. The aim was to engage people living in highly varied life situations.

Table 2: Criteria for participants.

(A) You are part of a couple or a family living together, and at least one of the following applies to you:
• One to four children live with you, or you dream of having children
• One or both of your parents live with you currently, or is/are likely to live with you soon
• You work permanently at home
• You work occasionally remotely from home
• You take care of your family member as a family carer
(B) You are interested in living with a friend in a flat where you share some spaces with your friend

In all, seven households were recruited for this study. Participants acting as family carers for their spouse, and those interested in co-housing were sought, but alas, were not recruited. The research took place between April and June 2021. Due to the Covid-19 pandemic, it was assumed that people were cautious about infection risks. This made recruiting participants more challenging as only part of the research could be arranged remotely.

2.1 INTERVIEWS

Pre-interviews took place one to three weeks before the virtual tour in 3D CAVE. The purpose was to discover the characteristics of the participants’ life situations and housing preferences, assess their understanding of housing adaptability, and help select four to six pre-planned, systematically transformable flats that best matched the household’s current and expected future housing needs. These interviews were conducted remotely using teleconferencing applications. Usually only one person of the household was interviewed.

Post-interviews were conducted in person right after the virtual tour in a room next to the 3D CAVE. All household members who toured were invited, including children. They were first asked to opine on the toured flats in general, and then on the value of the demonstrated adaptability features. Both interviews were recorded and later transcribed. The transcriptions were anonymised and their content analysed. The citations presented here were translated from Finnish by the researchers themselves. The aim was to provide as literal a translation as possible while still conveying the meaning intended by the interviewee, contextualised also by the phrasing right before and after the selected citation.

2.2 3D CAVE AND TEST FLATS

3D CAVE is a physical space where people can experience a virtual space in a fairly realistic manner. It is an automated virtual reality environment, where projectors project images onto the walls and the floor (and sometimes the ceiling) of an angular space to generate an immersive, three-dimensional experience. The virtual space is navigated with the help of a joystick. This research used the 3D CAVE facility of the City of Vantaa.

Two flats with different shapes and sizes were selected as the starting point. The smaller one was an 'L'-shaped flat with a floor area of 83 m²; the larger flat had a floor area of 102 m² (*Figures 1 and 2*). The flats were derived from an award-winning (Vantaan kaupunki 2018) adaptable building concept and a housing project designed by L Architects and to be built for A-Kruunu. During the research, the project was at an early design stage and the construction had not yet started.

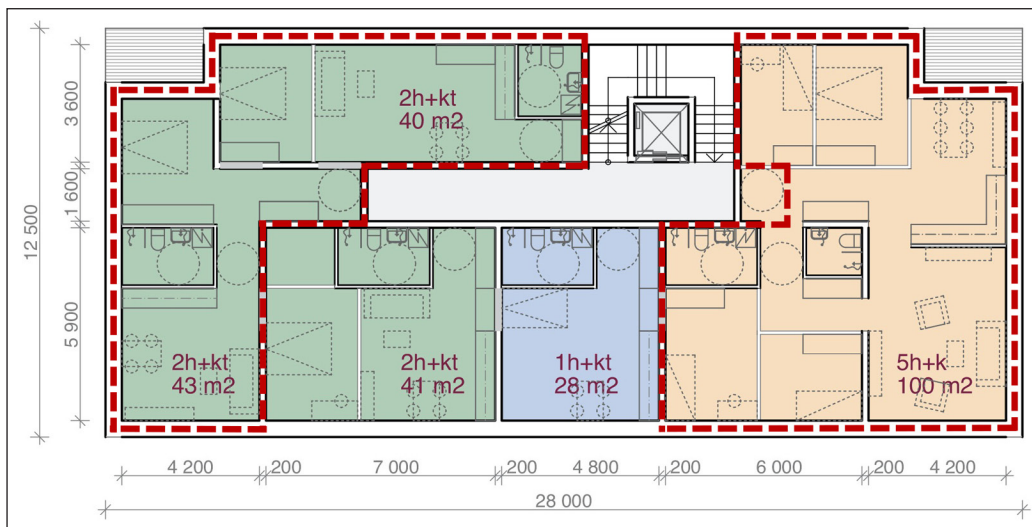


Figure 1: Early draft of the housing project in Verkkosaari, Helsinki.

Note: Test flats are marked with dashed lines.

Source: Adapted from a drawing courtesy of L Architects.

The internal transformability of the test flats was based on the idea of systematised pre-planned layout variations, which may follow a standardised dimensioning principle or another general rule for, for example, the placement of partition walls. The purpose is not to give the resident(s) maximal freedom, but to offer a limited variation of transformations that can be implemented over time without extensive construction works (cf., e.g., Becker & Prömmel 1976).

Both test flats had two entrances and two accessible bathrooms with roughly the same size. Various floor plan options to both flats were designed for the purpose of this research by the researchers by slightly modifying the original design by L Architects (*Figure 1*). The flat shapes and basic dimensions were maintained, but to improve the systematic floor plan transformability, minor adjustments were made to sizes and placements of windows, entrances, bathrooms and an outer wall. In all, 19 variations were designed to the smaller flat and 20 to the larger (for the plans, see the supplemental data online). The versions were designed with two criteria. First, for the expected participants and anticipated typical housing careers in mind (*Table 2*). Second, to limit the differences between the versions in order to create systematic transformability that would minimise the construction work required to transform one version to another (*Figure 2*). For example, this meant retaining partitioning walls in the same places as often as possible.

2.3 VIRTUAL TOUR ARRANGEMENTS

The design of different flat versions in building information modelling (BIM) were modelled by L Architects and then converted to the 3D CAVE format by a specialised company. The flats were furnished with a moderate amount of furniture. For each participating household, four to six flat versions were selected for a virtual tour based on the pre-interview. In the 3D CAVE, the household explored first two to three versions which were selected for their current situation, and then two to four variations which could serve their future needs.

At the beginning of the tour, the participants were instructed on how to use the joystick for moving. Usually, one household member operated it on behalf of the whole household. The researcher was available to answer questions during the tour, and the participants discussed many characteristics of the flats with him. In addition, printed floor plans of the flats were available with pens for participants to annotate the plans during the virtual tour. The floor plans were regarded as important for several reasons. First, they conveyed a good overall understanding of the flats as it was easy to see, for example, room sizes and their relationships at once. Second, the differences



between versions were best communicated by comparing the floor plans, as many plans could be looked at simultaneously. Third, they were an easy means for the participants to express what works for them and what does not in the different versions because they could write or draw notes directly onto the prints. Fourth, they were a means for the participants to suggest additional ideas and modifications.

The purpose of the virtual open house was to give the participants a thorough spatial understanding of the flat versions: to be able to enter the space; to have a look around; to visit individual rooms; to see from one space to another; to experience the effect of windows on the space; and to compare the differences between the different versions of flats for these aspects. The experience simulated physical visits to real flats (*Figure 3*).

Figure 2: Test flat versions presented to family E in the 3D CAVE environment.

Source: Adapted from drawings courtesy of L Architects.



Figure 3: 3D CAVE virtual environment with a test flat projected onto the walls and floor.

2.4 PARTICIPANTS' CHARACTERISTICS

Table 3 describes the participating households, each containing two to five persons. One is a couple without children, and six are families with one to three children. Three of them have a shared parenting arrangement in which children live approximately half of their time in the interviewed household and the other half with the other parent. Four of the families with children are one-parent households, and two are traditional nuclear families. One family had a unique life situation: the older child was severely disabled and needed round-the-clock care. At the home, nurses took care of the child at all times, in three shifts, which made the family's home a workplace for varied persons. Additionally, the family had a shared parenting arrangement, meaning that the younger child spent half their time in the father's household.

As families with children, most participating households approached their current and future housing arrangements placing high value to children's needs. However, the family structures were quite varied, and the needs of the families were not alike. If the families are compared by the number of parents, number of household members and shared parenting, all but two families appear different. The fact that one of these two is the family with the severely disabled child with special care needs makes all participating families different from one another. In all, the participants reflect well the diversity of contemporary families.

Table 3: Interviewed households and results from the first interview.

	HOUSEHOLD COMPOSITION	ANTICIPATED FUTURE CHANGES (WITHIN 2–7 YEARS) IN HOUSEHOLD COMPOSITION	MOST IMMEDIATELY DESIRED DOMESTIC SPATIAL CHANGE	ADAPTABILITY CONCEPTS RECOGNISED BEFORE THE VIRTUAL TOUR	PREVIOUS EXPERIENCE OF DWELLING TRANSFORMATIONS OR ADAPTABLE FEATURES	SPECIAL FAMILY FEATURES
Couple A	2 persons, no children	No expected changes	Additional space for work	1: Modifiable room layout	–	–
Family B	4 persons, mother and three children	Mother's parent possibly moving in	Additional room for a child	1: Changeable room uses with movable walls	–	–
Family C	3 persons, mother and two children	Child moving out, mother's parent possibly moving in	Additional room (guest room)	1: Modifiable room layout due to non-load-bearing partition walls	Experience of several dwelling refurbishments	Shared parenting
Family D	5 persons, parents with three children	No expected changes in the number of persons	Additional room for a child	3: Modifiable room layout; part of a flat with an own entrance can be used independently; joinable flats	Father's childhood home had two entrances	–
Family E	4 persons, parents with two children	Child moving out	Larger room for the younger child	4: Well-furnishable rooms; modifiable room layout; joinable flats; shared entrance between two (small) flats	Experience of two flat transformations	–
Family F	3 persons, mother and two children	Children moving out	Large storage space within flat	1: Modifiable spaces	Modifications implemented to current flat	Older child severely disabled; shared parenting
Family G	2 persons, father and one child	Child moving out, father moving together with his wife once the children of both have moved out, father's parent possibly moving in	Additional room for hobbies	2: Divisible rooms; joining rooms or flats by creating openings to walls	Experience of modifications in the spouse's and mother's flats	Shared parenting; reconstituted family with two family members living in another city

The pre-interviews showed that the participating households had a good, although varied, advance understanding of housing adaptability. When asked about conceptions of adaptable flats before the virtual tour, four could name one, but three described two to four spatial concepts providing adaptability (**Table 3**). It is remarkable that as laypersons they were aware of multiple adaptability concepts, and therefore showed good knowledge of housing and a considerable interest in it.

3. RESULTS

3.1 EXPERIENCED BENEFITS OF SERIAL ADAPTABILITY AFTER THE VIRTUAL TOUR

The participants regarded several features of the virtually tested adaptable flats as beneficial. These features include two entrances: the ability to make part of the flat an independent unit and room layout transformability. Next, the benefits are described from the more to the less frequently mentioned.

3.1.1 Two entrances experienced as beneficial in many ways

All participants regarded two entrances to a flat as a positive feature that creates various benefits. Some mentioned it as a means to separate domestic life and work, others as a way to provide adolescent and young adults a private entry or the first independent home, a means to generate privacy for a part of the family, or as a provision for future changes.

One interviewee expressed a need to have a workspace space within or close to her home. She and her husband, who worked remotely from home at the time of the interview, felt that it was important to be able to shift the mood in the morning from living to working in one way or another. She found two entrances served this purpose:

For me, it'd clearly be—a separator of home and work. I'd enter my own workspace through the separate entrance.

(couple A)

Another interviewee pointed out that two entrances enable altering the usage of some spaces from domestic functions to workspace, describing:

If I were self-employed, having these two doors here this [part of the flat] can really easily be used as an office, a reception or whatnot.

(family E)

Two interviewees considered the two-door arrangement valuable for the children as they grow up. One person described how one part of the flat, which he chose the most suitable for himself and his son in the virtual tour, could be used, thanks to its own entrance, as a small independent unit and a first own home of a young man. Another interviewee shared the idea that two entrances may be important for children's independence:

The other [entrance] could be located nearby children's rooms. The door, which may be not needed at all when children are small, could become valuable when their independent life's about to start.

(family E)

One interviewee highly appreciated two entrances and was convinced that two entrances would be an essential functional feature in the current stage of her family. This mother of a disabled child found it a key factor in generating enough privacy for her and her other son in their home. She noted:

As my son has a ring of nurses taking care of him 24/7, it's self-evident that it'd be a great benefit if it [his room] had its own entrance. The nurses changing their shifts late at night or early in the morning, that'd be the point of it.

(family F)

The other three households considered two entrances to a flat as a valuable provision for future changes. However, in their current family situation, they would likely not use the secondary entrance:

I'd rather use the space for storage for now. I'd probably place cabinets in front of the door until it's the time to divide the flat.

(family B)

3.1.2 Dividing the flat for intergenerational living and when selling the flat

Many interviewees regarded the possibility of dividing up the flat into two independent units good for intergenerational living. Three interviewees had considered having their own parent move close to them soon (*Table 3*). One interviewee emphasised that it was possible to use the smaller unit for either the older or the younger generation:

[T]o be able to make a separate studio for the teenager, so that it becomes an independent flat and the teenager takes care of all the duties there, or alternatively you can make it a granny flat.

(family E)

Additionally, many interviewees also raised economic motives. Most of them regarded flat divisibility as a valuable feature when selling the flat. Some interviewees mentioned the possibility to rent out a part of the flat:

For sure, the possibility to make an independent studio unit is a fairly big [financial] element. Even if you wouldn't utilise it yourself, you can inform the potential buyer about it and so justify your asking price.

(family C)

One interviewee considered divisibility of the units more important and lucrative than, for example, the transformability of the room layout:

Thinking financially, maybe above all the possibility to separate one part as a studio and rent or sell it. It'd perhaps give a significant incentive to pay some extra, more significantly so than the ability to decide whether a partition wall is here or there.

(family D)

3.1.3 Decreasing the flat size as a means to cope with future economic difficulties

Many interviewees approached adaptability as insurance for less wealthy times. They considered the ability to decrease the flat size during occupation as a way to cope with economically challenging life situations, either temporarily or permanently. Thinking of potential unemployment periods, two interviewees stated:

[T]here's the aspect, that if dividing up the flat is a real possibility, it also brings financial security.—[I]f you're renting the flat, you can sublet, or if you own it and turn a part into a true independent unit—. You can make that part of the flat yield you some income.

(family F)

If you lose income, and even if you think it's going to get better eventually but right now it's economically difficult, you're not forced to sell the whole flat but can sell just a part of it.

(family G)

The mother of family F approached decreasing the flat size and its relation to economics, too, but from a different perspective. She disclosed that she is used to changing life situations and has moved often. She also explained how her disabled child moved back home quite unexpectedly and, suddenly, she had to find a larger flat. In the interview she discussed the anticipated future changes in her family and forecasted the disabled child may move out within a couple of years, which would leave her and the other child living in a large flat with a considerable rent. In this likely future situation, she found diminishing the flat size a good means to continue living in the same place:

Now we need this large flat so that my son can live with the rest of us, and we can all live here decently. But I keep thinking what [will happen] when he moves out? Do I need to prepare to move once again after a year or two because I can't afford to pay this big a rent—[O]ne part [in the current home] is almost like a studio flat, so couldn't it be transformed into one and have someone else move in? Then we could stay here—it's a lovely neighbourhood.

(family F)

3.1.4 Adaptability as a way to meet the different demands of children and adolescents

Many participants noted that family members' need for proximity and privacy change during family life. Three interviewees opined that small children need proximity to parents, but when they grow older, they begin to appreciate privacy. This has direct impacts on the room layout of the flat, as some layouts that can be ideal for the small children phase may not be equally good with teenagers. This notion made interviewees consider room layouts and their transformability:

[W]hen kids [are still toddlers], they should be close [to parents], but quite soon they start to want some peace of their own. So then it would be good that the kids' rooms would constitute a compartment of their own. And to that these [adaptable flats] respond pretty well.

(family C)

3.1.5 Maintaining the proximity to children's schools and a familiar neighbourhood

When the needs for housing change, moving to a new flat is one solution. The participants were asked whether they would prefer moving or adapting their home. Some parents of schoolchildren pointed out that in the family's current life phase, adaptability would be important because they were not eager to move. Instead, they wanted to continue living in the current location to maintain proximity to the children's schools. However, moving can be a better option in another phase of life, for example, after the children have finished their school:

When they move from [elementary] school to [secondary] school, then they're no longer tied into this particular physical area. Then, instead of just like 'let's knock down this wall and transform our flat', many more options will become available. We can also consider moving house.

(family C)

For a family with small children, it is logical to consider the characteristics of the flat as one is going to stay there for longer:

Even when you're a family with babies, searching and then moving into a large family flat, it's [for] the [children's future] friends, kindergartens, schools. It's much nicer that we can live the whole 'family with children' phase in the same flat.

(family E)

However, one interviewee fleshed out that the permanence of the neighbourhood may be meaningful to adults too:

[I]f whenever something changes [means that] you'll need to find a new flat, it's—[rootless]. You're not afforded [the feeling] that this is my home and where I'll create relationships to the neighbours.—That's why the possibility for adaptability is so important for me—.

(family F)

3.1.6 Customisability focal for a family with special needs

Dwellers can have special needs or preferences for housing that cannot easily be fulfilled with the most commonly available housing solutions. The everyday life of family F differed substantially from that of the other participants. The mother described the special care needs of her disabled older child and the implications to their family life and spatial requirements. To help the child and his nurses with the daily routines, an extensive number of assistive devices are at their disposal. Some of them are large in size, which means, first, that the flat must be spacious enough to move and operate them, and additionally, space is needed to store the devices. The mother explained that it had not been easy to find a suitable flat to fit the family's needs. She described a recent contradiction in their needs and the current flat:

And now, as the nurses got fed up with my son's assistive toilet chair in his [small] toilet, they dragged it into our vestibule. So now I have an assistive toilet chair in my vestibule, and a standing device and a transfer lift in my living room. And a shower gurney in my bathroom.

(family F)

With these experiences in mind, she stated:

That a flat can be modified according to the needs of a family in general is an idea that I find highly, highly welcome.

(family F)

3.2 CRITICAL REMARKS ON THE CONDITIONS OF ADAPTABILITY

The participants found adaptability beneficial in many ways, but also raised some critical remarks about it. These notions are discussed next.

3.2.1 Articles of association or the rental agreement do not support adaptability

Three interviewees mentioned concerns related to tenure agreements because they feared these may hinder adaptability. Two interviewees discussed owner-occupied housing and articles of association in it, and one reflected on rental housing and rental agreements. One interviewee highlighted that separating flats must be allowed by the articles of association to enable sales as separate units:

[I]t can be a big problem if you think you can make this [transformation] just like that but then you're told you can't, as the articles of association cannot be changed [and updated] easily. It's quite a big majority [of votes] that's required to change the articles, and normally not a process one'll be bothered to start.

(family G)

One interviewee, living in a rental flat, was concerned about the tenant's ability to benefit from the adaptability of a dividable rental flat. Such a flat can be valuable for the building owner in the long term, since the number and sizes of dwellings can be modified, but to also benefit the tenant, she called for favourable conditions in the rental agreement:

[I]f it only were stated in the agreement that if our needs change, we can keep renting just a part of the flat and the landlord will find another tenant for the separated part. Then I could imagine that, hey, I'm able to stay here for like the next 20 years.—I could even pay more for it as a part of my rent or as sorts of a one-off payment.

(family F)

3.2.2 Reluctance to reduce flat size after the children have moved away

Many interviewees spoke positively about the possibility to divide up the flat and found it beneficial in various life phases. One phase that was often mentioned was the moment when adult children leave the childhood home to live independently. Consequently, there is often a surplus of domestic space in the home to be used only by the parents. Turning a small part of the flat into an independent unit would be a good option then, both socially and ecologically. However, two interviewees suggested that having lived with children, occasionally in cramped conditions, the parents may not be motivated to downsize the home:

If your financial situation is one where you don't really need some extra income, the threshold can be quite big to start converting, say, a 100 m² flat into a 60 m² flat. You might get the feeling that where on earth will I put all my stuff then?

(family D)

Another interviewee believed that many might rather consider new uses for the vacated spaces:

I would argue that—you might not right away downsize, for as long as you're in the working life, you're conscious there may once again be a sudden need for workspace at home [referring to Covid-19], and therefore you wouldn't immediately downgrade to a smaller flat.

(family E)

3.2.3 Remodelling may cause a disturbance to living

When asked to consider and compare flat adaptability to moving house, the son of one family began to ponder the disturbance to living in both cases. He stated:

I know that remodelling may seem a little laborious—and is maybe also disturbing, but then again, moving house seems also real difficult, that you need to lug all the stuff to another place.

(family G)

It is noteworthy that this relatively obvious notion was brought up only once in the interviews, and even then, only mentioned in passing. Perhaps this was due to the fact that the foremost idea behind the systematically adaptable flats is to reduce the burden of remodelling.

3.2.4 A willingness to pay for modifications in rental housing can be limited

Most interviewees approached housing through the lens of an owner-occupier. The interviewee who lived in a rental flat pondered her own willingness to pay for a share of the modification costs of a rental flat. She did not oppose paying a share of the costs, but stated the obvious:

If your dwelling's a rental flat, as a tenant you'd always be thinking how much you're willing to invest in the rental flat, as you don't know how long you're going to live there.

(family F)

3.3 UNDERSTANDING SPACE AND ADAPTABILITY

Many interviewees pointed out that it is not easy to grasp the various functional and experiential qualities of a space. The test event in which layout options and adaptability features were introduced and explained by a professional was experienced to be beneficial. Notions related to space and its understanding by the interviewees are highlighted next.

3.3.1 Spatial qualities better conveyed in 3D but adaptability properties in 2D

Two interviewees witnessed that the three-dimensional experience provided a better understanding of the space than merely looking at the two-dimensional plan:

[T]his [flat] is more attractive once we went into [in the 3D], it didn't look so promising in the plan drawing—.

(family E)

However, the adaptability, that is, the differences between different versions of the flat, was easier to understand from the plan layouts. This became clear during the virtual tour when participating family members compared the floor plans eagerly to discuss their preferences.

3.3.2 Adaptability is difficult to understand without demonstration

For a dweller who is not professionally involved in construction or housing, if understanding space can be difficult, so can the various aspects related to adaptability. This relates not only to spatial matters (what spatial and functional variations the space can provide) but also to the characteristics of a more technical nature (possibilities and limitations created by the building services and structural solutions).

One interviewee stated this problem directly, and another one, who works in a rental housing company, stressed the importance of a proper demonstration with visual means:

[B]eing a layperson in these matters, one doesn't know what's possible.

(family C)

But [the benefit of having two entrances and bathrooms] must above all be marketed using quite many visual examples, like, here's how you can use this flat among other things.

(family E)

3.3.3 A virtually hosted adaptability tour could be a valuable service

Some interviewees suggested that having a professional to demonstrate the adaptability options would be important to them. They believed that as laypeople, they are unable to understand all the options and the benefits they may bring. They also felt that demonstrating the options is a valuable service they could be willing to pay for:

Well, this is clearly an additional service, why wouldn't it cost more.—I see it as a service, being willing to customise.

(couple A)

Another interviewee envisioned a service where she as a home buyer would receive tips and ideas from a professional, which she would appreciate:

[If the developer] would offer these transformation options, like, this is the starting point, but these are the available flexible elements, would they serve your needs?

(family C)

One participant also called for marketing the adaptability options to the dwellers, and another thought it could be a good business idea:

[Y]ou'd know when purchasing that these two doors are here so that you can turn this part into another flat or workspace or whatnot, and if this marketing discussion would've taken place, my willingness to buy would be [enhanced].

(family E)

[A]ctually this [demonstration and customisation service] should probably be developed into a business model—.

(couple A)

3.4 WILLINGNESS TO BUY AND PAY

Many interviewees expressed a willingness to buy a home with the demonstrated adaptability characteristics. When specifically asked, some agreed to speculate on the additional investment they could be willing to make. However, as many of the interviewees themselves stated, this was a difficult topic to discuss speculatively:

It's hard to give a price for singular [adaptability] features or services.—You can think that this is the flat where I can live the rest of my life, which means you'd be willing to pay more for it.

(family C)

Nevertheless, 2–10% of the purchase price was thrown in the air as the limit for the upfront investment:

I could sell [the idea of] the additional investment to myself quite quickly.

I would say around 5%, maybe 20,000 €, also depending on the overall price of the flat, but not endlessly just for the affordances.

(family E)

Only the family renting their home also considered the cost to transform:

[L]et's say for the remodelling, like, €5k, as a lump sum. Like €20k is a lot already.—When you're renting, you may not have much capital to spare.

(family F)

They also added the perspective of someone receiving housing benefits and recognised that the benefit system may form a barrier:

Unless [the investment] can be embedded in the rent [over a longer time].—However, if the family receives housing benefit, will [the higher rent] be eligible?

(family F)

In the end, housing market prices are influenced by a multitude of factors, which one of the interviewees acknowledged. The discussion over the speculative case had reached its limits:

How much in percentages, I can't guess. Could it be €10k or even more, depends on the asking price.—And then, you don't know what the [economic] value of the flat will be in the future.—It's all speculation, you can never be sure.

(family G)

4. DISCUSSION AND CONCLUSIONS

The purpose of this paper was to construe a rich understanding about residents' valuation of adaptability in Finland and about the varying motives different kinds of households could have for buying or renting an adaptable home. The participants saw value in many adaptability characteristics that were demonstrated to them in 3D CAVE, such as two entrances, flat divisibility and systematic floor plan transformability. They gave insights into how the exhibited adaptability features would serve their household presently or in the future by providing a means to separate work from home life; to afford independence for maturing teenagers or proximity to ageing grandparents; to ease the professional care of a disabled family member; to adjust space according to children's changing needs as they grow up; and to guarantee permanence for children and adults alike by reducing the need to move house.

In general, these aspects are not new motives for adaptability. The ability to transform the layout of a dwelling to fit to the changing needs of a family with children is one of the first motives architects had for introducing more adaptable housing in the 1920s and 1930s (e.g. Rowe 1993; van Eldonk & Fassbinder 1990). Similarly to, for example, Braide's (2019) findings from Swedish residents' interviews, Finnish families with children participating in the current study valued the ability to transform the flat layout to fit to the changing needs of growing children and, thanks to it, be able to stay in the same neighbourhood and maintain social continuity. Additionally, some participants appreciated economic security by being able to diminish the size of the flat by selling or renting out a part of it in challenging life situations, the same as in Braide's research. In the current study, some participants also saw it as an economically advantageous feature when selling the flat.

The ability to work from home has also been discussed in recent decades in the context of adaptable housing (e.g. Jia 1994; Schneider & Till 2007; Loch 2011). The results presented herein as well as those from the interviews by Bettaieb & Alsabban (2020) witness that adaptable means to arrange working at home has gained significant importance during the Covid-19 pandemic. Furthermore, the needs of the ageing population and care provision, which too surfaced in the current research, have also been recognised previously (e.g. Loch 2011; Femenias & Geromel 2019). Thus, the results of the current research provide further empirical evidence of the relevance of many adaptability motives that have been proposed in the previous literature, specifically from the Finnish context.

While the participants of the research appreciated the presented adaptability characteristics, they pointed out that it is not easy for laypersons to comprehend the adaptability that a dwelling may afford. Many felt that adaptability options should be demonstrated by a professional, similarly to the research setting in 3D CAVE, where the features were explained by and discussed with the researcher. This reinforces earlier observations by Jia (1995) who found, in the context of Swiss rental housing, that adaptable features need to be properly communicated to the residents by professionals. Additionally, the 3D demonstration delivered a more realistic experience to the participants than only floor plans could have. It revealed spatial features and preferences they could not identify in two dimensions. From the research perspective, the 3D technology provided an additional tool that complemented two-dimensional floor plans and delivered some information that the floor plans could not. The comparison and discussion on the flat versions could have been accomplished by using floor plans only, but without them, subtle differences between flat versions would not have been comprehensible.

Systematically transformable floor plans proved, in the participants' opinion, a spatially viable way to prepare for upcoming life situations that have implications for people's housing needs.

In the study's test flats, the systematic transformability could be achieved with fairly simple means, such as an additional entry to a flat. The transformability was based on the idea that the perimeters of the flats and the locations and sizes of the wet spaces and vertical piping stacks will not be altered, so the most expensive modifications to the building structure and services can be avoided. Transforming between versions may still require modifications to non-load-bearing partition walls and other building services, such as electricity and ventilation systems, which bears a cost, unless their adaptation has also been pre-planned. This aspect, though, was not covered in the current study. Thus, the demonstration may have delivered a slightly too effortless impression of adaptability to some participants. However, four of the seven households (*Table 3*) had prior experience of home refurbishments and seemed to have an understanding of the conditions and requirements of such works. For instance, they opined insightfully about housing co-operations' articles of association or rental agreements enabling the division of flats as a precondition to make the economic investment in adaptability meaningful. Nevertheless, as prices for the flats or costs for their transformation were not available, the interviews were not a reliable method with which to explore the willingness to pay beyond the notion that the interviewees exhibited an interest to buy.

Whether there should be supply before demand can emerge is a classic 'chicken or egg' causality dilemma in housing adaptability. This study's results provide a reason to believe that demand for adaptability does exist in Finland within a specific customer segment. Even though expressing housing preferences in an interview is different from a real-life purchasing situation, the middle-class customer segment, represented by most interviewees in this research, can be expected to exhibit a capacity and willingness to pay too, as long as the potential benefits of adaptability are clearly communicated. The extent of that willingness should be explored in future research by housing economists by introducing precise cost data, which requires a housing project to be in a more advanced state than that used in this study.

Overall, the findings demonstrate that the benefits of adaptability as argued by several theorists over recent decades are not imaginary but factually valued by the study's participants. Due to the small number of self-nominated participants, though, the interviewees' perspectives may not reflect those of Finnish urban dwellers in general. The participants may have been more interested in their housing arrangements and the affordances in adaptability than most people. Nevertheless, similar valuations for adaptability have been reported at least from a cultural context similar to the current study, for example, Sweden, suggesting there may be a more universal dimension to people's desire to adapt their home. In addition, as witnessed by this research and some others before it, the Covid-19 pandemic has increased the diversity of usages for domestic spaces, causing unprecedented demands, which adaptable housing could help meet. The virtual reality-aided method presented in this research provides a viable tool for studying residents' needs and valuations in other times and contexts, as well as by any housing providers wishing to capitalise on the potentially emerging customer segment.

NOTE

- 1 The term 'housing career' means the progression of an individual throughout different types of housing, depending on the needs of their life phase, family situation and affordances of the housing stock in the given context (Coulter & van Ham 2019). A stereotypical housing career would progress from the childhood family home to independent living, alone or potentially with a spouse; if children are born, to a family with children phase; and eventually into independent or possibly assisted living as an ageing couple or individual. The phases are characterised by different spatial needs, which are often available in different types of housing.

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AUTHOR CONTRIBUTIONS

JT held the main responsibility for the research from research design to practical implementation, including sketching the systematically transformable flats on top of the baseline by L Architects, the viewings in 3D CAVE, associated interviews, analysing the transcriptions and reporting the results. SH participated in the research design, drafting the interview framework and improving the systematic transformability of the test flats, and contributed to the content of the manuscript as well as its editing.

COMPETING INTERESTS

The authors have no competing interests to declare.

DATA AVAILABILITY

The data generated in this study cannot be made openly available because sharing could compromise the research participants' privacy and consent. Due to potentially unique life situations that could lead to the participants being identifiable even if the data were anonymised, no interviewees were asked to consent to their data being shared.

ETHICAL APPROVAL

According to the guidelines of the ethics committee of the Tampere region, the used research protocol does not require an ethical review. Participation in the research was based on the participant's informed consent, or in the case of underage children of a family, on the parents' consent and presence.

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SUPPLEMENTAL DATA

Floor plan versions of the systematically transformable flats used in this study are provided in a separate file. This supplemental data can be accessed at: <https://doi.org/10.5334/bc.184.s1>.

- Aziz, S. S., Alobaydi, D., & Salih, A. B. M.** (2020). Studying flexibility and adaptability as key sustainable measures for spaces in dwelling units: A case study in Baghdad. *IOP Conference Series: Materials Science and Engineering*, 881, 012019. DOI: <https://doi.org/10.1088/1757-899X/881/1/012019>
- Becker, H., & Prömmel, A.** (1976). Flexible Wohngrundrisse. Ein Wettbewerb und die Realisierung seiner Ergebnisse. *Deutsche Bauzeitung*, 1976(4), 41–50.
- Benrachi, B., & Lezzar, S.** (2014). The impact of building modifications on Algerian social collective housing. *International Journal of Urban Sustainable Development*, 6(1), 123–132. DOI: <https://doi.org/10.1080/19463138.2013.780176>
- Bettaieb, D. M., & Alsabban, R.** (2020). Emerging living styles post-COVID-19: Housing flexibility as a fundamental requirement for apartments in Jeddah. *Archnet-IJAR: International Journal of Architectural Research*, 15(1), 28–50. DOI: <https://doi.org/10.1108/ARCH-07-2020-0144>
- Braide, A.** (2019). Dwelling in time. Studies on life course spatial adaptability (Doctoral dissertation, Chalmers University of Technology, Gothenburg).
- Carrasco, S., Ochiai, C., & Okazaki, K.** (2016). A study on housing modifications in resettlement sites in Cagayan de Oro, Philippines. *Journal of Asian Architecture and Building Engineering*, 15(1), 25–32. DOI: <https://doi.org/10.3130/jaabe.15.25>
- Coulter, R., & van Ham, M.** (2019). Housing career. In *The Wiley Blackwell encyclopedia of urban and regional studies*. DOI: <https://doi.org/10.1002/9781118568446.eurs0144>
- Femenias, P., & Geromel, F.** (2019). Adaptable housing? A quantitative study of contemporary apartment layouts that have been rearranged by end users. *Journal of Housing and the Built Environment*, 35(2), 481–505. DOI: <https://doi.org/10.1007/s10901-019-09693-9>
- Galletta, A.** (2013). *Mastering the semi-structured interview and beyond. From research design to analysis and publication*. New York University Press. DOI: <https://doi.org/10.18574/nyu/9780814732939.001.0001>
- Geraedts, R.** (2006). Upgrading the adaptability of buildings. In F. Scheublin and A. Pronk (Eds.), *Proceedings of the Joint CIB, Tensinet, IASS International Conference on Adaptability in Design and Construction, Adaptables 2006*, Eindhoven, July 2006. Eindhoven University Press.
- Geraedts, R., Olsson, N., & Hanssen, G.** (2017). Adaptability. In P. Jensen and T. van der Voordt (Eds.), *Facilities management and corporal real estate management as value drivers* (pp. 159–183). Routledge.
- Gilbert, P.** (2009). Social stakes of urban renewal: Recent French housing policy. *Building Research & Information*, 37, 638–648. DOI: <https://doi.org/10.1080/09613210903186638>
- Groák, S.** (1992). *The idea of a building. Thought and action in the design and production of buildings*. E&FN Spon. DOI: <https://doi.org/10.4324/9780203133781>
- Habraken, N. J.** (1972). *Supports. An alternative to mass housing*. Architectural Press.
- Habraken, N. J., Boekholt, J. Th., Dinjens, P. J. M., & Thijssen, A. P.** (1976). *Variations. The systematic design of supports*. MIT Press.
- Heidrich, O., Kamara, J., Maltese, S., Re Cecconi, F., & Dejaco, M. C.** (2017). A critical review of the developments in building adaptability. *International Journal of Building Pathology and Adaptation*, 35(4), 284–303. DOI: <https://doi.org/10.1108/IJBPA-03-2017-0018>
- Huuhka, S., & Saarimaa, S.** (2018). Adaptability of mass housing: Size modifications of flats as a response to segregation. *International Journal of Building Pathology and Adaptation*, 36(4), 408–426. DOI: <https://doi.org/10.1108/IJBPA-01-2018-0011>
- ISO.** (2011). *ISO 21929-1:2011. Sustainability in building construction—Sustainability indicators—Part 1: Framework for the development of indicators and a core set of indicators for buildings*. International Organization for Standardization (ISO).
- ISO.** (2020). *ISO 20887:2020. Sustainability in buildings and civil engineering works—Design for disassembly and adaptability—Principles, requirements and guidance*. International Organization for Standardization (ISO).
- Jia, B.** (1994). *Housing adaptability design*. Eidgenössische Technische Hochschule Zürich, Professur für Architektur und Planung.
- Jia, B.** (1995). Adaptable housing or adaptable people? Experience in Switzerland gives a new answer to the questions of housing adaptability. *Architecture & Behaviour*, 11(2), 139–162.
- Kendall, S., & Teicher, J.** (2000). *Residential open building*. E&FN Spon. DOI: <https://doi.org/10.4324/9780203056769>
- Krokfors, K.** (2017). Time for space. Typologically flexible and resilient buildings and the emergence of the creative dweller (Doctoral dissertation, Aalto University, Espoo).
- Leupen, B.** (2006). *Frame and generic space. A study into the changeable dwelling proceeding from the permanent*. 010.

- Loch, S.** (2011). *Das adaptive Habitat. Typologie und Bedeutungswandel flexibler Wohnmodelle* (Doctoral dissertation, Institut Wohnen und Entwerfen der Universität Stuttgart, Stuttgart).
- Minami, K.** (2007). A post-occupancy evaluation of layout changes made to KEP adaptable housing. *Journal of Asian Architecture and Building Engineering*, 6(2), 245–250. DOI: <https://doi.org/10.3130/jaabe.6.245>
- OpenBuilding.co.** (2020). *Case studies*. <https://www.openbuilding.co/casestudies>
- Rabeneck, A.** (2021). Housing adaptability: Some past lessons. In *Buildings & Cities Commentaries*, November 25. <https://www.buildingsandcities.org/insights/commentaries/housing-adaptability-lessons.html>
- Rabeneck, A., Sheppard, D., & Town, P.** (1974). Housing flexibility/adaptability? *Architectural Design*, 1974(2), 76–91.
- Rowe, P. G.** (1993). *Modernity and housing*. MIT Press. DOI: <https://doi.org/10.7551/mitpress/4727.001.0001>
- Saarimaa, S., & Pelsmakers, S.** (2020). Better living environment today, more adaptable tomorrow? Comparative analysis of Finnish apartment buildings and their adaptable scenarios. *Yhdyskuntasuunnittelu*, 58(2), 33–58. DOI: <https://doi.org/10.33357/ys.89676>
- Schmidt, R., III & Austin, S.** (2016). *Adaptable architecture: Theory and practice*. Routledge. DOI: <https://doi.org/10.4324/9781315722931>
- Schneider, T., & Till, J.** (2007). *Flexible housing*. Architectural Press. DOI: <https://doi.org/10.4324/9781315393582>
- Statistics Finland.** (2021). *Completed buildings and dwellings*. https://www.stat.fi/tup/suoluk/suoluk_rakentaminen_en.html
- Tarpio, J.** (2015). *Joustavan asunnon tilalliset logiikat. Erilaisiin käyttöihin mukautumiskykyisen asunnon tilallisista lähtökohdista ja suunnitteluperiaatteista* (Doctoral dissertation, Tampere University of Technology, Tampere). <https://urn.fi/URN:ISBN:978-952-15-3510-9>
- Tarpio, J., Huuhka, S., & Vestergaard, I.** (2021). Barriers to implementing adaptable housing: Architects' perceptions in Finland and Denmark. *Journal of Housing and the Built Environment*. DOI: <https://doi.org/10.1007/s10901-021-09913-1>
- Van der Werf, F.** (1993). *Open ontwerpen*. Uitgeverij 010.
- van Eldonk, J., & Fassbinder, H.** (1990). *Flexible fixation. The paradox of Dutch housing architecture/De paradox van de Nederlandse woningbouw*. Van Gorcum.
- Vantaan kaupunki.** (2018). 'Lähiösinfonia' voitti Asuntoreformi 2018 -kilpailun. https://www.vantaa.fi/asuminen_ja_ymparisto/kaavoitus_ja_maankaytto/suuralueet_ja_kaupunginosat/hakunila/hakunila_mukana_asuntoreformi_2018__arkkitehtikilpailussa
- Vreedenburgh, E., Mooij, M., & van Randen, A.** (1990). *Leidingsystematiek in relatie tot flexibiliteit*. Technische Universiteit Delft.

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