# Acceptance Factors of Wearable Computing: An Empirical Investigation

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***Abstract*—Despite the vast economic potential of wearable technologies, up to now there is only little scientific research on the acceptance determinants of the wearable computing phenomenon. Therefore, the overall aim of this study is to explain psychographic factors that lead to either acceptance or resistance of wearable computing. This paper synthesises a cause and effect model of wearable computing adoption in the European market. The basis of the proposed conceptual framework builds an explorative study consisting of expert interviews and a subsequent qualitative content analysis to identify salient acceptance factors. The results indicate that the strongest factor that supports the acceptance of wearable technologies is perceived usefulness, whilst the main reason for resistance towards these technologies are perceived IT security risks.**

***Keywords—wearable computing; technology acceptance model; perceived pervasiveness; perceived IT security; Big Five personality traits***

## I. Introduction

As a consequence of the proliferation of computer-augmented everyday objects along with the ever-increasing miniaturization of microprocessors, the recent advances in information technologies has considerably changed the manner in which people conceive, experience and employ IT. Regarding this, the convergence of variant Information and Communication Technologies (ICT) entails an evolving paradigm shift in the field of human computer-interaction, promising context-aware and seamlessly integrated on-the-fly computing across heterogeneous circumstances and irrespective of place and time. In this context, the wearable computing paradigm complements the concept of ubiquitous computing, since “wearables” afford a continuous connectivity to the environment by equipping the user with computational capabilities. Not least the forecasted wearable device market value with an amount of 12.6 billion U.S. dollars by 2018 implies the vast economic potential of the respective socio-technological gadgets [1]. Nonetheless, the diffusion of wearable computing highly depends on a variety of factors, which are primarily technological or socio-psychological in nature [2]. In view of the numerous efforts in the area of innovation, which failed due to a lack of consumer acceptance, it becomes clear that facilitation of acceptability is a key issue for entrepreneurship [3].

However, up to now, there is only little scientific research on the acceptance of ubiquitous computing in general and, in particular, on the latent acceptance determinants of the wearable computing phenomenon [4]. Also, it is significant that personality variables in terms of endurable dispositions have seldom been examined within the scope of information systems research [5].

## II. Conceptual Background

The convergence of various technological innovations in mobile and ubiquitous computing has fostered a promising new transdisciplinary field referred to as wearable computing with the goal to provide computational services anytime and anywhere in an unobtrusive manner. The universal notion of wearable computing covers a broad spectrum of concepts and implementations: In the broadest sense, the terms “wearable technology” or “wearables” both relate to computer systems or electronic technologies that are body-worn and utilised mostly hands-free [6]. Due to the remaining diversity in possible functional and technical implementations arising from this ambiguous definition, wearable devices are generally particularised and differentiated from other computer types by means of several properties. A first narrower conceptualisation is provided in [7]. Here, wearable computers are attributed by five characteristics:

- Portable while operational
- Enabling hands-free or one-handed utilisation
- Providing sensory features, e.g. Global Positioning System receivers or cameras
- Proactive notifications, attracting the user’s attention
- Constantly running and accessible

It has to be stated, that the aspect of portability per se makes up the central differentiator between wearable and ubiquitous computing, since wearable computers are conventionally defined as “fully functional, self-powered, selfcontained computers” [8], whereas ubiquitous computing necessitates distributed computing environments, pervading our surrounding world with small-scale, networked ICT components cumulatively.

In contrast to mobile computing, especially the wearable’s continuous operating and non-obtrusive character is accentuated in the academic literature. Mann clarifies this by introducing the “personal empowerment” requirement, focusing on a synergetic symbiosis between man and machine [9]. Moreover, given that wearables ought to be non-distracting, easily accessible everyday companions, multimodality has repeatedly been mentioned as another focal capability. In addition to their typically small form factors, intrinsically placing high demands on the design of Input/Output modalities (e.g. gesture-based data entry), the dynamically changing user’s environment requires that the interaction modalities ideally should be able to adapt to the given circumstances. Complementarily, Kortuem et al. posit the augmented-reality criterion, that is, wearable computers should be capable of “focusing the user’s attention and presenting information in an unobtrusive, context-dependent manner” [10]. Thus, in comparison to the aforementioned taxonomy the attribute “context-awareness” is particularly emphasised. Thereby, context-awareness describes the ability of a system to sense, interpret and respond to certain environmental states.

## III. Methodology

In view of the fact that the attitude formation towards innovative technologies involves multiple interrelated cognitive and affective activities, it is surprising that almost all empirical studies on technology acceptance solely depend on quantitative methodologies [11]. Moreover, up to now academic research in the area of ubiquitous and wearable computing acceptance is still relatively scarce [12]. This makes an initial explorative research study indispensable in order to motivate and legitimise research on intrapersonal factors of wearable technology adoption. In particular, the explorative insights are expected to highlight the need for developing a new multi-factor measurement model of effectuation and causation respectively from a consumer viewpoint. Furthermore, the qualitative study aims to explore subjective beliefs and perceptions adopters have towards wearable computing in order to establish a proper theoretical basis for the development of a coherent system of causal hypothesises.

Thus, seeking for a predictive cause and effect model of wearable technology acceptance, a multi-strategy research will be used, where methodological triangulation will pose a multi-stage research process in which data from a preliminary conceptual study and qualitative research will build the foundation for future quantitative research. The findings from the exploratory approach, yet, will be confronted with relevant theoretical concepts and behavioural models in literature, that relate to the adoption of new information technologies (such as utility and risk perceptions). The resulting categories of beliefs towards wearable computing acceptance will eventually constitute the main content of the Wearable Technology Acceptance Model (Wearable TAM, see Fig.1) that can be further tested quantitatively.

Actually, qualitative research has developed various methodological alternatives to collect verbal data. The different interview methods alternate between the goal of either producing openness or producing structure [13]. Therefore, the choice of a method should be based on the given research objectives as anchor points, which intrinsically pose the need for exploration or rather explanation. Recalling the research goals of the study at hand, the central aim is to develop a comprehensive understanding of which socio-psychological factors influence the decision-making towards the acceptance of wearable computing. Thus, the interviews should be oriented towards a thematic direction. At the same time, this study seeks to reveal *latent* beliefs towards wearable computing adoption in mass markets as a new field. In view of this persistent research gap, the need for a supplementary explorative function to acquire more background knowledge about the study topic becomes acute. Consequently, a semi-structured expert interview appears to be appropriate for the purpose of this study [11].

The target group of expert interviews comprises informants possessing a specific in-practice knowledge within a professional sphere of activity. Considering that qualitative research seeks transferability rather than generalisability of results, an adequate sample size is “one that adequately answers the research question” [14]. Typically, the participants are recruited on the basis of the potential contribution to the body of knowledge its members have in a certain social system. Hence, in qualitative research the sample is usually derived purposefully rather than randomly, focussing primarily on the *information-richness* of each case [15]. Consequently, significant information redundancy marks the point of theoretical saturation, when no further insights or perspectives are forthcoming from ongoing data collection and the conceptual categories or theories of relevance are fully explained.

### A. Empirical Setting

The objective of the present sample selection was to attain a sufficient sample heterogeneity in terms of maximal diversity of knowledgeable interview participants. Therefore, sample units from industry and educational sector with different perspectives on wearable computing, with different levels of personal experience and with experiences of different types of wearables - particularly in terms of smart watches and smart glasses - were selected.

Overall, four academics from different research institutions participating in multiple wearable technology projects and three professionals from different companies within the information technology sector were interviewed. All interviewees were particularly involved in diverse wearable computing issues and thus expected to have a higher level of affinity towards wearables and to provide more elaborative beliefs and pre-existing assessments concerning the social and individual-level causal mechanisms and processes involved in the adoption of wearable technologies. Besides the criteria of theoretical purpose and theoretical relevance, the sampling procedure was not controlled by any further selection criteria such as gender, age or social status.

The exploratory study was conducted in fall of 2015. All interviews were performed in German as the native language of the interviewees. The inquiries were carried out as semi-structured, open-ended interviews based on an interview guideline, and took between half an hour and one hour. Three out of the seven interviews were performed face-to-face, whilst the other four were telephone interviews, what allowed for wider geographical access. In terms of the general empirical setting, each interview was conducted at the subject's place of work, resembling "real-world" conditions in favour of ecological validity.

Based on the theoretical findings from literature review, the interview guideline comprised a small set of carefully worded questions, aiming at exploring the general perceptions of wearable technologies as well as the central success factors of their inter-individual acceptance. Subsequent to the introduction phase, the respondents were asked to convey their assessment of the current developments in wearable computing markets. Afterwards, the interviewees discussed the challenges, benefits and barriers to the usage of wearable technologies.

As a theoretical sampling procedure was chosen for this study, data collection was controlled by the emerging codes and categories. Hence, the author simultaneously collected, coded and analysed the material, attempting to “saturate” the relevant concepts and categories. After interviewing the seventh subject, the need for further interviews ceased since no further findings were expected to contribute to the conceptual and theoretical understanding of the subject matter. Consequently, no further interviews were conducted.

### B. Qualitative Content Analysis

Following the inductive category development process described by Mayring [16], data analysis started with a material reduction of the transcribed versions of the audiotapes and field notes by discarding those chunks of data that intrinsically do not relate to wearable technology usage. Thereafter, the process of data interpretation commenced by underlining relevant parts of the text with regard to wearable technology acceptance. Subsequently, in-vivo codes were constructed from each marked meaning unit of analysis supported by the text (e.g. via single words, sentences or paragraphs). Afterwards, these codes had been transferred into constructed codes in English, thereby being gradually abstracted into higher order concepts in the course of an iterative process of constant revision. In sum, 67 codes emerged from the analytical process, which constituted the basis for the further content analysis.

To further conceptualise the properties of inter-individual attitude formation in wearable technology markets, similar codes constructed were aggregated into a coherent, overarching concept. For instance, the codes “Status-consciousness” and “Openness to Experience” were clustered into one logical content unit, as all these concepts include personality-related elements relating to behaviourally-relevant traits. Thus, a more abstract, higher-level category was developed, being either one of the codes inferred from the text that readily represents the category in semantic terms or alternatively a newly developed theoretical construct, completely covering the implicit meaning of the code cluster. In the example given above, a new analytical category “Personality” was developed to reflect the common contents of the constructed lower-level codes. Particular emphasis was laid on defining categories that are exhaustive and at the same time mutually exclusive [17]. The code clustering procedure was performed until all constructed codes were assigned to a higher-order category, reflecting a specific theoretical construct. In total, 13 theoretical constructs emerged from the qualitative research phase.

## IV. Key Findings

The results from the qualitative study give manifold insights concerning the inter-individual adoption decision process in wearable technology markets. Table I gives an overview of the main qualitative research findings. As indicated by the frequent referencing to acceptance-related determinants, product growth is actually influenced by various demand factors, such as social acceptability and changes in beliefs. Apart from this, various non-psychographic macro-environmental forces were pointed at, which are, however, outside of the scope of the present study as they cannot be altered by managerial actions. Especially, the points of pricing structures and technical immaturity emerged during the process of coding and analysis. Furthermore, the results show that social influence plays a significant role in wearable computing adoption processes. From a social networks perspective, this suggests that social proof might also have some conative influence on usage decisions in terms of a sociocultural impetus that manifests in a bandwagon-based diffusion.

The strongest intrapersonal factor that is expected to support the acceptance of wearable computing is *Perceived Usefulness*, primarily attributed to work and learning support. Most respondents named hands-free instruction guidelines and real-time notifications as specific product features that they considered beneficial. Furthermore, the wearables' potential provision of assistance in the field of health and fitness - particularly through offering the possibility of continuous self-monitoring - was seen variously as a clear advantage. Based on the interviews, the usefulness of wearables can be mainly ascribed to the unique attributes of the respective, newly emerged computing paradigm. Theses abstract attributes are subsumed under the concept of *Pervasiveness*, meaning that this innovative class of IT systems ought to provide ubiquitous as well as context-aware information services and applications unobtrusively to the greatest possible extent in order to generate substantial benefits. Accounting for the main differences between traditional desktop systems and pervasive or ubiquitous computing models, wearables should be seamlessly integrated into the daily life, proactively enhancing all routine activities [18].

Moreover, from the results of the qualitative study it is apparent that the main reason for wearable computing resistance are IT security concerns. In particular, a majority of respondents reported that they would fear privacy risks in view of the fact that wearables would process highly sensitive personal data at an unprecedented rate. Yet, *perceived risks* outside IT security risks have seldom been mentioned, referring to ambiguous threats and physical risks due to possible distractions.

TABLE I. CODING CATEGORIES OF THE QUALITATIVE STUDY

| Category | *Code* | *References* | *Sources* |
|---|---|---|---|
| **Acceptance behaviour** | Acceptance | 9 | 4 |
| | Socio-psychographic factors of adoption | 11 | 5 |
| **Innovativeness** | Level of innovativeness | 2 | 1 |
| | Fear of innovations | 2 | 2 |
| | Early Adopter | 3 | 3 |
| **IT security aspects** | IT security | 4 | 4 |
| | System reliability | 1 | 1 |
| | Third Party Access | 2 | 1 |
| | Sensitive personal data | 4 | 3 |
| | Surveillance | 5 | 3 |
| | Data security threats | 11 | 7 |
| **Macro-environment** | Technical immaturity | 21 | 7 |
| | Price as an economical factor | 10 | 6 |
| | Competitive factors | 3 | 1 |
| | Political and legal aspects | 4 | 3 |
| **Perceived Risk** | Physical risks | 1 | 1 |
| | Generally risky | 1 | 1 |
| **Perceived Usefulness** | Relative Advantage | 12 | 5 |
| | Control of networked devices | 2 | 1 |
| | Work support | 24 | 7 |
| | Health | 17 | 5 |
| | Quantified Self | 10 | 4 |
| | Safety | 1 | 1 |
| | Efficiency enhancement | 7 | 4 |
| | Learning aid | 25 | 5 |
| | Error reduction | 3 | 3 |
| | Entertainment | 3 | 2 |
| | Strengthens social relationships | 11 | 4 |
| | Enhancement of self-confidence | 5 | 3 |
| | Gamification | 1 | 1 |
| | More comfort of life | 1 | 1 |
| | Schedule control | 5 | 3 |
| | Many application scenarios | 2 | 2 |
| | Boosts fitness | 7 | 5 |
| | Continuous and persistent logging | 4 | 3 |
| | More transparency and traceability | 1 | 1 |
| | Ubiquitous connectivity | 2 | 2 |
| **Personality** | Curiosity | 2 | 2 |
| | Lifestyle | 1 | 1 |
| | Status-Consciousness | 4 | 3 |
| | Open to new ideas and experiences | 2 | 2 |
| | Personal involvement | 7 | 4 |
| **Pervasiveness** | Sensory features (multimodality) | 11 | 5 |
| | Context-awareness | 5 | 3 |
| | Proactive | 7 | 6 |
| | Convenient | 9 | 4 |
| | Hands-free working | 8 | 3 |
| | Information accessibility | 9 | 6 |
| | Seamless integration into everyday life | 5 | 3 |
| | Real-time operation and output | 5 | 3 |
| | Always on | 6 | 5 |
| | Non-distracting | 2 | 2 |
| | Ubiquitous | 1 | 1 |
| **Prior Experience** | Prior Experience | 3 | 3 |
| | Familiarisation with wearables | 3 | 3 |
| | No personal experience | 1 | 1 |
| **Social Influence** | Other-directedness, Imitation | 2 | 2 |
| | Reactions of the social environment | 1 | 1 |
| **Trust** | Trust in consequences of usage | 4 | 3 |
| | Trust in the system's functionality | 2 | 2 |
| **Usability** | Fashionability and wearing comfort | 6 | 5 |
| | High demands on effectiveness and efficiency | 6 | 3 |
| | Demands on the range of functions | 1 | 1 |
| | Usability | 5 | 3 |
| **Behavioural change Behavioural change** | Behaviour modification due to continuous monitoring | 2 | 1 |
| | Mergence of private and business life (BYOD) | 3 | 2 |
| | Lives become more "digitized" as media consumption behaviour changes | 2 | 2 |

The interview statements show, that trust in the technology itself including its functionality and predictability directly relates to risk perceptions. Besides, based on the interview results prior experience with wearables as well as the degree of personal innovativeness seem to influence how consumers assess the perceived risk and usefulness of such technologies.

Furthermore, the interview analysis revealed that personality-related correlates of behaviour exert actually an important - albeit indirect - influence on wearable computing acceptance. The most common predisposition to behaviour mentioned by the respondents is the personal relevance or involvement with mobile and wearable computing. Since this factor is deemed to directly interact with compound personality traits [19], it may be considered as a more domain-specific trait relevant to consumption behaviour. Additionally, status concerns emerged as another salient socio-psychological variable that affect the decision to adopt wearables.

In order to develop an inter-individual path model of wearable technology acceptance the results from the study were finally confronted with extant theoretical and conceptual models in literature. Overall, the sought Wearable TAM aims at clarifying correlating effects of the identified acceptance factors and to thus holistically explain the consumer's intention to adopt wearable technologies. Due to its efficiency as well as its dominant role within acceptance research, in the context of the present study the Technology Acceptance Model (TAM) by Davis [20] served as a behavioural source model for successively deriving the research hypothesises. This model is specially geared towards understanding acceptance behaviour in technology markets. It conceptualises the behavioural intention to use a new technology as a direct consequence of the *perceived usefulness* and *perceived ease of use* as powerful and simultaneously parsimonious predictor variables.

Since contemporary research gaps as well as the results of the qualitative study prompted this, particular attention was furthermore directed to commensurable theories in the area of IT security and personality psychology for gradually augmenting the TAM with further explanatory variables. More precisely, the well-accepted Five Factor Model (FFM) of personality [21] in conjecture with the so called 3M model by Mowen [22] were employed for the purpose of the present study, resulting in a hierarchically ordered structure of personality-related correlates of behaviour. Besides, the subjectively perceived degree of IT security was modelled in terms of a multidimensional construct by seizing on the classical CIA triad (Confidentiality, Integrity, and Availability) in security literature [23] to be capable of fully evaluating the singular effect of each dimension on consumers' perceptions of security.

As a consequence, drawing on the results of both the qualitative expert interviews and the findings of prior research, the causal Wearable TAM depicted in Fig. 1 could be stepwise deduced in a theory-driven manner. In this acceptance model the behavioural intent to use wearables is defined as a causal effect of cognitive beliefs regarding the degree of both usefulness and pervasiveness of wearable computing. The latent variable of perceived usefulness is conceptualised as a multidimensional construct, reflecting several salient benefits of wearables which primarily relate to efficiency gains. Moreover, the perceived risk of IT security threats as another significant attitudinal component in intention formation is hypothesised to inhibit considerably the willingness to employ smart wearable devices. The effect of trust on consumer's usage intention is in turn supposed to be mediated by security risk perceptions and to thus indirectly influence the criterion variable. Likewise, the pervasiveness construct acts additionally as an upstream model parameter of usefulness perceptions. Furthermore, personal involvement with the product category of interest is also proposed to be positively associated with the adoption decision. Thereby, drawing on the 3M model intrapsychic predispositions are assumed to determine the level of personal involvement with the research subject and to thus find expression in behavioural patterns, as well.

## V. Conclusions and Future Work

Overall, the implications from the present exploratory study are substantial from the point of view that they deliver unique insights from a qualitative perspective, since it is the first study focusing on the social and psychological origins and contexts

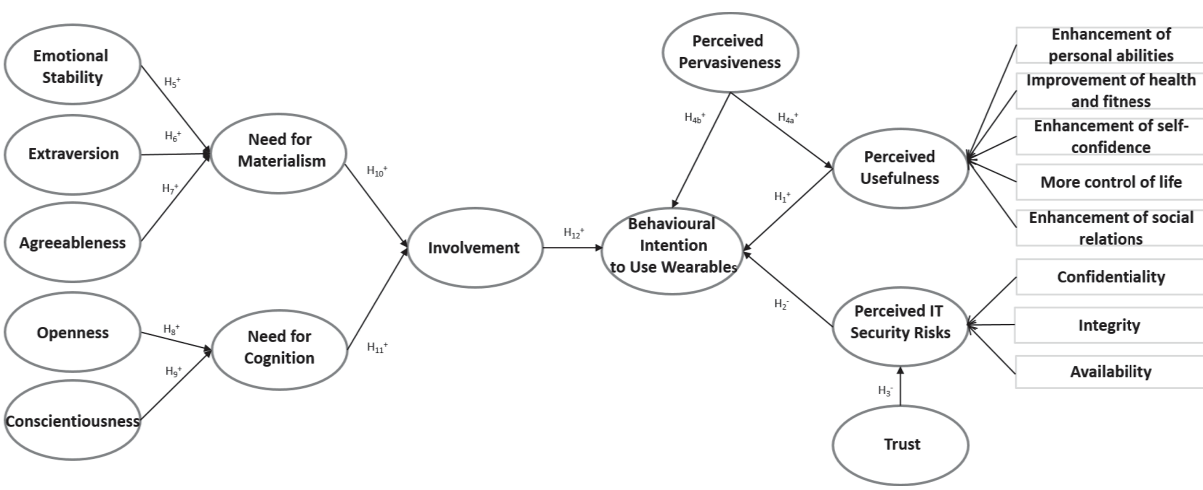


Fig. 1. Structural model for explaining behavioural intention to use wearables

of wearable computing usage intention. These inductive findings provide not only single belief sets, but also a holistic perspective on the acceptance behaviour in innovative IT markets. The empirical results from the expert interviews contribute to information systems research by revealing the substantial role of personality traits on the consumer' willingness to adopt wearable computing. However, it has to be noted that the results are not readily generalizable to the broad consumer market, as they are based on a theoretical sample. Rather, they build the basis for a subsequent development of the future quantitative study to validate the hypothesised Wearable TAM. Therefore, based on the preceding findings a questionnaire survey of consumer attitudes on wearables will be conducted in the next research stage in order to confirm or falsify where appropriate the proposed structure of the measurement model.

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