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In search of behavioural and social levers for effective social housing retrofit programs

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ABSTRACT

Our study proposes to analyze from a social practice and behavioural economics perspective the factors that influence a mismatch between energy behaviour and retrofit efficacy in the context of social housing. Retrofit interventions not only have the potential of improving energy efficiency of buildings, but they also change the context in which individuals live, therefore improving their wellbeing at home. However, the surrounding social context might suggest some context-specific practices and cognitive biases that negatively influence energy behaviour, creating a gap between expected and actual energy performance.

Addressing the context-specific practices and cognitive biases is especially necessary when it comes to social housing. Social housing neighbourhoods are not only low-energy efficient, but also socially vulnerable. This context might shape specific practices and make salient specific cognitive biases which require special consideration within an energy retrofit program.

The ambition of this study is to understand the context-specific practices and cognitive biases that characterize the pre-refurbishment phase of a retrofit program and to identify the ones that can be used as behavioural and social levers to enhance retrofit efficacy. To this aim, we analyze the results of a questionnaire administered to the tenants of a social housing district through the lenses of social practice theory and behavioural economics. Our results show that analysing tenants' behaviour through an interdisciplinary social science approach allows to identify a range of context-specific variables that can be used as levers to align behaviour to retrofit interventions.

1. Introduction

Buildings are responsible for about 40% of total energy consumption and 36% of CO_2 emissions in the European Union [1], which gives them a key role in reaching the EU climate-energy goals. Therefore, the EU has set several policy initiatives to promote energy efficiency in buildings, among which the creation of 100 innovative and integrated Positive Energy Districts/Blocks by 2025 [2], i.e. neighbourhoods that produce more energy than what they consume. The SINFONIA project (Smart INitiative of cities Fully cOmmitted to iNvest In Advanced large-scaled energy solutions[1]) is a "seeding point" for the creation of such districts and is designed to target social housing dwellings. In the context of social housing, retrofit is particularly relevant as it must overcome a series of difficulties: large investments allocated in large numbers of dwellings; actual occupancy of the flats to be refurbished; social segregation due to location in peripheral areas. At the same time, energy retrofit in social housing carries the advantages of an economy of scale due to the grouping of numerous flats in a few number of large building blocks. The retrofit process promoted by SINFONIA contains a combination of measures which include envelope insulation, solar energy and geothermal exploitation, monitoring system and mechanical ventilation installment. These interventions are being implemented under a collaborative scheme which involves researchers, local housing associations and municipalities, tenants and energy providers (the so-called *quadruple helix innovation model* [3,4]).

Intervening on the built environment, however, does not necessarily result in a greater building energy efficiency [5,6]: Wrong assumptions on users' energy behaviour determine a gap between the expected and the actual performance of a building - the *energy efficiency gap* [7,8]. In fact, within a group of identical buildings, individuals may engage in completely different energy consumption behaviours [9,10]. Technically, the *rebound effect* is used to explain the adverse effect that the introduction of new energy efficient technologies has on energy consumption behaviour [11]. However, this factor is difficult to quantify due to biases created by context-specific features [12]. For example, rented properties occu-

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[1] http://www.sinfonia-smartcities.eu/en/.

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pied by individuals with higher energy needs and low income lead to a higher rebound effect [13]. A way to circumvent this difficulty might be to scan before the retrofit the target context in search of social and behavioural levers which can be incorporated in subsequent behavioural change strategies.

A specific context is defined by a variety of factors that might affect energy behaviour and, in turn, intervention efficacy [14]. Individuals are greatly affected by their living environment which shapes their behaviour (making cognitive biases salient [15]), their cultural models [16] and social practices [17]. Considering the social housing example, outdoor temperature [18] in proximity to polluted areas [19] influences tenants' ventilation practices. In the same context, a low income and a poor energy education [20] might induce social housing tenants to choose more short-term rewarding but inefficient behaviours [21].

Previous studies on the same topic have investigated how energy behaviour is affected by context [14], cognitive biases [22] and social practices [23]. Our study provides instead an interdisciplinary [24] approach to scan ex ante the social housing retrofit context through the lenses of social practice theory and behavioural economics in an effort to extract from tenants' behaviours the context-specific biases and social practices. Using this approach, we analyze the results of a survey on tenants' energy behaviour in a social housing district before refurbishment to identify context-specific social practices and cognitive biases and extrapolate the levers that enable in a subsequent phase to align behaviour with the purpose of the intervention. This approach also uses the evidence-based approach centralized by the European Commission's Better Regulation Agenda [25].

The paper is organized as follows. In Section 2, we explain how energy behaviour is investigated under the lenses of behavioural economics and social practice theory. In Section 3, we present the SINFONIA project and describe the survey. Results analysed under the proposed interdisciplinary approach are presented in Section 4. Section 5 discusses the results and highlights the social and behavioural levers. Section 6 concludes.

2. Uncovering the behavioural and social levers in social housing

Here we develop an analytical guide for identifying appropriate levers in behavioural change strategies in social housing retrofit interventions. In order to better explain to the reader our interdisciplinary approach, in the following we outline our two points of view in studying energy behaviour in social housing retrofit: behavioural economics and social practice theory.

2.1. The behavioural economic lens

Behavioural economics may help explaining the determinants of the energy efficiency gap. Neoclassical economic theory assumes that human decision making and behaviour are based on rational choice [26,27], associating any change in behaviour to changes in predictable factors, like information and prices. Behavioural economics challenges this view by unveiling a realistic picture of individual behaviour through the application of psychological insights.

Individuals are bounded rational and make choices relying on mental shortcuts and habits, especially when they face cognitive overload [28]. This exposes their decision making process to cognitive biases that the *context* of the moment of decision makes salient [15]. Individuals are prone to the status quo bias, that is they are prone to resist change and stick to the status quo [29,30]. This is particularly true when they have to choose new electricity suppliers or devices, even when they are educated about the product benefits and features [31]. Individuals are also prone to perceive things as more valuable when they are closer in time, even when they might provide higher benefits when delayed in the future [21]. This "myopic" behaviour results in comparing the short-term costs and long-term benefits of energy behaviour, such as energy consumption and energy efficient investments. Another piece of evidence that helps us understanding energy behaviour is that people display privacy concerns, that is they prefer long-term privacy to short-term benefits [32], and that they draw on accessible memory and available information to understand how to behave (*availability bias* [33]).

The decision to consume or invest in energy efficiency is a decision to contribute to a public good, hence is a type of moral behaviour [34]. People are often tempted to engage in immoral behaviour, even if they value perceive themselves as moral actors [35]; therefore, they engage in moral licensing or cleansing when they recall past socially desirable or morally questionable behaviour [36]. This behavioural history-dependence might explain incongruous actions in energy domains. In particular, being recalled of a good behaviour, such as efficient water consumption, might predict a less good behaviour later on, such as inefficient electricity consumption [37].

A fundamental concept that suggests that behaviour is affected by contextual features is the absence or the presence of interpersonal trust [38]. In the domain of energy related behaviours, this translates in improving energy behaviour when information comes from a trusted source [39]. This links to the evidence that people's behaviour is also influenced by the behaviour of those who surround them: they draw from people's behaviour to understand which is the socially appropriate behaviour they have to conform to [40].

The features of the specific context of social housing influence how people behave and in a specific way. In particular, the social housing conditions of scarcity (like income and energy) affect people's available cognitive resources and, in turn, their behaviour. For instance, when there are several pressing needs to satisfy, attention is depleted, and future needs are neglected [20]. As a result, a context characterized by scarcity conditions shapes people's preference towards immediate rewards [41], exacerbating the human myopic tendency to value future benefits, such as those associated to energy efficient behaviours [42]. Another feature of social housing is that it can create a stigma. In particular, scarcity conditions might create a stigma that leads to cognitive distance [43] and underperformance [44] that poses barriers to the achievement of several benefits [45].

Overall, behavioural economics highlights that context shapes people's behaviour by making more salient some cognitive biases. And social housing is a powerful context at doing so. However, not only context shapes behaviour, preferences and perceptions by making certain cognitive biases more salient, but it also shapes who people are and how they interpret the world [16]. In the next section, this latter issue will be deepened under the lens of social practice theory.

2.2. The social practice theory lens

Context is also crucial in the social practice theory. This perspective underlines that people are actors who grow up, act, and make decisions in specific material and cultural context [16] with common rules and meanings [46]. Context is understood as people-place relations in which objects-technologies, actors, meanings, and knowledge interact each other [47]. It is the surrounding in which people decide how to act [14], the "mother" of social practices [47], and one of the main determinants of energy behaviours and social change [48]. Context is fundamental in the definition of how and why people act, since it shapes the main relationships and features of people's daily life. By taking into account the context in which people grow up (long deep social-

ization) and live (actual context), we examine peoples energy behaviours and actions more comprehensively in order to identify the elements that prompt changes [17,48,49].

Social practices are, in fact, specific to a surrounding context and reflect social-material interactions and social structure of meanings [50]. An actor learns which behaviours are culturally and socially recognized in the context [46,51] and the constant repetition creates the social practice [17,47,52]. Social practice - such as Nordic walking [53], bottle (and not tap) water consumption in a restaurant [54], food shopping [50], cooking [52] - is related to a structure of meanings and forms of understandings, physical and mental activities, agencies and technologies, knowledge, emotions, and motivations [17,55]. Changing a social practice, thus, requires a deepen process.

A new practice is created when new images, forms of knowledge, and technologies are combined [9]. Therefore, changing a practice requires that individuals and groups negotiate new actions with old ones through social learning [48]. In particular, social practice change requires the understanding of the reasons behind the change (e.g. environmental footprint associated to the old practice), and the participation to a new practice through individual and collective experience and training. Social practice change has to be systemic [14]. Community-based initiatives might move from cognitive to systemic change [24]. They work at the level of social interactions [52], creating alternatives that address the change of the social practices [17,50].

Energy consumption is not a practice [53]: it is the outcome of many different practices shared by a collectivity and performed by individuals [17,56], such as showering [48], bathing [56], cooking, clothes washing, entertainment, heating, and ventilation practices in daily life [54,57]. In this kind of practices, making a home comfortable [53] is a relevant aspect culturally embedded that could keep indoor climate comfortable [54] and drive energy consumption and saving [14]. For instance, in the context of social housing, families develop common practices that are influenced by the suboptimal built and social contexts in which they live.

3. Material and methods

Our study embraces the interdisciplinary perspective in order to isolate context and individual circumstances for an intervention aimed at changing energy behaviour. The integration of social practice theory and behavioural economics perspectives overtakes some of their own gaps: on the one hand, social practice theory considers individuals not responsible for their behaviours [48], because social context is more central. On the other hand, behavioural economics does not consider who is the individual according to the specific surrounding context. This intercultural communication between disciplines [17] allows to develop a more context-specific framework with the purpose to design behaviour change strategies enhancing retrofit intervention effectiveness. We consider the SINFONIA project and one of its case studies: Bolzano social housing district. This project is particularly relevant as it is an example of retrofit intervention to replicate in other European cities.[2]

3.1. Case study: social housing districts in Bolzano

Bolzano is a city in the middle of the Alps, on the North-East of the Italy. It counts about 106.000 inhabitants of two different mother tongue groups (Italian 73.8% and German 25.5%, remaining minority is the Ladin group) and an average density of 2000 inhabitants per km^2. Geo-morphologically, Bolzano is in a narrow valley. According to data provided by the Observatory of Italian Tax Agency (OMI), both rental and sales residential proprieties are characterized by high prices on the local real estate market, in comparison to other cities with similar size and features.[3] This is mainly due to the high attractivity of the city as urban center, and the scarcity of available new building surface. Energy efficiency building sector is well-developed thanks to several innovative enterprises and institutions, such as the local public body “CasaClima–KlimaHaus”, responsible in South Tyrol province for buildings energy audit and certification. Bolzano is separated into 5 administrative districts and the social housing buildings included in SINFONIA project are situated in three of these districts, far from the city center and the most expensive locations (namely the Gries - S.Quirino district).

These buildings were chosen because of their poor conditions and need to be refurbished. Energy retrofit interventions include envelopment of insulation, exploitation of solar and geothermal energy, installment of mechanical ventilation, and installation of monitoring system.

We conducted a survey during summer 2015, in order to identify behavioural and social levers for energy behaviour change in retrofit interventions. It elicits information on energy behaviours, renewable energy and energy efficiency knowledge, and indoor comfort perceptions of case study population, prior to the implementation of refurbishment interventions. This survey not only allows to get a glimpse on the poor conditions that call for a refurbishment intervention, but also to identify the existence of behavioural or social levers in order to attenuate the energy efficiency gap after the refurbishment.

3.2. Questionnaire design

Different scientific perspectives usually employ different methods [17]. Social practice theory uses mainly qualitative methods, such as in-depth and face-to-face interviews [9,54,57], while behavioural economics exploits the experimental approach in the laboratory and in the field [58,59]. Practically, the use of the quantitative tool of the survey is based on a decision to engage almost all the tenants involved in SINFONIA project without raising their annoyances in a project that already interfere with their daily life.

The survey, developed following methodological guidelines on survey design [60], involves multiple choice answers. It contains 38 closed-ended questions divided in four sections and nine subsections (Table 1).

3.3. Questionnaire administration

The survey was conducted door-to-door to 385 households, and 277 households completed the survey with the interviewer reading the questions. Collected questionnaires are approximately 72% of the population considered. We acknowledge the risk of self-selection bias as some individuals might have been more likely to complete the survey [61]. Moreover, there might be the risk of behaviour-attitude gap due to the fact that individuals’ stated intentions do not always align with actual behaviour [62]. However, our aim is not to generalize findings, but to diagnose factors that might affect energy behaviours and, ultimately, the efficacy of retrofit interventions in the specific context of Bolzano social housing district.

The responses collected were analysed with Stata. Each question was transformed as a variable in Stata for the statistical analysis. The ordinal and nominal questions were transformed into numeric and dummies.

[2] The other cities are Boras, La Rochelle, Pafos, Sevilla, Rosenheim.

[3] https://wwwt.agenziaentrate.gov.it/geopoi_omi/index.php.

Table 1
Sections, subsections, and contents of the survey questions.

Sections	Subsections	Questions
General information	Information on respondent	Street
		Gender
		Age
		Education level
	Information on household	Age of components
		Number of components
	Interest on	Energy saving
		Energy Performance Certificate Knowledge (CasaClima)
		Certified Buildings (CasaClima) Perceived Advantageous
	energy efficiency refurbishment	Renewable energy sources (RES) knowledge
		Willingness to be informed
		Way to be informed
		Willingness to be monitored
Economic information	Cost perceptions	Rent
		Electricity
		Heat
		How water
		Maintenance
Technical information	Satisfaction level	Building condition satisfaction
	Energy behaviours	Ventilation in summer
		Ventilation in winter
		Eco-bulbs
		Efficient devices
		Standby mode
		Temperature regulation
		Temperature regulation knowledge
		Temperature in summer
		Temperature in winter
		Bedroom temperature in summer
		Bedroom temperature in winter
Indoor comfort perception	Temperature perception	Perceived temperature in summer
		Perceived temperature in winter
		Perceived draft
	Humidity perception	Perceived humidity in summer
		Perceived humidity in winter
		Perceived mold
	Noise perception	Perceived noise
		Type of perceived noise

Table 2
Demographic data.

Variables	N	mean	sd	min	max
Female	277	0.578	0.495	0	1
Low education	277	0.7112	0.454	0	1
Young	277	0.0650	0.247	0	1
40–59	277	0.310	0.464	0	1
> 60	277	0.621	0.486	0	1
N young compon	277	0.242	0.616	0	3
N adult compon	277	0.968	1.033	0	6
N old compon	277	0.780	0.721	0	2
> 12 h at home	269	0.874	0.333	0	1

4. Results

Through the analytical lenses of behavioural economics and social practice theory, this section includes the results of the survey on energy behaviours administered on Bolzano social housing tenants. We first report on the description of the tenants' characteristics, then we provide an assessment on energy behaviours aimed at distinguishing social practices. Finally, we conduct a regression analysis on ventilation behaviour, as representative behaviour that might hinder retrofit interventions efficacy, with the aim to extrapolate social and individual levers to use in behaviour change strategies.

4.1. Descriptive statistics

Table 2 reports on the descriptive statistics of the study sample. The first five rows describes the respondent's characteristics, while the last four rows describe the household. It shows that low educated individuals (71%), elderly (62%), and people who spend more than 12 hours at home (87%) are predominant.

Table 3 shows the descriptive statistics of tenants' responses. With respect to individuals' interests to energy issues, we find that the majority of respondents (87%) is willing to receive information about energy issues. Furthermore, people who use Eco-bulbs (86%) and who know CasaClima buildings (80%) are also predominant. These variables signal context-specific facets of Bolzano city, since CasaClima is a reference and trusty institution. In particular, CasaClima, the local public agency entitled to emit energy efficiency certificates for buildings, spreads knowledge through training and courses dedicated to professionals and the wider public about energy efficient buildings and behaviours. These activities signal that CasaClima aims to improve indoor comfort, becoming a trustworthy institution in Bolzano.

Finally, we observe that the majority of respondents display negative perceptions of temperature and humidity[4], and costs, suggesting context-specific features of social housing (suboptimal house conditions) and the need of energy refurbishment, like the installment of a automatic ventilation system. This is particularly evident for humidity perceptions, of which the dispersion is low (*sd*: 0.386).

[4] The item scale has been homogenized to reflect negativity perceptions with 1 = not negative, 5 = very negative.

Table 3
Survey items.

Variables	N	mean	sd	min	max
Willingness to be informed	271	0.871	0.336	0	1
Willingness to meet a consultant	248	0.573	0.496	0	1
Willingness to be monitored	249	0.530	0.500	0	1
Eco-bulbs	275	0.855	0.353	0	1
Efficient devices	275	0.738	0.440	0	1
Summer ventilation	275	3.558	0.328	2	4
Winter ventilation	275	2.531	0.344	2	4
Energy performance certificate knowledge (CasaClima)	269	0.799	0.401	0	1
RES Knowledge	227	1.752	0.533	1	3
Satisfaction with house conditions	274	2.577	0.955	1	4
Negative temperature perceptions	275	3.658	0.545	2.5	4.5
Negative humidity perceptions	270	2.954	0.386	1.5	4
Cost perceptions	256	3.427	0.558	2	5
Certified buildings (CasaClima) perceived advantageous	241	0.801	0.400	0	1

Table 4
Energy efficient individual choices and social practices.

Energy behaviour 1	Energy behaviour 2	Levene's index
Eco bulbs	Efficient devices	0.0007763 ***
Eco bulbs	Summer ventilation	0.2637
Eco bulbs	Winter ventilation	0.5436
Efficient devices	Summer ventilation	8.398e-06***
Efficient devices	Winter ventilation	7.568e-05***
Summer ventilation	Winter ventilation	0.6092

The results of Levenes test for equality of variances and standard deviation.*($p < 0.10$), **($p < 0.05$), ***($p < 0.01$)

4.2. Understanding the nature of energy behaviours

To isolate opportunities to change behaviours in a way that the potential of retrofit interventions is fully released, we need to get a comprehensive understanding of people's behaviour accounting for the context-specific facets. In this section, we examine the nature of energy efficient behaviours, by starting providing descriptive information on self-reported answers. In particular, we look at the dispersion associated to the items surveying on the use of Eco-bulbs, use of efficient devices, ventilation in summer, and ventilation in winter.

This results in assessing whether some energy behaviours are recognized as social practices and whether others are mainly determined by individual factors.

From Table 3 we observe that while ventilation, both during summer (0,328) and during winter (0,344), and choice to buy Eco-bulbs (0,363) are barely dispersed, the choice to use efficient devices is highly dispersed (0,446). This suggests that there exist some culturally recognized social practices for ventilation behaviour and choice to buy Eco-bulbs, as answers are mostly homogeneous.[5] On the other hand, the higher heterogeneity in responses associated to the use of efficient devices suggests that individuals do not agree on a recognized way to behave, but rather their individual preferences play a more crucial role. These insights are confirmed by the results of the Levene's test for equality of variances (Table 4).[6] In particular, the test shows that the distribution of answers associated to the item surveying the use of efficient devices is significantly different from the distribution of answers associated to the items surveying on ventilation in summer, ventilation in winter, and use of Eco-bulbs.[7]

4.3. Deepening ventilation behaviour

One of the retrofit interventions to be implemented within the SINFONIA project is the installment of a mechanical ventilation system. Therefore, to better inform the process of designing strategies aimed at enhancing retrofit effectiveness in Bolzano social housing district, we deepen the determinants of ventilation behaviour. This step aims to identify potential levers to be taken into account in the design of behaviour change strategies.

We, therefore, employ the ordered probit model as the dependent variables are discrete outcomes that can take one of several values [63]. In particular, the dependent variable *ventilation* is an ordinal variable that does not describe the real level of ventilation behaviour, but does describe the ordinal category in which it is reported (1 = never ventilate, 2 = once a day, 3 = several times, 4 = always). Among the explanatory variables, we have dummies controlling for gender (*female*), age (*over*60), low education, knowledge of CasaClima buildings, whether CasaClima buildings are perceived advantageous, and spending more than half day at home. We also add number of young components, renewable energy sources (RES) knowledge, cost perceptions, negative humidity and temperature perceptions, noise perceptions and level of satisfaction with house conditions. We enrich the model with two dummies capturing individual willingness to be monitored and to meet a consultant.

As Table 5 shows, during summer, # *young component, RES knowledge, Efficient Buildings Knowledge* and *Negative Humidity Perceptions* explain ventilation behaviour. The regression analysis shows that the more individuals display negative humidity perceptions, the more they are likely to ventilate their house. Therefore, a social housing-specific feature, such as living in a less comfortable dwelling, leads to more frequent ventilation behaviour.

The evidence that individuals who have experience of CasaClima buildings affects ventilation behaviour, suggests that trust is a crucial determinant of behaviour [14]: Individuals who developed trust in CasaClima, which is a context-specific reference point in Bolzano, are likely to engage in more frequent ventilation behaviour.

[5] The two social practices might have developed because of different reasons. While ventilation behaviour might be recognized as a social practice because of the interaction among people within a specific context, the choice to buy eco-bulbs might be recognized as a social practice because of the introduction of European regulations aimed at regulating electrical lamps and luminaires, like the No. 874/2012.

[6] Levene's test is non-parametric test for measuring differences between variances. We chose non-parametric test because our variables (use of Eco-bulbs, ventilation in summer and winter, and use of efficient devices) are not normally distributed.

[7] While the introduction of the regulation of electrical lamps and luminaires (Reg. 874/2012) might be sufficient to enforce the efficient behaviour of using Eco-bulbs, the contrary is true for efficient ventilation behaviour, especially when this latter is recognized as a social practice, and the retrofit intervention, such as the introduction of a ventilation system, requires to develop a new social practice.

Table 5
Ventilation behaviour: Ordered probit model.

	(1) Summer ventilation	(2) Winter ventilation
Female	0.359(0.239)	0.155(0.223)
Over 60	0.0720(0.277)	−0.169(0.245)
Low education	0.0458(0.268)	−0.432*(0.237)
# young component	0.566**(0.238)	0.157(0.157)
RES knowledge	−0.521**(0.250)	−0.537**(0.239)
CasaClima buildings knowledge	1.233**(0.543)	0.686(0.464)
CasaClima buildings perceived advantageous	−0.564(0.485)	−0.416(0.373)
Cost perceptions	0.142(0.237)	0.00196(0.199)
Negative temperature perceptions	−0.285(0.231)	0.0698(0.206)
Negative humidity perceptions	1.085***(0.338)	0.308 (0.293)
> 12 h at home	0.269(0.341)	−0.00209(0.306)
Satisfaction with house conditions	0.190(0.134)	−0.353***(0.116)
Noise perceptions	−0.108(0.114)	−0.0801(0.111)
WT be monitored	0.0383(0.264)	0.155(0.225)
WT meet a consultant	−0.00307(0.287)	−0.0811(0.242)
Observations	153	153

Standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

On the contrary, we observe that RES knowledge might determine a sort of "moral licensing" that affects ventilation behaviour: the more RES types individuals know, the less frequent they ventilate. This suggests that RES knowledge makes a present or past concern for the environment salient that, in turn, provides the license to misbehave later on [64]. Finally, we find that having children has a positive significant effect on ventilation behaviour, suggesting that the presence of children elicits a more long-term focused behaviour [65].

During winter, similarly to what observed for the summer, we observe that RES knowledge has a significant negative effect on ventilation behaviour, and that some context-specific features of social housing affect behaviour. In particular, we confirm that forms of scarcity [41], proxied by low education, exacerbates myopic tendency in ventilation behaviour during summer. Finally, we find that individuals who are satisfied with house conditions, are less likely to ventilate their house, suggesting they are likely to resist change and stick to the status quo.

5. Discussion

The pre-refurbishment survey has been conducted and analysed to provide an understanding of tenants' current energy behaviours, and extrapolate the cognitive biases and social practices shaped by the context of social housing. This study shedded light on the contextual factors affecting energy behaviour of a sample of tenants in Bolzano social housing district. Through an interdisciplinary social sciences approach, it aimed to help develop behaviour change strategies to enhance retrofit program efficacy.

Overall, results highlight the role that the specific context of social housing plays on ventilation behaviour, and that it is not straightforward to distinguish from social and individual determinants of behaviour. By using the lenses of social practice theory and behavioural economics, we identified social or behavioural factors that might hinder retrofit intervention efficacy, and others that can be used as levers for behaviour change strategy.

We showed that the context of social housing might exacerbate some cognitive biases, like the myopic tendency to prioritize inefficient, but more short-term rewarding, behaviours [21]. Such a context-specific myopic tendency can be diluted in parents, as having children naturally makes people think about the future and care about the environment [65], or by acting on people's "future selves". A strategy aimed at correcting behaviour informed by behavioural economic insights would seek to remove the context-specific cognitive biases that pose barriers for people to perform optimal decisions [66], such as sending reminders mentioning a particular future action [67]. Another strategy would be installing a monitor displaying information on aggregate future benefits [68] from ventilating efficiently, or about what others do [69].

However, changing a behaviour that is recognized as a context-specific social practice, requires a more comprehensive investigation of determinants of behaviour that goes beyond the individual ones. As for the case of ventilation, an intervention leveraging only individual drivers might be less appropriate than another leveraging also social influence.

Regression results suggested that trust in a recognized institution positively affects ventilation behaviour. This can be used as a lever to change ventilation social practice. As community-based initiatives might help moving from cognitive to systemic change [24], trust in this institution might be leveraged not only to improve individual energy behaviour [39], but also to promote systemic change in ventilation social practice. A viable strategy might be the creation of a series of meetings or training promoted by the trusted institution to spread knowledge about old ventilation practices and the potential of new ones, and support tenants in ventilation behaviour change process (i.e. showing how and when ventilate). These meetings might make salient the efficient ventilation practice as a type of good green behaviour, which contributes to improve tenants' and their children's wellbeing at home.

6. Conclusions

In this paper, the scan of the specific context before the retrofit intervention implementation is central for its effectiveness. Social housing context is especially relevant exacerbating cognitive biases [20,43] and shaping social practices that are difficult to change [14,56].

Here, we investigated energy behaviours in social housing context through an interdisciplinary lens which links behavioural economics and social practice theory. This double analytical lens is a benchmark to attenuate the mismatch between energy behaviour and retrofitted flat after the energy retrofit. This interdisciplinary lens extrapolated the context-specific social and individual levers. These levers might be considered in strategy design with the aim to align behaviours with retrofit interventions.

We analyzed the results of a questionnaire administered to the tenants of a social housing context in the European project SINFONIA, before the retrofit intervention implementation. The interdisciplinary investigation unveils social and individual levers: on the

one hand, tenants' ventilation behaviour is recognised as a social practice; on the other, some context-specific factors, like trust in a recognised institution and scarce level of education, affect ventilation behaviour.

We proposed to include social and individual levers in the behaviour change strategy with the aim to build an effective interaction between individuals and new technologies. This new interaction not only involves the individual: it also involves the group and collectivity (e.g. family, peer-to-peer, neighbourhood) to make culturally recognizable the new behaviour thanks to some social levers. A behaviour change strategy might target central individuals in the social network [70], leverage social norms interventions, like providing normative feedback [68], or promote the change culturally recognizing the new behaviour [71].

This investigation feeds the next stage of the SINFONIA project. When all buildings will be refurbished, a monitor will be installed in each dwelling to display real-time energy behaviour. This will include information about other tenants' energy behaviour: the inclusion of this normative feedback might contribute to change a behaviour which is subject to social influence. Further, a participatory and educative process will work on defining new social practices (e.g. new ventilation behaviour), coherent with refurbished flats. Finally, the efficacy of such strategies will be evaluated to support local authorities' decision to scale these behaviour change strategies also to other cities.

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