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Technology Acceptance Models in Health Informatics: TAM and UTAUT

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Abstract. Both the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) aim at understanding better why users accept or reject a given technology, and how user acceptance can be improved through technology design. Two case studies are presented where TAM and UTAUT were successfully used in a health care setting to predict technology adoption. Both models have found popularity in health care. However, recent reviews show that TAM and UTAUT failed to provide stable predictive capabilities for acceptance and use of technologies in health care. Reasons for this may be the specific context of health care, where not only the technology, but also socio-organizational and cultural factors influence technology acceptance.

Keywords. Health informatics; Assessment, technology; Intention; Attitude to computers; Models, theoretical

Learning objectives

After reading this chapter the reader will understand:

1. How TAM and UTAUT attempt to predict and explain technology acceptance and technology usage.
2. How TAM and UTAUT can be applied in health informatics projects to predict and support health IT acceptance and usage.
3. The strengths and limitations of TAM and UTAUT with regard to prediction of the support needed for health IT acceptance and usage.

1. Introduction to TAM and UTAUT

This section introduces TAM and UTAUT as two technology acceptance models. Both have several similarities, which is not surprising, as UTAUT was among others developed based on TAM. We decided to focus on TAM and UTAUT, from a longer list of available technology acceptance theories (for an overview, see for example [1, 2]), as both have found widespread adoption in health care.

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Both TAM and UTAUT aim at predicting technology usage by looking at the factors that will influence technology acceptance. Both theories focus on two questions to explain technology acceptance and resulting technology use: Is the technology useful for me? And: Is the technology easy to use?

UTAUT adds two further questions to this list: Does my social environment want me to use the technology? And: Do I have the necessary technical and organizational infrastructure to use the technology?

Now let's have a more detailed look on TAM and UTAUT.

1.1. Technology Acceptance Model (TAM)

User acceptance is often a pivotal factor in the success or failure of a new information system [3]. The goal of the Technology Acceptance Model (TAM) is to understand better why users accept or reject a given technology, and how user acceptance can be improved through technology design. TAM was developed by Fred D. Davis in the late 1980s [4, 5].

The Technology Acceptance Model is based on principles from Fishbein and Ajzen's Theory of Reasoned Action [6]. TAM hypothesizes that two particular beliefs, Perceived Usefulness and Perceived Ease of Use, are of primary relevance for technology acceptance [7]. Perceived Usefulness is the expectation of a user that the system will be useful for the job. Perceive Ease of Use is the expectation that the system is user friendly and easy to use. Perceived usefulness is influenced by Perceived Ease of Use, as users will find easy-to-use systems more useful [3]. Both beliefs are determinants for Attitude towards Using. This Attitude towards Using is then a determinant of the Behavioral Intention to Use, which can be interpreted as technology acceptance [8]. The actual system usage is then determined by this Behavioral Intention to Use.

In a review of TAM usage in health care, Holden found that TAM was able to predict 30 - 70 % of variance of Behavioral Intention to Use, which can be considered reasonably high.

Table 1 summarizes the basic definition of the concept used in TAM. Figure 1 shows the TAM model.

Table 1. Definitions of the variables used in TAM [8].

Perceived Usefulness	An individual's perception that using an IT system will enhance job performance.
Perceived Ease of Use	An individual's perception that using an IT system will be free of effort.
Attitude toward Using	An individual's evaluative judgment of the target behavior on some dimension (e.g., good/bad, harmful/beneficial, pleasant/unpleasant).
Behavioral Intention	An individual's motivation or willingness to exert effort to perform the target behavior.
Use	One specific behavior of interest performed by individuals with regard to some information technology (IT) system.

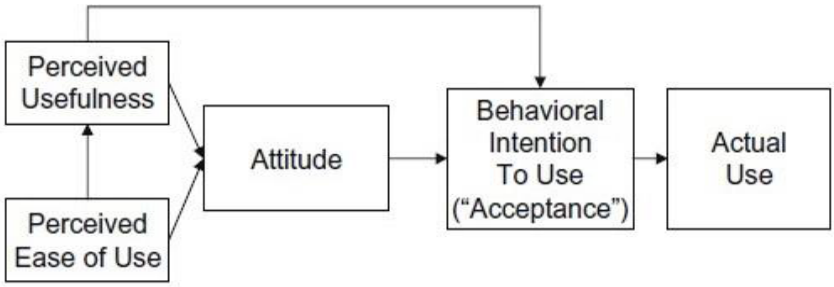

Figure 1. Technology Acceptance Model (TAM) [8].

A number of TAM extensions have been proposed to overcome some limitations in the original model. Several studies added single variables to the original TAM to increase the predictive power of the model, such as individual user factors, organizational readiness, or trust - an overview is given by Holden [8]. TAM2 by Venkatesh & Davis (2000) [9] extended TAM with variables that were seen as influencing perceived usefulness or user acceptance, such as subjective norm, image, voluntariness of use, or job relevance. Further extensions of TAM, such as TAM 3 [10], added other concepts such as computer anxiety or enjoyment.

The TAM theory of technology acceptance and use has gained significant popularity in the field of technology acceptance research and is considered a "key model" [11] or "gold standard" [8] in understanding predictors for IT acceptance. A PubMed query on "Technology acceptance model" retrieved 340 papers (search done on 7 June 2018), showing the popularity of TAM also within health informatics research.

1.2. Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) was published by Venkatesh and Davis in 2003 [2]. UTAUT is based on an analysis and comparison of eight technology acceptance models, among them TAM, TAM2, the Theory of Reasoned Action and the Diffusion of Innovation Theory. The aim was to synthesize the multitude of available models on technology acceptance into one unified model. The aim of UTAUT is to assess the likelihood of success for new technologies and to understand drivers of acceptance [2].

UTAUT describes four key variables: Performance Expectancy, Effort Expectancy, Social Influence, and Facilitating Conditions. Performance Expectancy is the expectation of a user that the system will be useful for the job; it corresponds to Perceived Usefulness in TAM. Effort Expectancy is the expectation that the system is user friendly and easy to use; it corresponds to Perceived Ease of Use in TAM. Social influence is defined as the degree to which a user perceives that important others believe he or she should use the new system. Facilitating Conditions are defined as the degree to which a user believes that an organizational and technical infrastructure exists to support system use.

In UTAUT, Behavioral Intention to Use the technology is determined by Performance Expectancy, Effort Expectancy, and Social Influence. Actual Usage is then determined by Behavioral Intention to Use and the Facilitating Conditions. Gender, age,

experience, and voluntariness of use moderate the impact of the key variables on usage intention and behavior.

The original UTAUT validation study [2] found that UTAUT was able to explain 70% of the variance of Behavioral Intention, which indicates high predictive power.

Table 2 summarizes the basic definition of the variables used in UTAUT. Figure 2 shows the UTAUT model. The similarities to TAM are obvious when comparing both models.

Table 2. Definitions of the variables used in UTAUT [2].

Performance Expectancy	Degree to which an individual believes that using the system will help him or her to attain gains in job performance.
Effort Expectancy	Degree of ease associated with the use of the system.
Social Influence	Degree to which an individual perceives that important others believe he or she should use the new system.
Facilitating Conditions	Degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system.
Behavioral Intention to Use	Measure of the strength of one's intention to perform a specified behavior.

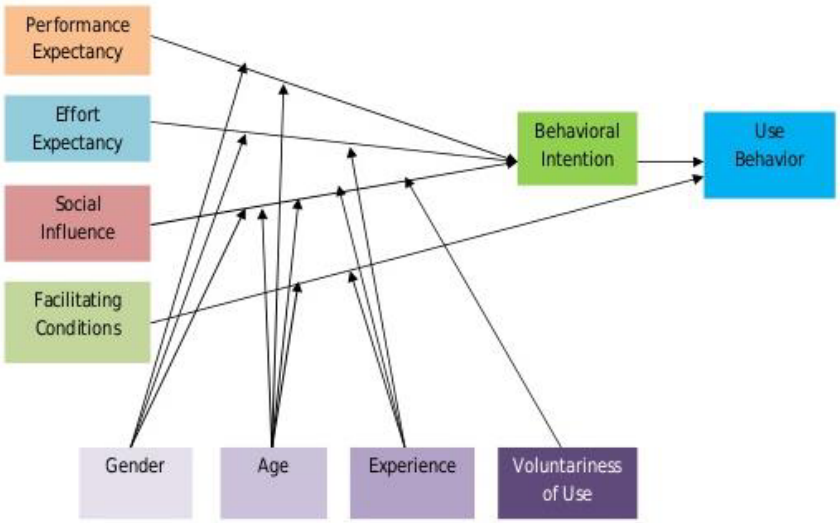

Figure 2. Unified Theory of Acceptance and Use of Technology (UTAUT) [2].

A PubMed query on "Unified Theory of Acceptance and Use of Technology" retrieved 80 papers from 2008 onwards (search done on 7 June 2018), showing the popularity of UTAUT within health informatics research.

2. Usage of TAM and UTAUT in health informatics

This section describes two use cases of health informatics interventions where TAM and UTAUT were applied.

2.1. Case Study 1: Perceived usefulness and perceived ease of use of electronic health records among nurses: Application of Technology Acceptance Model

In this study of Ahmad Tubaishat from 2017 [12], 1.539 nurses from 15 Jordanian hospitals using a nursing electronic health records (EHR) were surveyed using a 28-item questionnaire based on TAM.

Results show that the nurses demonstrated a positive perception of the usefulness and ease-of-use of EHRs, and their acceptance of the technology. Both Perceived Usefulness and Perceived Ease of Use had an influence on the intention to use EHRs: The effect of Perceived Usefulness explained 51% of the variance of intention to use EHRs, whereas Perceived Ease of Use predicted 42% of the variance.

Perceived Usefulness was affected by gender, professional rank, EHR experience, and computer skills of the nurses, these variables explained 55% of the variance of Perceived Usefulness. The Perceived Ease of Use was affected by nursing experience, EHR experience, and computers skills, these variables explained 44% of the variance of Perceived Ease of Use.

The authors concluded that training should include also basic computer skills, as this may positively influence Perceived Ease of Use and Perceived Usefulness and by this may increase EHR acceptance.

The case study shows how the TAM based survey can help to identify factors for further optimization of health IT implementation. In particular, it shows which variables influence directly or indirectly Behavioral Intention to Use in this context, opening ways to intervene e.g. by training.

2.2. Case study 2: Analyzing older users' home telehealth services acceptance behavior, applying an extended UTAUT model

In this study by Miha Cimperman from 2016 [13], 400 Slovenian participants aged 50 years or older were surveyed on their acceptance of a home telehealth service using UTAUT. Respondents were randomly selected equally across all regions. Respondents first got a short written explanation of the idea of home telehealth service and were then asked on their opinion on this. The survey comprised 47 standardized items based on UTAUT. Three context specific predictors were added to the original UTAUT model, namely Doctor's Opinion, Computer Anxiety, and Perceived Security.

As expected, Performance Expectancy, Effort Expectancy, Facilitating Conditions, and Perceived Security were found to have a direct impact on Behavioral Intention to Use the home telehealth service. In addition, Computer Anxiety was found to be an antecedent of Effort Expectancy with a strong negative influence, and Doctor's Opinion influence showed a strong positive impact on Performance Expectancy. Different to the UTAUT assumption, Social Influence was not a predictor of Behavioral Intention, which authors explained by the fact the elderly users may not be so much dependent on social pressure [13]. The model of the six predictors explained 77% of the total variance of Behavioral Intention to Use, indicating a strong predictive power of the revised model [13].

The authors concluded that health professionals should be involved as social agents to frame home telehealth services as useful and beneficial, as this will raise acceptance among the users. Also, home telehealth services should be promoted as secure, to build trust. Different types of technical equipment should be made available to reduce computer anxiety. Due to low social influence, they see it as unlikely that early adopters

as pioneer users will contribute significantly to the diffusion of home telehealth services among other users.

The case study shows how the UTAUT-based survey can help to identify factors for the further optimization of health IT implementation before the technology is introduced. This case study is one of the few examples where TAM or UTAUT were used in settings where the technology was yet to be implemented.

3. Explanation of success or failure of health IT system

TAM and UTAUT have been developed with the aim to understand better why users accept or reject technology, and to predict acceptance or non-acceptance of new technology. TAM and UTAUT define acceptance as the intention to use, or the willingness to use, a technology. The theories assume that intention to use is a direct determinant for actual system use. Thus, TAM and UTAUT attempt to reveal factors that have direct implication for the success or failure of technology, with success seen as equivalent to actual system usage.

We must note that TAM und UTAUT have not been developed within a health care setting. TAM was developed based on studies of an e-mail system and a word processing system [3]. UTAUT was validated based on studies related to introducing an online meeting manager, a database application, and an accounting system [2]. These types of application seem not comparable to much more complex health care technologies, such as computerized physician order entry systems, electronic health record systems, or nursing documentation systems. In addition, these latter types of technologies represent socio-technical information systems where the acceptance of a technology depends not only on its functionality or ease of use, but on many other factors such as hardware performance, training, support, and workflow integration. In particular, besides individual factors shaping decisions to use a technology, organizational, cultural and emotional factors will also influence technology acceptance in healthcare settings [14]. Overall, these socio-organizational-cultural factors are not well covered by TAM and UTAUT. Besides, TAM was developed with a focus on technology which can be used voluntarily. Typically, in health care, most technologies are mandatory to be used by the staff. This all distinguishes healthcare from the settings where TAM and UTAUT were developed and used.

Nevertheless, as the case studies and a short query in PubMed show, TAM and UTAUT have found wide adoption in health care. Reasons for this can be the quite simple assumptions of both models: System usage depends on only two (TAM) or four (UTAUT) key variables, including the usefulness of the system for the work and the ease-of-use of the system. This sounds quite intuitive and may have contributed to their popularity.

Still, in many health care studies where TAM or UTAUT were applied, authors have added variables to extend the original TAM or UTAUT models to better adapt it to the context of health care. Case study 2 [13] showed an example of this: The authors assess the acceptance of home telehealth services by elderly patients and added three context-specific predictors, namely Doctor's Opinion, Computer Anxiety, and Perceived Security. The authors argue that the "universal" variables in UTAUT are not specific enough for health care and thus decided to add these three "context-specific" variables as potentially important predictors for the acceptance of the telehealth service. And indeed, all three context variables were found to be important predictors in the study.

Holden [8] lists several other examples where TAM or UTAUT were extended by context-specific variables. This shows that despite their large popularity, both models may need to be parsimoniously applied in more complex health care settings.

Holden also points to the fact the key variables of TAM and UTAUT are not measured uniformly in different studies. Instead, studies often modify original survey items to adapt the questions to the local study context (either by rewording questions or by adding completely new questions). All this shows TAM and UTAUT are somewhat unspecific for health care settings.

In general, both TAM und UTAUT have been found to predict Intention to Use quite well, with explained variance up to 70%. Yet, closer analysis to their application in health care by Holden (2010) shows that only Perceived Usefulness was consistently found to be a significant predictor of Intention to Use (in all of the 16 reviewed studies) [8]. In contrast to this, Perceived Ease of Use was found to be a significant predictor of Intention to Use in seven of 13 studies only [8]. And Social Influence, an UTAUT variable, was found to be significant predictor in four of eight studies only. Also Gücin (2015) states, based on a literature review, that Perceived Usefulness is "the most powerful predictor of the technology acceptance" [15].

Summarizing these findings, we see that the key assumptions of TAM and UTAUT could not be confirmed in a large number of technology acceptance studies in health care. These findings indicate that health care is indeed a special setting where the simple assumption of TAM and UTAUT may not fully match the more complex reality. Holden (2010), for example, summarizes that Perceived Ease of Use may not be that important for technology acceptance and usage when users are sufficiently experienced with the system or when they have sufficient IT support. Also, Social Influence may not influence physicians as users so strongly, as they are more independent and "immune to peer pressure" [8]. Also, after an analysis of several acceptance theories, Gücin (2015) points to the fact that the acceptance factors for health care professionals and patients may be different, with patients seeing for example ease of use as more important than health care professionals [15]. Also, he argues that important acceptance factors such as suspicions of confidentiality and privacy or individual characteristics of the user (e.g. of early adopters) may be strong influencing factors, but these are not considered in the original models [15].

To conclude, while TAM and UTAUT have been broadly adopted as a means of predicting technology acceptance and usage, the findings in health care are quite mixed. Both the fact that many studies in health care cannot find support for some basic hypothesis of TAM and UTAUT, and the fact that many authors added variables to the original TAM and UTAUT models or revised the survey instruments to respond to context influencing factors, point to the fact that the original TAM and UTAUT fail to demonstrate strong predictive capabilities for technology acceptance in health care [14].

4. Conclusion

TAM and partly UTAUT provide a more technology-centered view on technology acceptance, where acceptance is understood to mostly depend on the nature of technology [14], i.e. functionality and ease of use. Socio-organizational, workflow, cultural or emotional aspects as well as differences in user groups (physicians, nurses, patents) are not well covered [14] and may explain why in several studies in health care, basic assumptions of the model could not be confirmed.

Overall, when applied to health care settings, TAM and UTAUT failed to provide stable predictive capabilities for technology acceptance and use[2].

Teaching questions for reflection

1. What are the major differences between TAM and UTAUT?
2. How do TAM and UTAUT accommodate for socio-organizational or cultural factors for technology acceptance and technology usage?
3. How could you use TAM or UTAUT when preparing for the hospital-wide introduction of a nursing documentation system?

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[2] See also Chapter 16, "The NASSS Framework – a synthesis of multiple theories of technology implementation".