Supporting people's independence through Voice User Interface (VUI) devices

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ABSTRACT The use of well-designed assistive devices may improve the quality of life of individuals living with severe and permanent impairments and reduce the burden on their caregivers.

Interactive Smart Agents (ISA)s use the latest smart home technology to control devices around the house through voice interfaces. This study aims to investigate whether ISAs may be effective to support individuals who are affected by multiple sclerosis, stroke and spinal cord injury (SCI). The study's approach is user-centred to ensure inclusion. The study has achieved NHS Research Ethics Committee (REC) and Health Regulatory Authority (HRA) approval (Project ID: 255096) and includes two main parts: 1. the initial development of an adoption model informed by secondary research and exploratory primary data, 2. a second in-depth investigation of the initially identified constructs and relationships through a multi-points qualitative study including prototype evaluation.

The research is in collaboration with the North Thames Regional Environmental Control Services (NTRECES), an NHS organisation that provides Environmental Control (EC) devices to manage the patients' electrical and computing appliances. Clinical staff have indicated an increasing patients' demand of ISAs instead of traditional EC devices and have suggested that their clients are keen to experiment with more intuitive interfaces.

This paper presents the findings from the first part of the study and it is structured as follows: in the first and second sections literatures on ISA and technology adoption are reviewed respectively. In the third section findings from the preliminary study are presented. In the fourth section a proposed model of adoption of ISAs among severely disabled patients is discussed.

Keywords: Voice User Interface, Sustainable Health and Well-being, Interactive Smart Agents, Technology Adoption.

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Interactive Smart Agents (ISA) and Sustainable Healthcare

The use of emerging technology in healthcare is one of the fundamental markers of a sustainable healthcare system. A sustainable healthcare system should be economical, adaptable and acceptable (Fineberg, 2012). In order to move towards a sustainable system, the healthcare services may have to invest more significantly in the latest technological equipment and inventions to be utilised at home (Pencheon, 2014). This also aligns with the NHS's goal (Smith, 2019).

ISA devices like Amazon's Alexa, can support the care of older adults with multiple and chronic conditions (Halim, 2019). ISA devices, or smart speakers, operate through VUI. Through ISAs users can control other smart devices around the house, including lights, door locks, TV and thermostats. ISA devices can also be used for streaming music, accessing online information and setting reminders. Investment in technology to deliver patient-centred care has been the focus of much debate (Klecun, 2016). Albeit not designed specifically to support healthcare services, ISA devices can aid the care of older adults with chronic conditions. Voice might be a preferred mode of interaction amongst older adults, given its natural attributes not requiring demanding and technical learning. Although ISAs adoption among this segment of the population is still ambiguous (Spinelli, Micocci, Martin, & Wang, 2019), their benefits in primary care settings have already been discussed (Halim, 2019).

Technology Adoption

According to previous research on average one third of all assistive technology devices get abandoned (Goodman, Tiene, & Luft, 2002). Factors responsible for this are: lack of motivation, changes in medical condition, difficulty in device configuration, appearance, performance, lack of training for the users (Goodman, Tiene and Luft 2002; Carmien 2010). Low appeal and basic functionalities contribute to increase the stigma associated with assistive technology (Ringland, Wolf, Boyd, Baldwin, & Hayes, 2016).

The Matching Person and Technology (MPT) model (Goodman, Tiene, & Luft, 2002), suggests that designers should focus on three factors: i) psychosocial environment ii) personal traits iii) technology. Factors like age, gender, social status, financial situation, have been recognised as having significant impact on access to information, digital literacy and availability of resources (Greenhalgh, T. et al., 2013).

The Technology Acceptance Model (TAM) (Davis, 1989), Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003) are well-known theoretical contributions in this field. Along with these theories the Theory of Reasoned Action (TRA) and the Theory of Planned Behaviour (TPB) (Ajzen, 1991) have been used to understand the adoption of technology, and through some adaptations, scholars have been able to cater for specific emerging technologies (Kowalczuk 2018; Yang, Lee and Zo 2017).

Given the ability of TPB to be used across different settings (Matheison 1991; Heath and Gifford 2002) TPB is the blueprint for the adoption model presented later on. TPB states that

an individual's behaviour is determined by the individual's intention to perform that behaviour. This behavioural intention is in turn affected by an individual's Attitude, Subjective Norms and Perceived Behavioural Controls (PBCs) (Ajzen 1991; Heath and Gifford 2002).

Technology adoption literature has little contribution to make towards the understanding of technology adoption behaviour by users with disabilities (Djamasbi, et al., 2006) and the application of any adoption theoretical framework without modifications may not be specific enough to capture the factors playing a role in the adoption of ISA devices by the specific user group considered in this research. This is the intellectual gap underpinning this research.

Findings from Primary Data: Patient's Observations

NTRECES is an NHS based organisation in north-west London. To gather an initial understanding of the patients' abilities and requirements some preliminary observations were carried out. Ethnographic-inspired observations occurred by shadowing NTRECES staff during patients' home visits and hospital outpatients' rehabilitation sessions. All the patients were either existing patients or new referrals. The observations were followed by interviews with clinical staff, patients, EC designers and providers. These initial explorations were carried out from August 2017 to October 2018.

Initial inquiries from the NTRECES clinical staff revealed that the target user group for this research has the following characteristics:

- They have minimal exposure to technologies available on the market due to their mobility impairments. Most of their exposure to market and innovations is through, friends, family, caregivers and the media.
- Their adoption or acceptance decision about a technology differs from the norm as their assistive technology devices are funded by the NHS.

NTRECES's patients are issued with EC equipment to control the electrical and computing devices around their homes. Most of the EC equipment is controlled by a switch, a single click button, which scans through a menu of options, until the required one is highlighted (Wellings & Unsworth, 2011). As more devices are added to the EC system, the selection and control of each individual device becomes a lengthier and slower task (Verdonck, Steggles, Nolan, & Chard, 2014). Moreover, for patients with severe or deteriorating mobility impairments, clicking the switch can be cumbersome (Craig, Tran, McIsaac, & Boord, 2004).

Patients demonstrated great interest in ISA devices and often enquired whether NTRECES would issue ISA devices. For patients who are paralysed from the neck down, the use of their voice to control facilities around the house would provide them with meaningful degree of independence. As humans communicate through verbal dialogue, ISA may prove to be the most intuitive device for them (Cohen & Oviatt, 2015).

A comparison between technology has highlighted that ISA devices can support all the functionalities that are enabled by EC devices, bar a few (Shamim, Spinelli, Woodcock, & Nair, 2019) (see figure 1). Hence, a network of EC devices controlled by a central ISA is possible and would enable patients with mobility impairments to have a better quality of life.

ISA devices are however designed as mainstream consumer technology and not as an assistive technology.

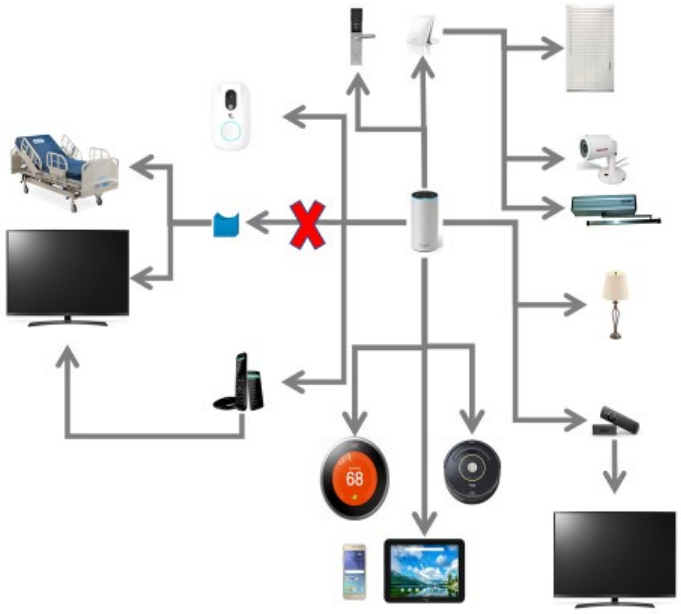

Figure 1: Map of the functionalities that ISA devices can and cannot provide

Due to the innovative nature of the technology and the unique interface modality, users may attribute to ISAs certain characteristics of anthropomorphism, that may lead to emotional attachment and recognition and/or assignment of agency (Lopatovska & Williams, 2018). In the next section a model of adoption bringing together secondary research and exploratory primary research is presented. It represents an attempt to modify existing technology adoption and consumer behaviour frameworks to consider the specifics details of the users in question and the technology considered.

A Proposed Model of Adoption of ISAs Among Severely Disabled Patients

The underlining assumption of this research is that understanding the factors that influence users' behaviour may directly impact the design of the technologies in both their functional and non-functional requirements and may suggest improvements in the service provided by NTRECES.

Model's Components

The model proposed here (see fig. 2) includes:

- A set of factors, here named User Characteristics, that are determinants of Attitude and of PBCs.
- An extended and modified list of items that constitute PBCs.
- An extended and modified set of items defining Subjective Norms.
- An additional set of items linked to the quality of the interaction with ISAs, here called Voice Interaction Experience

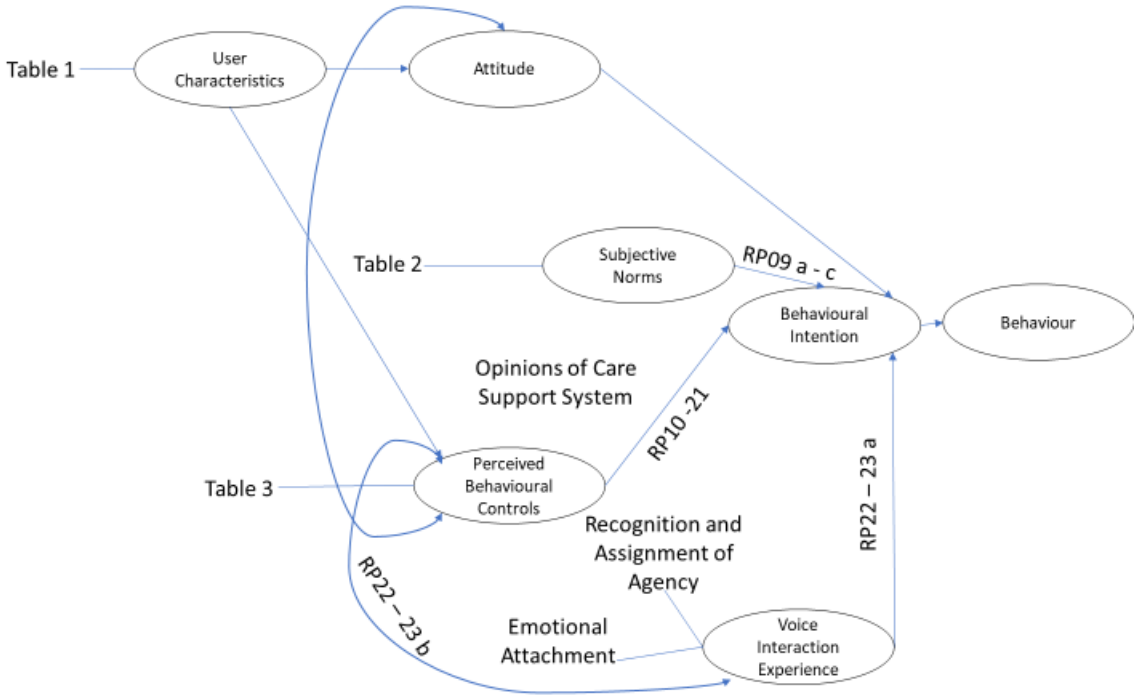

Figure 2: Proposed model of acceptance of ISA devices among NTRECES patients

Attitude

If a user has a positive attitude towards adoption of a technology, then the user develops a positive intention towards said behaviour (Ajzen 1991; Davis 1989). Scholars demonstrated that a positive user attitude leads to the adoption of smart speakers (Chu, Galetzka, & Van Deursen, 2019). Hence:
(RP) 01: Positive attitude towards ISA devices is associated with the intention to adopt them.

User Characteristics
Users' personal characteristics play a significant part in the uptake or abandonment of technology (Goodman, Tiene and Luft 2002; Samaradiwakara 2014). The relevant user characteristics are presented in table 1. In the proposed model the user characteristics affect both Attitude and PBCs (see fig. 2).

User characteristics	Literature in support	Research propositions
Age	(Conci, Pianesi, & Zancanaro, 2009)	RP02a: Old age has a negative effect on PBCs. RP02b: Old age has a negative effect on the attitude towards intention to adopt ISA device.
Gender	(Li, Glass, & Records, 2008)	RP03a: Females have a negative attitude towards intention to adopt ISA device. RP03b: Females have a negative effect on PBCs.
Desire for Independence	(Kintsch & Depaula, 2002)	RP04a: Desire for independence can positively influence attitude towards intention to adopt ISA device. RP04b: Desire for independence can have a positive effect on PBCs.
Voluntariness	(Agarwal & Prasad, 1997)	RP05a: Voluntariness to try a new technology have a positive attitude intention to adopt ISA device. RP05b: Voluntariness to try a new technology have a positive effect on PBCs.
Openness to Innovation	(Laukkanen & Pasanen, 2008)	RP06a: Openness to innovation leads to a positive attitude towards intention to adopt ISA device. RP06b: Openness to innovation has a positive effect on PBCs.
External Engagement	Primary research	RP07a: Users with higher external engagement have positive attitude towards intention to adopt ISA device. RP07b: a higher level of external engagement has positive effect on PBCs.
Income	(Feder, Just, & Zilberman, 1985)	RP08a: Users with higher income have a positive attitude towards intention to adopt ISA device. RP08b A higher income has a positive effect on PBCs.

Table 1: User Characteristics affecting Attitude and PBCs

Subjective Norms

According to the TPB, the opinion of the people who are important to the user, is vital in forming one's intention. Yang, Lee and Zo (2017) established in their study that if the people who are important to the users think they should use smart home services then it will result in the intention to use smart home services. This model suggests that:
RP09: There is a positive relationship between Subjective Norms and the Intention to adopt ISA devices
There are three items included in Subjective Norms, as per table 2.

Subjective Norms	Literature in support	Research proposition
Peer Pressure	(Ajzen, 1991), Primary research	RP09a: Social peer pressure positively affects the intention to adopt ISA device.
Trust in NTRECES Advice	(Ajzen, 1991), Primary research	RP09b: Trust in NTRECES advice is positively associated with intention to adopt ISA device.
Care Support System	(Ajzen, 1991), Primary research	RP09c: There is a positive relationship between the opinions of those who provide care and support and the intention to adopt ISA devices, specifically if caregivers are enthusiastic towards ISA devices, the users will form a positive intention to adopt.

Table 2: Subjective Norms affecting behavioural intention

Perceived Behavioural Controls

PBCs are the users' perception of how difficult or easy it is to perform a certain behaviour, in this case to use ISA devices. This perception is based on previous experience and anticipated obstacles (Ajzen, 1991).PBCs have been demonstrated to have a positive effect on behavioural intention (Yang, Lee, & Zo, 2017). The model here proposes that:
RP10: PBC is positively associated with the intention to adopt ISA devices.
Extending and applying the definition of PBCs by Ajzen (1991) to the context of this study, several factors that constitute PBS has been identified and listed in table 3.

PBC	Literature in support	Research proposition
Familiarity with technology	Primary research	RP11: There is a positive relationship between familiarity with technology and intention to adopt ISA device.
Technical support system	(Goodman, Tiene, & Luft, 2002)	RP12: Users with a good technical support network have a positive intention to adopt ISA device.
Residence type	Primary research	RP13: Users' residence owned by a housing association negatively effects the attitude towards the intention to adopt ISA devices.
Trust in NTRECES advice	Primary research	RP14: Trust in NTRECES advice leads to a positive attitude towards the intention to adopt ISA devices
Lack of access to open market	Primary research	RP15: The lack of access to the open market has a negative effect on the intention to adopt ISA devices.
Perceived ease of interaction	(Davis, 1989)	RP16: PEoI leads to positive attitude towards intention to adopt ISA device.
Perceived reliability	(Goodman, Tiene, & Luft, 2002)	RP17: Higher perceived reliability leads to positive intention to adopt ISA device.
Perceived confidentiality	(Yang, Lee, & Zo, 2017)	RP18: Higher perceived confidentiality results in a positive intention to adopt ISA device.
Perceived security	(Jutai & Day, 2002), (Kowalczuk, 2018)	RP19: Higher perceived security has a positive impact on intention to adopt.
Perceived usefulness	(Davis, 1989), (Kintsch & Depaula, 2002)	RP20: Higher perceived usefulness leads to a positive intention towards adoption of ISA device.
Perceived trust in service provider	(Chung, Iorga, Voas, & Lee, 2017)	RP21: Perceived trust in service provider leads to a positive intention towards adoption of ISA device.

Table 3: Items included in PBCs

Voice Interaction Experience

This study proposes a construct, Voice Interaction Experience, that acknowledges the unique characteristics that VUI enables (Lopatovska & Williams, 2018). These are described in table 4.

Voice Interaction Experience	Literature in support	Research proposition
Identification and Assignment of Agency	(Klein, 2016), (Wagner, Nimmermann, & Schramm-Klein, 2019)	RP22a: Identification and assignment of agency to ISA devices will positively affect the intention to adopt the ISA device. RP22b: Identification and assignment of agency to ISA devices has a positive effect on PBCs.
Emotional Attachment	(Knijnenburg, Willemsen, Gantner, Soncu, & Newell, 2012)	RP23a: The Greater the emotional attachment to the ISA devices, the stronger the intention to adopt the ISA device. RP23b: Emotional attachment has a positive effect on PBCs.

Table 4 Items included in Voice Interaction Experience

The model proposed is an initial elaboration of secondary and primary research. Future work, consisting of primary qualitative data collection and analysis will clarify and qualify the postulated research propositions and the existence of new ones.
To investigate the proposed research propositions, data will be collected from a sample of 15 patients. The protocol will include three visits to each participant at their place of residence. The repeated visits over a course of 5 months have been designed to enable the collection of deep insights in the characteristics, socio-technical environment and user requirements. Data generated from visit 1 will lead to a prototype of an ISA based EC hub able to demonstrate the control of few functions around the home. Visit 2 will be centred on the prototype and capture details on PBCs and Voice Interaction Experience. Visit 3 will focus on user-prototype interaction and service provision that may enable adoption. The final outcomes of this study will consist of a refined model for the adoption of ISA devices among patients with severe mobility impairments and a set of design and service improvements that would enable the adoption of ISA technologies as assistive devices.

References

Agarwal, R., and J. Prasad. 1997. "The Role of Innovation Characteristics and Perceived Voluntariness in the Acceptance of Information Technologies". Decision Sciences 28(3): 997.

Ajzen, I. 1991. "The theory of planned behavior". Organizational Behavior and Human Decision Processes 2(50): 179-211.

Carmien, S. 2010. "Socio-Technical Environments and Assistive Technology Abandonment". Socio-Technical Networks: 183-196.

Chu, L., Galetzka, M. and A. Van Deursen. 2019. "Why would I adopt a smart speaker?: Consumers' intention to adopt smart speakers in smart home environment." Master's thesis, University of Twente.

Cohen, P., and S. Oviatt. 2015. "The Role of Voice in Human-Machine Communication". In Voice Communication Between Humans and Machines. National Academies Press.

Conci, M., Pianesi, F., and M. Zancanaro. 2009. "Useful, Social and Enjoyable: Mobile Phone Adoption by Older People". Lecture Notes in Computer Science: 5726.

Craig, A., Tran, Y., McIsaac, P., and P. Boord. 2004. "The efficacy and benefits of environmental control systems for the severely disabled". Med Sci Monit 11(1): 32–39.

Davis, F. 1989. "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information". MIS Quarterly 13(3): 319-340.

Djamasbi, S., Tullis, T., Girouard, M., Hebner, M., Krol, J., and M. Terranova. 2006. "Web Accessibility for Visually Impaired Users: Extending the Technology Acceptance Model (TAM)". AMCIS 2006 Proceedings: 367.

Feder, G., Just, R., and D. Zilberman. 1985. "Adoption of Agricultural Innovations in Developing Countries: A Survey". Economic Development and Cultural Change 33(2): 255-298.

Fineberg, H. 2012. "A successful and sustainable health system - How to get there from here". New England Journal of Medicine, 366(11): 1020-1027.

Goodman, G., Tiene, D., and P. Luft. 2002. "Adoption of Assistive Technology for computer access among college students with disabilities". Disability and Rehabilitation 24(1-3): 80-92.

Greenhalgh, T., Wherton, J., Sugarhood, P., Hinder, S., Procter, R., and R. Stones. 2013. "What matters to older people with assisted living needs? A phenomenological analysis of the use and non-use of telehealth and telecare". Social Science and Medicine 93: 86-94.

Halim, S. 2019. "AI-based smart speakers in healthcare: a game changer or a fad?". Health Europa.
Heath, Y., and R. Gifford. 2002. "Extending the Theory of Planned Behavior: Predicting the Use of Public Transportation". Journal of Applied Social Psychology 10(32): 21 54-21 89.

Jutai, J., and H. Day. 2002. "Psychosocial Impact of Assistive Devices Scale (PIADS)". IOS Press
Kintsch, A., and R.Depaula. 2002. "A Framework for the Adoption of Assistive Technology". Supporting learning through assistive technology: 1-10.

Klecun, E. 2016. "Transforming healthcare: policy discourses of IT and patient-centred care". European Journal of Information Systems 25(1): 64-76.

Klein, L. (2016). "Design for Voice Interfaces". Sebastopol, CA: O'Reilly Media Inc. Retrieved from https://learning.oreilly.com/library/view/design-for-voice/9781492039518/copyright-page01.html.

Knijnenburg, B., Willemsen, M., Gantner, Z., Soncu, H., and C. Newell. 2012." Explaining the user experience of recommender systems". User Modeling and User-Adapted Interaction 22(4-5): 441-504.

Kowalczuk, P. 2018. "Consumer acceptance of smart speakers: a mixed methods approach". Journal of Research in Interactive Marketing 12(4): 418-431.

Laukkanen, T., and M. Pasanen. 2008. "Mobile banking innovators and early adopters: How they differ from other online users?". Journal of Financial Services Marketing 13(2): 86-94.

Li, S., Glass, R., and H. Records. 2008. "The influence of gender on new technology adoption and use-mobile commerce". Journal of Internet Commerce 7(2): 270-289.

Lopatovska, I., Rink, K., Knight, I., Raines, K., Cosenza, K., Williams, H., and A. Martinez. 2018. "Talk to me: Exploring user interactions with the Amazon Alexa". Journal of Librarianship and Information Science.

Mathieson, K. 1991. "Predicting User Intentions: Comparing the Technology Acceptance Model with the Theory of Planned Behavior".

Pencheon, D. 2014. "Sustainable healthcare: the NHS launches a new strategy". The Guardian.
Rauschnabel, P., He, J., and Y. Ro. 2018. "Antecedents to the adoption of augmented reality smart glasses: A closer look at privacy risks". Journal of Business Research 92: 374-384.

Ringland, K., Wolf, C., Boyd, L., Baldwin, M., and G. Hayes. 2016. "Would you be mine: Appropriating minecraft as an assistive technology for youth with autism". ASSETS 2016 - Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility: 33-41.

Samaradiwakara, M. 2014. "Comparison of Existing Technology Acceptance Theories and Models to Suggest a Well Improved Theory/Model". International Technical Sciences Journal 1 1(1): 21-36.

Shamim, U., Spinelli, G., Woodcock, A., and A. Nair. 2019. "Enabling by Voice: Voice Enabled Environmental Control (EC) Devices Using Interactive Smart Agents (ISA)". IEEE 23rd International Symposium on Consumer Technologies (ISCT): pp. 68-73.

Smith, A. 2019. "Amazon's Alexa to offer NHS healthcare advice". PharmaTimes.

Spinelli, G., Micocci, M., Martin, W., and Y. H. Wang. 2019. "From medical devices to everyday products: exploring cross-cultural perceptions of assistive technology". Design for Health 3(2): 324-340.

Van Biljon, J., and P. Kotze. 2007. "Modelling the Factors that Influence Mobile Phone Adoption". Annual Research Conference of the South African Institute of Computer Scientists and Information Technologists: 152-161.

Verdonck, M., Steggles, E., Nolan, M., and G. Chard. 2014. "Experiences of using an Environmental Control System (ECS) for persons with high cervical spinal cord injury: The interplay between hassle and engagement". Disability and Rehabilitation: Assistive Technology 9(1): 70-78.

Venkatesh, V., Morris, M., Davis, G., and F. Davis. 2003. User Acceptance of Information Technology: Toward a Unified View.

Wagner, K., Nimmermann, F., and H. Schramm-Klein. 2019. "Is It Human? The Role of Anthropomorphism as a Driver for the Successful Acceptance of Digital Voice Assistants". Proceedings of the 52nd Hawaii International Conference on System Sciences.

Wellings, D., and J. Unsworth. 2011. "Fortnightly review: Environmental control systems for people with a disability: an update". BMJ.

Yang, H., Lee, H., and H. Zo. 2017. "User acceptance of smart home services: An extension of the theory of planned behavior". Industrial Management and Data Systems 117(1): 68-89.