



# A cross cultural investigation of individuals' acceptance of Smart Home Technology: The role of needs satisfaction

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**A cross cultural investigation of individuals' acceptance of Smart Home Technology: The role of needs satisfaction.**

**Summary.** *Smart Home Technology manufacturers currently face significant issues with regard to the acceptance and intention to use their products. Evidence suggests that specific products have the lion's share of the smart home market, and fully integrated smart home set-ups are still rare. The aim of this study was to investigate the acceptance of Smart Home Technology by administering the Technology Acceptance Model and applying Self Determination Theory with a sample of English (N = 284) and Spanish (N= 209) technology users. Results showed that perceived ease of use and perceived usefulness act as mediators of the effect of need satisfaction on respondents' behavioural intention to use Smart Home Technology. Except for relatedness satisfaction, there were no gender effects; however, we found important differences between the English and Spanish participants, which are discussed in terms of cultural differences in the degree to which need satisfaction is important to participants.*

**Keywords:** *Technology Acceptance Model; Self Determination Theory; need satisfaction; Smart Home Technology; behavioural intention to use*

**Una investigación intercultural sobre la aceptación de las personas de la tecnología Smart Home: el papel de la satisfacción de las necesidades**

**Resumen.** *Los fabricantes de la tecnología hogar inteligente actualmente afrontan problemas importantes con la aceptación y la intención de usar sus productos. La evidencia sugiere que los productos específicos tienen la mayor parte del mercado de hogares inteligentes, y todavía es inusual experimentar una configuración de hogar inteligente completamente integrada. Este estudio tuvo como objetivo investigar la aceptación de la tecnología de casa inteligente utilizando el Modelo de Aceptación de Tecnología y la Teoría de la Autodeterminación con una muestra de usuarios de la tecnología de casa inteligente ingleses (N = 284) y españoles (N = 209). Predijimos que la facilidad de uso y las utilidades percibidas actuarían como mediadores del efecto de la satisfacción de la necesidad en la intención de comportamiento de los encuestados para usar la tecnología hogar inteligente. Excepto por la satisfacción de la relación, no hubo efectos de género; sin embargo, encontramos diferencias importantes entre los participantes ingleses y españoles, que se discuten en términos de diferencias culturales en el grado en que la satisfacción de necesidades es importante para los participantes.*

**Palabras clave:** *Modelo de Aceptación de Tecnología; Teoría de la Autodeterminación; necesidad de satisfacción; tecnología de hogar inteligente; intención de uso*

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## Introducción

### *Smart Home Technology*

Although Smart Home Technology (SHT) is widely available, the complete smart home set-up has not been fully integrated into everyday life. It is still uncommon to experience a fully integrated, entirely intuitive smart home environment. Despite promising future sales predictions (Mordor Intelligence, 2021; Research and Markets, 2020; Schill et al., 2019; Yang et al., 2018), the relatively low acceptance and modest usage of SHT suggest that SHT may be leaving consumers frustrated and may not be satisfying their needs. Other potential reasons for low acceptance include design flaws, consumer misunderstanding, anxiety (Powell, 2015), a lack of consumer technical skill (de Boer et al., 2019), pricing (Neumann, 2018), long product life cycles (Yang et al., 2018), privacy issues (Hubert et al., 2019; Van Hung et al., 2021), security concerns (Stoyanova et al., 2020) and complications in smart home infrastructure (Riquebourg et al., 2006). Additionally, SHT is viewed as an exclusive luxury item in many regions of the world, which limits more widespread adoption. Moreover, purchasing and sales figures do not automatically equate to continuous or actual use (Shuhaiber et al., 2019), as consumers may have buyer's remorse due to the complexities of using SHT (Marikyan et al., 2020). In addition, an optimistic sales forecast does not necessarily represent SHT's overall rate of acceptance, as groups of affluent technophiles might be buying up the majority of SHT.

Technology companies' business models seem to be based on attracting end users' attention and then selling their data to monetize and profit (Calvo et al., 2020). This leaves little scope for manufacturers to contemplate the end user's psychological needs, which could be an essential condition for increased acceptance and behavioural intention (BI) to use SHT. BI refers to the probability that an individual will behave in a specific way when presented with certain conditions. TAM clarifies that an individual's attitude, which PU and PEU shape, will determine the degree of BI to use technology (Davis et al., 1989). Individuals' behavioural intention to use SHT is an affective reaction to the performance of these technologies, which increases if PU and PEU are satisfied. BI is a tried and tested variable used in various models, including TAM (Davis et al., 1989), the Theory of Reasoned Action (TRA; Fishbein & Ajzen, 1975) and The Theory of Planned Behaviour (TPB; Ajzen, 1991) and in numerous articles exploring SHT acceptance (Hubert et al., 2019; Liu & Chou, 2020; Mital et al., 2018; Nikou, 2019; Park et al., 2017; Schill et al., 2019; Shuhaiber et al., 2019; Van Hung et al., 2021).

The satisfaction of psychological needs is said to allow individuals to thrive and promote their well-being (Chen et al., 2014). The meeting of these needs could be a precondition for increased acceptance and behavioural intention to use SHT, because a positive experience with these technologies is likely to increase usage.

In contrast, the negative impact of a failure to meet a consumer's psychological needs may cause the person to lose growth potential and evoke feelings of vulnerability, ill-feeling and even psychopathology (Bartholomew et al., 2011; Vansteenkiste & Ryan, 2013). In the context of SHT, a negative experience will feed scepticism and cause individuals to reject the devices. Research on the acceptance and usage of SHT is more relevant than ever, as more people are spending a lot more time at home (Sekar et al., 2018) due to recent events, including Covid lockdowns and the increase in working from home (Brynjolfsson et al., 2020). As they spend more of their lives at home, individuals become more likely to contemplate the purchase and use of SHT to make their experiences there more comfortable and convenient (Balta-Ozkan et al., 2013).

While technology use has expanded since the start of the pandemic, the trend of using SHT emerged before 2020, as exemplified by the fact that young adults spend over 60% of their home leisure time using technology (Office for National Statistics, 2017, UK). The explosion in home entertainment options, plus evidence of excessive usage (Rideout et al., 2010), cements the argument that humans were already more homebound due to accessible technological advances. More recently, the use of smart appliances such as touchless doorbells and face recognition has increased due to health concerns (McElroy et al., 2021). To sum up, the home environment now significantly influences our psychological needs, actions, and behaviour as individuals. Thus, it is more important than ever to critically assess SHT (Maalsen & Dowling, 2020).

### *Technology Acceptance Model*

The biggest challenge in information technology and systems research is understanding why people accept or reject new technology. The existing literature that addresses SHT through psychological models overwhelmingly uses the Technology Acceptance Model (TAM). The TAM (Davis, 1989) was created as a reliable model to examine the potential user's behavioural intention (BI) to use a specific technology, and the theory is usually applied in conjunction with another theory or additional variables (Hubert et al., 2019; Liu & Chou, 2020; Mital et al., 2018; Nikou, 2019; Park et al., 2017; Schill et al., 2019; Shuhaiber et al., 2019). TAM is an overarching model that addresses acceptance or rejection of new technology, as it allows researchers to understand the cognitive processes within users and sheds light on how they will adopt a new piece of technology and integrate it into their lives. The underlying idea is that consumers tend to form attitudes and intentions with regard to learning to use a given technology before initiating efforts to actually use it. Furthermore, people make cognitive decisions and adopt certain biases before engaging with a specific piece of technology, whether hardware or software.

The original constructs created to measure humans' attitudes towards technology were perceived usefulness

(PU), perceived ease of use (PEU), BI, attitude towards use and actual use. PU and PEU are antecedents to BI that promote actual usage (Rosli & Saleh, 2022). PU is defined as the extent to which a person perceives a worthwhile or positive impact while using a particular piece of technology (Davis, 1989). If an individual views SHT as providing valuable benefits in the form of information or effective outcomes, then BI to use these technologies will increase (Shuhaiber & Mashal, 2019). The existing literature concludes that PU is a significant factor that increases BI to use SHT (Neumann, 2018; Nikou, 2019; Van Hung et al., 2021). PEU is the degree to which a person believes using technology will be effortless (Davis, 1989). If an individual finds their SHT simple to use and applies the technologies without complication or major upheaval in their family environment and lifestyle, the person is likely to have a higher BI to use the product (Hubert et al., 2019). The existing literature supports the idea that PEU has an effect on BI to use, and that this relationship functions via two causal pathways: (1) a direct effect on the BI to use this technology (Sohn & Kwon, 2020) and (2) an indirect effect on BI to use it, via perceived usefulness (Marikyan et al., 2021). Moreover, contemporary literature concludes that, within the home, if PEU is satisfied, this contributes to increasing BI to use SHT (Liu & Chou, 2020; Mital et al., 2018; Nikou, 2019; Park et al., 2017; Schill et al., 2019; Shuhaiber et al., 2019; Van Hung et al., 2021). There is some disagreement among researchers regarding the relationship between PU and PEU, with the evidence slightly leaning toward the conclusion that PU has a more significant influence on PEU when predicting BI. (Aburagaga et al., 2020; Lu et al., 2019). In other words, perceived usefulness creates a greater sense of SHT being easier to use.

Although 34 factors have been found to influence BI, PU and PEU are generally the primary and most significant variables involved in SHT adoption, which makes their use as study variables highly justifiable (Kuebel & Zarnekow, 2015). However, due to the complexities of technology, in contemporary literature TAM is no longer used as the sole measure of technology acceptance. This points to the need to incorporate another model in order to gain a greater understanding of SHT acceptance. In the case of SHT, Self Determination Theory could be a unique and innovative model to use for this purpose.

### **Self Determination Theory**

Self Determination Theory (SDT) is a frequently researched psychological theory (Ryan & Deci, 2019) that emphasizes individuals' intrinsic motivational and behavioural tendencies rather than external influences (Ryan & Deci, 2020a). SDT proposes three basic human needs, namely, competence, relatedness, and autonomy. The theory explores what motivates individuals to seek out satisfaction of these specific needs. The concept of relatedness refers a feeling of connectedness or connec-

tion with others through an interaction that creates a sense of belonging and enjoyment (Khan et al., 2017; Nikou & Economides, 2017; Niemiec & Ryan, 2009; Ryan & Deci, 2000b). SHT can boost relatedness by connecting people, and this, in turn, could increase people's sense of well-being. However, communication with others via SHT may provide more data to companies, which can spark privacy and security concerns in the home. Autonomy is best defined as the feeling of agency or control over one's own actions and the experience of volition when carrying out an activity (Chen et al., 2014; Yoon & Rolland, 2012). Regarding the smart home, autonomous behaviour reflects the self and one's choices as to when and how to interact with SHT. Feeling competent means believing in one's ability to execute an action successfully and achieve the desired goal, an attitude that increases motivation (Deci & Ryan, 1985; Sørrebø et al., 2009). An end user's belief that they are competent at operating SHT is essential to ensure intentional and continued use. This feeling of competence may help lead to other milestones and endeavours, which adds a feeling of involvement (Hew & Kadir, 2016; Tschofen & Mackness, 2012).

On a psychological level, if competence, relatedness, and autonomy are fulfilled, individuals are less likely to manifest negative feelings and discomfort and more likely to maintain well-being, and, ultimately, their general health improves (Chen et al., 2014). Positive motivational factors are essential for SHT adoption and BI to use this technology (Pedrotti & Nistor, 2016; Venkatesh, 1999), and if these factors are adequately satisfied, the BI to use SHT increases.

SDT is based on decades of research (Ryan & Deci, 2017; Vansteenkiste & Ryan, 2013) that validates the three factors as the most predictive and dependable psychological mediators of people's motivation, engagement and well-being (Peters et al., 2018), especially if they are engaging in tasks of interest to them. The effect size or strength of the three psychological needs are not differentiated, but existing literature does suggest that autonomy is viewed as the most vital (Kuvaas, 2009) when assessing needs satisfaction.

### **Using a multi-model approach**

A few studies have combined TAM and SDT (Fathali & Okada; Nikou & Economides, 2017; Racero et al., 2020). A meta-analysis of 88 studies conducted by King and He (2006) promotes TAM as a reliable model for predicting the acceptance and use of technology, and this approach is widely used to gauge users' perceptions of technological innovations and the probability of acceptance (Moon & Kim, 2001). Due to the multifaceted complexity of SHT and the common use of various devices that often work and communicate with each other, it makes sense for researchers to merge different models in order to gain deeper insights and a better understanding of consumers' attitudes, and to unearth psychological issues associated with BI to use SHT (Tung et al., 2008; Yang et al., 2017). Turner et al. (2010)

concluded that TAM is a valuable model but advises integrating another theory or additional variables related to human processes.

### *Purpose of the present study*

Very few papers have explained the use of SHT using psychological models or theories (Kim et al., 2020), and to date, no papers have combined TAM and SDT. This paper addresses this gap in the research by measuring BI using a unique combination of models. Moreover, our study builds on Khasawneh's (2018) work, which suggests adopting a holistic perspective on behavioural intention (BI) to use SHT, rather than examining individual kinds of SHT, in order to gain a true sense of the issues and problems associated with acceptance and BI to use SHT. This paper is aligned with the opinion that more research should be done on SHT in general rather than on any specific SHT product (Martínez-Córcoles et al., 2017). This study uses a combined model to investigate the relational impact and mechanisms at work between the satisfaction of psychological needs (autonomy, competence, and relatedness) through SHT and the BI to use SHT. Evidence suggests that SDT variables are aligned to TAM as predictors of PU, and PEU (Nikou & Economides, 2017), and research has established the two models' compatibility when exploring BI. (Lu et al., 2019; Rosli & Saleh, 2022; Tsai et al., 2021). Moreover, Lee et al. (2015) proved the significant relationship between SDT and TAM. Nikou and Economides (2017) used SDT and TAM to assess mobile-based assessment and concluded that BI was significantly attributed to PEU and PU. Additionally, the motivational variables of autonomy, competence and relatedness had a significant and positive effect on PU, PEU and BI (Nikou & Economides, 2017). The incorporation of SDT could fill a gap in the research, as it has never been used in combination with TAM to assess BI to use SHT and, as such could reveal new insights.

Further, the combined model in our study also addresses the role of culture and gender. Studying SHT cross-culturally (in English and Spanish populations) helps fill a gap in the literature and highlights the different ways societies are transforming in response to the ever-changing world dominated by technology (Wang, 2016). Differing cultural outcomes will be examined through the lens of two countries, Spain and England. Studies have shown slight variations among European countries, but there is a general consensus that these needs are largely universal (Chirkov et al., 2003; Ryan & Deci, 2000a).

Despite this assumption of commonality among countries, there are reasons to expect cultural differences in our study. English and Spanish culture have some shared characteristics, but they also have some differences. A study on renewable energy adoption using Hofstede's (2011) six-point cultural framework model concluded that Spain has an intermediate collectivism score based on a low degree of individualism.

Different observers have categorized Spain as either a type I (individualistic) or a type II (collective) country (Beugelsdijk et al., 2016; Gomez-Lumbreras et al., 2019; Sharma et al., 2021). This lesser tendency toward individualism suggests that the Spanish may not regard autonomy as less essential than relatedness (Higueras-Castillo et al., 2019). Another study comparing British and Spanish cultures found that the British scored very high on individualism, implying they highly value autonomy when it comes to SHT adoption (Chepurna & Criado, 2021). Their Spanish counterparts recorded lower scores for individualism and higher scores for cooperation and interpersonal skills, which suggests relatedness again will be valued highly.

The digital divide in access to technology has narrowed over the years. Social media demographics show that females use Instagram and TikTok more than men (Barnhart, 2022; Dixon, 2022; Perrin, 2015) and are also growing in representation within the video game industry and as YouTube influencers (Lopez-Fernandez et al., 2019; Yokoi, 2021). Within the home environment, women still take on greater domestic workloads than men (Gram-Hanssen & Darby, 2018) and are more likely to use SHT for security and monitoring than males (Mamonov & Benbunan-Fich, 2020). Thus, it is still unclear how gender would affect BI to adopt SHT in the framework of our model. Therefore, gender will be used as a covariate.

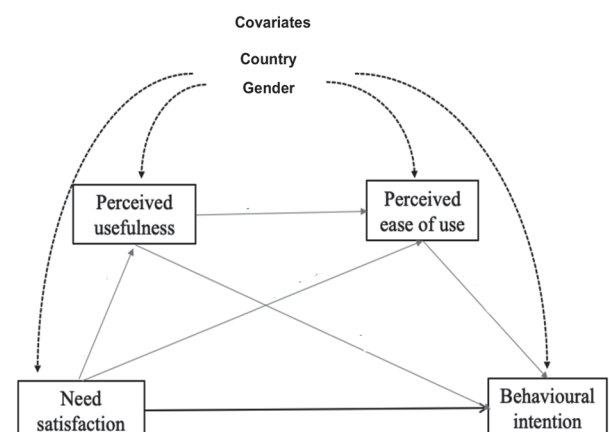
### *The mediation model*

We propose a mediation model with perceived need satisfaction (PNS) as the predictor, PU and PEU as mediator variables, and BI as the outcome variable, predicting that the effect of PNS on BI to use SHT will be mediated by PU and PEU (see Figure 1).

Thus, for the path model, we hypothesize the following positive significant correlations:

**H1:** Perceived needs satisfaction (PNS) with BI to use SHT

**H2:** PNS with perceived usefulness (PU) with BI to use SHT



**Figure 1.** Proposed serial mediation model-Analysis of behavioural intention.

**H3:** PNS with perceived ease of use (PEU) with BI to use SHT

**H4:** PU with PEU

**H5:** PU with BI to use SHT

**H6:** PEU with BI to use SHT

Further, we anticipate that English participants will score higher on autonomy, and Spanish participants on relatedness. Women will score higher on relatedness and men on competence.

## Methods

### Participants

A non-probability convenience sample of 514 individuals (56% women), with a mean age of 34 years ( $M = 33.53$ ,  $SD = 13.448$ ), was recruited online through personal social networks, including Facebook, Twitter, LinkedIn, WhatsApp, and forums dedicated to SHT. The participants were living either in England or Spain.

### Instruments

Both the English and Spanish language versions of the online battery of tests consisted of an ad hoc questionnaire on demographic data and the type and number of smart home devices owned, along with three scales evaluating self-determination, SHT acceptance, and behavioural intention.

To measure the satisfaction of psychological needs, a version of the validated instrument created by Longo et al. (2016) was used. It included nine items that measure the satisfaction of each basic need (autonomy, competence, and relatedness). The items were slightly modified to relate to SHT. For example, the original "I feel highly effective at what I do" was changed to "I feel highly effective at using Smart Home Technology". Participants were asked to indicate their level of agreement with each statement on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The reliability (Cronbach's alpha) of the scale in this study was  $\alpha = .78$ .

To measure technology acceptance, we used the original TAM scale (Davis, 1989). The scale was adapted to relate specifically to SHT. It included nine items, six of which measured perceived ease of use (PEU) ( $\alpha = .61$ ) and three of which measured perceived usefulness (PU) ( $\alpha = .66$ ). Each item was answered using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The Behavioural Intention Scale (Venkatesh et al., 2012) was incorporated into the TAM scale and was also adapted to relate to SHT. The scale included three items, each of which was answered using a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The reliability of this scale was  $\alpha = .72$ .

### Procedure

The questionnaire battery was designed and distributed online via the survey software SoGoSurvey. We surveyed

participants from Spain and England using an online questionnaire from April to June 2021. Before the presentation of the questionnaire battery, individuals were provided with a consent form that informed them about the research aims and the survey procedure. Participants gave their informed consent by clicking on the Yes/No tab before responding. The questionnaire batches were posted repeatedly on as many online platforms as possible, asking users to take part in a scientific study on SHT. The only inclusion criterion called for participants to be over 18 years old. The Ethical Committee of the authors' University approved the study protocol (reference number: 2021017D).

### Data analyses

A multivariate analysis of variance was run to establish possible gender and country differences in the study variables. Pearson correlations were used to check if the variables correlated significantly in the predicted direction. A serial mediation model was used because it is the most comprehensive technique to achieve the results for our path mediation analysis and to go beyond descriptive to a more functional understanding of the relationships among our chosen variables (Preacher & Hayes, 2004). The statistical significance of the mediation effects of the serial multiple mediation model tested in the study was investigated by using the ordinary least square regression method. Analyses were conducted through SPSS macro-PROCESS v4.1, which allowed us to estimate the indirect effect of successive mediators in a single model simultaneously. We generated 5000 bootstrapped samples to estimate the confidence interval of the model effect.

## Results

### Descriptive statistics

A total of 514 respondents participated in this study, but 19 had to be excluded because of incomplete data. A final sample of 493 (281 females and 212 males) completed the 30-item questionnaire battery. Participants owned an average of 2.7 smart devices; 56.7% owned two devices (mostly smartphones and smart TVs), 25.7% owned three, 10.1% owned four and 7.5% had five. Non-parametric statistics showed that there were no gender or country differences with respect to the number of devices owned. The number of devices owned did not correlate with age. It did correlate positively, but weakly, with autonomy satisfaction ( $\rho = .133$ ,  $p = .002$ ) and BI ( $\rho = .164$ ,  $p < .001$ ), PEU ( $\rho = .092$ ,  $p = .037$ ) and PU ( $\rho = .135$ ,  $p < .001$ ). Descriptive statistics for gender and country on the dependent variables are depicted in Table 1.

### Multivariate analyses

The results of the MANOVA showed that there were essential differences between the countries. UK par-

**Table 1.** Descriptive statistics (means and standard deviations) on study variables for men and women and for UK and Spain nationals

Variables	UK		Spain	
	Men n=87	Women n=197	Men n=125	Women n=84
Autonomy satisfaction	11.01 (2.31)	11.45 (2.0)	11.70 (1.85)	11.63(1.87)
Competence satisfaction	10.41 (2.25)	10.52 (2.2)	10.07 (1.71)	9.92(1.86)
Relatedness satisfaction	9.10 (2.52)	9.77 (2.7)	8.98(2.44)	9.40 (2.26)
Overall needs satisfaction	30.53 (4.86)	31.75 (5.37)	30.57 (4.35)	30.86 (5.52)
Perceived ease of use	21.10 (3.28)	21.10 (3.43)	20.15 (3.02)	20.15 (3.19)
Perceived usefulness	9.71 (2.32)	9.48 (2.3)	10.57 (2.20)	10.61 (1.92)
Behavioural intention	11.46 (1.87)	11.41 (2.21)	12.01 (1.81)	11.88 (1.83)

Note: Standard deviations are shown in parentheses.

**Table 2.** Pearson's Correlation Analysis on Study Variables

	1	2	3	4	5	6
1. Overall needs satisfaction	1					
2. Autonomy satisfaction	.70**	1				
3. Competence satisfaction	.76**	.40**	1			
4. Relatedness satisfaction	.77**	.27**	.35**	1		
5. Perceived ease of use	.57**	.47**	.55**	.30**	1	
6. Perceived usefulness	.51**	.42**	.45**	.31**	.40**	1
7. Behavioural intention	.54**	.56**	.38**	.31**	.46**	.45**

\*p < .05. \*\*p < .01.

Participants scored higher than Spanish participants on competence satisfaction (5.57,  $p=.019$ ), and BI ( $F=6.51$ ,  $p=.011$ ) and PEU ( $F=9.22$ ,  $p=.003$ ) and PU ( $F=15.13$ ,  $p<.001$ ). However, gender differences were found only for relationship satisfaction, where women scored higher than males ( $F=4.02$ ,  $p=.019$ ). Therefore, the gender variable was excluded from the mediation model, and only country was included as a covariate.

**Table 3.** Summary of serial mediation analysis of PU and PEU between NS and BI

Effects	Path	$\beta$	SE	t	95% CI	
					lower	upper
direct	NS → PU	0.234	0.017	14.115**	0.202	0.267
	Country → PU	0.984	0.168	5.871**	0.655	1.314
	NS → PEU	0.323	0.027	11.754**	0.269	0.377
	PU → PEU	0.210	0.630	3.343**	0.087	0.334
	Country → PEU	-0.871	0.242	-3.595**	-1.347	-0.395
	NS → BI	0.131	0.019	6.846**	0.092	0.168
	PU → BI	0.151	0.039	3.859**	0.074	0.227
	PEU → BI	0.145	0.028	5.239**	0.090	0.199
Total direct	Country → BI	0.570	0.151	3.786**	0.274	0.866
	NS → BI	0.220	0.015	14.749**	0.191	0.249
Indirect 1	Country → BI	0.622	0.150	4.135**	0.327	0.918
	NS → PU → BI	0.034	0.009	-	0.017	0.054
	NS → PEU → BI	0.047	0.010	-	0.028	0.066
Indirect 2	NS → PU → PEU → BI	0.007	0.003	-	0.002	0.013
Total indirect		0.089	0.014	-	0.063	0.117

Note: \*\*p<.001

NS= need satisfaction; PU=perceived usefulness; PEU= perceived ease of use; BI= Behavioral intention.

## Mediation analyses

Correlations between the variables can be consulted in Table 2. All correlations showed significant effects in the predicted direction, so the conditions for mediation analysis are met.

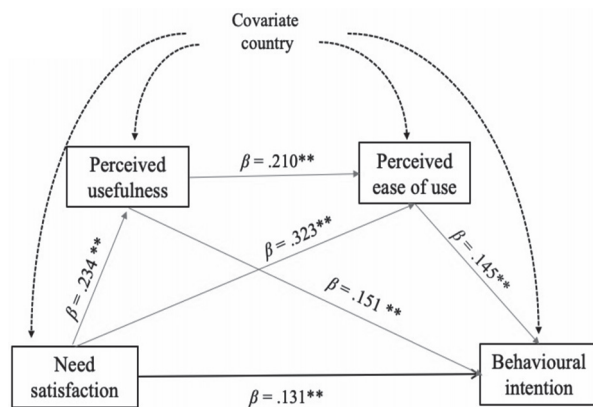
Table 3 presents the summaries of the predicted mediation analyses; beta values are also presented in Figure 2. Table 3 and Figure 2 present the effects of the serial mediation analysis on behavioural intention. Regression coefficients for the study variables and the covariate over mediators on outcome were significant, but  $R^2$  was lower than the overall indirect model. The indirect model explained 38% of the variance ( $R^2 = 0.378$ ;  $F(4, 492) = 74.825$ ;  $p < .001$ ). As can be seen, all paths were significant at  $p < .001$ , and the total effects of NS on BI (direct plus indirect) were stronger than the direct effects.

## Discussion

### The mediation model

This study investigated the relational impact and mechanisms at work between the degree of psychological needs satisfaction through SHT and the BI to use SHT, with a combined model using SDT and TAM. The results confirmed our main hypotheses. Firstly, when PNS is satisfied, then BI to use SHT increases (H1). Moreover, the effect of needs satisfaction on behavioural intention was mediated by perceived usefulness (H2) and ease of use (H3). Perceived usefulness and ease of use are essential factors that contribute to an individual's intention to use smart home devices, even if the device already satisfies basic psychological needs. Thus, the hypothesis agrees with the TAM and SDT postulates.

The findings imply that consumers prefer uncomplicated SHT that fulfils their individual needs (Schill et al., 2019) and allows them to carry out domestic chores with the least effort possible.



Note: \*\* $p < .001$

**Figure 2.** Effects of the serial mediation analysis on behavioural intention

The PNS to BI path analysis found a significant mediation effect of PU and PEU, individually or together. This could be because both constructs (PU & PEU) similarly affect the satisfaction of needs (H4). Therefore, autonomy, relatedness, and competence (PNS) are achieved to a similar degree when consumers feel that SHT are both useful and easy to use. This implies that when both PU and PEU are significant, consumers are more likely to buy and use SHT. A paper exploring students' intention to use open-source software (Racero et al., 2020) and another on e-learning (Roca & Gagné, 2008) found that their participants' BI was significant because the mechanics of SDT and TAM worked together harmoniously. Therefore, individuals are more likely to use technology when the satisfaction of their basic needs (autonomy, competence, and relatedness) influences both PU and PEU (Roca & Gagné, 2008). Although an exception to the rule exists (Kim et al., 2017), PU and PEU are generally linked by their utilitarian nature.

Although this study evaluated a range of different SHT, most participants owned a smart TV and voice controller, which may have influenced the findings, as these products are easy to use and require little effort. The basic functions of a smart TV are not too dissimilar to traditional remote-controlled TV, which we are accustomed to using. Meanwhile, using voice commands requires minimal effort and is easier than using devices such as a smart thermostat (Sohn & Kwon, 2020). This may be one reason why PU with PEU positively impacted BI to use SHT. However, on the whole, the participants gave similar positive feedback across all SHT products investigated (H4).

Furthermore, the extensive use of smartphones since their inception in 2008 has enabled a smooth transition to the use SHT of (Mital et al., 2018), as individuals are now accustomed to creating actions and commands via digital interfaces. Therefore, SHT is more likely to be perceived as easy to use, as the basic functionality across the board is familiar to consumers or

new adopters. The results highlight the importance of ease of use (H6) of SHT, which participants rated higher than usefulness (H5). This is in line with research on TAM and BI to use SHT, especially among older people (Marikyan et al., 2021) and women (Rode & Poole, 2018; Strengers et al., 2019). Both cohorts tend to want the device to work with simplicity and are generally satisfied once it performs its basic functions.

The results are also in line with other combined TAM and SDT studies. Nikou and Economides (2017) suggest that ease of use influenced participants' intention to use a mobile-based assessment system for increased learning. Fathali and Okada's (2018) study of technology-enhanced out-of-class language learning agreed with the findings of Nikou and Economides (2017). Joo et al. (2018) also found that perceived ease of use significantly affected participants' satisfaction when using Massive Open Online Courses (MOOCs). Moreover, ease of use strongly predicted continuous use of these courses. Although ease of use was found to be an essential factor contributing to BI to use of SHT, research has shown the effects of perceived usefulness to be just as important (Park et al., 2017; Yang et al., 2017).

The perceived usefulness of SHT significantly affects BI to use SHT (Neumann, 2018; Nikou, 2019; Shuhaiber & Mashal, 2019; Van Hung et al., 2021). For example, if a consumer does not find a device particularly useful, he or she is unlikely to use it. In that case, it is deemed difficult to master or incompatible with existing technology, and it creates a negative attitude and is considered less beneficial (Wang et al., 2018). The repercussions, either positive or negative, are far-reaching. Recent studies have provided additional evidence of this positive relationship between SDT and PU (Hew & Kadir, 2016; Huang et al., 2015; Lee et al., 2015) and BI.

While many studies have explored the intention to use SHT with two or more theories (Hubert et al., 2019; Liu & Chou, 2020; Nikou, 2019; Schill et al., 2019), there is a lack of literature based on both TAM and SDT on attitudes toward using SHT. This study is the first to tackle SHT using both TAM and SDT (PNS).

### Cultural effect

Gender had a negligible effect on the results. However, our study found significant cross-cultural differences between our respondents in the UK and Spain. English participants scored lower than Spanish participants on autonomy and relatedness satisfaction. Autonomy is a need that rests on one's personal choice, volition, and psychological freedom (Tóth Király et al., 2019) and is based on individuality or the individual decision-making process. Therefore, the English respondents may have felt less autonomy satisfaction, as the individualistic Type I society (Hofstede, 2011) is characterized by a great sense of self-determination, and people in such societies are more sensitive when their au-

onomy is challenged. Indeed, a UK survey with over 1000 participants concluded that the loss of autonomy and independence were perceived more strongly than the privacy and data security concerns (Wilson et al., 2017). In contrast, the Spanish are a moderate collective Type II group (Garcia et al., 2019) and, as a society, are not as aligned with autonomy.

The more individualistic English culture may also be the reason why the participants in England recorded a low degree of relatedness satisfaction. Using SHT seemed to increase feelings of a lack of connection and association with others (Nikou, 2019) for the English group, which again suggests a lack of support or a need to reach out to others. Meanwhile, Type II cultures, such as Spain, are concerned about building relationships and relatedness, whereas Type I cultures are more interested in personal dependability (Lee et al., 2013). The Spanish cohort did not feel lower satisfaction than their British counterparts. This could also be due to the Spanish lifestyle and attitude, which is more collective and laid back and less anxious than that of the English.

### Limitations

The study is not without limitations. Due to the anonymity of online questionnaires, self-reporting and acquiescence bias when dealing with questionnaires is a reality that can skew or influence participants' responses. Participants are prone to self-favouring bias and self-enhancement, which may affect the validity of the results (Paulhus & Vazire, 2007).

A mixed-method approach may prove more significant, especially when dealing with BI to use SHT. An alternative method would be to study comparative sample groups living in a fully integrated smart home, a living lab (Kidd et al., 1999), and examine their behaviour over a period of time. A recent study in a living lab environment concluded that participants preferred to connect with other users when looking for advice on SHT usage rather than going through training manuals (Wright et al., 2021). Finally, age did not affect the study, because the average age was 34. Further studies should consider a broader range of ages to get diverse results from different demographics.

### Conclusions

The study analysed consumers' intention to use SHT across two countries in Europe, Spain and England. The finding proved helpful as the study was not bound to a single country and thus provided a more general look at SHT acceptance and intention to use these technologies. As functioning organicism, each of the societies gave us a glimpse of human behavioural traits that might be typical and relevant to each country. The implication for SHT manufacturers is apparent, and each product should be tailored to suit the characteristics of differing cultures. Although needs satisfaction does have a culturally universal perspective, there are

slight cultural differences as to the degree of importance of autonomy, competence and relatedness. Future research could possibly incorporate a single country from each continent to get a more comprehensive and general view of SHT acceptance and adoption worldwide.

Our previously unexplored model agrees with the general acceptance that TAM is a viable mediator of the intention to SHT. The addition of SDT added value to the study by exploring human psychological factors, which proved that SDT and the TAM combined work well together and provide robust results.

Additionally, PU and PEU proved to be significant mediators when measuring BI to use SHT. Future research could adopt this two-model approach and additional variables such as price, compatibility and privacy to better assess the acceptance of and intention to use SHT. In light of these findings, smart device manufacturers need to maintain simplicity and focus on PEOU and PU so as not to overwhelm end-users with too many options or challenging controls (Hargreaves & Wilson, 2017).

As a consequence this analysis of the smart home environment, future researchers, policymakers, and manufacturers will be able to understand better the acceptance process (Hubert et al., 2019). In turn, the research may help reach a deeper understanding of SHT and address any issues that occur due to the interaction between SHT, TAM and SDT

Ownership of SHT may offer a sense of belonging to the modern technology-based society. Moreover, the products could provide a source of interaction and conversation with other SHT users or be used to connect digitally with other users. Additionally, SHT communities are being created by end-users to share their experiences (Ruiz, 2020). Apart from the personification of voice controllers like Amazon's Alexa (Lopatovska & Williams, 2018), SHT are gradually being used as toys for people's entertainment, increasing the sense of relatedness (Trajkova & Martin-Hammond, 2020), which motivates usage. Indeed, the gamification of SHT through domestic task competitions between families and competing households (Winnicka et al., 2019) will only add to the enjoyment of SHT and increase needs satisfaction.

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