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Culture & biometrics: regional differences in the perception of biometric authentication technologies

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Abstract Previous research has identified user concerns about biometric authentication technology, but most of this research has been conducted in European contexts. There is a lack of research that has investigated attitudes towards biometric technology in other cultures. To address this issue, data from India, South Africa and the United Kingdom were collected and compared. Cross-cultural attitudinal differences were seen, with Indian respondents viewing biometrics most positively while respondents from the United Kingdom were the least likely to have a positive opinion about biometrics. Multiple barriers to the acceptance of biometric technology were identified with data security and health and safety fears having the greatest overall impact on respondents' attitudes towards biometrics. The results of this investigation are discussed with reference to Hofstede's cultural dimensions and theories of technology acceptance. It is argued that contextual issues specific to each country provide a better explanation of the results than existing theories based on Hofstede's model. We conclude that cultural differences have an impact on the way biometric systems will be used and argue that these factors should be taken into account during the design and implementation of biometric systems.

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1 Introduction

Biometric authentication is the process of establishing an individual's identity through measurable characteristics of their behaviour, anatomy or physiology. Biometric authentication technology is beginning to mature and biometrics are finding application in both commercial and government environments. The International Biometrics Group predicts that the biometrics market will see steady growth over the coming years and will double in size by 2011 (IBG 2007). To date, biometrics have found the most traction in the United States and Europe, but future growth in the biometrics market is expected to be driven by emerging markets (Acuity 2007). For instance India, Pakistan and Ghana are countries which have all recently seen the introduction of biometric technology in the provision of financial services (Aziz et al. 2008; Michaels 2008).

There are many optimistic predictions about the future of biometrics (Jain et al. 2000; Ruttenburg and Jones 2006; IBG 2007) though numerous challenges are faced when information technologies (IT) developed in Western cultures are introduced into other cultures. There may be a poor match between a product or service designed in a developed country and its application in other cultures. This problem is perhaps more complex with biometric technology. Biometrics capture and store representations of one's 'self' and it has been argued that biometrics are an inherently emotive, ethically challenging technology (Alterman 2003). The technology may be seen as invasive or unacceptable depending on the context of use or the culture it is used in. There has been a limited amount of research investigating biometrics from a user centred perspective and most of the work that has been done has been conducted in European or North American contexts. There

has been less research that has investigated attitudes towards biometric technology in other parts of the world.

This paper presents a cross-cultural investigation of attitudes towards biometric technology. The aims of this research were two fold. Firstly, we aimed to understand how people perceive biometrics and investigate how this can change from one culture to another. Secondly, we hoped to understand how concerns about biometrics could affect the success of system implementations. A description of biometric systems and a review of related work are given. We then describe a cross-cultural investigation involving three countries and the results from this study. Finally, the implications of these findings and their relationship to existing cross-cultural methodology are discussed.

1.1 Biometric authentication

Traditional methods of user authentication are based on what the user knows or what the user has. In contrast, biometric authentication establishes identity based on what the user is; unique aspects of physiology, anatomy or behaviour are used to confirm someone is who they claim to be. Knowledge-based authentication methods, such as passwords and personal identification numbers (PINs) consist of non-obvious information that is recalled from memory to confirm the legitimacy of an individual. Token-based authentication relies on the presence of a physical object to authenticate users and keys, cards and documents are all used in this way. Many security systems use a '2 factor' approach (Sasse 2004) the card and PIN combination used at automatic teller machines being an example of this. Both knowledge- and token-based methods suffer from various drawbacks however. Passwords can be forgotten, copied or shared between users and token-based authentication suffers from similar problems (Renaud 2005). Biometric technology can confirm that the legitimate user is actually present, rather than just their password or identity token. The attraction of using biometrics is that the characteristics used to authenticate the user cannot be lost, forgotten or readily stolen. For a fuller discussion of different user authentication methods see Renaud (2005).

A review of the literature discussing biometrics reveals two distinct perspectives that authors take towards the technology. There are those who describe biometrics as a positive development and many seem to view biometrics as a new paradigm in user authentication that will eventually replace existing methods. For example Jain et al. (2000) predict that biometric technology will eventually be used in almost every transaction requiring the authentication of identity. There is also a large body of literature that discusses the limitations and problems associated with the use of biometric authentication. Perhaps chief among the criticisms levelled at biometrics are data security concerns. Ashbourn (2000) and Langenderfer and Linnhoff (2005) argue that people may have legitimate concerns about the security of their biometric information. Alterman (2003) citing the covert use of biometric technology at a major sporting event, argues that there are many uses of biometrics that are detrimental to the public at large. The concept of 'function creep' used to describe the situation where existing information is used in situations over and above what was initially agreed, has also been described as a potential problem for biometrics (Alterman 2003; Chandra and Calderon 2005). However, there has been less work published that investigates how the potential users of biometric systems perceive the technology. In the following section studies that have taken an empirical, user-centred approach to the evaluation of biometrics are reviewed.

1.2 Acceptability of biometrics

An early attempt to understand how biometric technology is perceived by the public came from Deane et al. (1995) who surveyed 76 people about their attitudes towards biometrics, as well as finding differences between peoples' perception of various different biometric modalities; they reported that biometrics as a whole were rated significantly less acceptable than passwords (Deane et. al. 1995). A more recent study that was designed to investigate how biometrics are perceived in the context of air-travel was conducted with 204 participants from Finland, Germany and Spain (BioSec 2004). Most participants reported having a positive attitude towards the use of biometrics when travelling by air, although concerns about the technology were also identified. Approximately 25% of participants worried that the use of biometrics would have a negative impact on their personal health and over 20% of respondents had concerns about the hygiene of biometric systems involving physical contact (BioSec 2004). Over half the people who took part in the BioSec survey were also afraid about a loss of privacy when using biometrics. Finally, the survey revealed cross-cultural differences between the countries surveyed, finding that German respondents knew the most about biometrics and had the most positive attitude towards their use (BioSec 2004).

Fears about the privacy implications of using biometrics have also been reported in other studies. Coventry et al. (2003a, b) reported that privacy concerns emerged during focus group discussions. A laboratory-based usability evaluation by Toledano et al. (2006) found that participants' views about the privacy of biometrics had a significant effect on their confidence in the technology. Confidence was not defined in this evaluation though, so

interpreting this result is problematic. The popular perception of biometric technology was also investigated in the UK Passport Service biometrics enrolment trial. This is one of the largest published studies of biometric technology, with over 10,000 participants tested in multiple locations in the United Kingdom. The results from this report indicate that most people were in favour of using some form of biometric technology in conjunction with national passports (UKPS 2005). However, almost one-quarter of participants were concerned about the effects of biometric technology on their civil liberties (UKPS 2005).

The research described above suggests that many people have complex, somewhat dichotomous opinions about biometrics. On the one hand, the research described above indicates that many people have concerns about the way biometric systems could be used and a number of issues with the technology have been identified. But many people also described biometrics positively or would be willing to use the technology, so there would seem to be some level of acceptability for the technology. However, all the studies described above have been conducted in Western cultures, so it would be more accurate to say that biometrics look to be appropriate for western cultures. There is much less research that has investigated how biometrics are perceived in other parts of the world, and cultural differences may mean that biometrics are a less acceptable technology in other contexts.

1.3 Culture and HCI

The social and cultural aspects of technology use are increasingly recognized as an important topic by the human computer interaction (HCI) community (Kamppuri et al. 2006). There has been a trend of moving beyond definitions of usability that emphasize efficiency and effectiveness, to include issues such as aesthetic appeal, context and culture in usability evaluation (Tractinsky 1997; Sun 2002). Culture and context are particularly important when investigating the acceptability and appropriateness of technology for a particular situation (Benyon et al. 2005). Recent examples of interactive systems that have been designed with culture in mind include automated speech recognition systems (Stewart and Chakraborty 2008), alphanumeric display interfaces (Han 2006) and mobile devices (Jhangiani and Smith-Jackson 2006). Despite this increasing attention, culture remains an under researched area in the field of HCI (Kamppuri et. al. 2006) and most usability studies do not take culture into account.

There have been several attempts at defining culture in a systematic way. In the context of this paper we will adopt the definition of culture proposed by Hofstede (1984, 2001). Hofstede describes culture as the "the collective programming of the mind which distinguishes the members of one group from people from another" (Hofstede 1984). Hofstede gives five 'cultural dimensions' that have been used to quantify differences between national cultures. There have been several reviews and replications of Hofstede's work. After a review of 550 citations of Hofstede's work, including 61 replications, Sondergaard (1994) concludes that Hofstede's cultural dimensions are largely supported. There are also detractors of Hofstede's work. Arguments have been put forward suggesting Hofstede's results were unduly influenced by the timeframe of data collection, the participants involved or that the work was methodologically unsound (Sondergaard 1994; McSweeney 2002; Jones and Alony 2007). While Hofstede's reductionist approach is in no way a comprehensive explanation of culture, the framework has been widely used across various disciplines, including information systems (e.g. Straub et al. 1997; Simon 2001), HCI (e.g. Yeo 2001; DeAngeli and Kyriakoullis 2006) and business and marketing (e.g. Everdingen and Waarts 2004; Sundqvist et al. 2005).

Hofstede proposed that there are five constructs that characterize national culture; power distance, individualism, masculinity, uncertainty avoidance and long-term orientation (Hofstede 1984). The power distance index is described as the extent to which a society as a whole accepts an unequal power distribution among its members. Hofstede suggests in cultures with high *power distance* values, people at the low end of the power hierarchy are as likely to accept power inequality as those at the top. The scale of *individualism* refers to the relative importance of individuals in a society. In collectivist societies greater emphasis is placed on groups such as the family, while in individualist societies the role of the individual is emphasized. The *masculinity* scale describes the difference between male and female gender roles. Masculine societies tend to have more assertive and competitive values, while in feminine societies gender roles and values differ to a less extent. The *uncertainty avoidance index* describes a society's tolerance of uncertainty and the unknown. According to Hofstede's model people from a culture with a high level of *uncertainty avoidance* will tend to be less comfortable in novel, unusual or unstructured situations. The final dimension of Hofstede's model, *long-term orientation* was added after the first four and describes the time focus of a culture. Cultures with a long-term orientation tend to have more respect for tradition and are orientated towards future rewards and benefits rather than short-term ones.

There has been a significant amount of research attempting to link attitudes towards technology with Hofstede's cultural dimensions. It has been suggested that *power distance* scores are negatively associated with the uptake of technology. Al-Gahtani (2002) and Everdingen and Waarts (2004) found that high *power distance* scores

had a negative impact on the acceptance of new technologies across countries. They argue that cultures with a high *power distance* score tend to have centralized decision making structures which has a negative affect on technology adoption. Previous research has found that *individualism* is positively associated with technology acceptance (Al-Gahtani 2002; Erumban and Jong 2006). It is argued that members of a collectivist society will be less likely to go against prevailing norms and attitudes, while members of an individualist society will be more willing to adopt new technologies even if they are not used by their peers (Erumban and Jong 2006). There is also evidence suggesting that *uncertainty avoidance* is negatively associated with technology adoption. Erumban and Jong (2006) and Everdingen and Waarts (2004) argue that in *uncertainty avoiding* cultures people will be less willing to venture into the unknown territory associated with new technological systems. There have been attempts to associate the dimension of *masculinity* with positive attitudes towards technology, but the empirical findings provide mixed support for this hypothesis (Erumban and Jong 2006; Everdingen and Waarts 2004).

Based on the literature discussed above we would expect biometric technology to be more acceptable in countries with low *power distance* scores, low *uncertainty avoidance* scores and high *individualism* scores. The United Kingdom and United States exhibit these characteristics under Hofstede's model and much of the user centric research into biometrics has been carried out in these countries. We would expect therefore, that biometrics would be perceived less favourably in cultures which are collectivist, have high *uncertainty avoidance* scores or high *power distance* scores. In particular, we would expect there to be a poor match between biometrics and collectivist cultures. Biometrics are an inherently individualistic technology, as access decisions are based on the physiology or behaviour of an individual. Traditional authentication approaches, such as passwords and cards, can be shared between individual or family groups. In some cultures family members or associates regularly perform tasks, such as banking, in place of the individual who registered for the service (Aziz et. al. 2008) and biometric systems would not support behaviour of this nature. We believe that there is a poor fit between biometric technology and countries where industry analysts predict the greatest growth, as many Asian and developing countries have high *power distance* and *uncertainty avoidance* scores and low *individualism* scores (Hofstede 1984). When evaluated in the West, people report significant reservations about biometrics and we predict that in many developed countries biometrics would be perceived even less favourably.

This study has two main aims. Firstly we will assess how biometrics are perceived in both Western and developing cultures. Based on the literature reviewed above we predict that the perception of biometrics across cultures will be negatively associated with Hofstede's dimensions of *power distance* and *uncertainty avoidance* and positively associated with the *individualism* scale. Secondly, this study will investigate what concerns people have about biometrics in developing countries. It is hoped that this information will be able to be used to improve the design and implementation of biometric systems in the developing world.

2 Methodology

A survey approach was used to investigate peoples' perceptions of biometric technology. Three counties were selected for this evaluation to investigate how perception differs according to national culture. Countries that are thought of as potential markets for biometric technology and that differ as measured along Hofstede's cultural dimensions were selected. India was selected as an example of an Asian country with an emerging economy that is often thought of as a large market for biometrics. South Africa was chosen as it is culturally and geographically different to India and is also seen as an emerging market for biometrics. The United Kingdom was included in this study as an example of a developed European country. India, South Africa and United Kingdom, as categorized by Hofstede's cultural dimensions can be seen in Table 1 below. A measure of economic development has also been included.

Technology acceptance models (TAMs) were considered as an evaluation tool during this study. TAMs, such as the original model from Davis (1989), have been widely used to investigate how IT systems are perceived and technology acceptance is a well researched area in the information systems domain. It was decided that a TAM approach was not suitable for this evaluation however. Firstly, this study includes an exploratory element and we hope to identify the full range of opinions people have

Table 1 Cultural dimensions and development rating for India, South Africa and the United Kingdom

	India	South Africa	United Kingdom
Power distance	77	49	35
Individualism/collectivism	48	65	89
Uncertainty avoidance	40	49	35
Masculinity/femininity	56	63	66
Long term orientation	61		35
UN development rating	0.611	0.653	0.940

Taken from United Nations Development Report 2006, Geert-Hofstede.com 2008

Table 2 Layout of the questionnaire

Survey categories	Number of questions
Knowledge of biometrics	7
Usability and reliability perceptions of biometrics	15
Acceptability of biometrics	3
Fears or concerns about the technology	9
Demographic questions	8

about biometrics. TAMs use a defined approach of previously accepted dimensions (Venkatesh et al. 2003) and are not well suited to exploratory investigations. Secondly, TAMs have found most application assessing systems which people may choose to use, to assist their work or daily life. Authentication systems are an unusual class of technology, however, as security and identity verification are seldom a users' primary goal. Typically, people are asked to use an authentication mechanism and make an on the spot decision about whether to use the system in order to accomplish what they originally planed do and issues like perceived usefulness become less relevant. Finally, previous studies have suggested that TAMs are poor cross-cultural investigation instruments (Straub et. al. 1997). For these reasons a TAM approach was not used in this study.

Based on the review of literature discussed above an original survey was designed to investigate peoples' perceptions of biometric systems. The questionnaire included questions on the perceived privacy, safety, usability and acceptability of biometrics. A combination of rating scale and ranking questions were used. A single open-ended question was also included to collect qualitative data. The five sections that made up the survey are described in Table 2. Following the knowledge of biometrics section, participants were given a brief description of biometrics where the operation of biometric technology as an authentication mechanism was described.

The survey was administered online and distributed in India, South Africa and the United Kingdom. Indian and South African respondents were rewarded for completing this survey while sampling in the United Kingdom followed a snowball approach and people were not paid for taking part. All respondents answered an electronic version of the questionnaire. The survey was conducted in the English language in all three countries.

3 Results

The results presented below include an outline of the sample characteristics from each country and a summary of the major results found. Results from the closed-ended questions are presented first followed by an analysis of the qualitative data. Unless otherwise stated, high ratings in the figures below indicate a positive opinion. The relevant questions are given below each figure.

Table 3 Sample demographics from India, South Africa and the United Kingdom

	India	South Africa	United Kingdom	Overall
Gender (%)				
Male	51	45	57	51
Female	49	55	43	49
Age(%)				
18–24	34	15	34	27
25–34	39	38	28	35
35–44	14	27	17	20
45+	13	20	21	18
N	202	202	177	581

3.1 Sample characteristics

The total number of respondents was similar across the three countries surveyed. The gender split of the sample was also broadly equal across each country. Table 3 gives the nationality, gender and age breakdown of all respondents.

3.2 Knowledge of biometrics

In general participants had a low level of familiarity with biometric technology, as can be seen in Fig. 1 below. A Kruskal–Wallis test revealed that there was a difference in the reported knowledge of biometrics across the three cultures ($H(2) = 25.4$, $p < 0.001$). Bonferroni corrected,

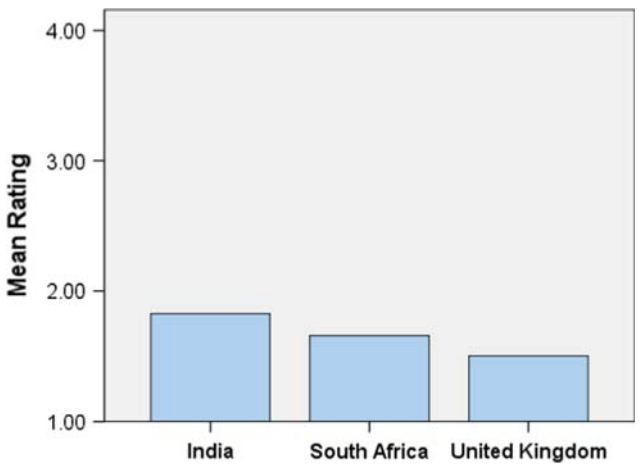

Fig. 1 Knowledge of Biometrics in India, South Africa and the UK (How much do you know about biometric technology? 1—very little, 2—a small amount, 3—a little, 4—a great deal)

Mann–Whitney post hoc tests were carried out at a 0.0167 level of significance. The post hoc testing showed that Indian respondents were more familiar with biometrics than British respondents ($U = 13948$, $p < 0.0167$) but there was no difference between Indian and South African ($U = 18270$, $p < 0.049$) or British and South African ($U = 15695$, $p < 0.022$) respondents. Participants were also asked whether they had used biometrics before. Thirty-nine percent of Indian, 36% of South African and 24% of British respondents reported having used biometric systems in the past. A Chi-squared test revealed this to be a significant difference in experience with biometrics across the three countries (χ^2 (2) = 10.40, $p < 0.01$).

3.3 Perception of biometrics as an authentication mechanism

Participants were asked about biometrics as a personal authentication method. Questions about the perceived ease of use, speed of use and security of biometric technology were asked and the results are shown in Fig. 2 below. Indian respondents rated biometrics the most positively across all three dimensions and British respondents the least positively. These data did not meet the assumptions of parametric testing, so Kruskal–Wallis tests were used to assess the results across the three cultures. These tests revealed significant cross-cultural differences in perception of ease of use ($H(2) = 46.3$, $p < 0.001$), speed of use ($H(2) = 57.2$ $p < 0.001$) and security ($H(2) = 84.4$, $p < 0.001$) of biometric systems. Bonferroni corrected, Mann–Whitney post hoc tests revealed that cross-cultural differences were significant across all three variables, with the exception of the perceived ease and speed of use between Indian and South African respondents.

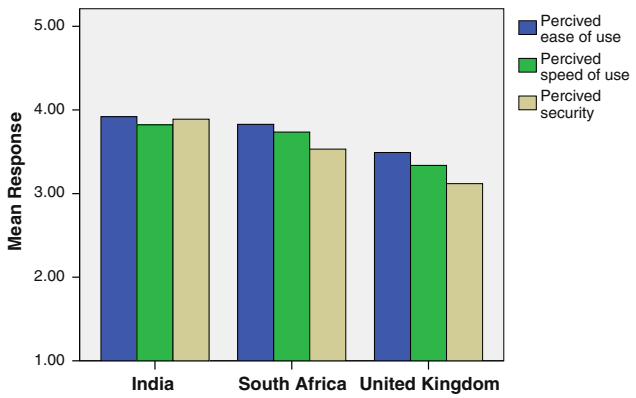

Fig. 2 Perception of biometric technology in India, South Africa and the UK *(I think biometric technology would be easy to use 1—strongly disagree 5—strongly agree; I think biometric technology would be fast 1—strongly disagree 5—strongly agree; I think biometric technology would be secure 1—strongly disagree 5—strongly agree)*

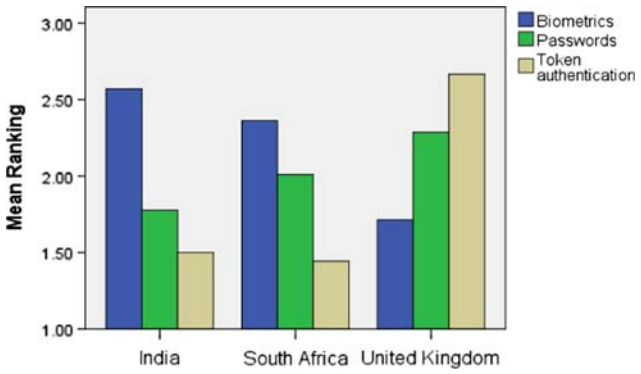

Fig. 3 Acceptability of biometric, knowledge and token based authentication *(Please rank the following methods of identification by how acceptable they are to you. 3—most acceptable, 1—least acceptable)*

Participants were also asked how they viewed biometrics relative to other methods of personal authentication. Indian respondents ranked biometric technology as the most acceptable authentication mechanism, preferring biometrics over knowledge- and token-based authentication. A Friedman's test revealed this to be a significant difference ($\chi^2(2) = 111.4$, $p < 0.001$). South Africans also ranked biometrics as the most acceptable form of authentication ($\chi^2(2) = 83.8$, $p < 0.001$), though they favoured biometrics to a lesser extent than Indian respondents. People from the UK ranked the acceptability of biometrics differently. For Britons, passwords were the most acceptable form of authentication, which were preferred over biometrics and token-based authentication ($\chi^2(2) = 50.9$, $p < 0.001$). These results are shown in Fig. 3 above. A Kruskal–Wallis test showed there was also a significant difference in the way the three countries rated biometrics overall ($H(2) = 24.7$, $p < 0.001$).

There were also cross-cultural differences in peoples' willingness to use biometrics. Overall, willingness to use biometrics was quite high, as the average ratings for all countries were well above the scale mid point. As the data did not meet the assumptions of parametric testing a Kruskal–Wallis test was used to compare scores for each of the countries. The test revealed that willingness to use biometrics changes over the three countries ($H(2) = 25.4$, $p < 0.001$) as can be seen in Fig. 4 below. Mann–Whitney post hoc tests showed that British respondents were less willing to use biometrics than either Indian ($U = 14312$, $p < 0.0167$) or South African ($U = 15218$, $p < 0.0167$) respondents, but there was no difference between Indian and South African respondents ($U = 19992$, $p < 0.762$). A weak but significant positive relationship was found between respondents' willingness to use biometrics and their self-rated knowledge of biometrics ($r_s = .21$, $p < 0.001$).

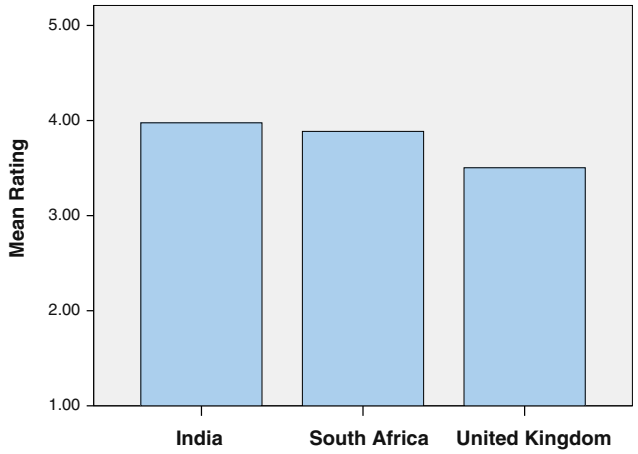

Fig. 4 Willingness to use biometric technology in India, South Africa and the UK *(How willing would you be to use biometric technology? 1—not at all willing, 5—very willing)*

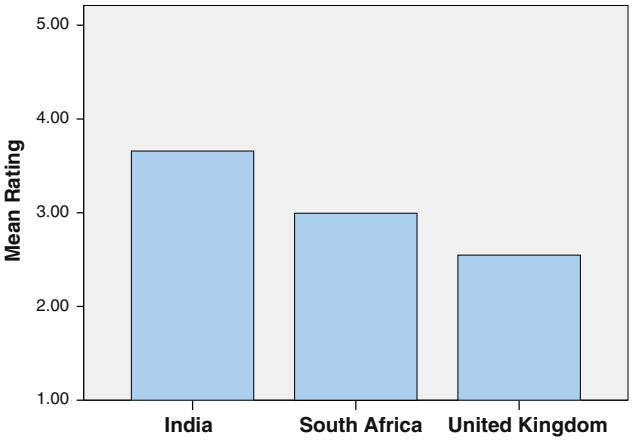

Fig. 5 Information security concerns for India, South Africa and the UK *(How confident are you that your biometric details would be stored securely? 1—not at all confident, 5—very confident)*

3.4 Concerns and barriers to the acceptance of biometrics

Questions were included on a range of issues which could be of concern when using biometrics. Two issues emerged as the most prominent. The security of biometric information was a significant concern for people in the UK with more than half of respondents indicating they were not confident their biometric information would be stored securely. Again, the data were not suitable for parametric testing so a Kruskal–Wallis test was used, which revealed a significant difference across the three countries ($H(2) = 88.3$, $p < 0.001$). South African and Indian respondents were more confident about the security of their biometric information. Mann–Whitney pair wise comparisons revealed that these differences were significant between all three countries. Indians were less concerned than South Africans ($U = 13651$, $p < 0.0167$), who were less concerned than the British ($U = 13887$, $p < 0.0167$). As seen in Fig. 5 below, average responses to this question were low, so overall it seems that participants were not confident about the security of their biometric information.

A second concern emerging from the data were fears about the health and safety implications of using biometric systems. 18.3% of Indian, 23.4% of South African and 15.8% of UK respondents believed that using biometric systems would have a negative impact on their personal health or safety. There was no significant difference between the three countries along this dimension. These are relatively small numbers of people who harbour concern about the safety of biometrics, but this variable proved to be a significant predictor of willingness to use the technology as described below.

3.5 Regression analysis

In an effort to understand the relative importance of the different elements of respondents' attitude towards biometrics, linear regression models were constructed from the results. Regression analysis was carried out to establish which variables had the biggest effect on respondents' willingness to use biometrics. In all cases, this was the dependant variable of the models described below. Tables 4 and 5 summarize the regression analysis.

Data security concerns seem to be one of the most import predictors of attitude towards biometrics for all three countries. Health and safety concerns also emerged as an important factor when predicting willingness to use biometrics. Both knowledge of biometrics and perceived speed of biometrics are significant constructs in the model describing the data from India. Perceived security of biometrics accounts for the most variance in the model for the British data. It should be noted that the model constructed for the Indian data explains a lesser amount of variance than either the South African or British models.

A regression model was also constructed for the data set as a whole. Data security and health and safety concerns emerged as the constructs which best predict willingness to use biometrics. Perceived ease of use, perceived security and knowledge of biometrics are also significant predictors, but to a lesser extent.

3.6 Qualitative analysis

An open-ended question was included in this survey to allow respondents to provide any further information about their opinion of biometrics. In all, over half of participants gave a response. A bottom up approach was used during

Table 4 Linear regression models for India, South Africa and the United Kingdom

	B	*SE B*	*β*
India $R^2 = 0.301$*			
Constant	2.192	0.183	
Data security concerns	0.284	0.029	0.342*
Health & Safety concerns	−0.402	0.105	−0.232*
Knowledge of biometrics	0.186	0.051	0.220*
Perceived speed of use	0.155	0.068	0.138*
South Africa $R^2 = 0.482$*			
Constant	2.664	0.390	
Data security concerns	0.300	0.047	0.368*
Health & safety concerns	−0.697	0.119	−0.326*
Would like more information	−0.138	0.047	−0.156*
Perceived ease of use	0.261	0.084	0.168*
United Kingdom $R^2 = 0.583$*			
Constant	0.720	0.329	
Perceived security	0.525	0.077	0.407*
Data security concerns	0.255	0.052	0.287*
Health & safety concerns	−0.717	0.146	−0.257*
Perceived ease of use	0.175	0.095	0.101*

* Significant at 0.001 level (Models forced entry)

Table 5 Linear regression model predicting willingness to use biometrics for all three countries

	B	*SE B*	*β*
Overall model $R^2 = 0.456$*			
Constant	1.518	0.185	
Data security concerns	0.280	0.029	0.360*
Health & safety fears	−0.599	0.072	−0.265*
Perceived security	0.194	0.044	0.176*
Perceived ease of use	0.167	0.053	0.114*
Knowledge of biometrics	0.131	0.039	0.106*

* Significant at 0.001 level (Models forced entry)

data analysis, where the content of the data was used to establish the themes and trends that are reported here.

3.6.1 India

One of the major themes that emerged from Indian respondents was a positive sentiment towards biometrics. Often respondents said they believed that biometrics were a positive technological innovation or that they thought biometrics would be good for particular applications in their life. Approximately one-third of respondents said they did not have any major concerns about using biometric systems. The following extracts are examples of respondents' comments about biometrics:

> [Biometrics] would be one of the most secure methods of identification.
>
> I think biometric technologies is very safe and reliable to use for personal identification of an individual. It ensures protection against unauthorized access.

A second theme that emerged was concern over the reliability and effectiveness of biometrics. People often seemed sceptical of how well the technology would work, questioning its reliability and practicality. Some respondents mentioned that they would like to see biometric systems working before they would be convinced, or gave lack of experience with biometrics as the reason why they had concerns. Many respondents also made reference to the security of their biometric information, questioning the security of centralized databases.

3.6.2 South Africa

Analysis of the qualitative data collected from South African respondents revealed concerns about the safety of using biometrics. This theme seemed to contain two elements: fear of biometrics attracting criminal activity and fears about one's own personal safety as a direct result of using biometrics. Fears about personal safety was the issue mentioned most often by South African respondents. Statements which typify this sentiment include:

> My Main concern is safety - if my body parts are like access keys, there is a threat to me?
>
> There are some criminals that pay more attention to detail in their profession than law abiding folk do to theirs! They have the resources to beat any system, and I don't think biometric technology is any different.

Concerns about the privacy and security of biometrics were a second theme that emerged from South African respondents. Many participants reported that they were wary of a centralized database where biometric information was held. Often, the potential for such a database to be compromised was implied in responses. A third theme that emerged from respondents was concern about the reliability and performance of biometric systems, with respondents questioning how well the technology would actually work. Overall, slightly less than one-quarter of South African respondents reported that they had no major concerns about biometrics.

3.6.3 United Kingdom

A major theme that emerged from British respondents was concern about the use and reliability of biometrics. This was expressed in a number of different ways, with

participants questioning the reliability, performance and accessibility of biometrics. Fear of being denied access also seemed to be part of this concern. The statement below is an example of one participant's response:

> [I am] concerned about the reliability of equipment and the personal consequences of system failure.

A second theme that was clear from United Kingdom respondents were concerns about the privacy impact of biometric systems. This was also a major theme in the data, with almost as many respondents mentioning privacy as reliability issues. Many people reported concerns about how their personal data would be used and stored. A number of respondents reported fears about biometric information being used for marketing or other commercial purposes. An example from one participant is given below:

> My major concern is not so much the reliability of the data capture and the technology used but the use of the data once it captured. I have concerns that the data may fall into the wrong hands and be used for purposes that were never intended e.g. insurance checks, identity theft etc.

Approximately 5% of British respondents reported that they had no major concerns about using biometrics, a smaller proportion than South African or India respondents.

4 Discussion

Clear cross-cultural differences were seen in this investigation and respondents from South Africa, the United Kingdom and India perceived biometric technology differently. In general, Indians had the most positive attitude towards the technology and British had the least positive views. This result was found in both the quantitative and qualitative data collected in this study. Indians tended to rate biometrics as more secure, faster and easier to use than either British or South African respondents. Indian respondents were also significantly less likely than their South African or United Kingdom counterparts to rate data security or privacy concerns as a problem.

Contrary to what was predicted at the start of this study, the construct of *individualism* was negatively related to participants' attitude towards biometric technology. India is a collectivist society and the UK is at the individualist end of the scale, though Indians were the most positive towards biometrics and Britons the least. Likewise *power distance* scores were positively associated with willingness to use biometrics, while the literature suggests that technology would be perceived more positively in individualistic societies. *Masculinity*, often thought to be negatively associated with technology diffusion was found to be positively associated with respondents' perceptions of biometrics. The construct of *uncertainty avoidance* did not have a clear relationship with attitude towards biometric technology in this study.

These results suggest that the Hofstede's cultural dimensions cannot be used to explain the cross-cultural differences seen here. The assertions of Al-Gahtani (2002), Erumban and Jong (2006) and Everdingen and Waarts (2004) about the relationship between culture and attitude towards emerging technologies were not supported by the results of this study. It is our opinion that it is difficult to move from high level, reductionist categorizations of culture to peoples' opinions about a specific technology in a meaningful way.

There are other interpretations of the cross-cultural differences seen in this investigation, which do not rely on taxonomic cultural models. We believe that local, contextual phenomena specific to India, South Africa and the United Kingdom offer a better explanation of the results of this study. For instance, the proposed identity card scheme currently receiving media attention in the United Kingdom may have influenced British respondents' perceptions towards biometric technology. The National identity card would be a mandatory system involving the collection of biometric information. The scheme has attracted a significant amount of negative media attention and a large proportion of the UK population are opposed to the programme (Joinson et al. 2006). Opposition towards the ID scheme may have transferred to biometric technology in a general sense and could account for some of the negativity seen among British respondents in this investigation.

Similarly, the comparatively high rates of violent crime in South Africa could be one of the reasons why personal safety fears emerged as a strong theme from South African participants. The level of violent crime in South Africa is significantly higher than either India or the United Kingdom (United Nations 2002), and provides a more direct explanation of the results than a system of cultural dimensions. The level of crime may also help explain why the technology tended to be perceived favourably by South Africans, as high crime rates could contribute to people viewing security and secure forms of authentication more favourably.

Finally, Indian respondents viewed biometrics the most positively. From the existing literature on culture and technology we predicted that Indians would have the most reservations about biometrics. One explanation for this finding could be the relatively strong position of IT in Indian society as a whole. India has a comparatively high number of university students studying technical or scientific disciplines, approximately 46% of undergraduate Indian students study science or technology (Shukla 2001),

compared with the 37% of British students (Royal Society 2006). India also has one of the world's largest and most successful IT industries, which accounts for a substantial proportion of Indian GDP (NASSCOM 2008). This emphasis on science and technology in Indian society may account for some of the positivity towards biometrics, a new and emerging technology that was seen in this study.

Differing levels of knowledge about biometrics offer a further explanation of the cross-cultural differences observed. It is possible that as people become more familiar with the technology they are less likely to harbour reservations about biometrics. As people habituate to biometrics, unrealistic fears about the safety or security of the technology may become less pronounced. Respondents from India, South Africa and the United Kingdom had different levels of familiarity with biometrics, which corresponds with the perception of the technology in each culture. At an individual respondent level, there was a small but positive correlation between knowledge of biometrics and willingness to use the technology. However, knowledge of biometrics was a weak predictor of willingness to use biometrics in the overall regression analysis, so the different level of familiarity provide only a partial explanation of the attitudinal differences observed.

4.1 Barriers to the acceptance of biometrics

The results of this study also highlight genuine concerns people have regarding the use of biometric authentication systems. Data security and personal safety concerns emerged as the two principal reservations that people have about biometrics, and this finding corresponds with the literature described in the introduction to this paper. The regression models revealed that concerns over the security of biometric data is the single most important issue when predicting opinion towards biometrics. Perhaps it is not surprising that data security concerns emerged as an issue considering the frequency of data security incidents that gain media coverage. Recent examples of large organizations failing to safeguard personal information are well publicized in the popular press and could well have contributed to peoples' distrust about biometrics. For example, US retailer TJX losing 45.7 million credit card records to malicious activities received international media attention (BBC 2007; CNN 2007). Organizations failure to safeguard this type of personal information is likely to have made some participants wary about the security of their biometric information.

Though only a small percentage of respondents were concerned about the health and safety of biometrics, this too had a substantial effect on opinion. The regression analysis suggests that the people who do harbour health and safety concerns are not at all willing to use the technology. A relatively small percentage of respondents reported such concerns though this variable accounted for the second largest amount of variance in the regression analysis. Perceived security of biometrics was the third strongest predictor of willingness to use biometrics, indicating that functionality of the technology is also an important issue for many. Doubts about the reliability of biometrics emerged as a major theme in the qualitative data, though this issue was not seen as clearly in the quantitative analysis.

4.2 Limitations

Significant results were found in this investigation, though there are limitations of the research approach that affect what conclusions can be drawn. This survey was conducted exclusively in the English language. Though English is spoken widely in both India and South Africa, it is not the first language of the majority of people in either country. The requirement of English proficiency will most likely have introduced a bias into the South African and Indian sample, with an over representation of educated participants. Given this sampling bias the results of this study best describes the perception of biometrics among a subset of the population in India and South Africa, rather than the public at large.

The extent to which the sample of this study and the sample of Hofstede's study overlap is a further issue which impacts the interpretation of results. If this study attracted respondents from a markedly different demographic than the participants in Hofstede's analysis, then any comparison of these results with Hofseted's model are weakened. Hofstede's model was based upon data collected from IBM employees. In both India and South Africa the people who worked for this organization were likely to be comparably well educated and have comparatively strong English language skills, given that they worked for a Western multinational company. Therefore, the sampling bias present in this study is likely to be similar to biases that were present in Hofstede's data collection and it is probable the respondent demographics in both studies are similar enough to allow meaningful comparison.

Participants in this study were offered an incentive to complete the survey, which could also have affected the responses collected. Literature on this issue suggests that financial incentives affect drop-out rates of online surveys, but do not have a large effect on the nature of participants' responses (Frick et al. 1999) or on respondent demographics (Roberts et al. 2000).

5 Conclusions

Overall the results of this survey suggest that most people have a positive attitude towards the use of biometric

systems. However, this investigation also revealed that some people have genuine concerns about biometric authentication technology. Chief among barriers to the acceptance of biometrics are concerns about the security of biometric information. This is a problem for the implementation of biometrics, as privacy and data security issues are 'back end' properties of a system. It is difficult to convey data storage or privacy policies through the design of a biometrics user interface, so this would be a difficult problem to overcome. The second biggest issue that may affect the uptake of the technology are the health and safety consequences of using biometric devices.

Cross-cultural differences were identified through this investigation. In general, Indians were more receptive to the idea of biometric authentication and were less worried about the implications of using the technology than the British or South Africans who took part in this study. Biometrics could be an appropriate technology in the Indian context given the positive opinion many expressed. The results from this survey also suggest that South Africans may be accepting of biometric technology. Respondents from the United Kingdom, however, did not rate the technology in a positive way and large-scale consumer facing implementations in the context would likely face significant resistance.

The use of Hofstede's model of cultural dimensions does not provide a clear explanation of the cross-cultural attitudinal differences observed. There are two interpretations of this result: theories about the relationship between culture and technology acceptance may have been overstated or biometrics may be a special or unique type of technology. We believe that specific contextual factors unique to each country and differences in the underlying familiarity with biometric technology provide a better explanation of the attitudes differences observed across India, South Africa and the United Kingdom than Hofstede's cultural dimensions. For almost any technological system though, there will be specific contextual or historic issues that affect the way it is perceived in a given culture or community. In this regard we do not view biometrics as unique; there will likely be similar contextual issues that affect the way other technologies are perceived. Making decisions about the implementation or design of technological systems based on high-level models of culture only is unlikely to be sufficient. An assessment of the culture and context of use is necessary to ensure that products are successful when released across multiple markets.

Organizations would do well to consider cultural differences before implementing biometric systems. Rather than following a technology deterministic course, implementing biometrics wherever transactions are carried out, biometrics are likely to be most appropriate where there is a need for new secure authentication mechanisms. Biometrics have proven to be a controversial and emotive technology and ultimately the success of biometrics depends on the views of those people who will use it.

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