BIOMETRICS: CULTURAL DIFFERENCES IN THE PECEPTION OF BIOMETRIC TECHNOLOGY.

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ABSTRACT

In a world of evolving technology and culture the use of biometric authentication technology is becoming increasingly popular in both commercial and government environments. However, the acceptance of biometric technology varies across cultures. 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 with Indian respondents viewing biometrics most positively while respondents from South Africa despite it being more diverse (by ethic fractionization) 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.

INTRODUCTION

Biometric authentication refers to the security procedure that involves the use of unique

biological characteristics of individuals such as retinas, irises, voices, facial characteristics, and fingerprints in order to

verify people are who they claim to be. This process is used to control access to physical and digital resources, such as

buildings, rooms, and different devices.

The word biometric is a combination of two words: bio (human) and metric (measurement). In simpler words, biometrics

are any metrics related to human features which make an individual different from other individuals.

Now, although biometric systems can combine authentication and identification, there is a major difference between the

two. Specifically, identification asks, "who are you?" while authentication asks, "Are you who you say you are?" Biometric

identification verifies you are you based on your body measurements. Biometric authentication goes one step further

and uses that information to compare you against a database and enters your information in service.

The International Biometrics Group predicts that the biometrics market will see steady growth over the coming years and

will double in size by 2025-2027. 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. For instance, Australia, Austria,

Brazil, India and China are countries that have introduced biometric authentication for various purposes, such as voting

and ePassports. According to J.D. Power's annual survey of U.S. retail banking, the percentage of new accounts being

opened through a bank's website or mobile app rose from 22 percent in 2019 to 31 percent in 2020. And by 2021, a full

41 percent of U.S. retail banking customers described themselves as "digital only." But this isn't just in banking. In other

verticals—take healthcare for example—remote onboarding of patients was barely in its infancy pre-pandemic, but the

sudden necessity of delivering high-volume digital health services (or "telehealth" services) led to a frantic adoption of

makeshift digital identity processes that, to be candid, weren't always so robust, convenient, or secure.

We expect several things about this to change in 2023. First, healthcare payers and providers are likely to rethink many

of their existing digital identity processes and replace One Time Passwords (OTPs) and other legacy factors with

biometric-based patient onboarding and ongoing authentication, which is both exponentially more convenient and more

secure.

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 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.

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 behavior are used to confirm who someone is who they claim to be. Knowledgebased 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. Tokenbased 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 '2factor' 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 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 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.

ACCEPTABILITY OF BIOMETRICS

Recent research has shown a growing acceptance of biometric technologies, particularly multimodal biometrics, which combine multiple biometric features for identification.

A study published in SpringerLink analyzed user awareness and acceptability of multimodal biometrics (MMB) for online transactions. The study was based on five perspectives: User Acceptability, Cognizant Factors towards Biometrics, Technological factors, Perceptional Factors (Fingerprints, Iris, Face Recognition, and Voice), and Data Privacy Factors. The research found a significant effect of Data Privacy Factors and Perceptional Factors on the adoption of MMB. In terms of User Acceptability, certain factors were found to be vital for consideration.

Another study published in MDPI found that multimodal biometric recognition received significantly more positive ratings than unimodal biometric recognition3. The study proposed that universities utilize biometric technology, particularly facial recognition, to assess users' acceptance of the system3. However, it's important to note that while the acceptance of biometrics is growing, there are still challenges to overcome, particularly in terms of data privacy and security4. The success of biometric technologies depends on user acceptability, ease of application, and the assurance of data privacy and security.

Fears about the privacy implications of using biometrics have also been reported in other studies. Coventry et al. (2003 a,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 n 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 favor 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.

CULTURE

Recent research has explored the social and cultural aspects of biometrics, focusing on issues such as privacy, individual participation, societal impacts, and legal considerations.

A study titled "Social Impact of Biometric Technology: Myth and Implications of Biometrics: Issues and Challenges" discusses the myths and misrepresentations, vulnerability points, and major concerns of biometrics. The study emphasizes that the effectiveness and acceptability of biometrics depend upon the social and cultural values of users' population. It also highlights that every innovation faces social, cultural, and legal constraints, which influence the acceptance of the system by clients, its throughput, or the decision to utilize biometrics as a primary security tool.

Another research paper investigates the social implications of biometrics pertaining to the ethics of privacy and the ownership of individual biometric data. The paper suggests that these issues can be resolved through the establishment of a Biometric Commission by introducing global standardized biometric uniformity and guidelines that will ensure their technological foundations.

The National Academies Press also published a report titled "Biometric Recognition: Challenges and Opportunities", which explores biometric systems and individual participation, potential impacts on society of biometric systems, legal considerations with respect to biometrics, and data collection and use policies.

In a report titled "The Effects of Social Issues and Human Factors on the Performance of Biometric Systems", the authors review the most important/recent works concerned with the effects of human factors on the performance of biometric systems. The report covers the state of the art on time-passing effects, mood-variation effects, and behavioral factors effects on the performance of biometric recognition systems.

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 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 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 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 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 score had a negative impact e impact on the acceptance of new technologies across countries. They argue that cultures with a high-power distance score tends to have centralized decision-making structures which has a negative effect on technology adaption. 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 sug- gesting 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 favorably in cultures which are collectivist, have high uncertainty avoidance scores or high-power distance scores. We would expect there to be a poor match between biometrics and collectivist cultures. Bio- metrics are an inherently individualistic technology, as access decisions are based on the physiology or behavior 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 behavior 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 favorably. 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.

METHODOLOGY

A survey approach was used to investigate peoples' perceptions of biometric technology. Two 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. India and South Africa, as categorized by Hofstede's cultural dimensions can be seen in Table 1 below.

	India	Saoth Africa
Power Distance	77	49
Individualism/collectivism	48	65
Uncertainity avoidance	40	49
Masculinity	56	63
Long term orientation	61	
UN development rating	0.611	0.653

A measure of economic development has also been Included. Technology acceptance models (TAMs) were condidered 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 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 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.

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

The survey was administered online and distributed in India and south africa. All respondents answered an electronic version of the questionnaire. The survey was conducted in the English language in both countries.

★ *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 biometric

"[*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 skeptical of how well the technology would work, questioning its reliability and practicality. Some respondents mentioned that they would like to see biometric 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.

★ *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, is there 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.

DISCUSSION

Clear cross-cultural differences were seen in this investigation and respondents from South Africa and India perceived biometric technology differntly. In general, Indians had the most positive attitude towards the technology and Africans had less 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 South African respondents. Indian

respondents were also significantly less likely than their South African 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. 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 crosscultural 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 manner.

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 India , 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 favorably by South Africans, as high crime rates could contribute to people viewing security and secure forms of authentication more favorably.

 Indian respondents viewed biometrics 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. India has a comparatively high number of university students studying technical or scientific disciplines, approximately 46% of undergraduate Indian students study science or technology 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 technology, they are less likely to harbor 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 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 provides only a partial explanation of the attitudinal differences observed.

CONCLUSION

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

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 biometric technology. 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 better explanation of the attitudes differences observed across India and 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 each 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.

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