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Me or the machine, who decides? Acceptance spillover of digital automation for a sustainable transition

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Abstract

To meet net zero targets and achieve a sustainable transition, the electricity network needs to become more integrated, decentralised, and flexible. Digitalisation – specifically provided through algorithms and automation – of daily life activities has huge potential to enable such a network. Many daily life activities have already become automated and/or are controlled through algorithms, e.g., paying our monthly bills, searching for information online and streaming entertainment recommended to us. However, activities with greater impact on the energy system, such as home energy management, struggle with issues of trust and acceptance from end-users. Research is lacking on the concept of acceptance spillover, the acceptance and use of automation in one activity or domain of daily life and the impact it has on acceptance and use in another.

As part of a living lab of UK households with wide ranging characteristics (household composition, socio-economic, digital engagement, home type and ownership, rural/urban location), this research will conduct two distinct trials which automate daily life activities. We will use a mixed methods approach of interviews, surveys and activity-specific behavioural and energy monitoring data to: 1) detect feedback mechanisms of automation experience and potential acceptance spillover across activity domains that have varying levels of impact for a sustainable transition; 2)

identify generalisable insights on factors influencing acceptance of automation across different activities of daily life; and 3) contribute to the literature on time-use, energy and resource impacts of specific automation technologies.

Key words

Daily life, energy use, IoT, automate activities, technology acceptance model

Introduction

Digitalisation is a transformative force rapidly shaping how we socialise, travel, shop, work, relax and manage our homes. Despite digitalisation's potential to reduce energy and resource use to help tackle climate change - for example, through substituting physical movement, accessing services rather than owning physical goods and helping manage energy use – current uptake of innovations providing such potential are far from reaching the mass market (Wilson, Kerr, Sprei, Vrain, & Wilson, 2020).

One aspect for achieving a sustainable energy transition requires not only end-user demand reduction but also increased flexibility in energy consumption as a response to the more volatile production patterns of renewable resources such as wind and solar. Automated demand-side management solutions support flexibility but struggle with trust and acceptance issues from end-users. We investigate whether positive experiences of automation in one activity or domain of daily life results in greater acceptance and uptake of automation in another, especially for contexts which help the energy transition.

Daily life automation

Technical developments enabling automation – the machine execution of a function or operation previously performed by a human – have dramatically evolved in the past decade and have entered many aspects of our daily life. From information acquisition online to smart devices in the home and transport route optimisation. Different levels of automation (LoA) exist, with the literature developing a wide range of taxonomies adapted to specific contexts (Vagia, Transeth, & Fjerdingen, 2016). Diamond, Mirnig, & Fröhlich (2023)'s study on trust in demand-side energy management in the home builds of Vagia et al.'s work and categorised automation into six levels. Examples of their LoAs include manual programming of devices by the user, consensual automation with the user actively being contacted to agree, and full automation whereby the user has no possibility to interrupt or control. As our research looks across contexts (different activities and domains) we draw upon Vagia et al. (2016)'s literature review and use a LoA taxonomy widely applicable to activities across daily life (Table 1).

Table 1. Levels of automation taxonomy adapted from Vagia et al. (2016)

Level of automation	Description	Explanation
Level 1	Manual control	Computer offers no assistance
Level 2	Decision proposal	Computer offers decision. User is responsible to decide and execute
Level 3	Execute with approval	Computer decides and executes with user approval
Level 4	Autonomous control	Computer decides and executes without user notification

Digitalised daily life activities have varying impacts on energy and carbon resources, and some activity domains are more saliently digital to end-users. Table 2 summarises the scientific interest of the different activity domains of daily life and provides examples of possible automation for each. Our research aims to improve understanding of the factors which influence people's acceptance of different LoAs in their daily lives, whilst also contributing to the literature on the impacts of automation on energy and carbon.

We first present literature informing the theoretical framing for our research design to investigate automation acceptance. We then describe our living lab and provide an outline of: the mixed methods data collection being conducted during 2023; our progress to date; and expected contributions towards a green digital transition.

Theoretical framing

Drawing upon insights from Information System and Cognitive Engineering research, Ghazizadeh, Lee, & Boyle (2012) developed an extension of the well-established Technology Acceptance Model (TAM) to provide a comprehensive perspective of automation and evaluate user acceptance - aptly named the Automation Acceptance Model (AAM) shown in Fig.1. TAM theorises that perceived usefulness and ease of use are key determinants of attitude towards a technology, which in turn, predict behavioural intention to use and accept (Davis, 1989). Ghazizadeh et al. (2012) extended this model and posit that compatibility of the technology for the task at hand impacts upon other constructs and ultimately acceptance. In addition to compatibility, trust in the predictability and performance of the automated activity is deemed a key component in AAM.

Diffusion of innovations theory (DOI) states that users' trust and relationship with a technology often progresses through various phases of adoption as they adapt to a new system, from initial discovery of its existence to deciding to adopt and continue usage (Rogers, 2003).

Table 2. Scientific interest and estimated energy/carbon impacts of domain categories of daily life activities and examples of automation

Scientific interest		Activity domain	Automated activity example
Low	*Most salient digital daily life activities*	*Communication, socialising*	Receiving, sorting and replying to emails
		Information search, provision	Creating online content (e.g., for a webpage) Information searching Information providing e.g., weather, news
		Entertainment, media	Choosing a movie/episode to watch
	Possible spillovers via thematic similarities	*Health, fitness*	Arranging medical treatment Fitness tracking, Developing an exercise plan
		Education, study, learning	Progress tracking
Energy/carbon impacts	*Possible spillovers via thematic similarities*	*Work (paid)*	Scheduling meetings Coding
		Managing home - non-energy intensive (e.g., hygiene, childcare, finances)	Paying household bills
		Retail - other	Buying new clothes
		Retail - food & drink	Doing grocery shopping Creating a menu/diet plan
	Uncertain direct carbon impacts	*Managing home - energy-intensive (1) lighting, devices, appliances (exc. food-related)*	Turning home lighting on/off Turning washing machine on Hoovering
		Managing home - energy-intensive (2) cooking, dishwashing, other food-related	Preparing a cup of tea/coffee Preparing a meal Washing the dishes
		Managing home - energy-intensive (3) heating, cooling, hot water, + own energy (e.g., PV, storage)	Turning home heating on/off
High		*Travel*	Booking travel tickets Optimising journey route Driving to visit friends/ family Refuelling/charging private transport mode

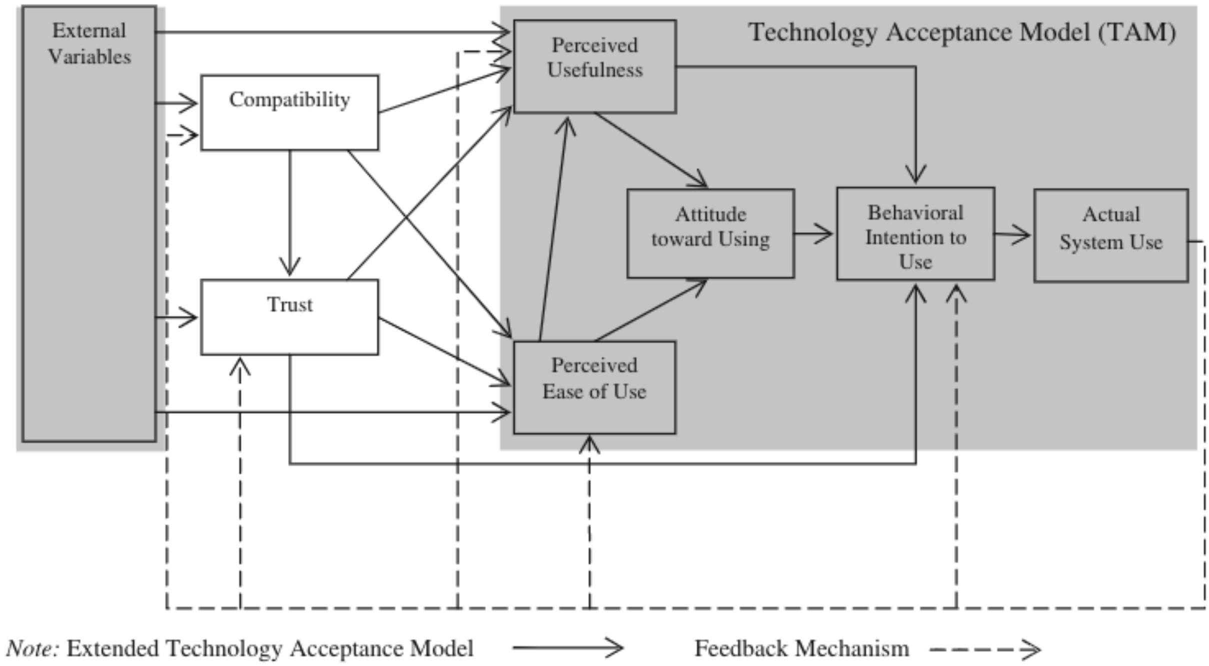

Fig.1 The Automation Acceptance Model (AAM). Source: Ghazizadeh et al. (2012)

Such changes over time and the impact on acceptance and use are captured by AAM through feedback mechanisms (Ghazizadeh et al., 2012).

Our research uses AAM as a theoretical framework to empirically investigate the range of constructs and feedback mechanisms hypothesised in the model to impact acceptance and investigate whether spillover of acceptance occurs.

Research methodology

Living lab

Our living lab infrastructure was developed as part of a European Research Council project and focuses on digital daily life and its impact on climate change. The living lab consists of households in and around Oxford, UK who provide insights into real-world conditions in their own homes and are committed to trial, learn, interact, and share data with the research team on digitalised daily life. A current sample of 47 households have been recruited with wide ranging characteristics (composition, socio-economic, digital engagement, home type and ownership, location -

rural/urban). Strong relationships between researchers and all members of the households were established during the recruitment process in autumn 2022 and enthusiastic engagement is maintained through offering short, gamified activities referred to as 'mini missions'. Data collected from all individuals within the households thus far include: 1) qualitative insights from home visits on their daily routines (across work, leisure, travel, food/grocery habits and home management), social dynamics and decision making processes for managing and co-ordinating daily life, use of digital devices and online services; and 2) quantitative insights through an online survey into their digital skills, technophilia, innovativeness, values, data privacy concerns and attitudes towards internet usage. Our proposed research in this paper builds on this data and explores the theme of automation.

Automation trial study design

For households to participate in smart energy networks the automation characteristic required involves the automation of when energy is used/an activity occurs (scheduling and execution). Two distinct sub-samples of 10 households will each trial an innovation for one month which automates such aspects for one of their daily life activities. Our sub samples will consist of households along a spectrum of prior automation experience, categorising them by the number of different domain activities and frequency of automation they use. Fig. 2 summarises the study's protocol highlighting the data collection process, timings and data used to investigate specific research questions. The two different trials proposed are: 1) automation of the scheduling and execution of meal planning and grocery shopping provided through a subscription to a meal kit delivery service, and 2) automation of the scheduling and execution of floor cleaning through the use of a smart hoover/mop.

Following Ghazizadeh et al. (2012)'s suggestion, we aim to validate the feedback mechanisms of AAM using a multi-wave experiment capturing changes in behaviour and perceptions at several points in time, e.g., pre introduction of activity automation, after one month of usage, and after 6 months (of usage or discontinuance). Baseline data on activity-specific time and energy use will be collected for one month prior to the trial. Then, during the pre-trial interviews, we will conduct an interactive mapping exercise to collect data on the different ways they currently automate their daily life (the level of automation - Table1 and across activity domains – Table 2).

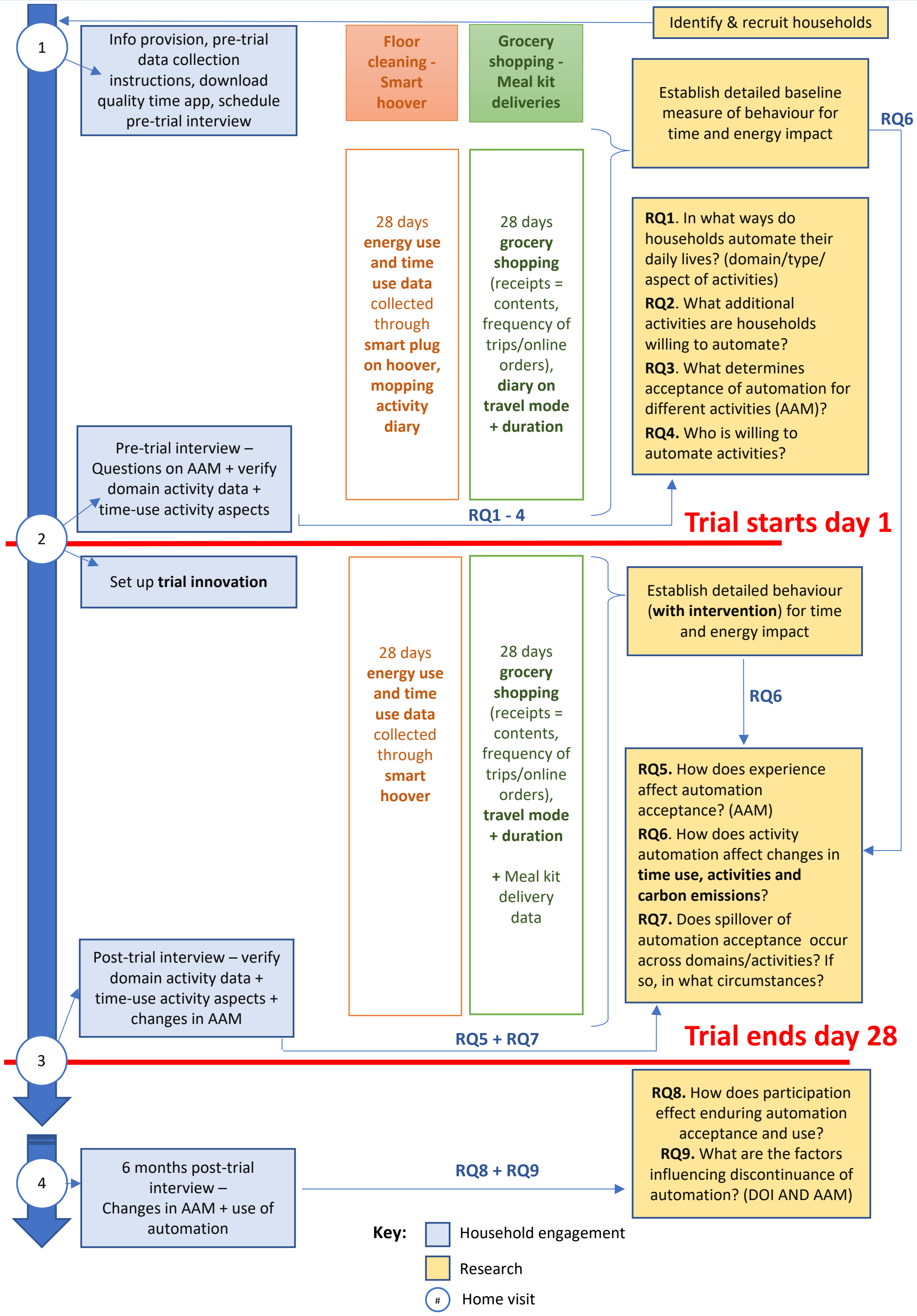

Fig. 2. Summary of the living lab trial protocol

We will also ask what additional activities they are willing to automate and then explore AAM constructs to determine what influences acceptance of automation for different activities. After the one-month trial we will return and repeat the interview activity on AAM constructs to detect changes in acceptance and the impact of feedback mechanisms through automation experience.

To analyse the impact of the trials on time and energy use, we will compare the activity-specific monitoring data collected pre and during the trials. We will also use a conceptual framework developed by Bieser & Hilty (2020), who categorise ICT impacts on time and energy as distinctly different phases and aspects of an activity: Phase 1 – activity planning (consisting of activity selection, scheduling, planning horizon, duration and frequency) and Phase 2 – activity execution (consisting of activity manner, duration and fragmentation). Bieser & Hilty (2020) qualitatively describe their framework and apply it to the example of telecommuting. They encourage researchers to apply their framework to other activities and to use more empirical evidence. We propose to use this framework as one of our analytical dimensions to investigate whether acceptance spillover is likely to occur for certain aspects of an activity e.g., scheduling, but not for all.

Conclusion

Utilising a living lab of diverse households in the city of Oxford, UK, this research investigates the factors influencing acceptance of automation across different activities of daily life and the possible feedback mechanisms and acceptance spillover to activities impacting the sustainable transition. As a research resource, our project's living lab provides an invaluable opportunity for gathering in-depth, multi-wave insights at the individual and household level on automation acceptance and adoption which supports a sustainable digital transition. By September 2023, the grocery shopping trial will have been conducted and smart hoover trial underway. Preliminary results will be available to present. Results from a potential further trial on EV charging automation, as well as a longitudinal study measuring enduring automation acceptance/use and discontinuance are expected to be available in 2024.

The unique contribution of our study is threefold. First, we comparatively assess a range of automated daily life activities using a standardised methodology and data. Second, we focus on feedback mechanisms of automation experience and potential spillover of acceptance across activity domains and aspects that have varying levels of impact for a sustainable transition. Third, our results will identify generalisable insights on drivers of automation acceptance that hold across daily life activities and contexts to inform macro-level understanding, policies and intervention strategies for harnessing digitalisation and support less energy-intensive forms of consumer behaviour.

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