Beyond the Technology Acceptance Model: Elements to Validate the Human-Technology Symbiosis Model

Éric Brangier and Sonia Hammes-Adelé

Université Paul Verlaine – Metz. InterPsy-ETIC, EA 4432. User Experience Lab. Faculté des Sciences Humaines et Arts BP 30309 Île du Saulcy - F-57006 Metz (France).
brangier@univ-metz.fr

Abstract. This chapter forms part of an area of research on the Human-Technology-Organisation relationship. This research has emphasised the emergence of closely linked, intense and symbiotic forms of activity in workplaces and at home. Despite the relevance of the « Technology Acceptance Model », the use of technology doesn't always depend on « perceived usefulness » and « perceived usability », but on the level to which a process of human-machine symbiosis has developed. Based on a survey of 482 respondents we examine this technosymbiosis on three dimensions: (a) a sense of control; (b) the benefit of human- machine mutual adaptation; and (c) the perception of utility. We show that the use of a new technology is correlated with a high level of technosymbiosis, i.e. correlated with these three elements. Finally, the link between these dimensions and the use of technology is established. This validation is based on the correlation between the average score of the rating of attitudes in a questionnaire and the number of technologies the respondents reported using ($r = .597$, $p < .0001$). In addition, these three dimensions explain for 35% of the variance (adjusted $R^2 = .355$) in the use of technology.

Keywords: Technosymbiosis, Neosymbiosis, Technology Acceptance, Human-technology relationship.

1 Introduction

A large number of theories try to explain the phenomena behind the use of new technologies. Globally, models of the human-technology-organisation relationship have been put forward which can be fitted into three categories [8, 9]:

- Models focused on operative acceptance emphasize that human-machine interaction must be ergonomically optimised to facilitate communication, to make it usable, convivial, simple, effective, efficient, and enjoyable… [4]. In this approach the interaction between humans and technology is often decontextualised from socio-economic and organisational processes which, however, give evidence about the context of use. The main objective is to design and develop technologies adapted to humans, aiming to guarantee a software operative acceptance leading to technology usage.

M.M. Robertson (Ed.): Ergonomics and Health Aspects, HCII 2011, LNCS 6779, pp. 13–21, 2011.

- Social acceptance models address the problem of the introduction of new technologies into socio-organizational situations, highlighting the disrupting effect of the forms of regulation imposed by new usages which primarily depend on social factors. From this point of view, the impact of the technology depends on social acceptance, which is on the one hand an interpretation of the determinant variables of user acceptance (e.g.: perceived usefulness and perceived usability) [10] and on the other hand determined by the disruptive effect of factors involving social regulations (socio-economic organizational, and cultural changes…) [1].
- In symbiotic models, technology is considered as neither unknown nor distant, and nor foreign to us, which would justify our accepting or rejecting it, but it is regarded as an extension of ourselves, we live with it, humans and technology cohabit. Furthermore, technology is man-made: It appears as if humans have entered into a sort of technosymbiosis where they transfer what is programmable in themselves to technology, at the same time these technologies become symbiotic agents which transform human beings.

The aim of this paper is to highlight the importance of three variables in the characterization of the symbiotic relationship between humans, technology, and contexts. We will show that technosymbiosis is based on (a) a sense of mastery of technological uses, (b) a representation of the benefits of a mutual adaptation between human beings and technologies, and (c) a usefulness perception, all of which reinforce and augment technology usage. In order to do this we will return to the key points of the theory of human-technology-organization symbiosis, followed by the results obtained from our questionnaire of 14 items given to 482 respondents, these results fitting in with our model.

2 Human-Technology Symbiosis

2.1 Theoretical Reminder

Seeing the computer as a symbiont created by humans is a thesis developed by Licklider [17]. At that time, the famous American psychologist, who was greatly instrumental in giving the computer its present day form, had envisaged the emergence of an era of interdependence between human beings and computers, where the interaction between the two would become tightly linked: symbiosis. In this way users would be able to « dialogue »with the machine as they do with their fellow human beings enabling the provision of a real conversation. Since Licklider's first article, symbiosis, a notion originating from the Natural Sciences defined as « living together», is no longer reserved for relationships in nature, but also describes the relationship between human beings and their artefacts.

Today Licklider's ideas have never been more topical [11, 12, 13]. Technological evolution has proved him right: technologies are becoming more and more embedded, complex, miniaturised, robust, and autonomous... They have become invisible, yet they have an enormous impact on our lives whether we use them or not. The idea of the human-technology relationship in terms of symbiosis, hybridization, fusion or coupling, is of increasing relevance. In this sense, the interdependency formed

between humans and their symbiont, the technological artefact is made explicit in the symbiotic approach.

More than 40 years later, the human-technology-organisation symbiosis model [2, 3, 4, 5, 6, 7, 8, 9]; postulates that human beings and technologies coexist so well that human beings shape technology just as technology shapes human beings. Without referring back to the theoretical elements, this symbiosis between humans and technologies produces permanent interactive loops enabling technology and the human psyche to develop in parallel. To summarize, the human-technology symbiosis theory can be synthesized into the following four ideas:

- **Co-extension**: Technology becomes a human extension. It stretches human skills, aptitudes, capacities and properties. Humans transfer what can be done by machines from themselves to their symbionts. Once this is achieved, the technosymbionts become a part of ourselves, possessing similar and expanded human properties (augmented intelligence, greater perceptivity, error management resilience, user empowerment…).
- **Co-evolution** defines the transformations occurring during the evolution of the two elements: Human beings benefit from their relationship with technology, which in turn (via inventors, designers and engineers) benefits from successive improvements. In the living world, co-evolution is often observed in the relationship between natural symbionts and their living hosts. In the technological world, technologies' features are integrated into an evolutionary process as part of sustainable and mutual interactions with human beings, this creating technosymbiosis. Interactions between natural and artificial organisms lead to competition driven evolution making adaptation necessary.
- **Co-action**. This is the state of permanent feedback of one element to the other elements. Human beings and technology act together following complex and continuous cycles. They have an effect on each other. Humans bring about changes in technology as the latter enables humans to bring about change in their own activities.
- **Co-dependence**. Humans have confidence in their technology and often use it to think, to act, to work, to expand their feelings, to communicate, to play, to buy… Humans rely on their technosymbiont to the extent that daily activities carried out in the past, have disappeared or have been forgotten. Sometimes humans cannot carry out certain activities without their techno-symbiont.

The metaphorical use of the biological term "symbiosis", has no other purpose than to describe an interdependent relationship between two living or non living entities who each benefit from cohabitation. But if the notion of human-techno-symbiosis is relevant in this respect, one needs to define the psychological factors which are required to demonstrate that humans engage his/her mind to live in a symbiotic relationship with technology.

2.2 The Human Perception of Technosymbiosis

By emphasizing that humans and machines are connected by strongly dependent links, the human-technology symbiosis theory assumes first of all that certain human beings have developed a high level of mastery of these technologies, more specifically, that they are confident in their capacity to use them.

Hence with this mastery, human beings have developed a strong **sense of control**. Experiencing a sense of mastery, means experiencing a sense of control of the technology that will enable them to understand it better, to define its limits, to understand how it functions, and even to develop the capacity to make repairs. The notion of technosymbiosis implies therefore that humans have developed sufficient mastery to enable them to interact with the technology.

However, a sense of control isn't enough to explain technosymbiosis, humans also perceive the benefits derived from **mutual adaptations** established with technologies, as for example, exchanging information, and knowledge transfer, developing forms of delegation, or sharing resources. This is what characterizes the notion of technosymbiosis: The existence of mutual adaptation where humans and machines gain new benefits through mutual adjustment.

Finally, symbiosis fosters a **perception of self performance**: The technology is perceived as useful and efficient, and hence it increases our sense of accomplishment.

3 Problem and Method

3.1 Main Questions

Our general research question is to investigate whether human behaviour, when facing technological systems can be assessed effectively according to a symbiotic framework which highlights the existence of technosymbiosis based on (figure 1):

- The benefit perceived through mutual adaptation: Humans and technology mutually adapt via the redesigning processes to upgrade the technology. It is the degree to which a person believes that mutual adaptations, from humans to technology and technology to humans, would give more benefits to upgrade interaction quality.

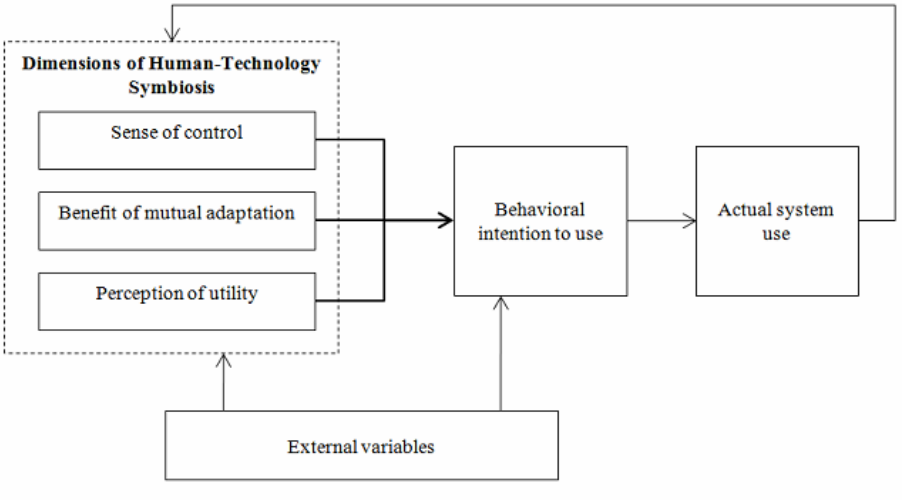

Fig. 1. Basic model of technosymbiosis

- Sense of mastery of the technology: Self perceived efficiency in the use of technology enhances the level of human technosymbiosis; that is the degree to which a person believes using a technology would enhance his or her sense of control of the technological world.
- Perceived utility related to the technology and perceived usefulness; that is the degree to which a person believes using a technology would empower their interaction or enhance their performance.

3.2 From Interviews to Questionnaires

The quantitative assessment was made in five stages:

- Setting out the questions. As well as the considerable bibliography on the subject, unstructured interviews were conducted with 4 interviewees. The aim was first, to verify the appropriateness of the themes used in conversation with the interviewees, and second, to check that the vocabulary used to design the questionnaire was generally easy to understand. On this basis 54 questions were constructed.
- Semi-structured interviews. These 54 questions were then given to 10 people with differing profiles. They responded to the questions as well as giving their opinions on the design of the questions and their understanding of them.
- Pre-test. The instrument was then given its first real examination through a pre-test on a sample of 172 people [6, 7]. This pre-test showed how well the instrument had been put together as well as indicating where the instrument did not work, particularly in certain items.
- Correction of parts which did not work well. The problems encountered in the deficiencies were taken into account in the current validated version of "questionnaire on human-technology symbiosis". The items are shown in the table below (table 1).
- Final interviews. The items were again given to 10 people, as in stage 2. Finally, the questionnaire was self-administered to 482 people. The participants had to rate their agreement with the set of items on a Lickert type scale ranging from 0 (completely disagree) to 6 (completely agree). A high score for an item denotes a high degree of symbiosis, conversely a low score denotes a low degree of symbiosis

3.3 The Content of the Questionnaire

The questionnaire is split into two parts. The first part deals with collecting information about the participants, (age, profession, gender…) and their use of technologies (time spent using it, types of hardware/equipment/software used…). The second part comprises 14 questions on technosymbiosis (table 1). The statistical analysis seeks to validate the quality of the instrument and to describe its use (measured by how much technologies have been used) through a series of set attitude statements.

Table 1. List of items used to assess the hypothetical dimensions of technosymbiosis

Sense of control(6 items)	
Feeling of simplicity	*I find Information and Communication Technologies simple to use. (ICT).*
Sense of ease	*I feel at ease when handling ICT's.*
Operative agility	*I know how to obtain what I need from ICT's.*
Maintenance skills	*I think I am able to make repairs to ICT breakdowns.*
Control of change	*I know how to handle changes imposed by ICT's.*
High level of mastery of use	*I never have any problems with ICT's .*
Benefit of mutual adaptation (6 items)	
Adaptation to expectations	*Changes in ICT's increasingly meet my expectations.*
Adaptation to changes	*In the workplace or at home, I think ICT's generate changes that are easy to deal with.*
Preferential Adaptation	*For everyday activities I prefer using ICT's to more traditional methods.*
Belief in technological adaptation	*I feel that ICT's will meet my future needs.*
Benefit of inventiveness	*Social changes brought about by ICT's are beneficial as they enable me to be inventive.*
Benefit of fun and pleasure.	*Activities using ICT's become more enjoyable and fun to do.*
Perception of utility (2 items)	
Usefulness	*ICT's offer useful functionalities.*
Effectiveness	*ICT's offer functions which enable me to be more efficient.*

3.4 Sampling

The participants in the study have an average age of 39.7 (σ = 18.9). The sample (n = 482) is made up of French adults divided into three groups: students (167), employees (161) and senior citizens (154). Within these three subsamples, the proportion of women and men was split (47% women and 53% men. There was an equal distribution of participants by socioeconomic status in the sample.

4 Results

In order to validate our grouping of the attitude statements into conceptual meaningful sets, we conducted a principal components analysis. The matrix of partial correlations is shown in (table 2). The Eigenvalues for the three factors were 5.35, 2.15, 1.16 respectively. The first factor explains 38.25% of the variance, the second explains 15.39% and the last 8.31% (Cronbach's α = 0.88). From the component matrix, we can confirm that the distribution generally corresponds to our hypothesis, even though we would have thought that the benefits of adaptation would have had a greater weight.

Table 2. Results of the factor analyses and Cronbach's α

	Items / Factors	1	2	3	*α*
Sense of control	Feeling of simplicity	***.837***	.134	-	**.852**
	Sense of ease	***.882***	.107	-	
	Operative agility	***.665***	.308	.124	
	Maintenance skills	***.747***	-	.128	
	Control of change	***.733***	.187	-	
	High level of mastery of use	***.572***	.218	.200	
Benefit of mutual adaptation	Adaptation to expectations	.257	***.755***	.296	**.855**
	Adaptation to changes	.263	***.645***	-	
	Preferential adaptation	.446	***.589***	-	
	Benefit of inventiveness	.115	***.741***	.145	
	Belief in technological adaptation	.142	***.715***	.244	
	Benefit of fun and pleasure	.135	***.786***	-	
Perception of utility	Utility	.176	.156	***.859***	**.787**
	Efficiency	.118	.262	***.827***	

The first factor corresponds well to the theme of sense of control of technologies. We find once more, the configuration of the items linked to the need for people to control their technological environment, to feel at ease, and to master it as well as possible.

The second factor relates to the benefits of adaptation, which is that people perceive the benefit from adapting to technologies and technologies adapting to them.

Finally, the third factor which is made up of two items clearly refers to perceived usefulness as Davis [10] envisaged it; i.e. it refers to utility and perceived efficiency.

This analysis also highlights the relative weight of each factor: firstly the sense of control, followed by benefit of mutual adaptation and finally perceived usefulness. Whilst perceived usefulness is effectively a classic factor which is often identified [14, 15, 16], nonetheless, a sense of control and benefit of adaptation, add to our knowledge base in order to allow us to explain the use of technology. These two factors are essential for us to identify the technosymbiotic effects:

- Having the feeling of mastering the technology, i.e. controlling technology to develop a highly developed relationship between human and technology;
- Taking into account the benefits of the mutual adaptation of human and technology.

Finally, validating the link between measurements and the use of technology was made, based on the correlation between the average score of respondents to the questionnaire and the number of technologies they reported using ($r = .597$, $p < .0001$). In addition, the measured dimensions explain for 35% of the variance (adjusted $R^2 = .355$) in the use of technology.

5 Discussion – Conclusion

These results give weight to the notion of symbiosis which introduces the awareness of technological feedback on the user as being an important point in the use of technologies. On the fringe of the technological acceptance theories [14, 16], it appears therefore, that a successful human-technology relationship is not based, (not sufficiently, or not only,) on perceived usability and perceived usefulness, leading the user to develop intention to use, then actual use of the system, as believed in the social acceptance of technology theories. It lies in establishing a durable partnership based on interactions which will enable the development of a sense of technological control, the impression of a benefit of mutual adaptation, and perceived utility.

Today human beings draw the benefit of being connected to technology, which carries out certain tasks, leaving them free to do other activities, which sometimes, unfortunately, give little satisfaction. In any case, technosymbiosis is a form of relationship with technology, in the sense that its main aim is to help, facilitate, or give pleasure to the user in a given activity. It's about assisting the user in improving their degree of efficiency and quality of life. Technosymbiosis is also a process generating behaviour patterns which (a) reflect a process of technological mastery, (b) generate a benefit of mutual adaptation and (c) confer a perceived usefulness. No doubt, these three dimensions represent new leverage to a better understanding of human behavior in relation to technical systems and most of all to facilitate the integration of technology into the work place and at home.

References

1. Bobillier-Chaumon, M.-E., Bessière, C., Brangier, E.: Les effets du changement technologique sur le travail collaboratif. Revue d'Interaction Humain-Machine 4(1), 37–58 (2003)
2. Brangier, E.: L'assistance technique comme forme de symbiose entre l'homme et la technologie. Esquisse d'un modèle de la symbiose homme-technologie-organisation. Revue d'Interaction Humain-Machine 3(2), 19–34 (2002)
3. Brangier, E.: La notion de « symbiose homme-technologie-organisation ». In: Delobbe, N., Karnas, G., Vandenberg, C. (eds.) Evaluation et Développement des Compétences au Travail, pp. 413–422. Presses Universitaires de Louvain, Louvain (2003)
4. Brangier, E., Barcenilla, J.: Concevoir un produit facile à utiliser: Adapter les technologies à l'homme. Éditions d'Organisation, Paris (2003)
5. Brangier, E., Dufresne, A., Hammes-Adelé, S.: Approche symbiotique de la relation humain-technologie : perspectives pour l'ergonomie informatique. Le Travail Humain. Tome 72(4), 333–353 (2009)
6. Brangier, E., Hammes, S.: Élaboration et validation d'un questionnaire de mesure de l'acceptation des technologies de l'information et de la communication basée sur le modèle de la symbiose humain-technologie-organisation. In: Brangier, E., Kolski, C., Ruault, J.-R. (eds.) Actes de la Conférence Ergo'IA 2006, pp. 71–78. Estia, Biarritz (2006)
7. Brangier, E., Hammes, S.: Comment mesurer la relation humain - technologies – organisation ? Élaboration d'un questionnaire de mesure de la relation humain-technologie-organisation basée sur le modèle de la symbiose. PISTES 9(2) (2007a), http://www.pistes.uqam.ca/v9n2/articles/v9n2a1s.htm

8. Brangier, E., Hammes, S.: Les approches psychosociales du management des technologies de l'information et de la communication. In: Trognon, A., Bromberg, M. (eds.) Psychologie Sociale et Ressources Humaines, pp. 463–478. Presses Universitaires de France, Paris (2007b)
9. Brangier, E., Hammes-Adelé, S., Bastien, J.M.C.: Analyse critique des approches de l'acceptation des technologies : de l'utilisabilité à la symbiose humain-technologie-organisation. European Revue of Applied Psychology 60, 129–146 (2010)
10. Davis, F.D.: Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly 13, 319–339 (1989)
11. Griffith, D.: Neo-symbiosis: a system design philosophy for diversity and enrichment. International Journal of Industrial Ergonomics 36(12), 1075–1079 (2006)
12. Griffith, D., Greitzer, F.L.: Neo-Symbiosis: The Next Stage in the Evolution of Human Information Interaction. International Journal of Cognitive Informatics and Natural Intelligence 1(1), 39–52 (2007)
13. Hancock, P.A.: Man, machine and Morality: toward a philosophy of human-technology symbiosis. Ashgate, 184p (2009)
14. King, W.R., He, J.: A meta-analysis of the technology acceptance model. Information & Management 43, 740–755 (2006)
15. Lee, Y., Kozar, K.A., Larsen, K.R.T.: The technology acceptance model: Past, present, and future. Communications of the Association for Information Systems 12, 752–780 (2003)
16. Legris, P., Ingham, J., Collerette, P.: Why do people use information technology? A critical review of the technology acceptance model. Information & Management 40, 191–204 (2003)
17. Licklider, J.C.R.: Man-Computer Symbiosis. IRE Transactions on Human Factors in Electronics HFE-1, 4–11 (1960)