

Two Fingerspelling Keyboard Layouts for Myanmar SignWriting

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Abstract

Sign language is the first language for the Deaf. The Deaf people could communicate with the hearing people by Sign language. The use of sign language technologies in the interface of computing systems to improve their accessibility for deaf signers. In this paper, we propose two fingerspelling keyboard layouts for typing Myanmar fingerspelling characters with SignWriting. Fingerspelling is used in sign language to spell out names of people and places for which there is not a sign. We discuss the usability of our approach based on the user study and the evaluation results. The evaluations were made in terms of typing speed CPM (Character per Minute) and Likert scale feedbacks from both hearing-impaired and hearing users. The outcome of the research will be useful in implementing Myanmar SignWriting text input interface for Myanmar sign language.

1. Introduction

According to the 2014 Myanmar national census, about 1.3 percent of the population is Deaf and hearing impairment. They mainly use

Myanmar Sign Language (MSL) as an essential communication language among Deaf people. Deaf people are facing many difficulties in communicating with other hearing people and also in education. They can be attributed to the limited resources of information written in their language. Although sign languages do not have a traditional or formal written form, SignWriting is used for writing sign language. In Myanmar, there are very few MSL users who know about SignWriting and those do not use it. And thus, we studied SignWriting by ourselves to represent Myanmar sign language fingerspelling with SignWriting symbols. There is no Myanmar language specific SignWriting text editor for Myanmar Deaf society yet. Therefore, we start working on finding user-friendly and efficient Myanmar fingerspelling keyboard layout for SignWriting. Moreover, we believe that SignWriting will be very useful for Deaf children education and documentation of sign language literature in Myanmar. In this paper, we propose two fingerspelling keyboard layouts, one is based on pronunciation of Myanmar characters and another is based on the shapes of SignWriting symbols. A user study with both hearing-impaired and hearing users was conducted and the comparisons are made between two keyboard

layouts in terms of CPM and Likert scale feedbacks.

2. Myanmar Sign Language

Myanmar Sign Language (MSL) that Myanmar deaf people used is different with Myanmar language in grammatical structure. Like in other sign languages, a complete MSL is constructed with manual sign (MS) and non-manual sign (NMS). The manual sign is a combination of hand shape, movement, locations, and orientations to represent meaning. The non-manual sign is used to give meaning and feeling with facial expression, head, eye, mouth and chin movements without including hands. There are only four deaf schools in Myanmar and they are "Mary Chapman School for the Deaf in Yangon," "School for the Deaf, Mandalay," "Immanuel School for the Deaf in Kalay" and "School for the Deaf, Tarmwe, Yangon". To the best of our knowledge, MSL used in each region are not the same. Figure 1 shows an example of an MSL difference between Yangon and Mandalay. In 2010, a government project was set up to establish standard sign language with the aid of the Japanese Federation of the Deaf.



**Yangon sign of
'Mathematics'**



**Mandalay sign of
'Mathematics'**

**Figure 1. An example of MSL differences
between Yangon and Mandalay**

2.1. Myanmar Fingerspelling

In MSL, Myanmar fingerspelling can be used to represent Myanmar consonant, vowel, and numbers with hands. It is the basic language of sign language for deaf people. Especially, it is used for signing names, city names and words that are not existing in sign language. Sometimes, fingerspelling is used in combination with existing signs to clearly express the concept or meaning. There are two different fingerspelling character sets for Myanmar language: one is used in southern Myanmar (e.g. used at "Mary Chapman School for the Deaf", Yangon city) and the another is used in northern Myanmar (e.g. used at "Mandalay School for the Deaf", Mandalay city). They are similar in consonant but mainly different in vowel, medial and symbols [2]. In this paper, fingerspelling character set of a Myanmar sign language dictionary book (published by Department of Social Welfare, Ministry of Social Welfare, Relief, and Resettlement) is used for designing two SignWriting keyboard layouts. This is because that fingerspelling character set was recognized as a standard in 2007 (See Figure 2, Figure 3 and Figure 4).

2.2. SignWriting

There are many writing systems to represent sign languages in written form in other countries such as Gloss Notation, Hamburg Notation System (HamNoSys) and SignWriting. Among them, SignWriting is becoming widespread because it is language independent, which contains a large number of basic symbols [6]. It is usable by deaf people in their daily life such as education, communication, and reading. It was developed by Valerie Sutton in the 1974s. It is a writing system of sign languages using a combination of iconic symbols and the shapes of characters, that are abstract pictures of the hand, body, face and so on. It includes International SignWriting Alphabet (ISWA) with 30 groups of symbols used to write any Sign Language in the world. It is composed of seven categories of base symbols [6]: Hand, Movement, Dynamics and

Timing, Head and Face, Body, Detailed Location, and Punctuation. The words in SignWriting may be written from the point of view of the signer and assume the right hand is dominant. The orientation of the palm is indicated by filling the glyphs for the hand shape [6]. A white glyph indicates that one is facing the palm of the hand, a black glyph indicates that one is facing the back of the hand and half-shading indicates that one is seeing the hand from the side. SignWriting is the first writing system for sign languages to be included in the Unicode Standard. The Unicode block for Sutton SignWriting is U+1D800-U+1DAAF [7].

SignWriting is widely used as the written form for sign language in over 40 countries. There are many text editor programs to write their sign language with SignWriting such as SignMaker 2015 [8], SignPuddle Online [9], SignWriter studio [10], Rand SignWriting Keyboard [11], DELEGS SignWriting editor [12] and so on. SignWriting is not currently used in Myanmar deaf society, and in deaf education. We defined Myanmar fingerspelling characters with SignWriting symbols as follows:

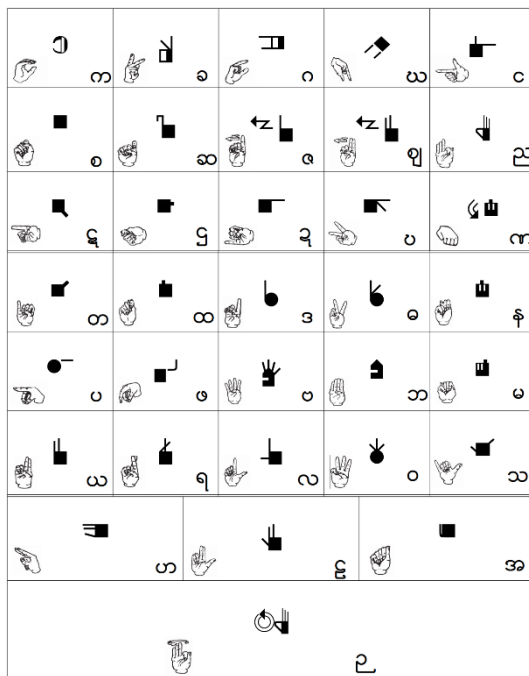


Figure 2. Consonant

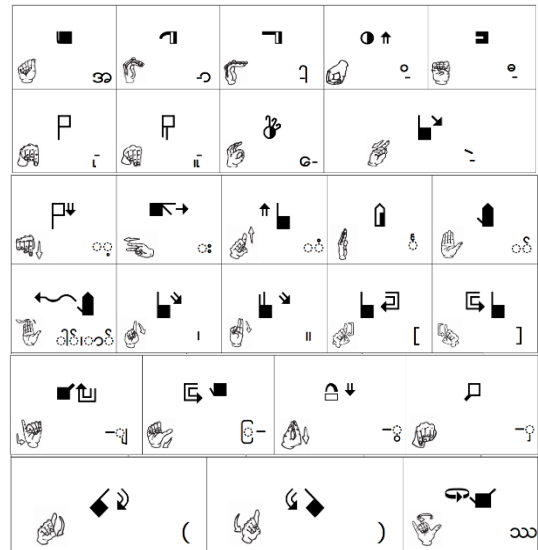


Figure 3. Vowel, consonant sign, various sign and symbol

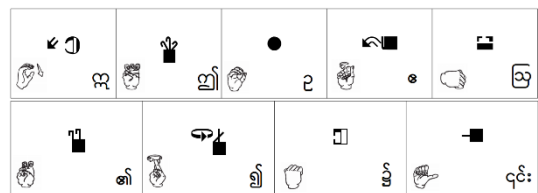


Figure 4. Independent vowel and symbol

3. Related Work

The first Myanmar fingerspelling TrueType font was developed by Ye Kyaw Thu et. al. [4]. They proposed Direct Keyboard Mapping (DKM) fingerspelling software keyboard based on the existing Unicode Myanmar keyboard layout named "Myanmar3 keyboard layout". They also used standard Myanmar fingerspelling character set [1]. The DKM software keyboard prototype provided two typing methods: one is typing with a physical QWERTY keyboard and another is typing with a software keyboard by using a mouse. The software keyboard layouts between fingerspelling and Myanmar characters can be switched. The experiment compared three text input methods (typing with physical QWERTY

keyboard, typing with software keyboard labeled by fingerspelling, typing with software keyboard labeled by Myanmar character) with 18 hearing-impaired users, 16 general users, and 14 DTP staff. For each text input method, the user study was held for 10 users who entered a total of 5 fingerspelling names for 10 times. From their user study results, there are various CPM values depends on typing with a physical keyboard, a software keyboard labeled by fingerspelling and a software keyboard labeled by Myanmar characters. However, they reported based on the users' comments and Likert scale evaluation that the fingerspelling software keyboard layout labeled by Myanmar character has a better user interface for the first-time users than one labeled by fingerspelling.

SignWriting was already applied to British Deaf Association (BDA) and American Sign Language (ASL) fingerspelling. SignWriting alphabets of BDA and ASL can be typed with QWERTY and Dvorak keyboard. As far as we know, there is no such font development for SignWriting and SignWriting keyboard development for Myanmar fingerspelling yet. Moreover, there is also no text editor for Myanmar SignWriting.

4. Prototype Development

In this paper, we propose two Myanmar fingerspelling keyboard layouts with SignWriting (MSW). Generally, typing SignWriting symbols are very different with typing Myanmar characters. For typing a SignWriting symbol, we need to press at least two keys (i.e. symbol modifier and fill modifier keys). For some SignWriting symbols (see Table 1), we need a combination of symbol modifier, fill modifier and rotation modifier keys. For example: to type Myanmar character ‘င’ (nga) with SignWriting, င (symbol), င (filling) and င (rotation) keys











are needed. For example, typing a Myanmar words ‘ကလေးငယ်’ (children in English) with SignWriting, we need to type 18 keys (See Table 1). Here, the typing order is symbol key, filling key and rotation key.

Table 1. Example of typing Myanmar word ‘ကလေးငယ်’ (children in English) with SignWriting














ကလေးငယ်	က	လ	ေး	င	ယ	ဲ	်
Symbol	၇	၈	၉	၆	၇	၈	၉
Filling	၇	၈	၉	၆	၇	၈	၉
Rotation	-	-	-	၇	၇	-	-

4.1. Phonetic-based Keyboard Layout for Myanmar SignWriting

The Phonetic based keyboard layout is mapping Myanmar characters on English QWERTY keyboard based on their phonetic similarities with English characters such as Myanmar consonant “က” (Ka) on k key, “ခ” (Kha) on K (Shift + k) key, “ဂ” (Ga) on g key, “စ” (Ca) on s key, “ဆ” (Cha) on S (Shift + s) key and so on. The concept is same with the kKg (ကကဂ) Myanmar keyboard [5]. Although all Myanmar characters are difficult to map based on phonetic similarities with English keys, many Myanmar consonants and vowels are easily mapping on English keyboard layout. The merit point of the kKg keyboard mapping is very easy to type Myanmar characters even for the first-time users who already familiar with English QWERTY keyboard. From this reason, we applied kKg keyboard mapping concept for mapping SignWriting symbols for Myanmar fingerspelling. Generally, Myanmar SignWriting fingerspelling characters’ symbols under the group of unaspirated Myanmar consonants such as “၇” (Ka), “၈” (Ca), “၉”, (Ta) etc. on

unshifted keys and Myanmar SignWriting fingerspelling characters under the group of aspirated and voiced Myanmar characters' symbol such as “” (Cha), “” (Ga), “” (Da), “” (Dha) etc. are mapped on shifted keys. However, most of the SignWriting symbols for fingerspelling characters are same shapes such as “” (Ga) and “” (Gha), “” (Ttha) and “” (Tha) etc. and thus, we do not need to map every fingerspelling character on the keyboard. As we followed the kKg keyboard mapping concept, for some Myanmar fingerspelling characters are mapped on English keys based on the similar shape of characters, for example: Myanmar consonant "c" (Nga) is mapping to English small c key, Myanmar  (sign dot below) and  (sign anusvara) are mapping on the “.” or full stop key. The phonetic-based keyboard layout for MSW can be seen in Figure 5.

4.2. Symbol-based Keyboard Layout for Myanmar SignWriting

The Symbol-based keyboard mapping is based on the shape similarities of SignWriting symbols as shown in Figure 6. Generally, MSW symbols are grouped by the shape of the symbols. For example: symbols with the same shape  and  are mapped on s key and S (shift + s) key and  and  symbols are on d key and D (shift + d) key, respectively and so on. Moreover, Thumb group of SignWriting symbols such as “” (Le gaung), “” (Ca), “” (a) are mapped on the bottom row keys (i.e under the home row keys) of QWERTY keyboard layout. The group of filling such as “” (White glyph), “” (Half-shading), “” (Black glyph) etc. and rotation modifiers such as “” (-45°), “” (-90°), “” (-135°) etc. are on the top row keys (i.e. above the home row keys) of the keyboard layout. This keyboard mapping concept might be difficult for the first-time users who are

unfamiliar with Myanmar fingerspelling and SignWriting symbols.

4.3. Implementation

Both phonetic-based and symbol-based keyboard layouts were implemented for Linux or Unix like operating system computers using X Keyboard Extension (XKB). The XKB is a part of the X Window System (used on most Unix Like systems) that extends the ability to control the keyboard and provides access to internal translation tables of keyboard codes. We prepared two new symbol files (i.e. mapping file between keyboard codes and SignWriting Unicode symbols) for our two Myanmar fingerspelling SignWriting keyboard layouts (See Section 4.1 and Section 4.2). We can activate Myanmar fingerspelling SignWriting keyboards by copying our two new symbol files to the default path of XKB symbols (e.g. “/usr/share/X11/xkb/symbols/” for Ubuntu Linux OS) and adding that two new keyboard names into the list of text entry setting of X Window System. We used TrueType font of Sutton SignWriting built with the SignWriting 2010 Tools to display Myanmar fingerspelling characters with SignWriting [13].

5. Methodology

5.1. Participants

The nineteen volunteer participants (9 males, 10 female) were recruited and we considered both hearing-impaired and hearing participants. Eight male hearing-impaired participants are ranging in age from 15 to 22 years. All of them are students of School for the Deaf, Mandalay and most of them are not familiar with personal computer. User study with hearing-impaired users was held at School for the Deaf, Mandalay. Eleven hearing participants (10 females, 1 male) are ranging in



Figure 5. Phonetic-based keyboard layout for Myanmar SignWriting



Figure 6. Symbol-based keyboard layout for Myanmar SignWriting

age from 20 to 30, most of them are students of the Faculty of Information Science, University of Technology (Yatanarpon Cyber City), Pyin Oo Lwin city, Myanmar and all they are familiar with one of the Myanmar Keyboard layouts (Zawgyi or Myanmar 3). None of them had prior experience with SignWriting Keyboard for Myanmar fingerspelling characters.

5.2. Apparatus

Testing was done on five Ubuntu desktop computers running Ubuntu 16.04 LTS Linux OS. The two Myanmar fingerspelling SignWriting keyboards were installed in advanced. Figure 7 shows user study environment with hearing-impaired users at School for the Deaf, Mandalay.

5.3. Procedure

The experiment was performed in a quiet room of School for the Deaf, Mandalay. Participants sat in front of a desk of a laptop or a desktop computer that were already installed our SignWriting keyboard prototypes. We also provided printouts of the two keyboard layouts and three SignWriting poems (parallel sentences with Myanmar language) for the user study (See Figure 7). At first, introduction to what is SignWriting and two keyboard layout mapping concepts to all participants. The demonstration of how to type Myanmar SignWriting characters for all Myanmar consonants (characters Ka to A) and one poem was given before starting the user study. All participants were allowed to practice typing all Myanmar consonants (characters Ka to A) for two times to get some level of understanding on

two keyboard layouts. The typing speed of all participants for each poem for 10 times were recorded. After finishing typing processes, we made discussion with participants and collecting their feedbacks, suggestions and comments.

5.4. Design

We selected three poems from Myanmar language Primary School textbook for user study and they are as shown in Figure 8 [3]. All Myanmar participants are already familiar with all these three poems. They cover most combination patterns of vowels and medial with a consonant.

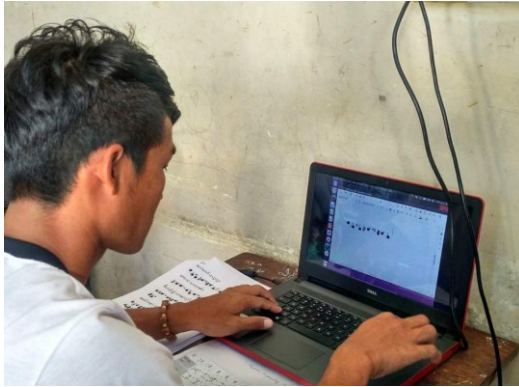


Figure 7. Experimental Environment with hearing-impaired users

6. Result and Discussion

6.1. Typing Speed

We used Character per Minute (CPM) to evaluate typing speed of participants. The formula for computing CPM is as follows:

$$CPM = \frac{|T| - 1}{S} \times 60$$

Here, |T| is the length of this string and T may contain SignWriting symbols. S indicated how many seconds are spent from the entry of the first character to the last.

Poem No.1:

စာရသလား
 ခဏလာပါ။
 ဆရာမအနား
 လာ သာ လာပါ။

Poem No.2:

လယ်သမား လူငယ်
 စပါး နယ်နေသည်။
 မမ စပါး သယ်၏။
 မေမေ စားစရာ ဝယ်လာသည်။
 ဖုရဲသီးပါသလား။

Poem No.3:

အလံတော် တလူလူ။
 တေးသံ သာယာ၏။
 စီးတန်း၍ လာနေသည်။
 အခမ်းအနား စတော့မည်။

Figure 8. Three fingerspelling poems with SignWriting for user study

Although some space was put between SignWriting symbols in Figure 8 for easier reading, we don't need to consider a space for calculating CPM. This is because we did not allow users to type a space between symbols.

Figure 9 shows average CPM values of 8 hearing-impaired participants for typing each Myanmar fingerspelling SignWriting poem 10 times. CPM values of typing with phonetic-based keyboard layout are 8.3, 10.9 and 12.6 for poem 1, 2 and 3, respectively. CPM values of typing with symbol-based keyboard layout are 9.1, 10.7 and 11.5 for poem 1, 2 and 3, respectively. CPM of typing with phonetic-based keyboard layout is slighter higher than that of typing with symbol-based keyboard layout for poem no.2 and poem no.3.

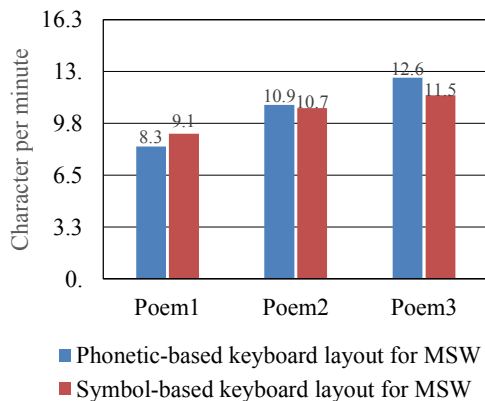


Figure 9. Average CPM of hearing-impaired participants' typing for three poems with both two fingerspelling keyboard layouts for MSW

Figure 10 shows average CPM of 11 hearing participants for each user study. CPM values of typing with phonetic-based keyboard layout are 18.9, 24.1 and 26.5 and that of typing with symbol-based keyboard layout are 16.9, 21.5 and 23.5 for poem 1, 2 and 3, respectively. From the results, CPM values of typing with phonetic-based keyboard layout achieved higher typing speed for all three poems.

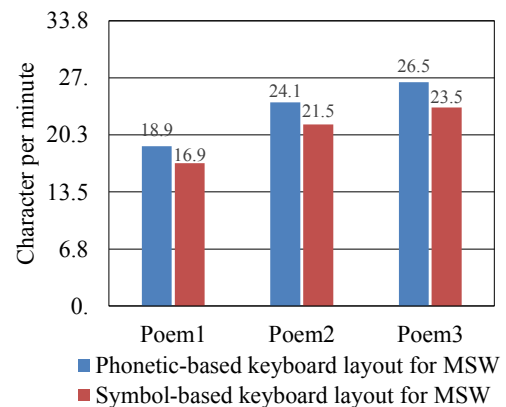


Figure 10. Average CPM of hearing participants' typing for three poems with both two fingerspelling keyboard layouts for MSW

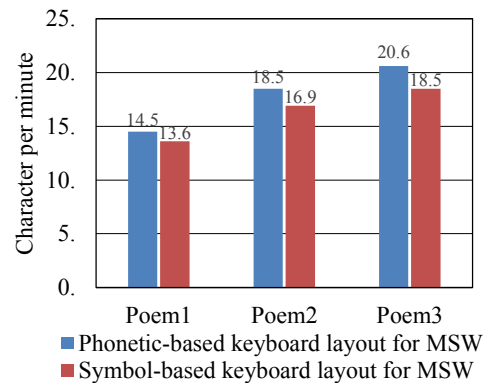


Figure 11. Average CPM typing speed of two types of participants: hearing-impaired and hearing participants for three poems with both two fingerspelling keyboard layouts

According to the average CPM values of both hearing-impaired and hearing participants, typing speed with phonetic-based keyboard layout is obviously faster than symbol-based keyboard layout (see Figure 11).

6.2. Participant Questionnaire

After the typing experiments with one keyboard layout, questionnaires were taken to the participants immediately in order to get their

comments and suggestions on that keyboard layout. Hearing-impaired participants were communicated through sign language teachers' translation as well as writing messages on the paper. The questions are:

1. Do you have any experience of using personal computer?
2. Are you familiar with one of the existing Myanmar PC keyboard layouts?
3. Can be skillfully used QWERTY keyboard layout?
4. Which keyboard layout is the best suitable to use in real time?
5. Do you have any comments or suggestions?

In summary, we received the answer “No”, “Yes” and “Yes” respectively for the question no.1, 2 and 3 from 8 hearing-impaired participants. For the question 4, 63% of hearing-impaired participants chose phonetic-based keyboard layout is the best suitable to use. As for the question 5, we received some comments such as “Phonetic-based keyboard layout’s keys mappings are easy to remember”, “Phonetic-based keyboard layout is possible to use” and “Symbol-based keyboard layout is good because of grouping the symbols but it is difficult to memorize”. We also received some suggestions to change some key mappings. For example: in phonetic-based keyboard layout, the group of filling which are frequently used such as “၎” (White glyph), “၎” (Half-shading), “၎” (Black glyph) etc. should not be mapped on comma (,) , full stop (.) and slash (/) keys.

The answers to questions 1, 2, and 3 from 11 hearing participants are “Yes” to all. For the question 4, 82% of hearing participants chose phonetic-based keyboard layout is the best suitable to use. As for the question 5, we received some comments such as “Phonetic-based keyboard layout is easy to remember Myanmar characters with SignWriting symbols”, “Symbol-

based keyboard layout is difficult to memorize but it is very fast in typing”. We also received the same suggestions to change some key mappings with hearing-impaired users and to develop platform independent.

Four Likert scales (1 to 5) are set to rate the user-friendliness of two fingerspelling keyboard layouts for Myanmar SignWriting. The scales are (1) difficult-easy (2) slow-fast (3) dislike-like (4) impossible-possible. Likert scales value 1 is the most negative, value 3 is neutral and value 5 is the most positive. The average or arithmetic mean results of Likert scale questions to hearing-impaired users and hearing users can be seen in Table 2 and Table 3.

Table 2.
Evaluation by hearing-impaired users

Likert scales	Phonetic-based keyboard layout for MSW	Symbol-based keyboard layout for MSW
Difficult-Easy	4.3	4.1
Slow-Fast	4.3	3.9
Dislike-Like	4.5	4.3
Impossible-Possible	4.4	4

According to the Likert scale evaluation results, we can generally say that both hearing-impaired and hearing participants are enjoyed of typing SignWriting symbols with phonetic-based keyboard layout of fingerspelling. We calculated the overall average Likert scale value on four categories (Difficult-Easy, Slow-Fast, Dislike-Like, Impossible-Possible) and made a comparison graph for two proposed keyboard layouts (see Figure 12). As the results of this comparison, interestingly, 4.4:4.1 (from hearing-impaired users) and 4.5:4.2 (from hearing users). And thus we can say hearing-impaired participants prefer phonetic-based keyboard

layout. On the other hand, hearing participants accepted both of the keyboard layouts clearly.

Table 3.
Evaluation by hearing users

Likert scales	Phonetic-based keyboard layout for MSW	Symbol-based keyboard layout for MSW
Difficult-Easy	4.5	3.7
Slow-Fast	4.1	4.1
Dislike-Like	4.4	4.5
Impossible-Possible	4.8	4.6

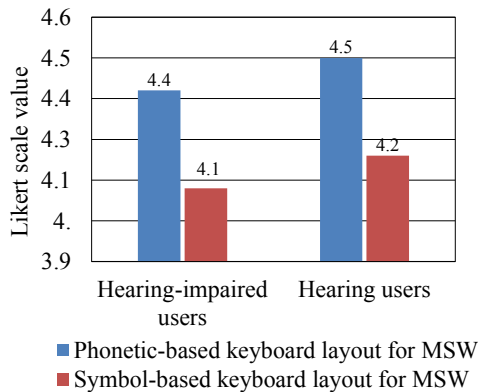


Figure 12. Comparison of Likert scale evaluation results for “Phonetic-based keyboard layout for MSW” and “Symbol-based keyboard layout for MSW”

As mentioned above, we conducted both CPM and Likert scale evaluations on the user study experiment of two Myanmar SignWriting keyboard layouts. Our result show that phonetic-based keyboard layout achieved higher CPM values for all the experiments. The evaluation results on two proposed keyboards in terms of Likert scale show that both of them are comparable.

7. Conclusion

In this paper, we have proposed two fingerspelling keyboard layouts for Myanmar SignWriting: phonetic-based and symbol-based keyboard layouts. An experiment was made to compare two keyboard layouts with 8 hearing-impaired participants and 11 hearing participants. For each keyboard layout, user study was held by entering one poem for 10 times for three poems. Our results proved that even the hearing participants who are not familiar with Myanmar fingerspelling characters with SignWriting achieved maximum typing speed 26.5 CPM with phonetic-based keyboard and 23.5 CPM with symbol-based keyboard. Moreover, hearing impaired participants who are not familiar with both computer keyboards and Myanmar fingerspelling characters with SignWriting give 12.6 CPM with phonetic-based keyboard and 11.5 CPM with symbol-based keyboard respectively.

From the evaluations in terms of both CPM and Likert scale, we can conclude both of the keyboard layouts are applicable for typing Myanmar fingerspelling SignWriting. However, it looks phonetic-based keyboard layout is more flexible to use for both hearing-impaired users and hearing users based on the participants’ comments, suggestions and Likert scale values. We will share our two fingerspelling keyboard layouts with public via GitHub. In the near future, we have plan to make further study on current fingerspelling keyboard layouts. We also plan to develop GUI Myanmar SignWriting text editor to cover the whole Myanmar Sign Language (MSL).

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