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APPLYING THE TECHNOLOGY ACCEPTANCE MODEL TO VR WITH PEOPLE WHO ARE FAVORABLE TO ITS USE

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This study aims to test how the Technology Acceptance Model (TAM; Davis, 1989, 1993; Venkatesh, 2000) applies to the use of virtual reality in clinical settings. The sample is composed of 141 adults interested in using this technology. We adapted the standard items used to test the TAM and added a perceived cost factor as it was expected to play a role on Intention of Use. Structural equation modeling was used and, after removing several parameters, an adequate fit to the data was found. The final model revealed that Intention to Use VR is predicted only by Perceived Usefulness. These results pinpoint what should be better documented in order to foster the dissemination of virtual reality among clinicians.

Introduction

Virtual reality (VR) is a therapeutic tool that has proven effective in the field of training, health, and the treatment of mental health problems (Murphy, 2003). Its effectiveness has been demonstrated on many occasions (Bouchard, Côté, & Richard, 2006 ; Tate & Zabinski, 2004) and it seemed interesting, based on this observation, to attempt to identify in an empirical way the elements that play a role on the intention to use or not to use VR in clinical practice. In order to do so, we chose to adapt the Technology Acceptance Model (Davis, 1989; Davis & Venkatesh, 1996; Venkatesh, 2000) to VR.

Since the mid 70's, various researchers have been interested in factors that explain or predict the use of different technologies. The Technology Acceptance Model (TAM) represents one of the explanatory models having most influenced the theories of human behavior (Venkatesh, Morris, Davis, & Davis, 2003).

The TAM was specifically developed with the primary aim of identifying the determinants involved in computer acceptance in general; secondly, to examine a variety of information technology usage behaviors; and thirdly, to provide a parsimonious theoretical explanatory model (Davis, Bagozzi, & Warshaw, 1989). It is rooted in social psychology and draws on Fishbein's and Ajzen's reasoned action model (1975), which establishes that the intent to produce a behavior depends on two basic determinants: attitude toward behavior and subjective norms. Subjective norms refer to the reasons for producing a certain behavior or not and make the link between the latter and an expected result, whereas attitude toward behavior refers to the positive or negative value the individual associates to the fact of producing the behavior.

The TAM suggests that attitude would be a direct predictor of the intention to use technology, which in turn would predict the actual usage of the technology. Davis and Venkatesh (1996) however, suggest that attitude would not play a significant role but rather that perceived ease of use (expectation that a technology requires minimum effort) and perceived usefulness

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(perception that the use of a technology can enhance performance of a task at hand) would determine the intention to use a technology. Venkatesh (2000) adds that the TAM is a good model but that it does not help understand and explain the acceptance of a technology in a way that promotes the development of a strategy having a real impact on the usability and acceptance of the technology. He therefore proposed a modified model. To the TAM, he added determinants to perceived ease of use, that is, four personal anchoring factors (computer self-efficacy, perception of external control, anxiety towards computers, and computer playfulness) and two adjustment-based factors that develop with experience (perceived enjoyment and objective usefulness). These anchors represent general beliefs about computers and their use. Furthermore, they would seem to play a critical role in the formation of the perceived ease of use of a new system and would be independent of the latter.

A number of meta-analyses on the TAM have demonstrated that it is a valid, robust and powerful model. Lederer, Maupin, Sena, and Zhuang (2000) have recorded more than 15 published studies that examined the existing relations between perceived ease of use, perceived usefulness, attitude towards use, and usage of information technologies over a period of 10 years (from 1989 to 1999). The results of these studies support the use of the TAM as a predictive or explanatory model of the usage of different technologies. King and He (2006) identified 88 studies published on the TAM. The results of this meta-analysis confirm that the model can be used in a wide variety of contexts and that the impact of ease of use on the intent to use is mainly brought about by perceived usefulness. In a critical review of the TAM, Legris, Ingham and Collerette (2003) retained 22 studies that tested the model in its integrity with a well-defined methodology as well as complete and available results. Their conclusions follow the same direction as those of King and He (2006), that is, the TAM is a theoretical model used in different contexts to help understand and explain the use of information technologies. The studies retained were testing among others, the use of technologies such as word processing and telemedicine software, electronic mail, the internet, personal computers and university resource centers.

The robustness of the TAM, his parsimony, and the interesting results of the meta-analyses aforementioned, convinced us to opt for this model. As the aim of the study is to understand what can encourage therapists to use virtual reality, we have retained the following elements from the TAM: a) the central concepts of perceived usefulness, perceived ease of use, and intention of use; b) the concept of attitude toward use, and c) the four anchoring factors of the model determining the perception of ease of use (Venkatesh, 2000). We also decided to add to our acceptance model of VR (Figure 1) the variable of perceived costs associated with the use of virtual reality. This last variable should permit documenting the impact of costs associated with the use of virtual reality. Furthermore, we chose to keep attitude as a mediator of intention of use, given the diverse opinions on the subject (Davis, 1993; Davis, Bargozzi, & Warshaw, 1989; Schepers, & Wetzels, 2007; Sun, & Zhan, 2006; Venkatesh, 2000; Venkatesch & Davis, 2000).

Schepers and Wetzels (2007) listed 53 studies using either one of six basic TAM constructs (attitude, intention of use, real use, subjective norms, perceived usefulness, perceived ease of use). Of these 53 studies, 15 of them found a significant relationship between perceived usefulness and attitude, varying from 0.29 to 0.84, 15 out of 16 discovered a significant relationship between perceived ease of use and attitude, varying from 0.05 to 0.73, and 14 noted that there was a significant relationship between attitude and intention of use, varying from 0.11 to 0.75. Sun and Zhan (2006) also studied the principal relations existing between the different basic constructs of the TAM. They retained a total of 72 studies all of which measured the perceived ease of use, 71 measured perceived usefulness, 22 measured attitude, 47 measured intention of use, while 39 measured real usefulness. They were thus able to confirm the existence of significant paths between attitude and intention of use as well as perceived usefulness: intention of use and real use, perceived usefulness and attitude as well as intention of use, and perceived ease of use and attitude as well as intention of use.

Hypotheses:

1. The model proposed in Figure 1 will be valid for describing the data relating to the intention of using virtual reality to treat mental health problems.
2. The parameters linking computer self-efficacy, perception of external control, anxiety toward computers and computer playfulness to perceived ease of use will be significant.
3. The parameters linking perceived usefulness and attitude will be significant.
4. The parameters linking perceived ease of use to perceived usefulness and attitude will be significant.
5. The parameter linking attitude toward use of virtual reality to the intention of use will be significant.
6. The parameter linking the cost variable to the intention of use will be significant.

Method

Sample

The sample is composed of 141 adults familiar with virtual reality. They originate from different countries : 49% from Canada, 23% from the United States, 12% from Spain, 3.5% from France, 2% from Israel, 2% from Italy, 1.4% from the United Kingdom and 0.7% from each of the following countries : Australia, Germany, Greece, Japan, Korea, Luxembourg, Scotland and Sweden. Two individuals refused to indicate their country.

The participants were invited to fill a questionnaire measuring the variables of the model (questionnaire available on demand). These individuals come from various backgrounds and were contacted in two different ways. The first method consisted of inviting the participants to the Cybertherapy Conference, held in Gatineau, Québec in June 2006, to fill in a paper version of the questionnaire and to return it to us on site or by mail. Close to 190 questionnaires were distributed and 51 were returned (27%). The second method consisted of inviting people on mailing lists (VRPsych List, Presence, Société Québécoise de Psychologie) to answer the questionnaire directly on-line. Ninety-five individuals responded to the questionnaire electronically, which represents 67% of the sample of the present study. In all cases a consent form was tendered and accepted by the participants.

The average age of the respondents is 39.6 years, 58% are women, 78% describe themselves as belonging to a cognitive-behavioral approach, 14% as being eclectic, 1.6% humanistic and .8% psychodynamic or in neuropsychology. People in our sample work at 32% in the public sector, 23% in the private, 19% work in the public and private sector, 8.7% were research assistants and research coordinators and 7% do not work at all. Twenty-one percent of respondents are directors of a clinic or of a virtual reality laboratory. The respondents have on average 11 years of clinical experience and, during the last year, 63% have rarely or never used virtual reality.

Instrument

The questionnaire measures perception toward the use of virtual reality for the treatment of mental health problems (available upon request). This questionnaire written in English is adapted from the questionnaires of Davis (1993), Venkatesh (2000) andVenkatesh and Davis (2000). The only modification to the nine sub-scales of the questionnaire consists of applying the items to the context of VR (e.g. "Using Virtual Reality to Treat Mental Disorders Enhances My Effectiveness in My Clinical Practice"). Items were also added to address perceived costs of using VR. All the items, except those measuring attitudes, utilise a seven-point Likert scale ranging from "strongly agree" to "strongly disagree" with a middle neutral point.
Ease of use of virtual reality. Perceived ease of use is measured with the help of an already validated scale by Davis (1989) with Cronbach's alpha reliability coefficient of 0.87 (King & He, 2006) and of 0.80 in our sample. The perceived ease of use comprises four items.

Perceived usefulness of virtual reality. Perceived usefulness is measured with the four- items scale developed and validated by Davis (1989) with a reliability coefficient of 0.89 (King & He, 2006) and of 0.92 in our sample.

Intention of use. The intention of use of virtual reality in the treatment of mental health problems is measured with the help of two items scale validated by Davis (1989). It has a reliability coefficient of 0.86 (King & He, 2006) and of 0.96 in our sample.

Attitude toward usage of virtual reality. Attitude is measured with the help of a semantic differential scale, as suggested by Ajzen and Fishbein (1980) and Davis (1989), which allows to operationalize the attitude toward a behavior : « all things considered, my use of virtual reality in my clinical practice is : good-bad ; wise-foolish ; favorable-unfavorable ; beneficial-harmful ; positive-negative » everything on a seven-point scale with a neutral value in the middle. This scale has a reliability coefficient of 0.85 (King & He, 2006) and of 0.97 in our sample.

Perception of personal efficacy to use a computer. Self-efficacy to use a computer refers to the perception an individual has of his capacities and abilities to use the technology. This scale comprises 10 items with an internal consistency of 0.85 (Venkatesh, 2000) and of 0.83 in our sample. In order to carry out the analyses, we reduced the number of items to enter in our model to five, by calculating the mean of paired items having the highest and lowest item-total correlation.

Perception of external control toward computers. Perception of external control is defined as the feeling of control an individual has toward the use of a computer based on the availability of knowledge, resources and opportunities required for its use (Venkatesh, 2000). This scale comprises five items and has a mean internal consistency of 0.85 (Venkatesh, 2000) and of 0.63 in our sample.

Anxiety toward computers. Anxiety toward computers is described as the apprehension, or even the fear, an individual has toward the possibility to have to use a computer (Venkatesh, 2000). This scale comprises nine items and a mean internal consistency of 0.87 (Venkatesh, 2000). In order to carry out the analysis we reduced the number of items to enter in the model by calculating the mean of the items having the highest item-total correlation, the lowest correlation and another one located mid-way, and we obtained an alpha coefficient of 0.82.

Intrinsic motivation to use a computer. Intrinsic motivation refers to the perception of pleasure and satisfaction felt while using a computer. This scale is composed of three items and has a mean internal consistency of 0.85 (Venkatesh, 2000) and of 0.94 in our sample.

Perceived costs of virtual reality. Perceived cost is defined as the concerns associated with the costs of purchasing the necessary equipment for the use of virtual reality. This scale comprises two items and has a mean internal consistency of 0.77 in our sample.

Results

The hypotheses previously presented were evaluated with the EQS software version 6.1 for Windows and the complementary analyses (internal consistencies, correlations, etc.) were computed with SPSS. Our initial sample consisted of 147 respondents. Six were removed because their questionnaires revealed too many missing values (between 5 and 14 on a total of 44 questions). Of the 141 respondents remaining, three had a single missing value (overall, three missing data on a total of 6204), all to the question « I find it easy to apply virtual reality for my specific needs to treat mental disorders in my clinical practice » and for which we replaced, independently for all of them, the missing data by the mean value of the other items in the perceived ease of use construct. One participant did not indicate his/her age, six did not indicate their principal theoretical

orientation, four omitted to indicate their place of practice, one respondent did not indicate the number of years of clinical experience and the number of years of experience with virtual reality, and three did not indicate whether they were director of a clinic or a research center.

A descriptive analysis of the data and their distribution revealed that there was no extreme univariate or multivariate data. There was evidence indicating that the univariate and multivariate normality assumption was not respected according to Mardia's normalized coefficient (12.95, $p < 0.001$). The analyses were thus performed with the maximum likelihood method and the fit tested with the Satorra-Bentler scaled chi square (Satorra & Bentler, 1988; S-Bχ^2). The standard errors of measure of the parameters were also adjusted by EQS owing to the problem of normality. In order to assess the quality of the estimated model, the following indices and criteria values were used as suggested by Byrne (1994), Tabachnick and Fidell (2007) and Hu and Bentler (1998) : CFI (>0.95), NNFI (>0.95), RMSEA (< 0.05) and SRMR (<0.08). All these indices were corrected for normality with the help of the Satorra-Bentler (S-Bχ^2) index, with the exception of the SRMR. The percentage of variance explained by the final model was obtained with the help of the GFI, as suggested by Tanaka and Huba (1989). The descriptive data at the different scales and their intercorrelations are presented in Tables 1 and 2.

Table 1
Descriptive Statistics

Variables	Average Score	SD
Intention to use	2.33	1.44
Usefulness	2.99	1.37
Perceived ease of use	3.67	1.30
Self-efficacy	3.45	1.01
External control	3.79	1.24
Anxiety	1.64	0.73
Motivation	2.97	1.33
Attitude	2.76	1.30
Perceived Cost	2.32	1.24

Table 2
Inter-correlations between variables (N=141)

	2	3	4	5	6	7	8	9
Variables								
1. Intention to use	0.85**	0.47**	0.28**	0.43**	-0.11	0.64**	0.68**	-0.17*
2. Perceived usefulness		0.58**	0.25**	0.51**	-0.16	0.72**	0.77**	-0.13
3. Perceived ease of use			0.36**	0.63**	-0.16	0.65**	0.63**	-0.16
4. Self-efficacy				0.27**	-0.08	0.27**	0.31**	0.01
5. External control					-0.12	0.60**	0.61**	-0.17*
6. Anxiety						-0.11	-0.19*	-0.02
7. Motivation							0.76**	-0.12
8. Attitude								-0.17*
9. Perceived cost								

Note. ** $p < 0.01$, * $p < 0.05$.

As 67% of our sample consisted of online respondents, ANOVAs were conducted for all variables (see Table 3) in order to document whether any differences existed between the participants responding online and those filling out a paper questionnaire. As we can note in Table 3, the participants who completed the online questionnaire obtain more favorable scores in relation to virtual reality and its use (more positive attitude, stronger intent, less anxiety, etc.), than those who completed the paper questionnaire. In order to assess whether these differences have an impact on the relation between the constructs at hand, we compared the correlation patterns between the different variables. These analyses reveal that the correlation patterns remain similar, suggesting that the differences between the paper version and the online respondents do not affect the relations between the variables in the model. To be on the safe side, the final model was also tested separately for the participants having completed the online questionnaire or the paper version, and the conclusions remain identical. Therefore, all the participants having completed the paper and online versions were grouped into a single sample for the entire analyses.

Table 3
ANOVAs comparing answers obtain via paper form and online form.

Variable	Average score	SD	F (1,139)
Intention to use			26.02***
Online	2.73	1.55	
Paper	1.51	0.65	
Perceived usefulness			28.55***
Online	3.39	1.37	
Paper	2.18	0.95	
Perceived ease of use			11.22**
Online	3.91	1.22	
Paper	3.16	1.33	
External control			8.46*
Online	3.99	1.24	
Paper	3.36	1.14	
Anxiety			2.16
Online	1.58	0.71	
Paper	1.77	0.75	
Motivation			21.09***
Online	3.30	1.29	
Paper	2.27	1.15	

Note. Online, (n=95), Paper (n=46) ***p=0.000, **p<0.001, *p<0.05

ANOVAs and correlations were also performed to document if there were any significant differences between participants who have rarely or never used virtual reality (67%) and participants who used it more frequently (33%). These analyses did not reveal any meaningful difference, except for a stronger relationship among frequent users of VR between perceived self-efficacy and intention of use virtual reality and perceived usefulness.

The initial model studied revealed many non-significant parameters and could not adequately fit the data. These problems were predictable by looking at the correlation matrix between the constructs (see the weak, but significant correlations in Table 2), most notably for cost, self-efficacy and attitude. To remedy these problems, these constructs were removed from the model. A revised model (see Figure 2) was tested, while retaining the path between perceived ease of use and intention of use.

To obtain a refined model, the covariance between the following standard errors was permitted: items 9 and 10, items 13 and 7, items 14 and 8, items 9 and 8. This model was found to be valid, as evidenced by the adequacy indices such as Satorra-Bentler's chi-square χ^2 (176, N = 141) = 226.8, $p < 0.01$, robust CFI (0.98), RMSEA = 0.045, NNFI = 0.96 and SRMR = 0.06. However, the parameter linking perceived usefulness to intention to use virtual reality remained non-significant (β = -0.06, ns). It was thus removed in order to arrive at a model that also turns out to be very adequate but more parsimonious [Satorra-Bentler chi-square χ^2 (177, N = 141) = 227.4, $p < 0.01$; Robust CFI = 0.98; RMSEA = 0.45; NNFI = 0.96; SRMR = 0.06]. This model allows predicting 85% of the variance of the intention to use virtual reality for clinical purposes.

Discussion

In this study, TAM was adapted and used to describe factors predicting the intention to use virtual reality as a therapeutic tool by mental health professionals. Significant support was found for a model and good fitting. Several important findings emerge from this study. Among others, the perceived usefulness seems to be the only significant predictor of intention of use. Basic factors such as attitude, perceived cost and perceived ease of use have no direct effect on intention to use virtual reality. At most, perceived ease of use influences intention of use only indirectly through perceived usefulness. In addition, personal factors (perception of external control, anxiety towards computers, intrinsic motivation) play an important role in the formation of perceived ease of use of virtual reality but do not have a direct impact on intention of use.

Generally speaking, and taking into account the strong proportion of variance demonstrated by the model (85%), the TAM can predict well the intention of a favorable population to use virtual reality as a tool for treating mental health problems. We note however that two constructs in the original models from Davis and Venkatesh (Davis, 1989; Venkatesh & Davis, 2000) did not permit to predict the intention to use virtual reality. A direct path is not found between perceived ease of use and intention of use, between perceived ease of use and attitude, as well as between attitude and intention of use. These results seem to support Davis' (1989) contention that, from a point of view of causality, perceived ease of use could be an antecedent to perceived usefulness rather than a direct parallel determinant of usage. The explanation, according to Davis (1989), would be that the users adopt a technology firstly on the basis of the tasks it can perform for them and then consider the level of difficulty associated with its operation, at least in the case of professional uses of a technology. He adds that an increase in experience with the technology influences the intention of use on account of the fact that in the beginning the user assesses the ease of use on the basis of self-efficacy and, with time, it becomes instrumental. Virtual reality, being a different technology than those analysed in previous studies on the TAM could explain in part the slight differences encountered in this study. In addition, the samples of these studies comprised mostly students, employees, a few professionals and internet users (Sun & Zhan, 2006). These individuals were likely trained or had the opportunity to acquire experience with these various technologies, which is not the case for a good part of our sample.

Of the four personal factors retained in our model, three are determinants of the perceived ease of use (perception of external control, anxiety towards computers, computer playfulness). Our results are in line with those obtained by Venkatesh (2000). It seems here that the users had general beliefs associated with the use of computers and these could remain stable and constant as long as experience with the system matches expectations.

There are a few inherent limitations to this study. First, 32% of the participants work in the private sector, 19% in the private/public sector, and that 21% are directors of virtual reality clinics or laboratories, implies that a good number are professionals and in a better position to decide on the type of treatment or the kind of tools they want to use in their practice. Second, the sample is composed of individuals who are favorable (to a variety of degrees) to virtual reality, which prevent the generalization of our results to the general population of mental health professionals. These people are considered as "in favor of the use of VR" in the sense that people who answered our questionnaire already have an interest in the

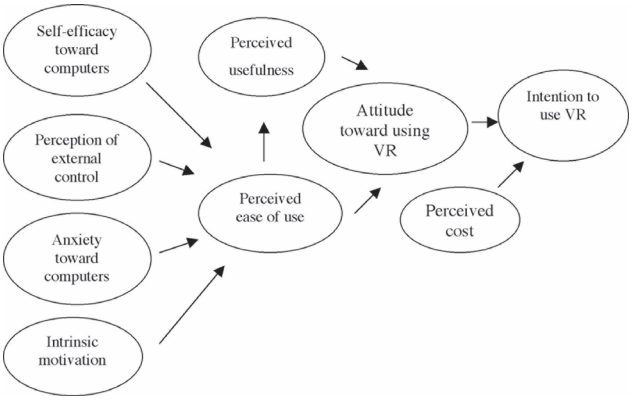
use virtual reality; they are attending conferences on virtual reality or are members of mailing lists dedicated to virtual reality (i.e. VRPsych List and Presence). Third, and as mentioned by Sun and Zhan (2006), the model does not take into consideration the impact of moderators such as the voluntary dimension and professional autonomy. The addition of these moderators would result in a more practical explanatory model and one closer to the reality of mental health professionals. Fourth, the final model presented in Figure 3 aims to predict the intention of use and not the real use of virtual reality. Knowing that intention of use mainly predicts usage (Davis, 1989; Davis et al., 1989; Venkatesh & Davis, 2000), we can only expect that real use effectively corresponds to intention of use. Future research using the model while adding the dimension of real use could help verify such a hypothesis. However, trying to predict intention of use among people who do not know what VR is would add quite a lot of error variance.

For many years, mental and physical health specialists as well as rehabilitation specialists have been working towards the development and application of virtual reality as a therapeutic tool in the treatment of people suffering from various ailments. This technology is effective and useful. Rothbaum (2004) mentions that: a) thanks to the ease of use of virtual reality, treatment acceptance and adoption can improve (for example, many patients expose themselves more readily in virtuo than in vivo); b) environments based on real situations can provide a realistic, ethical, and secure clinical context for the patient; and c) the content of the virtual environment can be reused for patients with different problems. Until now, it was difficult to understand why this technology was underutilized outside of research facilities despite its demonstrated effectiveness and the advantages associated with its use. Now we understand this phenomenon somewhat better and we have data upon which we can base our dissemination efforts.

The results of the present study lead us to believe that mental health professionals favorable to virtual reality are more influenced by the practical advantage of the VR technology than its perceived cost or ease of use, as we had been lead to believe in the past (Bouchard et al., 2006). It therefore appears that professionals would willingly buy or use this technology for their practice if researchers could document and demonstrate to them the added value of virtual reality as well as the useful and practical aspects in the application of treatments. Research on dissemination could benefit from Rogers' (1995) theory of innovation dissemination. According to Stirman, Crits-Christoph and DeRubeis (2004), Rogers' theory distinguishes itself as a theoretical model of dissemination because its central factors are highly predictive of successful adoption. These factors being : a) the perceived advantage (implying that the rate of adoption of an innovation is associated to the advantages it seems to have on procedures) ; b) the consistency or compatibility that exists between innovation and procedure (the more a therapist has to adapt to a procedure the less he/she would be ready to accept the change) ; c) the complexity of the procedure ; d) the introduction of the innovation that must be gradual and e) being able to see it in the surrounding (noticeable). These five factors allow us to go even further in our reflection and to contemplate in an interesting way the dissemination of virtual reality among professionals.

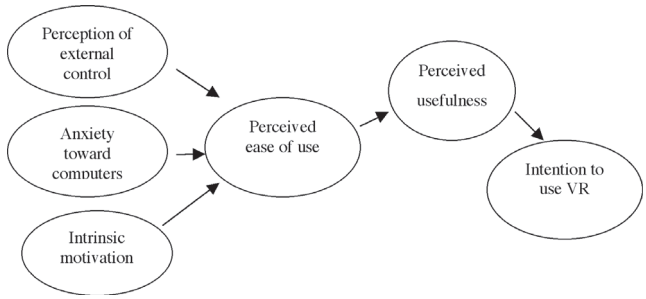
No study to date had sought to understand why mental health professionals made little use of virtual reality as a tool for treatment. Having demonstrated its effectiveness on many occasions and in different contexts (Bouchard et al., 2006; Riva, 2005), the inquiry was obvious. The proposed model thus provides interesting answers and avenues for reflection, allowing us from now on to note that for favorable professionals, perceived usefulness is what influences them primarily in their intention to use virtual reality in their practice. This takes into account factors such as anxiety towards computers and computer playfulness. These results differ from previous studies using the TAM (Davis, 1989; Sun & Zhan, 2006, Venkatesh & Davis, 2000). The latter had, for the most part; identified attitude and perceived ease of use as important predictors of intention of use. Attitude is not even part of the final TAM model adapted to virtual reality.

Figure 1



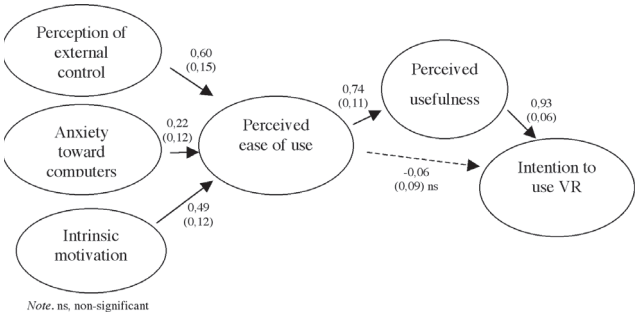
Studied Model : MAT adapted to VR

Figure 2



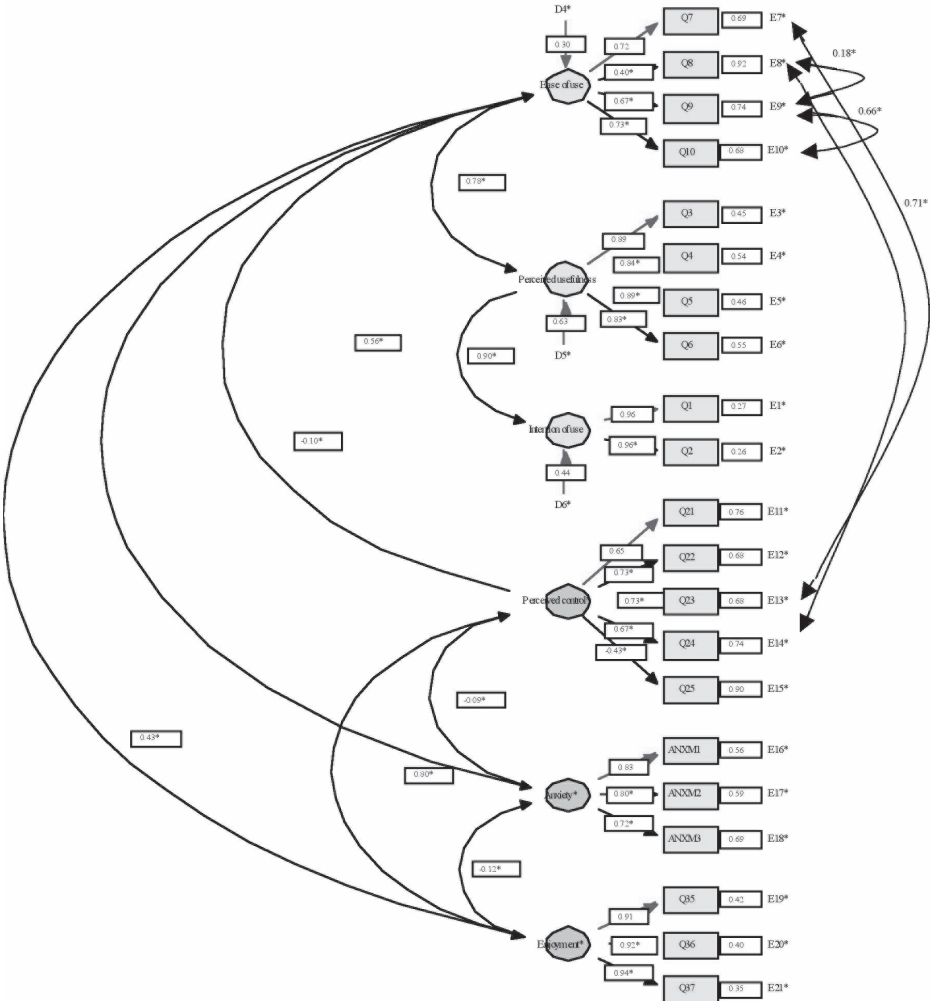
Revised Model

Figure 3



Final Model

Annexe



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