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Research Article

Antecedents of the Intention to Use Implantable Technologies for Nonmedical Purposes: A Mixed-Method Evaluation

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This study investigated the rise of implantable or cyborg technologies, also known as insideables, which offer the potential to improve health-related conditions and enhance the capabilities of healthy individuals. This research focused on the acceptance of insideables among university students in Spain, utilizing the unified theory of acceptance and use of technology (UTAUT) framework along with analytical tools such as partial least squares structural equation modelling (PLS-SEM) and fuzzy set qualitative comparative analysis (fsQCA). The PLS-SEM analysis revealed that factors such as performance expectancy, effort expectancy, and social influence positively influenced the intention to use insideables. However, the fsQCA revealed that no single variable is a necessary condition for explaining technology acceptance or rejection. Instead, a combination of constructs is needed to understand both intention to use and rejection. Configurational analysis emphasized the importance of factors such as performance expectancy, social influence, and hedonic motivation in explaining technology acceptance, whereas effort expectancy and perceived risk were less conclusive in their impact on behavioral intention. Moreover, the research revealed that the configurations related to the acceptance and rejection of insideables are asymmetrical. This study sheds light on the complex dynamics of implantable technology acceptance and provides valuable insights into the factors influencing its adoption. From a theoretical perspective, the sequential use of both correlational and configurational methods within the UTAUT framework allows us to gain a deeper understanding of the reasons behind the adoption of emerging technology rather than using only one data analysis methodology.

Keywords: body hacking; cyborg technology; fuzzy set qualitative comparative analysis; implantable technology; insideables; man–computer interaction; PLS-SEM; unified theory of acceptance and use of technology

1. Introduction

The technological revolution, which commenced in the mid-20th century and continued into the early 21st century, profoundly altered how individuals engaged with the world. With a special acceleration due to the COVID-19 pandemic [1], an increasing number of people maintained constant connections with their environment through technological extensions such as wearables, insideables, or implantable technologies [2].

During the 21st century, the number of human beings dependent on information technology has grown exponentially. According to Ramoğlu [3], the first stage of dependency is psychological. The second stage is the wearable stage, in which a device wearer temporarily extends their perception. The third stage involves the physical integration of technology into the human body. An example is an articular implant. The fourth stage involves a neurological relationship with technology created by extending the senses with new input to the brain.

In this regard, we must differentiate between wearable and implantable (or cyborg) technologies, also known as insideables. Wearables can be defined as intelligent electronic devices that are noninvasively attached to the human body, typically within an accessory such as a smartwatch [4]. On the other hand, insideables are technological devices that are implanted within the human body [5]. In other words, while wearables do not compromise the personal autonomy of the user, they become part of the individual's organics in such a way that they are usually addressed as cyborgs [1, 6].

The use of insideables has essentially two objectives. The first is medical, which aims to improve health, and the second involves enhancing and modifying physical and cognitive capabilities [7, 8]. This use does not generate controversy, at least if it allows for overcoming a disease or disability [9]. The first pacemakers date back to the mid-20th century and are relatively common today, as are cochlear or articular implants. However, because insideables are technological devices inserted into the human body, numerous challenges remain to be addressed to improve their functionality, durability, and compatibility [10].

Wearables such as activity trackers, which motivate users to practice sports, have become commonplace in households [4]. Conversely, the use of insideables for recreational purposes is more limited than that of wearables [5, 11, 12] and is highly controversial, both from legal [13] and ethical standpoints [14]. Insideables have the potential to enhance physical abilities, even in individuals with disabilities, by leveraging a super compensation effect [15]. A widely discussed example in the literature is that of athlete Oscar Pistorius, who has implants in his lower limbs [16].

Implantable technologies also offer the potential to enhance intellectual capabilities such as memory and computational capacity [6]. They can improve the healthcare of individuals who do not suffer from any disease, enabling continuous monitoring, early diagnosis of potential illnesses, and personalised medical care [17, 18]. Furthermore, they provide new capabilities [19] such as manipulating objects without physical contact, accessing doors, operating computers, making payments, or controlling machines [20]. They can even enable the control of living beings that have an insideable implant [21] or develop skills that are more typical of other species, such as emitting and detecting ultrasonic signals [3].

The market for nonmedical insideables has significant growth potential [5, 11]. However, at present, it remains relatively small, as its products have not achieved mass production and mass customisation, and are not currently used domestically [11, 15, 22]. Their use is popular in underground cultures heavily influenced by transhumanism, such as cyberpunk [23], some alternative feminist movements [24], and do-it-yourself (DIY) communities. Therefore, while there is extensive literature on the factors affecting the adoption of wearable devices through technology acceptance theories [25, 26], the literature concerning the acceptance of nonmedical insideables is much more limited [8, 27].

This study, thus, was aimed at expanding the literature on the adoption of insideables. The approach we adopted was based on the unified theory of acceptance and use of technology (UTAUT) [28]. The explanatory factors evaluated to understand usage intention include performance expectancy (PE), effort expectancy (EE), social influence (SI), facilitating conditions (FCs), and hedonism. Additionally, we introduced perceived risk (PR) into our analysis. The motivation behind this is that these types of technologies pose a risk to the user, both in terms of the information they generate regarding privacy and the use of that information [18], alongside their health because the devices are inserted into the body [18, 27].

From the standpoint of data analysis, the most common analytical tool for the analysis of implantable technologies is partial least squares structural equation modelling (PLS-SEM) [9], as well as qualitative analyses (Komkaite et al., [29]; [30, 31]). Configurational analysis is more residual [32], and the combined use of PLS-SEM and fuzzy set qualitative comparative analysis (fsQCA) is nonexistent. Thus, this study presented a novel combined use of SEM-PLS and fsQCA. The combination of correlational and configuration techniques, grounded in different analytical schemes, allows for the reduction of measurement errors, identification of average links between variables, and identification of necessary prerequisites and configurations that lead to a given output [33, 34].

This study addressed two research questions (RQs):

Research Question 1. What is the overall impact of each explanatory factor on the acceptance of nonmedical insideables? To address this, we employed a structural equation model using partial least squares (PLS-SEM). Additionally, a preliminary analysis of the descriptive statistics of the responses regarding the input and output variables provided initial insights into the mainstream attitudes of the respondents regarding the variables under scrutiny in our analysis.

Research Question 2. How do explanatory factors configure paths to explain the intention to use (IU) and nonintention to use insideables? In complex phenomena, such as the acceptance of disruptive technology, a given response can result from more than one path. In such circumstances, fsQCA is a suitable method [35] because it is case-oriented and allows capturing various ways in which input factors interact to produce an output [36].

The use of fsQCA in quantitative organisational and management studies is common [35]. In the technology acceptance arena, although less common than the use of correlational methods such as PLS-SEM, fsQCA is highly valuable in identifying profiles linked to the analysed outcome [33, 37]. Andrés-Sánchez, Arias-Oliva, and Pelegrín-Borondo [32] examined the conditions influencing the acceptance of and resistance to wearables and insideables using the multiple ethics scale and data used in Olarte-Pascual et al. [7].

While the PLS-SEM analysis indicated that PE, EE, and SI positively influence the attitude towards using insideables, other factors, such as hedonic motivation (HED) and FCs, were found to be insignificant. However, through fsQCA, it became evident that no single factor is pivotal in explaining the acceptance or rejection of the technology, and all evaluated constructs play roles in various explanatory configurations of acceptance and nonacceptance. Furthermore, research has revealed that configurations linked to positive and negative views of implantable technologies are asymmetrical.

2. Theoretical Framework

2.1. Preliminary Considerations. The predominant theoretical frameworks used to analyse the acceptance of implantable technologies are largely derived from Davis' [38] technology acceptance model (TAM), UTAUT and its extension, unified theory of acceptance and use of technology 2 (UTAUT2) [28, 39], and the cognitive–affective–normative (CAN) model [9].

The TAM, which is built on the theory of reasoned action (TRA), allows the identification of a small number of fundamental variables suggested by previous research addressing the cognitive and affective determinants of technology acceptance. It focuses on two utilitarian constructs: perceived usefulness and perceived ease of use [40]. In contrast, UTAUT and its extension, UTAUT2, attempt to expand the TAM by integrating up to eight different technology acceptance theories in the most parsimonious way possible [40]. The original formulation of the UTAUT considers that behavioural intention is influenced not only by utilitarian factors but also by SI and external conditions that can facilitate or hinder the use of the evaluated technology. The empirical works of Venkatesh et al. [28] and Rondan-Cataluña, Arenas-Gaitán, and Ramírez-Correa [40] showed that the UTAUT usually offers a better fit than other alternatives.

The CAN model considers that technology acceptance, especially if voluntary, relies on cognitive factors (perceived usefulness and expected ease of use from the TAM), normative factors (the social norm, which, as in UTAUT, directly affects behavioural intention), and affective factors. The latter have a particularly significant weight in CAN and are measured through positive and negative affect schedules [41].

The TAM has been employed in studies by Reinares-Lara et al. [42]; Gangadharbatla [43]; Klemenc, Vrhovec, and Mihelič [44]; and Andrés-Sánchez et al. [45]. The UTAUT has been utilised in research conducted by Sabogal-Alfaro et al. [8], Arias-Oliva et al. [5], and Luciani et al. [46]. In addition to Pelegrín-Borondo et al. [9], studies by Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47]; Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [48]; and Reinares-Lara, Olarte-Pascual, and Pelegrín-Borondo [49] have applied the CAN model.

The outcome to be explained in this study is the intention to use (IU), which is a uniform concept for all respondents; it includes whether they have experimented with insideables or not, or face barriers to their use, which can be high because of the emerging nature of the industry [5], making it challenging for the responding individual to use them effectively.

This study adopted the UTAUT model of Venkatesh et al. [28] as its conceptual basis. Therefore, we assessed PE, EE, SI, and FCs as explanatory variables. Additionally, as in the UTAUT2 extension, we included the survey respondents' HED and PR due to significant concerns regarding privacy, personal information shared through devices, and even the practitioner's health [27, 43].

It should be noted that gender, which Venkatesh [28] considers a potential moderator of PE, ease of use, and SI, was also considered, although no specific hypothesis was made about the direction of these moderating effects. These effects may stem from social aspects related to the roles assigned to a specific gender in the society in which the research was conducted. If gender roles are less differentiated, this moderating capacity becomes less relevant.

Regarding the basic constructs of the TAM, Venkatesh and Morris [50] highlighted that while men's attitudes towards technology are influenced more by perceived usefulness, women's attitudes may be influenced more by perceived ease of use.

The use of insideables is related to practices such as body hacking, which are closely linked to personal image. Females are usually more sensitive to their image; therefore, gender is a potential moderator of SI [51]. In the context of Internet shopping technology, Hwang [52] reported that women are more impacted by social pressure to use new channels. Similarly, in a TRA on ecological behaviours, López-Mosquera [53] showed that women are more influenced by subjective norms than men.

Furthermore, Murata et al. [54] suggested that men and women may have different perceptions of the implications and consequences of using insideables; movements such as queer and pro-sex feminism, which are devoted to body modification practices, are communities that may naturally accept the use of insideables [24].

The distinct nature of Research Questions 1 and 2, which were examined using different analytical instruments, meant that the analytical frameworks used while sharing input variables and outcomes also differed. This is illustrated in Figures 1 and 2, respectively. In Research Question 1, we aimed to measure the average impact of each construct, focusing on variable orientation; in Research Question 2, we sought to establish, within the sample, the combinations of conditions (absence or presence) of each factor that produces either acceptance or resistance towards nonmedical insideable use [55].

2.2. Formulation of Hypotheses in the Analysis of Research Question 1

2.2.1. PE. PE is the degree to which individuals believe that using a system can benefit their activities [28]. In the literature, PE is considered a key factor in explaining the acceptance of wearables [25, 26, 56, 57]. Therefore, this factor is expected to play a similar role in the acceptance of implantable devices.

Depending on the type of insideable, humans can enhance their mental and physical capabilities and connectivity with computers, improve their senses, and even create new senses [58]. This approach can improve performance across various job domains [59], such that perfectionism influences the intention to use this technology [60].

Implantable technologies have been applied in areas including the control and access to places, computers, parking, and payments [30]. Implantable devices could become alternatives to identification cards, and the need to remember PINs could lead to improvements in security [61]. Additionally, various avant-garde artists use implantable technologies

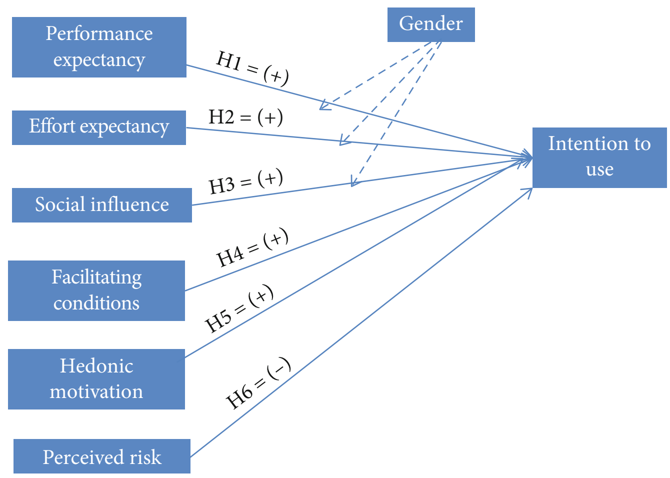

Figure 1: Theoretical framework for implementing correlational analysis.

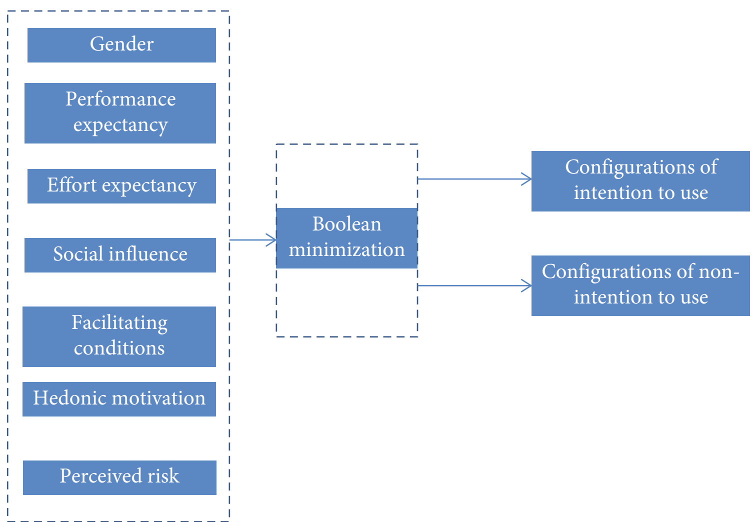

Figure 2: Conceptual framework for configurational analysis.

to stimulate creativity. Examples of this include the magnets used by Moon Ribas and the antenna worn on the head by Neil Harbisson [3].

Of course, the introduction of implantable technology can also lead to disadvantages, such as health problems [23] and psychological concerns [62], which may ultimately result in decreased performance in everyday activities.

Regarding nonmedical insideables and with a TAM modelling approach, Reinares-Lara et al. [42]; Gangadharbatla [43]; Klemenc, Vrhovec, and Mihelič [44]; and Andrés-Sánchez et al. [45] found that this construct has a significant positive impact on behavioural intention. Using the UTAUT framework, Arias-Oliva et al. [5] and Sabogal-Alfaro et al. [8] confirmed that PE positively affects usage intention. Pelegrín-Borondo et al. [9]; Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47]; and Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [47] obtained similar results using a CAN model. Additionally, by utilising a multidimensional ethical scale, Pelegrín-Borondo et al. [14] and Olarte-Pascual et al. [7] observed that dimensions related to egoism and utilitarianism, which can be seen as precursors to PE, significantly influence behavioural intention towards insideables. Therefore, we proposed the following hypothesis:

Hypothesis 1. *The perceived PE of insideables positively influences consumers' intention to use them.*

2.2.2. EE. The latent variable EE in the UTAUT model, as proposed by Venkatesh et al. [28], is akin to the ease of use described by Davis [38] in the TAM and is defined as "the degree of ease associated with the use of a system." The impact of this variable has been revealed to be significant for understanding behavioural intention towards wearables [25, 26]. Murata et al. [54] noted that the use of insideables is currently perceived as more complex than the use of wearables, especially in the medical field, where patient consent is required for implantation. A challenging aspect mentioned in the literature is the comprehension of explanatory documents for the intervention and functioning of implantable devices [63].

Another classic problem with insertable devices is that, in practice, they have little connectivity and compatibility with other devices and operating systems, such as Android [30]. In addition, the durability of the devices and the limitations of the materials they are made of must be considered [64].

One factor that makes insideables more challenging to use than wearables is that they are inserted inside the body [6]. This complexity is compounded by the fact that healthcare professionals typically introduce these devices only for medical reasons [24]. Moreover, the insertion of these devices requires continuous monitoring during the initial stages because of issues such as material rejection and the possibility of infection [17, 27].

Implantable devices require training to achieve their functionality [65]. Thus, controlling insideables may be challenging [61] and uncomfortable [15, 23]. For instance, Neil Harbisson reported experiencing headaches until he acclimated to an antenna implanted in his head [66]. These devices can complicate several daily living activities. For example, radiofrequency emitter devices can interfere with other electronic devices [17].

Incorporating the TAM framework, Klemenc, Vrhovec, and Mihelič [44] and Andrés-Sánchez et al. [45] discovered a positive impact of EE on IU. UTAUT modelling by Sabogal-Alfaro et al. [8] confirmed that reduced effort positively impacts IU. Olarte-Pascual et al. [47] and Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [47] obtained similar results using a CAN model. Consequently, we proposed the following hypothesis:

Hypothesis 2. *Perceiving less effort in using insideables has a positive influence on consumers' behavioural intention.*

2.2.3. SI. The latent variable SI is commonly conceptualised as "the extent to which an individual perceives that significant others believe that he or she must use the new system" [28]. Research indicates that the acceptance of wearables is notably influenced by the cultural context in which acceptance studies are conducted [25, 26, 67].

The social acceptance of insideables is profoundly dependent on context. While a generally positive perception exists when these technologies are employed to address disabilities, a divided perception emerges when they are utilised to augment human capabilities beyond the norm [15, 68] since there are concerns about the detrimental consequences of artificial changes in human nature [60]. This dichotomy explains why the nonmedical use of insideables is presently confined to subcultures that are strongly influenced by philosophical currents such as transhumanism [11, 24].

For a large part of society, extreme body modification practices associated with the use of implantable devices are considered disgusting [69]. Thus, the evolution of technological device implantation can follow the path of tattoo practices. In the past (e.g., in the mid-20th century), tattoos were associated with marginal social groups in Western society. However, today, tattoos are commonly implanted in numerous social groups [11].

Religious and cultural factors are also relevant, as observed in the case of insideables [8, 20]. Therefore, liberal people are more likely to agree with body modification practices than conservative people [27]. Likewise, monotheistic religions believe that the human body was granted by God and, therefore, should not be modified, at least for nonmedical reasons. Consequently, body modification practices may be regarded as sacrilegious [70]. Heffernan, Vetere, and Chang [69] reported that individuals using implantable technologies have faced abuse from religious groups who interpret certain Bible passages to mean that these users bear the "mark of the beast."

Within the literature on the acceptance of insideables, using a TAM modelling approach, Klemenc, Vrhovec, and Mihelič [44] and Andrés-Sánchez et al. [45] found that SI had a significant influence on IU. Utilising the UTAUT approach, Arias-Oliva et al. [5] and Sabogal-Alfaro et al. [8] reported that SI influences behavioural intention. Similarly, employing the CAN model, Pelegrín-Borondo et al. [9]; Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47]; Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [47]; and Reinares-Lara, Olarte-Pascual, and Pelegrín-Borondo [49] supported this influence. Murata, Arias-Oliva, and Pelegrín-Borondo [20] also identified a significant impact of SI. Consequently, we proposed the following hypothesis:

Hypothesis 3. *Perceived favourable SI towards implantable devices has a positive influence on the intention to use such devices.*

2.2.4. FCs. FCs can be defined as "the degree to which an individual believes that organisational and technical infrastructure exists to support the system" [28]. The factors influencing FC for potential consumers are diverse. Insideables are not typically standardised products; therefore, they are often expensive and require continuous maintenance [64]. Additionally, implantable technologies that require Internet usage need areas where they are used to having good connectivity, and their effectiveness depends heavily on the platform used for interconnections [10]. Furthermore, this technology influences the user's lifestyle, as certain insideables may be incompatible with materials commonly found in clothing [23] or may interfere with other electronic devices, such as those used in airport security checks or diagnostic tests such as magnetic resonance imaging [27].

Among the FC, the financial burden of this technology must be considered. It is a relatively expensive technology that requires professional insertion and maintenance [31]. However, some of these issues are not accessible to everyone. In addition, people living in rural areas may find it more challenging to obtain assistance with device implantation and use [69]. It should also be noted that an ecosystem of reader devices for implantable technology is lacking. High knowledge of electronics and computer science is required to install access-unlocking devices (such as cars or house doors) that can identify the insideables installed in the body [30].

The fact that insideables require implantation into the body is another aspect that undoubtedly influences perceived FC. When the use of implantable devices is not for medical purposes, health professionals are reluctant to insert electronic devices for nonmedical reasons [24], and they may even be prohibited from doing so if it involves a device that is not authorised by health authorities [23]. Therefore, implantation either requires knowledge of how to do it and where on the body it should be done, which aligns with the DIY philosophy [23], or belonging to a community where assistance can be found.

Thus, we proposed the following hypothesis:

Hypothesis 4. *The perceived FCs for using insideables have a positive influence on the intention to use them.*

2.2.5. HED. HED encompasses behaviours aimed at maximising positive emotions and minimising negative ones [71]. Inherent hedonism in purchasing and using a product revolves around seeking beneficial experiences [72].

In the wearable technology acceptance setting, it has been reported that perceived expressiveness and perceived enjoyment serve as significant drivers of adoption [26, 56, 57, 67]. The concept of insideables refers to individuals who seek novel experiences by exploring the potential that can be achieved by humans with the aid of technological advancements [3]. Moreover, practices related to body hacking often serve as a means of reaffirming one's personality and self-esteem [2, 27].

Komkaite et al. [29] and Heffernan, Vetere, and Chang [30] highlighted that the main motivation for users of these technologies is a playful and hedonistic objective without any perspective on improving daily tasks.

Ramoğlu [3] highlighted that the integration of insideables, by enhancing existing senses and introducing new ones, aims to experiment with novel ways in which people can interact with reality. This serves as the primary justification for avant-garde artists [3, 23, 73].

Regarding insideables, Reinares-Lara et al. [42], Arias-Oliva et al. [5], Sabogal-Alfaro et al. [8], Luciani et al. [46], and Andrés-Sánchez et al. [45] used the TAM or UTAUT frameworks and noted that HED is a crucial variable in explaining the IU of nonmedical insideables. In the CAN framework, Pelegrín-Borondo et al. [9]; Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47]; and Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [47, 48] observed that the pursuit of positive emotions significantly influences behavioural intention.

Hypothesis 5. *HED to use insideables positively affects behavioural intention towards them.*

2.2.6. PR. In accordance with Gidron [74], PR can be conceptualised as an assessment of the likelihood of illness or adverse outcomes, often in the context of engaging in a specific risky behaviour, which, in our case, pertains to the use of insideables. Risk has often been recognised as a major factor deterring consumers from adopting new technologies [51]. Some of the risks associated with insideables are inherent, such as those related to health [27], and are common in aesthetic implants [20]. Others, such as privacy concerns, are shared with wearables [26, 57, 61].

Health-related risks arise primarily because technological implants must be inserted into the body, which carries the risks of infection [23] and material rejection [75]. This risk is exacerbated by the fact that in many cases, individuals self-implant these devices [11]. Once the device is inside the body, discomfort and pain can occur [24]. Given the novelty of this technology, its long-term health impact remains unknown [61]. In the case of brain implants, hacking can lead to psychological problems due to false memory implantation or hallucinations [76].

Thus, in qualitative research by Shafeie, Chaudhry, and Mohamed [31], the most frequently mentioned concerns regarding implantable chips were related to users' physical and mental health. Interactions between implantable technologies and the body can cause allergies and interfere with cognitive and physiological processes. Additionally, there are concerns about potential long-term adverse effects, and microchips, which are not natural or new technologies, can cause new health problems for which there is currently no known cure.

Most technological implants contain or transmit user-specific information, which raises privacy concerns regarding the data they generate [16, 61]. These data can be vulnerable to theft through hacking [61] or misuse for purposes other than those originally intended for device implantation [77]. Ultimately, the rapid evolution of nanotechnology has outpaced the pace of regulatory measures for data protection [76]. Legal uncertainty stemming from the absence of regulations for these technologies amplifies the PR associated with them [13, 63, 76].

Gangadharbatla [43] and Klemenc, Vrhovec, and Mihelič [44] noted that the PR in terms of privacy and personal security significantly and negatively affects the use of insideables. Negative emotions, often generated by the perception of danger, have been reported as barriers to devices, such as brain implants [42] and exoskeletons [46]. Therefore, we proposed the following hypothesis:

Hypothesis 6. *The PR of using insideables negatively influences the intention to use them.*

2.3. Formulation of Hypotheses in the Analysis of Research Question 2. The path coefficient determined with PLS-SEM concerning IU fits the average influence of each explanatory variable on the outcome. Thus, using PLS-SEM, we assigned a single sign to the impact of an exogenous variable on the outcome, which was common in the sample. Correlational methods, which are variable-oriented techniques, do not capture the fact that certain individual profiles may consider the presence of a specific input as the cause for a particular judgment about insideables, whereas in other profiles, the absence of the same input may stimulate acceptance.

Using fsQCA, a case-oriented technique, allows us to understand that specific outcomes can result from various paths [35]. Thus, fsQCA identifies different profiles associated with an outcome by stating the membership degree of each case in the set of attributes and outcome sets using the intersection and union of fuzzy sets [78].

Furthermore, there is no single typology of potential insideable users [15] or individuals reluctant to use them [61]. It is reasonable to assume that there are multiple pathways that can lead to the same attitude regarding the nonmedical use of insideables. Therefore, fsQCA is a powerful tool for assessing the acceptance of new technologies, allowing us to capture the nuances that correlational analysis cannot [33, 36, 37].

It is widely acknowledged that ease of use and FCs generally promote positive attitudes towards technology [28, 38]. However, certain groups influenced by the DIY culture, such as cyborg activists, aim to enhance their individual capabilities through the use of technology, including insideables [2, 11]. Therefore, the absence of ease of use or the neglect of FCs can serve as a motivation for such practices. Domesticating technology to transcend the limits of the human body presents a challenge for the members of these collectives.

Regarding subjective norms, it is usually accepted that a favourable social perception of technology adoption encourages its use [28]; conversely, social rejection discourages its use. However, practitioners of body hacking and cyborg activism, who advocate for complete individual freedom to transform their bodies with technology [23, 27], are a clear exception. They are considered marginal movements [11] commonly seen as underground countercultural movements characterised by strong individualism and activism [2]. Gauttier [61] noted that being a pioneer in using implantable technologies could be a motivating factor that may contradict mainstream perceptions.

Although the perception of risk may tend to inhibit the use of insideables [43], seeking pain is an incentive for certain body modification practices. Overcoming pain is correlated with improved self-esteem resulting from the success of self-imposed challenges. Thus, pain seems to alter ordinary sensory function, offering individuals the opportunity to feel (and be) in new states of being [79].

However, these contradictions cannot be captured using correlational methods. On the other hand, fsQCA may reveal different paths in which the presence of EE, subjective norms, FCs, and the absence of risk perception leads to a positive attitude towards the use of insideables. However, in some cases that might not align with the mainstream, the absence of EE, SI, FC, and risk perception can also lead to an intention to engage with insideables. With fsQCA, strong hypotheses, such as those evaluated using correlational methods, as justified in Section 2.1, are not formulated. Instead, "soft" laws have been proposed [37, 80], often referred to as propositions or tenets. Therefore, we proposed the following:

Proposition 1. *Configurations preceding the IU insideables typically (but not always) have a combination of the following conditions: the presence of PE, ease of use, SI, FCs, HED, and the absence of PR.*

However, regarding negative attitudes and resistance to the use of new technologies, some authors have identified profiles that do not necessarily consider the same parameters. For example, in the context of social media acceptance, Neves et al. [81] differentiated nonusers as resisters, rejecters, surrogate users, and potential converts. Paluch et al. [82] distinguished between resisters and saboteurs in the context of the acceptance of robotic technologies in the workplace. Moreover, in the field of insideables, Gauttier [61] identified resisters, rejecters, the expelled, and the excluded.

In any case, this overview serves to justify the fact that the paths leading to the rejection of technology are not unique but depend on the cognitive, material, or emotional circumstances of individuals [61]. Therefore, we proposed the following:

Proposition 2. *Configurations preceding the rejection of insideables typically (but not always) have a combination of the following conditions: absence of PE, ease of use, SI, FCs, HED, and the presence of PR.*

The explanation for insiders' acceptance and rejection is asymmetrical. Although acceptability may not drive acceptance, it may drive resistance and nonacceptance of technology [61]. This phenomenon has been reported in the context of sustainable technology with the theoretical background of a multidimensional ethical scale and fsQCA by Andrés-Sánchez et al. [32]. The theoretical framework presented in Section 2.1 and the considerations outlined in Figure 2 provide the analytical foundation used to address Research Question 2. Therefore, we proposed the following:

Proposition 3. *The explanatory configurations for the acceptance and rejection of insideable use are asymmetric.*

3. Materials and Methods

3.1. Materials. We surveyed Spanish students from two universities. The survey was conducted in 2021 and targeted a population of 10,000. The questionnaire was sent to the email addresses provided by the universities to all students through the distribution lists and was subsequently answered via a hyperlink to a questionnaire created in Google Forms. A total of 310 responses were obtained (3.1%), 286 of which (approximately 2.86%) were considered valid because they were complete. The low response rate can be explained by the fact that many students do not typically use their university email but rather their personal Gmail accounts. Additionally, participation in the research was entirely voluntary; therefore, it was expected that only students who were genuinely motivated to participate in the research would respond.

Although the survey is not completely up-to-date, it is sufficiently informative, as the state of implantable devices for nonmedical purposes still has an underground character, and their uses and functionalities have not varied significantly from the late 2010s to the early 2020s. This aspect can be inferred from a comparison of studies, such as Pelegrín-Borondo et al. [9]; Fox [11]; Heffernan et al. [30], Shafeie, Chaudhry, and Mohamed [31]; and Chaudhry, Shafeie, and Mohamed [15].

The sample profiles are presented in Table 1. Regarding the gender distribution, the sample was nearly balanced, consisting of 144 women and 142 men. The majority of responses were provided by individuals aged 20–24 years, accounting for 56.29% of observations. Among the participants, 29 acknowledged having experience with the use of implants for health-related reasons and 64 reported regular use of wearables. A significant portion of the respondents stated that they were studying social sciences or law (46.92%), followed by health sciences (18.48%) and engineering (17.60%). Students in the arts and humanities constituted 9.09% of the total responses, whereas those in pure sciences constituted 7.92%.

Using university students as the focal point of our research offers several advantages [32]. First, electronic data collection methods were employed, and virtually all university community members were well versed in these procedures and possessed readily available electronic devices to facilitate survey completion if they were truly engaged in the research. Additionally, the university setting ensured that the survey participants had a sufficiently high level of cultural literacy to comprehend the questionnaire's content. Within a university environment, there is a diverse range of perspectives on technological advancements, with members hailing from various academic disciplines, including the health sciences, engineering, basic sciences, and humanities. Moreover, achieving gender parity among respondents was relatively straightforward in university communities.

Common method bias (CMB) is a potentially relevant issue [83]. To mitigate this problem, the questionnaire underwent a preliminary review with 10 members of the target population who volunteered. Their feedback helped address possible ambiguities and/or difficulties in interpreting some items. Additionally, for scales with a high number of points, as is the case with the questionnaire we used, CMB was more likely to occur at scales with fewer points, such as five or seven. Moreover, because the survey was self-administered and anonymous, respondents could freely provide answers according to their opinions, thus limiting certain sources of CMB such as social desirability and consistent response bias. Furthermore, the voluntary nature of the questionnaire motivated responses from individuals genuinely interested in participating in the study. These circumstances provided protection against CMB [83].

3.2. Measurement of Variables. The gender variable, represented as FEM, is a dichotomous variable that can take the value of one if the response comes from a female and zero otherwise. The remaining factors are latent variables measured using commonly accepted scales. The items originally formulated in Spanish for the questionnaire are listed in Table 2. The questions were answered on an 11-point Likert scale ranging from 0 (*strongly disagree*) to 10 (*strongly agree*).

Specifically, the IU scale is based on that used by Venkatesh and Davis [84] as part of their TAM2. Similarly, practically all scales used to measure exogenous variables are adaptations of the UTAUT2 model [39]. The only scale used outside the UTAUT2 model is related to PR, which is an adaptation of Faqih [51] and has been used in an Internet shopping setting. Faqih [51] measured risk from two perspectives: absolute, by enquiring about the general perceived level of uncertainty; and relative, by comparing the PR of online shopping to a clear benchmark, such as shopping through traditional channels. We understand that this approach is useful in our case, as both the absolute perception of risk that the potential user may have regarding the use of unstable technology and the perception they may have regarding similar technologies, such as wearables [30], are equally interesting.

Table 1: Sample profiles ($N = 286$).

Gender Women: 50.35% Men: 49.65%	Age ≤ 19 years: 34.27% ≥ 20 years and ≤ 24 years: 56.29% ≥ 25 years: 9.44% Mean = 20.60 Standard deviation = 2.49 years
The surveyed person has Implants (dental, cochlear, etc.): 10.14% Wearables: 22.38%	Academic profile Engineering: 18.81% Health sciences: 16.43% Pure sciences: 6.64% Social and law sciences: 51.05% Arts/humanities: 7.69%

3.3. Data Analysis. To assess the overall positioning of the sample regarding the items of various constructs, we conducted a two-sample t-test to compare the mean value of items with a neutral score of "5." We subsequently employed a sequential approach involving PLS-SEM and fsQCA. Modelling with PLS-SEM does not require strict assumptions regarding data normality or excessively large sample sizes, as is the case with covariance-based SEM [85]. Similarly, the use of fsQCA does not require any specific data behaviour, and it performs effectively with large samples as well as medium or small samples [36].

PLS-SEM was performed using SmartPLS 4.0 software. Subsequently, the fsQCA was performed using some of the results from the previous step. In terms of the correlational methodology, we followed the standard steps [85]:

Step 1: We assessed the reliability of the scales using conventional measures, including Cronbach's alpha, convergent reliability, average variance extracted (AVE), and factor loadings. Similarly, we examined the variance inflation factor (VIF) of the outer model to evaluate possible issues of scale collinearity.

Step 2: We examined the discriminant validity of the scales using both Fornell and Larker's [86] criteria and heterotrait–monotrait ratios [87].

Step 3: To analyse the robustness of the data regarding CMB, we conducted three tests.

1. The Harman one-factor test is based on exploratory factor analysis. In the Harman test, it is conventionally accepted that there is no CMB when the factor

Table 2: Items of the scales used in the research.

Latent variable	Items
Intention to use (IU) (Venkatesh and Davis, 2002 [84])	IU1: I intend to use insideables. IU2: I predict that I will use insideables.
Performance expectancy (PE) (Venkatesh, Thong, and Xu, 2012 [39])	PE1: Insideables will make my daily life more useful. PE2: The use of insideables will increase the likelihood of achieving my goals. PE3: Using insideables will boost my productivity.
Effort expectancy (EE) (Venkatesh, Thong, and Xu, 2012 [39])	EE1: Learning to use insideables will be easy for me. EE2: My interaction with insideables will be clear and understandable. EE3: Becoming an expert in using insideables will be easy for me.
Social influence (SI) (Venkatesh, Thong, and Xu, 2012 [39])	SI1: People who are important to me will think I should use insideables. SI2: People who influence me will think I should use insideables.
Facilitating conditions (FC) (Venkatesh, Thong, and Xu, 2012 [39])	FC1: I will have the necessary resources to use insideables. FC2: I will have the needed knowledge to use insideables. FC3: Insideables will be compatible with other technologies I use. FC4: I can receive assistance if I encounter difficulties using insideables.
Hedonic motivation (HED) (Venkatesh, Thong, and Xu, 2012 [39])	HED1: Using insideables will be enjoyable. HED2: Using insideables will be pleasant.
Perceived risk (PR) (Faqih, 2016 [51])	PR1: There is too much uncertainty associated with the use of insideables. PR2: Compared to other technologies, such as wearables, insideables are riskier.

loadings of all items used in the research on the first principal component are less than 50%. However, Fuller et al. [88] recommended raising this critical percentage to 60% because Harman's test tends to report false positives.

2. The strategy is based on the use of confirmatory factor analysis (CFA). In this approach, all items used in the research are modelled as indicators of a single factor that represents method effects. Thus, the CMB is considered relevant if a single factor attains a satisfactory result in the CFA [89, 90].

3. Kock and Lynn [91] method. This method runs a regression in which the explanatory variables are the standardised loadings of all latent variables in the research and the explained factor is a randomly uncorrelated variable with these standardised loadings. The absence of CMB can be accepted when the VIF of all factors is less than 3.3, and the critical presence of CMB occurs when some VIFs are greater than 5. Among these scenarios, a situation arises that, although not optimal, poses a serious problem for estimations.

Step 4: We conducted a PLS analysis and determined the path coefficients using percentile bootstrapping with 5000 subsamples. We also considered goodness-of-fit measures: R^2, normed fit index (NFI), and standardised root mean square (SRMR).

Step 5: We used the Q^2 measure by Stone and Greisser to assess the predictive ability of the relationships proposed in Section 2.

Subsequently, we applied fsQCA with the assistance of fsQCA 3.1 software [92], using some of the results from the previous step. The steps are as follows:

Step 1: For factors composed of multiple reflective items, it is advisable to conduct an analysis of the scale's reliability. This step was performed in the initial stage of the SEM-PLS analysis.

Step 2: We calibrated the membership functions of the explanatory variables and outcomes. We assigned membership values of 1 for women and 0 for men. For other variables with multiple scales that needed to be aggregated, we considered the standardised factor loadings used in the PLS-SEM adjustment. This approach was utilised in the field of fsQCA by Arias-Oliva et al. [5] and Andrés-Sánchez, Arias-Oliva, and Pelegrín-Borondo et al. [32]. When an explanatory factor is applied to the items of a scale and the resulting factor analysis is satisfactory, this approach of aggregating the items is reliable [93].

To fit the membership functions, we defined full membership as the 90th percentile of the factor loading, no membership as the 10th percentile, and the crossover point as the 50th percentile. Membership levels in the intermediate factor loadings were determined using linear interpolation.

Step 3: Analysis was conducted to determine the necessity of the presence or absence of factors as inputs to IU and its negation, represented as ~IU (nonacceptance of the assessed technology).

Step 4: We implemented the fsQCA 3.1 software of Ragin [92]. This enabled us to find logical implicates that fit the output results by running a Boolean minimisation algorithm. We formulated two Boolean functions as follows:

$$\mathrm{IU} = f(\mathrm{FEM, PE, EE, SI, FC, HED, PR}) \quad (1)$$

$$\sim \mathrm{IU} = f(\mathrm{FEM, PE, EE, SI, FC, HED, PR}) \quad (2)$$

Step 5: While Equation (1) explains IU, Equation (2) captures nonacceptance. Finally, to determine how the factors impact the output, we considered the so-called intermediate solution, which consists of configurations that include core conditions that are present in both intermediate and parsimonious solutions, as well as strong causal conditions and peripheral variables that are only present in the configuration displayed in the intermediate condition and can be considered weak causes [94].

To assess the explanatory power of a given recipe, its consistency (cons) and coverage (cov) were established. Whereas cons measures the significance of a particular configuration or complete solution, cov indicates empirical relevance and is similar to R^2.

The sequential application of PLS-SEM and fsQCA allows for data analysis from two complementary perspectives [34, 36].

1. PLS-SEM is a correlational method that focuses on variables. Path coefficients measure the average impact of an input variable on output production. By contrast, the philosophy of fsQCA is closer to case analysis, determining the different ways in which input variables combine to reach the same outcome [35, 36].

2. In the regression analysis, the influence of each input variable on the output variable is associated with a single sign, which is considered significant if the p value is less than 5%. By contrast, configurational analysis allows the same input to impact an output with different signs in two different configurations that produce the same output. Suppose the average impact of PR on behavioural intention is revealed to be nonsignificant in PLS-SEM. With fsQCA, we could identify profiles in which the presence of PR can indeed be a condition in various paths associated with the rejection of insideables, as well as profiles in which the presence of this perception is a condition for their acceptance, such that the net effect becomes null.

3. Furthermore, the utilisation of fsQCA is appropriate when dealing with nonsymmetrical relationships between variables, although there are no limitations to its use, even when relationships are symmetrical [36]. This applies to scenarios such as the behavioural intention towards insideables [61], where the attitudes and motivations for acceptance and resistance towards these technologies are not opposite.

4. Results

4.1. Findings From Structural Equation Analysis With Partial Least Squares. The mean values and standard deviations of the items are listed in Table 3. It is noteworthy that the average score for IU was 3.43 for IU1 and 3.50 for IU2, indicating a much closer proximity to rejection than acceptance of the cyborg technology. We observed that, in general, while the average scores of PE and EE items tended not to differ from 5, those related to SI had values below 4 and were significantly lower than 5. Items concerning HED, while exceeding 4, did not reach a value of 5, and were also significantly different from 5. Items related to PR scored above 7 and were significantly different from 5.

Table 3 demonstrates that all the scales exhibited high reliability. Both Cronbach's α and convergent reliability exceeded 0.8, and the AVE exceeded 0.5 in all cases. Similarly, the factor loading was > 0.702 for all the items. We observed in several constructs that the values of their Cronbach's α and convergent reliability were close and even above 0.95, which could indicate excessive collinearity in the latent variable construction. However, we believe that these values did not imply a real problem because the VIFs of the items never exceeded five.

Table 4 shows that the factors possessed discriminant capability, as indicated by the Fornell–Larcker criterion. Moreover, the corresponding HTMT ratios also met the established criteria, consistently remaining below 0.85. The highest HTMT ratio (0.837) was observed between the ease of use and FCs.

In terms of the CMB, the tests conducted did not show the existence of relevant problems. While the Harman one-factor test demonstrated that there were four factors with an eigenvalue greater than 1 and that the first factor accounted for 48% of the variance, the test based on CFA showed that considering a single factor with all indicators yielded very poor results since the comparative fit index, Tucker–Lewis index, and goodness-of-fit index never exceeded 0.7, far from the value of 0.90–0.95 that is commonly considered an acceptable threshold. Using Kock and Lynn's [91] test, we observed that no latent variable presented a VIF greater than 5 in the regression with the uncorrelated response variable. The highest VIFs (slightly above 3.3) were observed for PE (3.4) and HED (3.8).

Figure 3 shows that the quality of fit was moderate to good ($R^2 = 68.9\%$). The SRMR was 0.046, indicating a good fit, as it was less than 0.1 [95]. The NFI was 0.857, which was close to 0.9, indicating that the fit was satisfactory [95]. The model also exhibited predictive capability as $Q^2 = 64.9\%$, which was greater than 0 [85].

Table 5 displays a significant positive influence of PE on IU, supported by a path coefficient (β) of 0.353 with a $p <$ 0.001. This facilitating effect on IU was also significant for EE ($\beta = 0.177$, $p = 0.017$) and SI ($\beta = 0.249$, $p < 0.001$). There was also a statistically significant negative impact of PR on IU ($\beta = -0.091$, $p = 0.007$). In all cases, the hypotheses outlined in Section 2 regarding these latent variables on IU were accepted.

Furthermore, although the path coefficients of FC and HED exhibited the expected signs in relation to IU, their influence was not statistically significant. Similarly, Figure 3 shows that gender did not moderate PE, EE, or SI.

4.2. Results of the fsQCA. The first step of the fsQCA aligned with that of PLS-SEM, which involved verifying the internal cons of the scales used. This cons is shown in Table 3. Second, the membership functions of the variables involved in the analysis were calibrated. The points of full membership, nonmembership, and crossover determined based on the factorial loading of the constructs are provided in Table 6.

For example, in the case of IU, the membership function was constructed based on an assessment of the two items

Table 3: Descriptive statistics and reliability of the scales.

Latent variable	Item	Mean	SD	Factor loading	VIF	CA	CR	AVE
Intention to use	IU1	3.43***	3.02	0.970	4.62	0.939	0.97	0.943
	IU2	3.52***	2.89	0.972	4.62			
Performance expectancy	PE1	4.73	3.05	0.944	3.98	0.928	0.954	0.873
	PE2	4.44***	3.04	0.943	4.04			
	PE3	5.28	2.97	0.916	3.20			
Effort expectancy	EE1	5.24	2.85	0.926	3.40	0.925	0.952	0.869
	EE2	4.78	2.80	0.946	4.00			
	EE3	4.58***	2.71	0.925	3.36			
Social influence	SI1	3.15***	2.76	0.974	4.88	0.943	0.972	0.946
	SI2	3.26***	2.72	0.971	4.88			
Facilitating conditions	FC1	4.10***	2.70	0.841	2.05	0.898	0.929	0.766
	FC2	4.98	2.86	0.905	2.89			
	FC3	5.57***	3.01	0.869	3.04			
	FC4	5.34**	2.77	0.883	3.33			
Hedonic motivation	HED1	4.56***	2.98	0.959	3.50	0.916	0.96	0.923
	HED2	4.13***	2.85	0.963	3.50			
Perceived risk	PR1	7.14***	2.93	0.994	2.91	0.895	0.931	0.872
	PR2	7.15***	2.84	0.869	2.91			

Note: With "**" and "***," we denote that the mean is significantly different from 5 at a 5% and 1% significance level, respectively.
Abbreviations: AVE, average variance extracted; CA, Cronbach's alpha; CR, convergent reliability; SD, standard deviation; VIF, variance inflation factor.

Table 4: Discriminant validity measures.

	IU	PE	EE	SI	FC	PR	HED	Gen
IU	**0.971**	*0.819*	*0.745*	*0.723*	*0.679*	*0.789*	*0.057*	*0.207*
PE	0.768	**0.935**	*0.788*	*0.667*	*0.699*	*0.845*	*0.236*	*0.184*
EE	0.695	0.73	**0.932**	*0.631*	*0.837*	*0.802*	*0.208*	*0.148*
SI	0.681	0.624	0.59	**0.972**	*0.623*	*0.757*	*0.046*	*0.114*
FC	0.631	0.642	0.769	0.582	**0.875**	*0.762*	*0.237*	*0.174*
PR	0.732	0.778	0.739	0.704	0.694	**0.961**	*0.147*	*0.033*
HED	0.072	0.236	0.206	0.026	0.22	0.159	**0.934**	*0.141*
GEN	−0.201	−0.179	−0.15	−0.112	−0.164	−0.037	−0.138	**1**

Note: The square root of the AVE is displayed on the principal diagonal (bolded). The Pearson correlations are displayed below the squared AVEs, and the HTMT ratios are displayed above the squared AVEs (in italics).

that comprise this latent variable. The aggregate value of these items is considered the factorial score, with the 10th percentile being −1.212, the median being −0.163, and the 90th percentile being 1.405. Thus, complete acceptance of the technology occurred at a factorial score of 1.405 (membership in IU = 1), and complete rejection occurred below −1.212 (membership in IU = 0). The crossover point implied a completely neutral position and occurred at the 50th percentile (membership = 0.5). Based on these values, the degree of acceptance (between 0 and 1) of any observation was graded by considering the factorial score of the IU.

The necessity analysis in Table 7 shows that there was no factor whose presence or absence was a necessary condition for IU or nonintention to use. PE, EE, and hedonistic outcomes were > 0.8 but did not reach 0.9. Similarly, when the output was resistant to use, the absence of SI and HED were both > 0.8 but fell short of 0.9.

The determination of sufficient conditions is presented in Tables 8 and 9. Table 8 displays the sufficient conditions for IU. We obtained 10 configurations with a cons of 0.876 and a cov of 0.752. All explanatory factors appeared to be core conditions for more than one prime implicate of IU.

Therefore, the influence of certain variables on IU is unequivocally positive, as they must be present in configurations where they are conditions. Specifically, we referred to PE (must be present in seven configurations and five as a

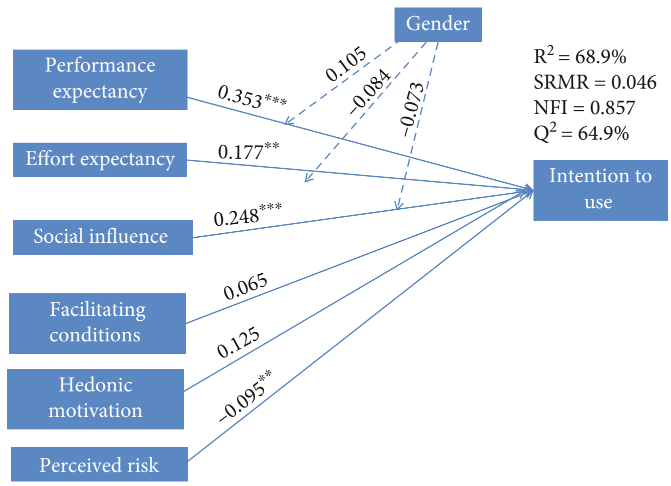

Figure 3: Results of the PLS-SEM estimate. Note: "**" denotes significance at the 5% level, and "***" denotes significance at the 1% level.

Table 5: Fitted coefficients for the inner model.

Relation	β	SD	p value	VIF	Decision
PE→IU	0.353***	0.069	< 0.001	3.057	Acceptance
EE→IU	0.177**	0.074	0.017	3.355	Acceptance
SI→IU	0.248***	0.069	< 0.001	2.162	Acceptance
FC→IU	0.065	0.055	0.241	2.754	Nonacceptance
HED→IU	0.125	0.084	0.142	3.661	Nonacceptance
PR→IU	−0.091**	0.034	0.007	1.112	Acceptance

Note: "**" denotes significance at the 5% level, and "***" denotes significance at the 1% level.

core condition), SI (must be present in six configurations and always as a core condition), FC (must be present in six configurations and four as a core condition), and HED (must be present in six configurations and five as a core condition).

Moreover, the influence of FEM, EE, and PR were not uniform. EE tended to be present in the configurations in which it participated (in five configurations as a core condition). FEM (in five prime implicates) and PR (in three prime implicates) tended to be part of the recipes in which they appeared as absent factors, which was consistent with the idea that men are more inclined to accept body hacking and that the perception of risk is negatively related to the acceptance of insideables. Therefore, Proposition 1 could not be rejected.

However, it is also worth noting that being a woman was detected as a condition in one prime implicate as a core condition, the absence of EE in one recipe, and the presence of PR in two prime implicates as core conditions. These findings occurred specifically for the seventh and eighth configurations. Configuration 7, ~FEM•PE•FC•HED•PR, might be associated with being a man combined with hedonism and a certain inclination towards risk, and Configuration 8, ~FEM•PE•~EE•HED•PR, could represent potential users with a similar profile to those who might be attracted to the challenge of mastering the technology that they perceive as not easy to use.

Table 9 shows that the links between PE, SI, and HED and resistance to using insideables are symmetrical to those of their acceptance. Their involvement in ~IU (no IU) always takes the form of absent factors in the prime implicates they participate in. Therefore, ~PE is a core condition in six recipes, ~SI is a core condition in seven, and ~HED is a condition in eight configurations (seven as prime implicates).

Being a woman (five configurations as core conditions), the absence of EE (five configurations, four as core conditions), the absence of FC (six configurations, four as core conditions), and the absence of PR (three configurations as core conditions) represented the most common ways in which these four factors influenced resistance to insideables. However, in this case, the sign of this impact allowed for exceptions. For instance, the presence of EE and FC were a core condition in one prime implication, whereas the absence of PR was a core condition in two recipes. Therefore, we accepted the Hypothesis 1.

The quality of the models representing acceptance and rejection was not symmetrical. While the model explaining acceptance had a broader cov, the model explaining rejection exhibited greater cons. Furthermore, it can be confirmed that the number of sufficient conditions obtained for intention and nonintention differed. Similarly, the configurations explaining intention and nonintention were asymmetrical. Thus, Table 8 shows that the configuration

Table 6: Points of standardised loadings used to define membership in the assessed latent variables.

	IU	PE	EE	SI	FC	HED	PR
Nonmembership	−1.212	−1.570	−1.545	−1.203	−1.606	−1.548	−1.537
Crossover point	−0.163	0.051	0.124	−0.068	0.191	0.106	0.165
Full-membership	1.405	1.235	1.180	1.445	1.209	1.288	1.172

Table 7: Necessity analysis of the conditions for IU and nonintention to use.

	IU		~IU	
	Cons	Cov	Cons	Cov
FEM	0.433	0.417	0.569	0.582
PE	0.854	0.799	0.46	0.458
EE	0.822	0.778	0.465	0.469
SI	0.787	0.815	0.398	0.438
FC	0.796	0.766	0.487	0.497
HED	0.830	0.807	0.442	0.456
PR	0.622	0.567	0.674	0.651
~FEM	0.566	0.553	0.43	0.497
~PE	0.421	0.423	0.798	0.853
~EE	0.47	0.436	0.78	0.821
~SI	0.457	0.417	0.831	0.806
~FC	0.475	0.466	0.77	0.802
~HED	0.441	0.426	0.814	0.836
~PR	0.616	0.64	0.551	0.608

that precedes the IU is ~FEM•PE•SI•~PR, whereas in Table 9, we do not observe a symmetric counterpart for ~IU, which must be FEM•~PE•~SI•PR. Therefore, we accepted the Hypothesis 3.

5. Discussion

5.1. General Considerations. This study addressed two RQs (Research Questions 1 and 2) regarding the acceptance of insideables, using the theoretical background provided by an extended UTAUT model. The first RQ (Research Question 1) was, "What is the overall impact of each explanatory factor on the acceptance of nonmedical insideables?" The second question (Research Question 2) was "How do explanatory factors configure paths to explain intention and nonintention to use insideables?"

To address Research Question 1, we used PLS-SEM. As expected, PE, EE, and SI had significantly positive influences on IU, while PR had a significantly negative influence. The impact of HED and FC on IU, although in line with our hypotheses, was not significant. Gender was not a relevant mediating variable.

Answering Research Question 2 involves understanding how the presence and absence of factors combine to produce IU and nonintention to use. We used fsQCA, which allowed us to observe how the presence or absence of explanatory factors was combined to produce acceptance and rejection. The results obtained from the analysis of Research Question 2 enrich the issues addressed in the analysis of Research Question 1.

We observed that all the variables are relevant in explaining the attitude towards insideables, since they appear to be core conditions in various prime implicates that precede IU and its negation. While Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47] suggested that a positive or negative attitude towards implantable devices can vary in degree and motivation, Gauttier [61] indicated that there are no reluctant profiles for the use of insideables, but rather identified resisters, rejecters, expelled, and excluded. The use of fsQCA allowed us to capture the existence of a multitude of profiles associated with the same outcome, both in the case of acceptance of insideables (10 profiles) and rejection (nine recipes). Andrés-Sánchez et al. [32] conducted a similar analysis using a multidimensional ethical scale.

By employing fsQCA, we determined that the manner in which acceptance and rejection were generated in our sample was asymmetric, as observed by Gauttier [61] and Andrés-Sánchez et al. [32]. Although the acceptability of implantable technologies does not necessarily imply acceptance, nonacceptability often results in rejection [61].

Configurational analysis revealed that all factors influenced the intention to use the expected sign. It is usually necessary for PE, EE, SI, FC, and HED to be present or absent in configurations where they are conditions for producing IU; these variables are normally absent when explaining nonintention to use. This finding is consistent with the statistical hypotheses stated in Section 2.2 and the first two propositions in Section 2.3. However, we also found that the positive relationships among SI, HED, and PE were "strict," meaning that these three factors are always present when they participate as explanatory conditions for acceptance and are absent for rejection. In contrast, in the case of EE and FC, there were configurations where the absence of EE in explaining use was observed; we also observed configurations in which the presence of ease of use and FCs is a condition to explain nonintention.

The role of PR in the configurations obtained with fsQCA is consistent with its negative relationship with IU, but this result is nuanced. In most configurations of IU, where PR participates, IU should be absent; however, in a minority, it is also present. Similarly, when explaining nonintention to use, when PR participates as a condition, it usually requires being present (three times); however, there are conditions that require its absence.

The clear positive impact of PE on behavioural intention and the sign with which this construct participates in the conditions that are part of the prime implicates of acceptance and rejection is consistent with mainstream literature

Table 8: Intermediate solution for intention to use insideables.

	1	2	3	4	5	6	7	8	9	10
FEM	⊗	⊗			⊗		⊗	⊗		•
PE	•		•	•			•	•	•	•
EE		•			•	•		⊗	•	•
SI	•	•	•	•	•	•				
FC				•	•	•	•		•	•
HED			•			•	•	•	•	•
PR	⊗	⊗	⊗	⊗			•	•	⊗	
Cov	0.262	0.257	0.464	0.448	0.350	0.612	0.160	0.151	0.475	0.300
Cons	0.936	0.926	0.936	0.942	0.911	0.919	0.884	0.873	0.932	0.914
Cov	0.752									
Cons	0.876									

Note: "•"indicates the presence of a factor as a condition, "⊗" indicates the absence of a factor, and a blank indicates no relevance in the prime implicate. Large circles represent core conditions, and small circles represent peripheral conditions.

Table 9: Intermediate solution for nonintention to use insideables.

	1	2	3	4	5	6	7	8	9
FEM	•	•	•				•	•	⊗
PE			⊗	⊗	⊗		⊗	⊗	⊗
EE				•	⊗	⊗	⊗	⊗	⊗
SI	⊗	⊗	⊗	⊗	⊗	⊗		⊗	⊗
FC		⊗		⊗	•	⊗	⊗	⊗	⊗
HED	⊗	⊗	⊗	⊗	⊗	⊗	⊗		⊗
PR	⊗					•	•	•	⊗
Cov	0.247	0.377	0.402	0.276	0.284	0.412	0.231	0.227	0.094
Cons	0.947	0.953	0.973	0.933	0.932	0.949	0.952	0.977	0.917
Cov	0.676								
Cons	0.926								

Note: "•" indicates the presence of a factor as a condition, "⊗" indicates the absence of a factor, and a blank indicates no relevance in the prime implicate. Large circles represent core conditions, and small circles represent peripheral conditions.

showing that perceived utility in insideables is usually the main explanatory factor for the behavioural intention in the adoption of implantable technologies [5, 7–9, 14, 42–45, 47, 56].

The average positive impact of EE on IU is consistent with the results obtained by Andrés-Sánchez et al. [45]; Klemenc, Vrhovec, and Mihelič [44]; Sabogal-Alfaro et al. [8]; Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47]; and Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [47] in the field of insideable tech. According to the PLS-SEM analysis, the influence of this variable is lower than that of PE. Reinares-Lara et al. [42], Gangadharbatla [43], and Arias-Oliva et al. [5] reported a positive but nonsignificant link between EE and IU. The use of fsQCA suggests that this lower statistical influence may be because both the presence and absence of EE can be conditions for positive behavioural intention; typically, the absence and presence of the perception of ease are conditions in explanatory configurations for negative behavioural intention. These contradictory results obtained with fsQCA are consistent with the fact that certain groups of potential consumers such as those influenced by the DIY movement and cyborg activists view the absence of EE as a positive stimulus for using implantable technologies [2, 11].

SI had the second most relevant impact on IU according to the estimation of its path coefficient in the PLS-SEM. We found that the presence of this construct participates as a condition in various prime implicates of IU and its absence in various configurations of nonintention to use. These findings are consistent with those observed regarding insideable acceptance [5, 8, 9, 20, 44, 45, 47–49].

In the case of FC, we observed that the positive sign of their influence on IU, obtained with PLS-SEM, was not significant. This finding is in line with the results of Arias-Oliva et al. [5], who obtained a slightly significant impact (p value = 0.066) on behavioural intention, and a review conducted by Chiu, Oh, and Cho [25] on the literature related to the acceptance of wearables, where they reported that the least relevant UTAUT factor was FC. In fact, fsQCA detects that it participates in various configurations of intention and nonintention as a peripheral condition, and in nonintention, its absence is a condition in the recipes in which it participates, and there is a configuration in which its presence is a condition.

Although we observed that HED had a positive but nonsignificant relation with IU in the PLS-SEM estimation, its participation in the configurations of IU and nonintention to use indicated that the "sign" of its impact on acceptance and rejection is uniform. The presence of HED in intention and the absence of HED in nonintention participated in as many prime implicates as PE or SI. Therefore, the results of fsQCA (but not those of PLS-SEM) align with those of Reinares-Lara et al. [42], Arias-Oliva et al. [5], Sabogal-Alfaro et al. [8], Luciani et al. [46], and Andrés-Sánchez et al. [45], using TAM and UTAUT theoretical grounds, and those of Pelegrín-Borondo et al. [9]; Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [47]; Pelegrín-Borondo, Reinares-Lara, and Olarte-Pascual [48]; and Reinares-Lara, Olarte-Pascual, and Pelegrín-Borondo [49], using the CAN model; this shows that HEDs have a positive impact on attitude towards insideables.

Although the path coefficient of PR was not high (its absolute value is less than 0.1), its negative impact was significant, in line with the findings of Gangadharbatla [43]; Klemenc, Vrhovec, and Mihelič [44]; and Luciani et al. [46]. In fact, some studies, such as Murata et al. [16], reported that PR has no statistical significance in explaining IU. The results of the fsQCA help to understand this small absolute value because, in the configurations of IU, although PR tends to participate as a condition with its absence, and in the configurations of rejection with its presence, there are two exceptions in both the explanatory model of acceptance and rejection.

We also found that the nonsignificant moderating effect of gender does not imply that it is not significant in the explanatory configurations of intention and nonintention to use. In fact, the results of the fsQCA indicate that men tend to be more inclined to accept insideables, whereas women tend to reject them. This is in line with the proposition of Venkatesh et al. [28], who suggested that gender moderates the impact of explanatory factors on attitude towards new technologies, and with the findings of Murata et al. [54], who indicated different perceptions of insideables by women and men.

5.2. Theoretical and Practical Considerations. The findings of this study indicate that the extended UTAUT framework satisfactorily fits behavioural intention towards nonmedical insideables, whether we use correlational methods, such as PLS-SEM (the coefficient of determination exceeds 60%), or adopt a configurational approach. Models that fit both acceptance and rejection have cons levels above 0.8 and covs exceeding 0.65.

From a methodological perspective, it has been demonstrated that the sequential use of correlational and configurational methods can be useful for understanding how behavioural intention towards a new technology is formed. Similar to Reyes-Mercado [96], who, within the UTAUT conceptual framework, combined PLS-SEM and qualitative comparative analysis in research on wearable acceptance, this research shows that the combined use of PLS-SEM and fsQCA provides a deeper explanation of nonmedical implantable technology acceptance than the use of a single analytical instrument.

By employing a mixture of PLS-SEM and fsQCA, we determined that while some variables, such as PE, unequivocally impact usage intention, others depend on the user profile, such as EE or PE. The positive sign of PE in its PLS-SEM coefficient was accompanied by the fact that, in all acceptance configurations in which it participates as a condition, it must be present, and in rejection configurations, its absence is part of the recipe. Conversely, although the average impact sign of PR on IU was negative, both the presence and absence were associated with acceptance and rejection.

By combining correlational and configurational methodologies, we observed that gender may be relevant in explaining the acceptance of insideables, which is of interest both commercially, as it can identify groups of interest, and sociologically, in fields such as gender studies. We found that although being male or female does not have statistical significance, this circumstance does participate as a condition in some prime implicates in certain acceptance and nonacceptance profiles. Thus, in configurations related to IU, a large part of the prime implicates requires that the response does not come from the female. It is also noteworthy that, in some acceptance configurations, gender does not matter, whereas in others, it is associated with being female. Conversely, in profiles associated with nonacceptance, most prime implicates consider either gender as irrelevant or being female as a condition.

In terms of the practical implications of the results, the variables with the highest average weight were, in this order, PE, EE, SI, and PR. In this regard, the average ratings for the items related to PE and EE generally did not differ from 5 out of 10. On the other hand, while the ratings for SI were approximately 3 out of 10, PR was rated 7 out of 10. It was also observed that the average acceptance of nonmedical insideables was low at 3 out of 10. This result, which is consistent with the fact that this technology is far from being standardised and domesticated [11], can be attributed to its low social acceptance and high PR. On average, nonacceptance tends to be perceived as technology, which is reflected in its rejection.

The configurations obtained with fsQCA allow for the visualisation of different profiles of potential insideable users, which enables the design of various market penetration strategies based on the user profile that the seller aims to target and/or the type of insideable they intend to market. For example, within the profiles of people who accept the use of implantable technologies, there coexist, for instance, a profile associated with men who perceive them as useful, find the use of insideables challenging because they are not easy to use, and may pose a risk (~FEM●PE●~EE●HED●PR), and women who perceive they will have FCs for their use and seek hedonic use (FEM●EE●FC●HED). The cov indicator indicates the empirical relevance of the potential users. In both cases, they are not common profiles;

in the first case, the cov was 0.151 and in the second case, it was 0.3. In this sense, cov indicates that the most relevant profiles in our sample are associated with those who value ease of use, where SI is relevant and the motivation for use is hedonic (EE●SI●FC●HED, cov 0.612), and those who have both HED and utilitarian motivations, where SI is relevant but so is the absence of PR (PE●SI●HED●~PR, cov 0.464).

6. Conclusions

This research assessed the attitudes of a sample of Spanish native digitals towards the adoption of nonmedical implantable devices. This study was conducted using a sample of Spanish university students. Widespread reluctance towards their use was observed, likely limited to individuals who were sympathetic to underground collectives and inspired by transhumanism. To determine the drivers of the IU insideables, this study used the conceptual grounds provided by the UTAUT. Specifically, it evaluated the influence of PE, EE, FC, and SI, along with hedonism and PR, on IU.

PLS-SEM revealed that PE, EE, and SI significantly and positively impacted behavioural intention, whereas PR had a significant negative impact. On the other hand, with fsQCA, it was found that all latent variables used to explain IU were significant, as they participated as core conditions in the prime implicates explaining positive or negative behavioural intention. Although the signs of the influence of PE, SI, and HED on IU and nonintention to use were clear, those of EE, FC, and PR were less defined. It was also observed that there were clearly more configurations in which the condition for acceptance was being a man and for rejection was being a female, rather than vice versa.

This study had some limitations. It was conducted in Spain on individuals under 30 years of age in a university environment. Therefore, the level of education and economic status may bias conclusions about the behavioural intention to engage with insideables. Additionally, the age group covered in this study was typically more open to accepting such technologies [8]. To draw more comprehensive conclusions, it would be necessary to include a wider range of countries, as culture is relevant not only to explaining acceptance in a wearable setting [25, 26] but also in the context of nonmedical use of implantable technologies [20].

However, it is also noteworthy that many of the reviewed studies were limited to specific countries, which allowed for comparisons with our results. Gangadharbatla [43] in the United States; Klemenc, Vrhovec, and Mihelič [44] in Slovenia; and Sabogal-Alfaro et al. [8] in Chile and Colombia showed that PE and EE are relevant factors in the use of wearables and biohacking. Similarly, Klemenc, Vrhovec, and Mihelič [44] and Sabogal-Alfaro et al. [8] observed the relevance of SI, whereas Gangadharbatla [43] observed that of PR, as in our study.

In qualitative research focused on the United States, Shafeie, Chaudhry, and Mohamed [31] observed several concerns regarding the use of implantable chips that are related, on the one hand, to health reasons and, on the other hand, to ethical and religious issues. This finding is consistent with our observations of the relevance of SI and PR. Similarly, the emphasis on ethical and religious issues reported by some respondents in Shafeie, Chaudhry, and Mohamed [31] underscores the interest in focusing on the acceptance of insideables from an ethical standpoint, which is in line with Murata et al. [20]; Pelegrín-Borondo et al. [14]; and Olarte-Pascual, Pelegrín-Borondo, and Reinares Lara [7]. In this sense, factors such as perceived usefulness or EE can be likened to consequentialist philosophical positions, according to which the ethical goodness of a decision depends on its outcomes [97]. In contrast, the relevance of SI is related to ethical positions, such as relativism, where the moral correctness of an action should be understood within a social and cultural context [14].

The conclusions drawn from this research may not be extrapolated to the medium and long term, as the evolution of implantable technology in the coming years in terms of materials, portability, and reliability is expected to be very high [10]. Society's views on certain practices have evolved over time. Body hacking practices such as tattooing and piercing, which were not commonly accepted in Western societies 25 years ago, are now relatively common practices [11]. Therefore, there is no reason to believe that the nonmedical use of insideables will not be commonly accepted in the near future [11].

Data Availability Statement

The data supporting the findings can be found at https://www.researchgate.net/publication/375662206_ANTECEDENTS_OF_THE_INTENTION_TO_USE_IMPLANTABLE_TECHNOLOGIES_FOR_NONMEDICAL_PURPOSES_A_MIXED-METHOD_EVALUATION.

Disclosure

This research has been published as a preprint in ResearchGate (https://www.researchgate.net/publication/386275618_ANTECEDENTS_OF_THE_INTENTION_TO_USE_IMPLANTABLE_TECHNOLOGIES_FOR_NONMEDICAL_PURPOSES_A_MIXED-METHOD_EVALUATION).

Conflicts of Interest

The authors declare no conflicts of interest.

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