A “person” in the interface: effects on user perceptions of multibiometrics

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Abstract

In this paper we explore the possibilities that conversational agent technology offers for the improvement of the quality of human-machine interaction in a concrete area of application: the multimodal biometric authentication system. Our approach looks at the user perception effects related to the system interface rather than to the performance of the biometric technology itself. For this purpose we have created a multibiometric user test environment with two different interfaces or interaction metaphors: one with an embodied conversational agent and the other with on-screen text messages only. We present the results of an exploratory experiment that reveals interesting effects, related to the presence of a conversational agent, on the user's perception of parameters such as privacy, ease of use, invasiveness or system security.

1 Introduction

The term biometrics, in Information Technology, refers to an array of techniques to identify people based on one or more unique behavioural or physiological characteristics. The techniques themselves have improved considerably over the past few decades, in terms of performance and reliability, with reported error rates at levels that indicate a reasonable level of technological maturity (Wayman et al., 2005). But in order to be truly useful the technology has to be acceptable to people in each of its areas of application. It is widely recognised (BioSec, 2004) that to achieve this goal a user-centred understanding much deeper than that which we have today is needed, and one which encompasses the important problem of interaction with the interface. These, of course, are basic goals of the more general field of Human-Computer Interaction, added to which are more specific issues regarding security (Sasse, 2004).

As regards application interface technology, ever more realistic animated characters or embodied conversational agents (ECAs) are being gradually introduced in the hope that they will enhance the users' experience and enrich the interaction. Some applications of ECAs promise to bring us closer to achieving universal usability. For instance, they can be used to communicate with hearing impaired people through sign language (Huenerfauth, 2005) or lip-reading (Beskow et al., 2004). Furthermore, language and the appearance, style, gesture repertoire and attitude of the character can be tuned to each application's context, to user preferences, and more importantly to take into account cultural particularities.

The effects of animated characters on users and on the dynamics of user-system interaction are still unclear, as is the question of how to use them in order to maximize the benefits desired. However, the literature does report significant improvements in users' *perception* of the system and their interaction with it when the interface includes an animated character (Moundridou and Virvou, 2001; Mori et al., 2003; Van Mulken et al., 1998).

Proceedings of the Workshop on Embodied Language Processing, pages 33–40,
Prague, Czech Republic, June 28, 2007.

In what way and to what extent are the perceptions of users affected by the presence of an animated character in the system interface? And how does this affect users' opinion and acceptance of a biometric authentication system? We designed an experiment to learn a bit more about these important usability questions. Expanding on previous studies of factors that impact on the usability of a biometric authentication system, the present paper reports the differences we have found in the subjective perceptions of users interacting with our biometric authentication system through interfaces offering two different forms of assistance: information and assistance in the form of text shown on-screen, and given by a talking animated character.

In the following section we review a variety of social and user perception parameters identified in the literature as being potentially affected by an ECA. In section 3 we describe our user test framework and we show our results in section 4.

2 Background

According to Nass et al. (1994) human–machine interaction is fundamentally social. This has clear implications for user interface design. The user's view of how the system works doesn't always correspond to the actual way the technology works, but, rather, it depends on the user's preconceptions, on the interaction process itself and on mental models that are influenced by the system interface. Introducing an ECA in the interface can have a visual impact on the user that can affect her perception of the system as a whole. Ruttkay et al. (2002) compile a number of user parameters (such as trust, ease of use, effectiveness, and personal taste) that have been shown in the literature to be affected by the presence of an ECA.

Basically, there are two lines of work related to the effects of ECAs on the users' perception of a system. On one hand, the so called "persona effect," associated with the presence of the ECA, and on the other, effects connected with the characteristics or qualities a specific ECA might have.

2.1 The persona effect

People seem to like and enjoy using systems with ECAs more than without them, they tend to find systems easier to use and tasks easier to accomplish, and they also feel more motivated and find learning easier (both learning to use the system and learning about a particular subject in the case of teaching applications), even though their performance is in fact roughly the same as that of users interacting without the ECA: Some authors speculate that objective performance improvements beyond user perceptions will be achieved in the long-run. For instance, Moundridou and Virvou (2001) believe that the increased motivation of students using a tutor application with an animated character may enhance their learning capacity in the long-term.

Animated characters can even help contain user stress and frustration caused by difficulties during interaction with the system (Mori et al., 2003), and as a result they may improve the efficiency of the interaction over that of a text-only system (Hone et al., 2003). An interesting point is that many of these psychological effects are observed as a response to the mere presence of the animated character, without it providing any obvious cues or expression to help the user: people's perceptions have also been found to be affected by an ECA's behaviour. The phenomenon has been called 'Persona Effect' (Lester et al., 1997). Later research (Van Mulken et al., 1998) has shown that the mere presence of an ECA can make tasks seem easier and more enjoyable to the user. Furthermore, an ECA showing greater empathic emotion towards the user improves the latter's overall impression of the system and perception of ease of use (Brave et al., 2005; Mori et al., 2003).

The presence of a human-like character can also have potential dangers such as the system anthropomorphisation effect that may lead to users having unrealistic expectations that are frustrated by actual interaction, as Walker et al. (1994) points out, concluding that a human face in an interface can help attract the user's attention and increase her level of motivation. At the same time, however, it can create high expectations about the intelligence of the system, which can lead to frustration if they are then not met.

2.2 ECA feature-related effects

Some authors have studied how the *attitude* displayed by the ECA, for instance regarding its proactivity and reactivity (Xiao et. al, 2004), may induce in the user certain responses such as a sense of ease of use, system usefulness, frustration or sluggishness in task execution. Indeed, it has been shown that an affective and empathic attitude on the part of the ECA can have a very positive effect on the user's perception of the interaction, lowering the level of frustration (Hone et al., 2003; Mori et al., 2003) and improving the user's opinion of the system (Brave et. al 2005).

Another line of research deals with the *gestures* and nonverbal behaviour of the ECA. A good gestural repertoire may promote in the user a perception of naturalness of interaction with the system and system socialness (see, *e.g.*, Cassell and Bickmore, 2000).

The physical appearance of the ECA has also been seen to have an influence on the user. For instance, Leenheer (2006) has studied the effect of the colour of the clothing on the ECA, and Hone (2006) shows that a female character reduces user frustration levels better than a male one. Hone also points out that the actual efficiency of the interaction may depend on the ECAs characteristics.

Dehn and Van Mulken (2000) suggest that the great variability of results in the literature may be due not only to the different features of the ECAs across the studies, but also to the different areas of application in which the ECAs were used. In this paper we present a study of the influence of an ECA in a specific application domain: biometric authentication. First we identify the user perception parameters that we have considered may be affected by the ECA. Then we describe our exploratory test to examine the persona effect. We have left the observation of the effects of the physical, attitudinal and gestural features of the ECA for future experiments.

3 Test design

We created a multibiometric authentication test platform with two user interfaces, one with an ECA guiding the user through the steps of the required tasks, the other with the same information provided only through text displayed on the screen. We asked the users to carry out two general tasks: a) to try to access the system acting as impostors, and b) to enrol using their own biometric traits and then authenticate their real identity.

3.1 System architecture

The test platform architecture simulates a scenario in which a user has to securely access restricted information stored on a remote server across an IP network (Internet or Intranet). In order to access such information the user's identity must be authenticated on the basis of two biometric traits (hence our characterisation of the system as multibiometric). The user may choose the two modes she wishes to authenticate her identity with from among the following four: fingerprint, signature, voice and iris pattern.

The specific technologies used for each biometric mode were:

- Fingerprint: *Sensor:* Precise 100 digital fingerprint reader. *Software:* 'Precise Java' by Precise Biometrics. (Precise Biometrics, 2007).
- Signature: Sensor: Wacom Intuous2 A6 digitizing tablet (WACOM, 2007). *Software:* CiC iSign verification software (CIC, 2007).
- Voice: *Sensor:* standard microphone. *Software:* speech and speaker recognition by Nuance Communications (Nuance, 2007).
- Iris: *Sensor:* Panasonic Autenticam BM-100ET iris video camera (Panasonic, 2007). *Software:* 'Private ID' recognition algorithms by Iridian (Iridian Technologies, 2007).

3.2 User interface

We have created a web interface (using Java Applet technology) with five flaps; one to access the general instructions of use, and one for each of the four biometric modes (in left to right order: fingerprint, signature, voice and iris). Below is a biometric trait visualisation area and a text message bar through which (in addition to the ECA) the system guides the user throughout the interaction.

In addition, we divided the test users into two groups to which we presented two different interaction "metaphors":

- *ECA Metaphor:* An ECA is permanently present on the right side of the screen to assist the user by giving her general instructions and guiding her through the steps of the interaction. The ECA gives no information regarding the details of each particular biometric mode. The ECA has been created and integrated into our application using the technology provided by Haptek (Haptek, 2007). The ECA uses free Spanish Text-To-Speech (TTS) software (Lernout and Hauspie, 2007) to speak to the user. Figure 1 shows the interface with the ECA.

- *TEXT Metaphor*: The user is only guided through text messages.

Note: In the ECA metaphor the text message bar remains active, serving as subtitles to what the ECA says. The messages read by the ECA are exactly the same as those given in text form in both metaphores.

Figure 1: User interface for the multibiometric authentication system.

3.3 Description of the tests

We designed the tests following the recommendations issued by the International Biometric Group (IBG, 2006). We worked with a sample of 20 users, half of which interacted with the ECA metaphor and the other half with the TEXT metaphor. The users carried out the following tasks distributed in two separate sessions (on different days):

- On the first day an experimenter trained each participant in the use of each biometric mode. The training is specific for each mode and results in the creation of a biometric trait pattern for each user. After creating the user models the impostor tests were carried out. We allowed the users to consult the biometric traits (*i.e.*, fingerprint, signature, voice sample and picture of the iris) of four people (2 females and 2 males), and we asked them to choose one of them in each of five impersonation attempts. In order to access the system (in this case as impostors) users had to successfully mimic any two biometric traits of the same person. The system returned the result of the attempt (success or failure) at the end of the verification process. After taking all of the 5 attempts the users were directed to a web questionnaire to rate the ease of use, sense of security and preference of each of the biometric modes, and to give an overall score for the system.

- The second day the users were asked to authenticate their own identity. The task was to successfully access the system three times in a maximum of 6 attempts. Just as in the impostor attempts, users had to enter two of their biometric traits in succession, after which they were informed of the system's decision to accept or reject them. In case of failure in either of the two chosen modes, the system didn't inform the users of which mode failed. At the end of this second session the users completed another web questionnaire to give us their evaluation of system privacy and an overall score of merit for the system, and for each biometric mode they rated pleasantness, ease of use and preference. In addition, those users who interacted with the ECA metaphor were asked to rate the usefulness and pleasantness of the ECA.

In addition to the questionnaire information we collected user-system interaction efficiency data such as number of failures, verification times and so on. However, in this paper we focus primarily on the users' impressions. To summarise, the parameters we have analysed are Preference, Security, Ease-of-use, Pleasantness and Privacy, all measured on 7-point Likert scales.

4 Results

We carried out a series of two sample t-tests on the two groups of users (ECA Metaphor and TEXT Metaphor) and examined the influence of the ECA on the subjective parameters of the interaction. For each of the tests we propose a null hypothesis, H_O, and an alternative hypothesis, H_1. We have chosen the 5% ($p=0.05$) significance level to reject the null hypothesis. (The questionnaire values were normalised to values between –3 and 3 for statistical processing.)

4.1 Comparative analysis of the ECA y TEXT metaphors

Our general working hypothesis is that interaction with the ECA interface will be more pleasant for the user, which will result in a higher opinion of the system. We specify this in a series of hypotheses for each of the perception parameters we introduced in the previous section:

***Hypothesis 1*:**

H_O: ECA and TEXT Metaphor users rate the **ease-of-use** of the biometric modes equally.

H_1: ECA Metaphor users rate the **ease-of-use** of the biometric modes significantly **higher** than TEXT Metaphor users.

The average ease-of-use score for the ECA Metaphor is: μ_{ECA} = 1,30; and for the TEXT Metaphor: μ_{TEXT} = 0.65. The two sample t-test showed that the difference was statistically significant (t(74)=1.94; p=0.028). Therefore we may accept the alternative hypothesis that the ECA increases the user's perception of ease-of-use of biometric technology.

***Hypothesis 2*:**

H_O: ECA and TEXT Metaphor users rate the **pleasantness** of the biometric modes equally.

H_1: ECA Metaphor users rate the **pleasantness** of the biometric modes significantly **higher** than TEXT Metaphor users.

The average pleasantness score for the ECA Metaphor is: μ_{ECA} = 1.98; and for the TEXT Metaphor: μ_{TEXT} = 1.20; The two sample t-test showed that the difference was statistically significant (t(77)=2.32; p=0.011). Therefore we may accept the alternative hypothesis that the ECA increases the pleasantness of the interaction with the biometric modes.

***Hypothesis 3*:**

H_O: ECA and TEXT Metaphor users rate the **privacy** of the system equally.

H_1: ECA Metaphor users rate the **privacy** of the system significantly **higher** than TEXT Metaphor users.

The two sample t-test showed no statistically significant difference. We are therefore unable to reject the null hypothesis. Instead we propose the opposite alternative hypothesis:

***Hypothesis 3.1*:**

H_1: ECA Metaphor users rate the **privacy** of the system significantly **higher** than TEXT Metaphor users.

The average score for the perception of privacy for the ECA Metaphor is μ_{ECA}=-1.20; and for the TEXT Metaphor: μ_{TEXT}=-0.60. The two sample t-test showed that the difference was statistically significant (t(67)=-3.42 ; p=0.001). Thus we accept in this case the alternative hypothesis that users' perception of privacy is lower with the ECA Metaphor than with the TEXT Metaphor. This result might lend support to Zajonc's (1965) suggestion that the presence of a character may enhance arousal or user sensitivity, which might explain why the user might feel uneasy letting the agent have her personal biometric traits.

***Hypothesis 4*:**

H_O: ECA and TEXT Metaphor users rate their perception of **security** of the biometric modes equally.

H_1: ECA Metaphor users' trust in the **security** of the biometric modes is **higher** than in the case of the TEXT Metaphor users.

We obtained no statistically significant results, so we reverse the alternative hypothesis:

***Hypothesis 4.1*:**

H_1: ECA Metaphor users' trust in the **security** of the biometric modes is **lower** than in the case of the TEXT Metaphor users.

Once more, our results were not statistically significant. Therefore we cannot infer any relationship between the presence of an ECA and users' sense security of a biometric system.

***Hypothesis 5*:**

H_O: Interaction with the ECA Metaphor and with the TEXT Metaphor is equally **efficient**.

H_1: Interaction with the ECA Metaphor is **more efficient** that interaction with the TEXT Metaphor.

The objective parameter categories compared were speed (verification times and reaction times) and efficiency (number of verification failures, false matches and false rejections). We found no statistically significant differences between the averages of any of these variables across the two metaphors. Therefore we cannot determine any influence of the ECA on the actual efficiency of the interaction.

The fact that our system is multibiometric –in that it requires simultaneous verification of two from among four possible biometric traits– affects the complexity of the verification process (Ubuek, 2003). We now look at the effect our ECA had on the users' perception of the cognitive demand and of the need for the extra security our multibiometric system is supposed to provide:

***Hypothesis 6*:**

H_O: ECA and TEXT Metaphor users feel equally about the need to require two biometric modes for identity verification to ensure **security**.

H_1: ECA Metaphor users feel that the requirement of two biometric modes for verification enhances **security** to a **greater** extent than in the case of the TEXT Metaphor users.

The average score for the perceived need for the enhanced security provided by multibiometrics is, for the ECA Metaphor: μ_{ECA}= 2.8; and for the TEXT Metaphor: μ_{TEXT}=2.1. The two sample t-test showed that the difference was statistically significant ($t(12)=2.28$; $p=0.021$). Therefore we may confirm the alternative hypothesis.

We found no statistically significant differences between the two metaphors regarding the users' perception of the extra cognitive demand of multibiometrics.

Table 1 summarises our results.

EFFECTS ON THE USER	ECA Metaphor (vs. TEXT Metaphor)
Subjective impressions of users	Greater ease-of-use Greater pleasantness
	Less privacy
User behaviour throughout the interaction with the system	We didn't reach definitive conclusions
Improvement in task execution	We didn't reach definitive conclusions
Impressions regarding multibiometrics	Enhanced security

Table 1: Comparative results

5 Conclusions and future lines of research

Some of the most serious obstacles to widespread use that biometic technology is facing are related to user interaction and acceptance. We believe the results presented in this paper open interesting new lines of research. We found that the presence of an ECA (persona effect) makes users experience interaction as easier and more pleasant. Regarding sense of security, our results are in line with other studies on ECAs. The increased pleasantness of use of the biometric modes could help overcome users' reluctance to accept biometric systems. On the other hand, the presence of the ECA could have a negative affect by enhancing the users' perception of encroachment on their privacy.

We believe it may be possible to increase the level of users' perceived privacy and user trust by adopting strategies such as allowing the user to personalise the appearance and even the behaviour of the avatar, as Xiao et al. (2007) suggest. Giving the ECA greater and more natural communication skills (e.g., small talk, specific gestures, etc.) and a more empathic attitude (in line with ideas in the area of affective computing) could have further positive effects.

We may mention the inclusion of ECAs on multibiometric systems as another interesting specific line of research, given the enhancement in the users' perception of the security of such systems compared to the same without ECA.

6 Acknowledgements

This study has been possible thanks to the support grant received from the TEC2006-13170-C02-02 project of the Spanish Plan Nacional de I+D and the 04-AEC0620-000046/06 ("Recognition of facial and speech patterns for safe multimodal services in mobile communications") project by Telefónica, funded by the Comunidad Autonoma de Madrid.

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