

# An Empirical Study of Korean Culture Effects on the Usability of Biometric Symbols

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## ABSTRACT

Biometrics is an umbrella term for methods that identify an individual based on physiological and/or behavioral characteristics such as fingerprint, face, iris, retina, vein, palm, voice, gait, signature, etc. The use of biometric systems is increasing worldwide; consequently there is a need for understanding its procedures via common biometric symbols. However, people with different backgrounds, such as native language, culture, customs, life style, education level, and religion, have various perceptions and expectations of any given symbol. We evaluated how Korean culture influences the use of biometric symbols. Our study was performed by interviewing 100 subjects residing in South Korea using 24 symbols which were developed by the National Institute of Standards and Technology (NIST) Biometrics Usability group. The results present empirical evidence of potential differences in understanding and expectations of biometric symbols due to Korean culture and user knowledge.

**Keywords:** Biometrics, Usability, Symbol, Cultural factors, Korean

## **INTRODUCTION**

The collective term for methods that identify an individual based on physiological and/or behavioral characteristics (e.g. fingerprint, face, voice, etc.) is biometrics (Jain et al., 2004).

System designers and developers recognized early on that products should be user-friendly. An usability study is one way that ensures that products are both usable and intuitive, i.e. the user is able (a) to figure out what to do, and (b) to tell what is going on (Norman, 1988).

The use of biometric systems is increasing worldwide, e.g. airport, access control, etc. Consequently, there is a need for users to understand easily and efficiently the procedures of any biometric systems. The National Institute of Standards and Technology (NIST) Biometrics Usability group is devising symbols for use within biometric systems, aiming for biometric usability improvements (Mary et al., 2008).

One important aspect is that people with different backgrounds, such as native language, culture, customs, life style, education level, and religion, have varying perceptions and expectations of any given symbol. This means that a symbol might be clearly understandable for one user (or one nation), but not understandable for another (or another nation) (Nielsen, 1994).

In this paper, we present an empirical study to evaluate possible Korean cultural effects on interpreting symbols that were designed to be used in biometric systems. 100 participants residing in South Korea contributed to our evaluation via interviews and structured surveys. We illustrate our results using the usability method “As-Is-Analysis” (Mary et al., 2008) and discuss our assumptions based on the analyzed data.

This paper is divided into five sections. This section served to introduce the notion of biometrics and its usability. The second section gives an overview on our method and evaluation procedure. We present the collected data and discuss the analyzed results in the third and fourth sections. The last section contains conclusion and future works.

## **METHOD**

### **PARTICIPANTS**

All 100 participants were of Korean origin except for one person. We later discovered that the person was born in Indonesia, but he has been staying in Korea for some period of time. Based on the fact that this person has enough knowledge of Korean’s culture we decided to include him in our experiment.

Of the 100 participants, gender was near evenly distributed with 51% of the participants being male and 49% female. The average age of the participants was 28 years old. The data was collected of people with diverse occupations such as student, associate, service worker, soldier, teacher, etc. Some of associates are related to IT field and some are

not. The demographic results for age and occupation are illustrated in Figure 1.

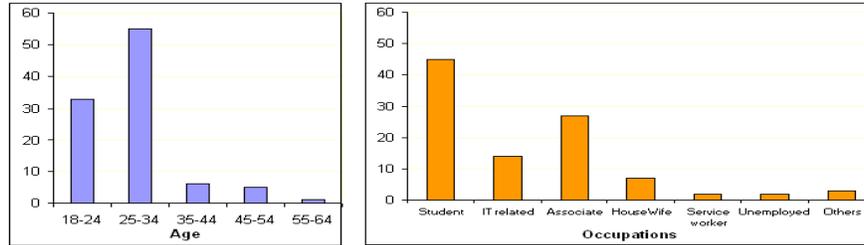
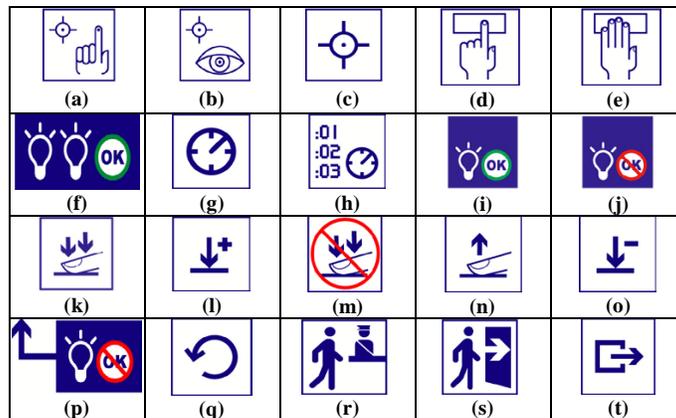


FIGURE 1 Participant's Age and Occupation Ranges

We conducted the study by interviewing two different groups. For the first group (Group-1), the data was collected from 22 participants who were either attending (or visitors) the engineering school of Chung-Ang University. The data of the second group (Group-2) was gathered by asking people on the street or by visiting commercial stores nearby Chung-Ang University. There were 78 people in Group-2. The occupations and ages of Group-2 were more diverse than those of Group-1.

## APPARATUS

The symbols provided by NIST were of two types. The symbols in the first type were designed such that each symbol has only one meaning: the symbols with their intended meanings are given in Figure 2. The second type (Figure 3) was composed by combining multiple symbols to indicate sequential steps in a biometric collection process.



**Intended Meanings:** (a) Fingerprint scan, (b) Iris scan, (c) Capture, (d) Left Index finger on platen, (e) Left 4 fingers on platen, (f) Ready State, (g)-(h) Wait/hold, (i) Acceptable, (j) Unacceptable, (k)-(m) Press less, (n)-(o) Press less, (p)-(q) Try again, (r) See guard, (s)-(t) Exit

FIGURE 2 Symbol Evaluation Type 1

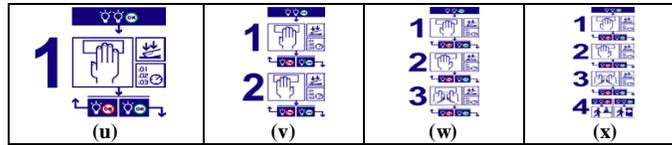


FIGURE 3 Symbol Evaluation Type 2

## DATA COLLECTION PROCEDURE

As a preliminary step to the study itself, all textual materials were translated into Korean by a native speaker residing in South Korea. All participants were instructed and interviewed by a native speaker.

The study was conducted in two parts. In part one, *Interpretive*, the participants were shown 24 biometric symbols (Figure 2 and 3) one at a time and were asked to interpret them freely and to describe their impressions in words. The only instruction given to the participants was that the symbols might be used for biometric systems. In part two, *Matching*, each participant was presented the 20 biometric symbols (Figure 2) and were asked to pick, for each symbol, one answer out of the 22 choices (Table 1) which they thought matches the symbol the best. The symbol order for the two parts was different, to avoid interference between the interpretive and matching results.

Table 1 Given Meanings for Matching

Num	Meaning	Num	Meaning	Num	Meaning
1	Ready state	9	Start iris scan	17	Unacceptable capture
2	Wait/Hold	10	Look here	18	Try again
3	Start Capture	11	Move hand forward	19	Exit
4	Go in that direction	12	Press more	20	See guard
5	Scan fingers	13	Press less	21	Turn in a circle
6	Start biometric scan	14	Do not press	22	None of the above
7	Start fingerprint scan	15	Give up		
8	Scan index finger	16	Acceptable capture		

## RESULTS

### PART ONE: INTERPRETIVE

In this part, the participant provided a free-form written description of what he/she believed each symbol represents. For analysis purposes, the collected written responses were categorized into three classes: 1) "Correct"- the interpretation matched the intended meaning; 2) "Approximate"- the interpretation is related to the intended meaning or to a concept that can lead to the intended meaning, but not exactly; and 3) "Incorrect"- the interpretation is totally unrelated to the intended meaning. The results from this analysis are presented in Table 2. The lower-case letters in Table 2 correspond to the symbols in Figures 2 and 3. On average, across all 24 symbols, only 16% were correct, 24% were approximate, and 60% were incorrect.

**Table 2** Categorized Answers (Average: correct (16.3%) approximate (24.0%) incorrect (59.6%))

Symbols	(a) fp scan	(b) iris scan	(c) capture	(d) left index	(e) left 4fp	(f) ready
Correct	18%	25%	5%	13%	16%	7%
Approximate	24%	26%	22%	45%	33%	16%
Incorrect	58%	49%	73%	42%	51%	77%
Symbols	(g) wait/hold	(h) wait/hold	(i) accep.	(j) unaccep.	(k) press •	(l) press •
Correct	4%	7%	18%	17%	21%	43%
Approximate	50%	28%	7%	6%	48%	19%
Incorrect	45%	64%	75%	77%	30%	38%
Symbols	(m) press •	(n) press •	(o) press •	(p) try again	(q) try again	(r) see guard
Correct	13%	0%	40%	4%	9%	19%
Approximate	53%	1%	7%	12%	27%	46%
Incorrect	34%	99%	53%	84%	64%	35%
Symbols	(s) exit	(t) exit	(u) 1 step	(v) 2 steps	(w) 3 steps	(x) 4 steps
Correct	22%	17%	12%	22%	21%	17%
Approximate	39%	29%	12%	6%	11%	10%
Incorrect	39%	54%	76%	72%	68%	73%

For symbols (a) and (b), the intended meanings are “fingerprint scan” and “iris scan”. Several participants interpreted symbol (a) as “pointing at something” or “press something”. Over 30% of the participants commented that symbol (b) was related to the eye rather than specifically to the iris. Of this 30%, some were categorized as correct, while others were categorized as approximate or incorrect—depending on the details of the participant’s response.

Most participants struggled with symbol (c)—only 5% got this symbol correct and 73% got it incorrect; the answers ranged from “sun” to “aiming/shooting” instead of the intended meaning “capture”. The symbols (f), (i), and (j) with their intended meanings of “ready state”, “acceptable”, and “unacceptable” were also not well understood. Most comments involved “light”, e.g. “turning on/off the light.”

Symbols (g) and (h) both stand for “wait/hold, both of these symbols scored poorly (4% and 7% correct, respectively). More than 30% people interpreted (g) as “clock” which we classified as “approximate”.

Symbols (k) and (l) with the intended meaning of “press more”, the answers for (k) were mostly related to “press”, while for (l) the answers were either very accurate or very disconnected from the intended meaning (e.g. “dropping” or “hospital”).

Symbols (m), (n), and (o) stand for “press less”. More than 40% of the participants interpreted (m) as “do not press” which was classified as “approximate”. Over 60% thought of symbol (n) as “lift your finger”. Our analysis showed that symbol (o) was much clearer (40% correct answers) to participants than the symbols (m) and (n).

Symbols (p) and (q) share the same meaning: “try again”, but symbol (q) turned out to be easier to understand for the participants. For (s) and (t), many participants were struggling between “exit” and “enter” and (s) turned out to be easier to grasp (+15%) for the participants.

For symbols (u)-(x) in Figure 3, if participants interpreted the symbol (u) correctly, then most of the time the answers for (v)-(x) were correct too. We noticed that some participants thought of these symbols as “too complicated” or “do not answer” because of the composite design.

## PART TWO: MATCHING

For each symbol, percentages of meaning options (Table 1) selected by participants were calculated and ranked. Table 3 shows rank 1 (most common answer) to rank 5. The answers that matched the intended meanings (IM) are bold with gray background. For example, the first row in Table 3 is read as: Symbol (a) with an intended meaning of 7, “fingerprint scan”, had most (26%) of the participants correctly matching it to 7, a lesser number (19%) matching symbol (a) to 8 “scan index finger”, 15% of the participants identifying it as 5 “scan fingers”, and so forth.

**Table 3** Ranked Matching Rate for Meaning to Symbol

SB	IM	1st / %		2nd / %		3rd / %		4th / %		5th / %	
(a)	7	7	26%	8	19%	5	15%	4	8%	1	5%
(b)	9	9	68%	10	12%	2	6%	6	5%	20	5%
(c)	3	10	30%	1	17%	22	11%	3	10%	9	7%
(d)	8	8	58%	13	15%	5	8%	7	6%	12	4%
(e)	5	5	32%	7	29%	12	17%	11	4%	13	4%
(f)	1	16	33%	22	26%	1	10%	3	6%	18	4%
(g)	2	22	32%	2	20%	1	10%	4	7%	11	6%
(h)	2	22	37%	2	19%	1	8%	6	7%	18	6%
(i)	16	16	66%	22	7%	1	4%	3	3%	12	3%
(j)	17	17	69%	22	12%	15	4%	1	2%	2	2%
(k)	12	12	53%	22	12%	5	7%	11	6%	13	6%
(l)	12	12	55%	22	10%	4	5%	13	5%	3	4%
(m)	13	14	76%	22	6%	15	5%	7	4%	5	2%
(n)	13	15	27%	22	18%	13	16%	14	11%	16	5%
(o)	13	13	59%	22	15%	15	5%	17	4%	12	3%
(p)	18	17	31%	22	25%	18	14%	15	6%	19	5%
(q)	18	21	54%	18	25%	22	6%	4	4%	1	2%
(r)	20	20	77%	22	7%	11	5%	17	3%	19	3%
(s)	19	19	72%	22	7%	4	4%	9	4%	17	3%
(t)	19	22	29%	19	27%	4	13%	21	12%	15	6%

SB (Symbol)-The relevant symbol is illustrated in Figure 2; IM (Intended Meaning)-Number in Table 1

Based on Table 3, participants were still confused with some symbols. The “confusion criterion” had two components: 1) when the first choice was not the correct choice: symbols (c), (f), (g), (h), (m), (n), (p), (q), and (t); or 2) when the first choice was the correct choice, but it’s less than 50%--symbols (a) and (e). For symbols (b), (d), (i), (j), (k), (r), and (s), the results are much better for this matching case than for the prior interpretive case. For example, symbol (b) had a first choice correct rate of 68% for matching, while only a 25% correct rate for the interpretive case (Table 2).

On the other hand, Table 3 also shows that the top five choices for symbol (m), “press less”, were all incorrect; while for the interpretive case (Table 2) symbol (m) had a 13% correct rate. In the matching case, 76% of the participants selected “do not press” as the meaning for (m).

Interestingly for (n), “press less”, 27% participants picked meaning option (15), “give up”. Unfortunately, the symbol (n)’s often-given answer in the interpretive case, “lift your finger” was not provided as one of the choices in Table 1 and so no direct comparison could be done.

# DISCUSSION

## SYMBOL USABILITY

The graph in Figure 4 illustrates the comparison result between interpretive and matching cases, sorted by level of difficulty in understanding the symbols (from hardest (n) to easiest (l)), based on the correct rates from the interpretive case. It appears that, when options were given, the matching case has better interpretations than interpretive case, except for symbol (m). Nevertheless, the participants were still struggling with the symbols (n), (g), (p), (c), (f), (h), (q), (m), (e), (t) and (a) as shown in Figure 4, with matching and interpretive rates less than 50%. Those symbols (e.g. c, f, m) will require clearer illustration so that ordinary people would understand them better.

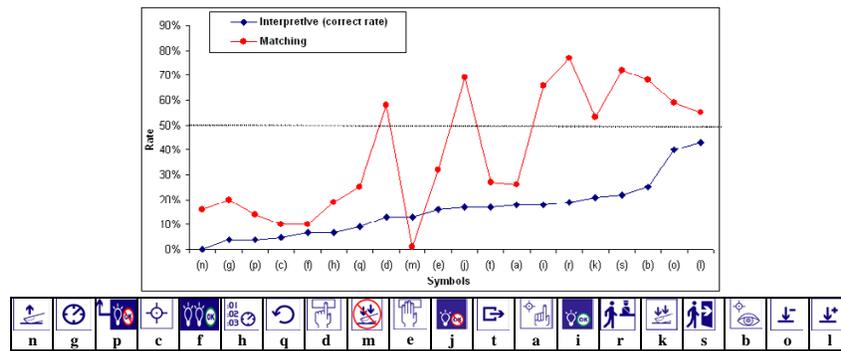


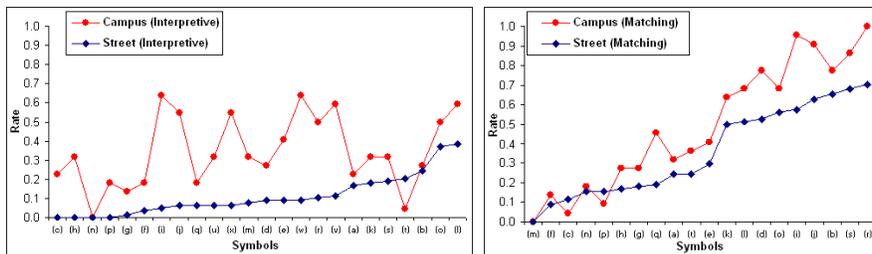
FIGURE 4 Comparisons between Interpretive and Matching cases (Sorted by Interpretive (Correct Rate) - Hardest (n) to Easiest (l))

## USER KNOWLEDGE OF BIOMETRIC SYSTEMS

As stated earlier, the participants were recruited from two groups: Group-1 with 22 engineering school attendees and Group-2 with 78 street volunteers. Participants from Group-1 appeared to be more familiar with biometric systems, because the majority was students majoring in engineering where classes about biometrics are offered. Some participants in Group-2 lacked the knowledge with regards to biometrics. This section investigates the implications of users' biometric knowledge on their interpretations of the symbols. Figure 5 (a) and (b) below show comparisons of Group-1 vs. Group-2 participants for the interpretive and matching cases, respectively. Before comparing them, the symbols were sorted based on the results of Group-2 (lowest to highest) to investigate the trend patterns between the two groups.

We observed that users' comprehension of the symbols and their knowledge about biometric systems were related. In general, Group-1 participants had better

understanding of the symbols than Group-2 participants did, in both the interpretive and matching cases, Figure 5(a) and (b). However, the perceived difficulties were different for Group-1 and Group-2. For example, symbols (c) and (h) were the most difficult to comprehend for Group-2, whereas (n) and (t) were the most difficult for Group-1. When pre-defined meanings were provided, the data of the two groups follows a more similar pattern (Figure 5 (b)) than in interpretive case (Figure 5 (a)).



(a) Interpretive (Correct Rate) (b) Matching Rate  
 FIGURE 5 Evaluation of Group-1 (campus) and Group-2 (street) –Sorted by Group-2

### CULTURAL FACTORS

From the results of this empirical study, we ask the question, “Do Koreans have a difficult time to understanding a symbol because of the symbol’s design or because of Korean cultural factors?”

To investigate possible answers to this question, all responses for 20 symbols (Figure 2) from the interpretive case were re-analyzed. Using our Korean background and experience to judge, we flagged responses that were not correct but had references to Korean culture. Of the 100 participants, 30 provided culturally referenced interpretations to one or more symbols while 70 participants made no cultural references in interpreting any of 20 symbols. Table 4 shows these 30 participants whose responses were with Korean cultural references for some symbols (marked in green). The 20 symbols were pre-sorted—from hardest (n) to easiest (l)—based on the overall average correct rates.

Participants made culturally misinterpretations to eight symbols with three that are worth paid attention to, namely, symbols (c), (e), and (l). Symbol (c), “capture,” had the highest number of participants (20) who made culturally referenced responses. Symbol (e), “left hand on platen,” had eight participants and symbol (l), “press more,” had four participants who gave culturally referenced interpretations. The difficulties in understanding of the remaining 17 symbols were considered design related and culturally insignificant since those symbols had no or fewer than two misinterpretations with cultural references.

It should be noted that Korea currently has one of the world’s largest troops (Anthony et al, 2006). Also, serving in the military is mandatory for male citizens of South Korea. Thus, this fact may possibly contribute to the multiple occurrences of the “aiming” and “shooting” misinterpretations for symbol (c).

**Table 4** Reponses Affected by Korean Culture - Hardest (n) to Easiest (l)

ID	n	g	p	c	f	h	q	d	m	e	j	t	a	i	r	k	s	b	o	l	
G1_14																					
G1_21																					
G2_1																					
G2_2																					
G2_5																					
G2_7																					
G2_8																					
G2_11																					
G2_12																					
G2_13																					
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G2_39																					
G2_42																					
G2_47																					
G2_51																					
G2_54																					
G2_59																					
G2_60																					
G2_64																					
G2_67																					
G2_72																					
G2_73																					
G2_78																					
Total	0	1	0	20	1	0	0	1	0	8	0	0	2	0	0	0	0	0	2	4	

For symbol (e), “left hand on platen,” there were answers such as “vending machine” or “ticketing in metro”. The vending machines in Korea normally have a big rectangular button for each product, unlike the vending machines common in Western countries. Participants may view the rectangular platen shown in symbol (e) as similar to their experience with the big button on the vending machines.

Korea also holds the world’s highest internet access (NationMaster, 2009) and the highest rank for computer game addiction including action/violence games. This also might contribute to misinterpretations such as “aiming/shooting” for (c), and also responses of “level up” for (l) which have their source from the environment or computer games.

There are other possible cultural sources that may contribute to the confusion. For example, several participants also interpreted some symbols as a singer’s name or an animation character, both part of the Korean pop culture as well. One participant interpreted the symbol (o), “press less,” as “unhappy face”- (☹) influenced by Korean emoticon illustrations. Emoticons are different between Korean and Western countries, e.g., Korea vs. the United States:

laughing: ^o^ vs. :D crying: ㅠ.ㅠ vs. :`-(

The results show that misinterpretations of some symbols were affected by the Korean culture and participants’ environment. Yet, symbols (e.g. (n)) which participants had most difficulties in understanding were not affected by cultural factors (see Table 4). In these cases, it is more likely that the symbol’s design, rather the user’s cultural background, was causing the confusion.

## CONCLUSIONS

We presented and analyzed the biometric symbol data collected in South Korea. This empirical study represents an initial step in understanding how Korean users may interpret symbols designed for use in biometric systems.

We examined three factors that potentially affected the usability of biometric symbol: 1) the symbols themselves, 2) user knowledge of biometric systems, and 3) Korean culture. In general, some of the symbols are more difficult to interpret than others for the Korean participants in this study.

We evaluated in detail how Koreans interpreted the proposed symbols in the context of biometrics. It became apparent that most participants seemed to understand a simple symbol design better (e.g. Figure 2) compared to a composite symbol design (e.g. Figure 3). Participants were able to match symbols with intended meanings better when pre-defined choices were provided which only requires users to recognize (as in the matching case), rather than have to generate meanings (as in the interpretive case). The results show that some participants were affected by the Korean culture and environment in understanding some symbols. We observed that besides cultural factors, the symbol design influences a user's understanding the most. At last, we found that a user's knowledge and experience about a system also influence symbol comprehension.

The results will provide a valuable basis to further research on investigating cultural implications in operational biometric environment.

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