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DESIGNING KHOM THAI LETTERFORMS FOR ACCESSIBILITY

FARIDA VIRUNHAPHOL

A thesis submitted to the University of Huddersfield in partial fulfilment of the requirements for the degree of Doctor of Philosophy

The University of Huddersfield

November 2017

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Abstract

This practice-led research aimed to design letterforms for an ancient Thai script known as Khom Thai, to aid learning of the script by today's Thai population. Khom is a script that was developed in Thailand around the 15th century. It was widely used as the country's official script for historical documents and records in Pali, Sanskrit, and Thai until 1945. Now, very few members of younger generations can read the script, which poses a major obstacle for preserving the knowledge of Khom Thai and severely limits access to the country's historical documents and heritage. Although there are some relationships between contemporary Thai letters and Khom Thai letters, the unfamiliar letterforms constitute the largest hurdle for Thai readers learning to read the Khom Thai script.

This study's goal was to resolve this problem by creating three new Khom Thai letterform designs for use as learning materials and writing models for beginners. This study investigated whether Khom Thai letterforms could be redesigned so that modern Thai readers could recognise them more easily. To explore this possibility, three letterform designs, TLK Deva, TLK Brahma and TLK Manussa, were developed.

This practice-led research employed mixed methods, including interviews, a questionnaire, and a letter recognition study. The first section of the research discusses the theoretical framework regarding familiarity in enhancing letter recognition. Additionally, analyses on Thai, Khom Thai, and Khmer letterforms were also included in this part.

The second section is about the design process resulted in three designs. Among the three, TLK Brahma and TLK Deva maintain a close connection to the proportions and writing style of the traditional script, and could potentially be used as writing models for those learning the script. By contrast, TLK Manussa is adapted to characteristics and proportions of the present-day Thai script and is intended to look more familiar to Thai readers. One potential use of TLK Manussa is as a mnemonic aid for learning Khom Thai characters.

Interviews were conducted with Khom Thai palaeographic experts to gather opinions on the designs. A questionnaire was also used with 102 participants to establish which of the three TLK designs had most familiar characteristics for Thai readers. The results showed that TLK Manussa was the most familiar among the three.

After further refinement of the designs, the third section describes the data collection procedures. A short-exposure technique was used with 32 participants who already had some knowledge of Khom Thai, to compare letter recognition. This method was used for gathering reader feedback on the designs. In general, the findings did not indicate any significant differences between the three designs regarding the accuracy rate of letter identification. However, certain individual letters that more closely resembled the Thai script received higher scores than did unfamiliar characters.

The three TLK designs constitute the primary contribution to knowledge. However, further contributions made by this research are its analyses of Khom Thai characters and its systematic guidelines for developing Khom Thai letterforms, the guidelines will aid future type designers of Khom Thai on letterform design. The study contributes to the field of research in non-Latin type design by endorsing the role of design in enabling contemporary audiences to learn ancient Thai scripts.

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Dedication and Acknowledgements

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Academic Biography

I am a graphic designer, and I have been a lecturer at Suan Sunandha Rajabhat University's Visual Communication Design Department since 2009. I completed my undergraduate studies in Visual Communication Design at Silpakorn University, Thailand in 2005, and I finished my master's degree in Graphic Design at Florence Design Academy, Italy in 2007. My research interests focus on the relationships between typography, ancient Thai scripts, and graphic design. The summary of my academic background is as follows:

Education:

2005 B.F.A. Visual Communication Design, Silpakorn University
2007 Master of Graphic Design, Florence Design Academy
2013–2017 Ph.D. Art & Design, School of Art, Design and Architecture, University of Huddersfield

Conferences:

- 1. The Asian conference on education 2013 (ace 2013), October 23-27, 2013, Osaka, Japan
- 2. 2013 2nd international conference on social science and education (ICSSE 2013), December 24-25, 2013, Hong Kong, China
- 3. 2014 2nd international conference in humanities, social sciences and global business management (ISSGBM 2014), June 21-22, 2014, London, UK

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- 3. Virunhaphol, F. (2015). Letter recognition theories: how perception of design impacts vision? *Advances in education sciences*, *5*, 33-35.

Chapter 1: Introduction

In recent years, Thailand has witnessed mounting interest in traditional knowledge. This attentiveness is due a change in national policies emphasizing the importance of Thai cultural heritage to national pride. This trend began in 1992 and continues to the present day. The drive to preserve traditional Thai knowledge has motivated many educational institutes to grant funds for research on the topic. Prior to this PhD research, I therefore received a research grant from Suan Sunandha Rajabhat University in 2012. As a graphic designer and a lecturer in the Department of Visual Communication Design, I decided to carry out a study on the development of Thai ancient letterforms. First of all, there was a lack of teaching material available on this subject. Moreover, ancient Thai scripts are recognised as Thai local knowledge that deserves preservation. My findings would provide deeper insights into why the Thai script looks the way that it does and how type designers can create Thai typefaces that are not too detached from their history. While reviewing the literature for that previous project, I came across the Khom Thai script in an old manuscript entitled Trai Phum. It was my personal interest in working with Khom Thai and designing it that prompted me to conduct this PhD research.

The Khom Thai script has played a vital role in Thailand's history as a cultural asset (for details, see Appendix A). Nowadays, the National Library of Thailand contains many Khom Thai documents that have not yet been transliterated (for example, some parts of Atthakatha, which is comprised of Theravada Buddhist commentaries on the main scriptures). Although linguists and archaeologists in the field of oriental palaeography have intensively studied these documents, their contents are not accessible to the majority of Thai people, who cannot read the script. The main difficulty in learning Khom Thais is the unfamiliar letterforms. Many of the characters structurally differ from their Thai counterparts. In addition, the Khom Thai script has different proportions than modern Thai, which has been adapted over the centuries. Concern is growing regarding the shortage of people in Thailand who can read the Khom Thai script. In the future, this lack of expertise could lead to serious problems in preserving the Khom Thai script and interpreting the many historical documents that are written in it.

While some epistolographic research has examined the Khom Thai script, no studies have focused on resolving the main difficulty, which is that the unfamiliar letterforms make Khom Thai alphabet recognition a challenging process. This obstacle represents the chief hurdle for beginner Khom Thai students. Thus far, however, little discussion has taken place on the subject, since the expertise of epistolography lecturers is limited to their field, which does not include the design aspect that could resolve this problem. This indicates a need for different approaches, and especially those from a design perspective, to promote methods of learning the script that would make it accessible to Thais.

However, I could only find one practice-led study on the Khom Thai script (Meetrijit, 1999). That said, that paper did not demonstrate a clear understanding of the design process (and of the critical importance of typography) that other non-Latin type designers could use as a model. Apart from that study, practice-led studies on the Khom Thai script are lacking. Thus, this thesis seeks to address these issues.

This study is the first to establish a design process for Khom Thai letterform designs and to conduct initial investigations of those letterform designs in terms of familiarity and letter recognition. This research project's central question asks whether the Khom Thai script can be designed in such a manner that it is familiar and easy to recognize for readers of modern Thai while also retaining a close connection to the historical script. There are at least two pre-existing Khom Thai typefaces, and both are inadequate as present-day writing models (for more details, see Chapter 2).

Due to the shortage of Khom Thai learning materials in Thailand, the major objective of this practice-led study was to develop a series of three Khom Thai letterform designs to promote accessibility, learning, and script preservation from a practitioner's perspective. Moreover, since no previous guidelines on the subject existed, this study established a framework for Khom Thai letterform designs that type designers can use as a reference. Other designers can study the working process of TLK letterform designs and the dimensional proportions of each character to develop their own works in the future.

A large volume of historical literature has been published on the Khom Thai script in Thailand. Most of these documents use the term "the Khom script" to describe Khom Thai. However, the word "Khom" can refer to various scripts used in Thailand and Cambodia, including the ancient Khmer script, the Khmer Mul script, the Khmer script, the Khom Pali script, the Khom Sanskrit script, and the Khom Chaliang script. While many definitions have been proposed, this paper utilizes the term "Khom Thai", suggested by Wimonkasem (2011), to refer to a type of Khmer script only used in Thailand. Although this script is also used for writing Pali and Sanskrit, this study only focuses on its application for writing Thai.

Other terms that require clarification here are "typeface" and "font". Although these two words are used almost interchangeably in today's world, they in fact have different meanings.

According to Haley (2002), the difference of the terms can be clarified as:

Typefaces are designs like Baskerville, Gill Sans or Papyrus. Type designers create typefaces...Fonts are the things that enable the printing of typefaces.

Type foundries produce fonts. Sometimes designers and foundries are one and the same, but creating a typeface and producing a font are two separate functions.

This project designed Khom Thai letterforms, not fonts or typefaces. It focuses on the designs, not the font nor typeface production since the three letterform designs are intend to be usable as writing models and learning materials for beginners. Therefore, each character would be used separately. The scope of the project was delineated in this way, because the research question addressed whether different Khom Thai letter shapes affect recognition. It was beyond the scope of this research project to specify fully-functioning typefaces, which are dependent on context, and require consideration of such factors as character fitting, use of optical compensation, production at different sizes etc. (For more information on typeface design see Tracy, 1986). By contrast, the letterforms in this study are intended to be seen as individual characters.

The thesis is divided into five chapters. The first is the introduction. Chapter 2, the contextual review, explores the research problem in relation to three major factors: (1) the history of the Khom Thai script, (2) psychological components, and (3) design reviews. First, Chapter 2 focuses on the historical background of the Khom Thai script, so as to build a foundation of knowledge before moving on to the design process. It describes the Khom Thai script by providing relevant terminology to avoid misunderstandings. However, this contextual review does not claim to include a complete history of the Khom Thai script. Rather, it introduces the script via an important review of the design context, which is later used as a reference for the design framework in Chapter 3. This historical understanding helped me to develop the TLK letterform designs and to ensure a close connection with the history of the Khom Thai script.

The second key aspect covered in Chapter 2 is the psychological component of letter recognition, which formed the basis of the method for comparing TLK designs (see Chapter 4). Again, the contextual review does not incorporate all theories on reading, since they are not all relevant to the topic of study. Moreover, this research was conducted from a designer's perspective, rather than from that of a psychologist or educator. For these reasons, only those theories that other type designers or typographers have discussed and that are applicable to my project are included in Chapter 2.

The last part of Chapter 2 investigates type designers' working methods. Their design processes helped to establish the design framework for the Khom Thai script. The criteria for choosing working methods to investigate were based on their relevance to the topic. The evaluation of the materials focused on the scope and content that could be applicable within my practice. The contextual review also enabled an understanding of portfolio development.

After reviewing the historical background, design frameworks, and psychological aspects, I brought them together to frame the structure of the design process in Chapter 3, which is the heart of this research. That chapter, in conjunction with the portfolio, explains the design process for the three letterform designs. It covers all of the steps, from sketching to the finished design process, including the specification of the three designs' elements.

Chapter 4 focuses on the questionnaire and the letter recognition study. These methods compared the three designs to establish: (1) which one had the most familiar characteristics for Thai readers unaccustomed to the script, and (2) which one was the easiest to recognize once the Khom Thai script had been learned. These approaches allowed me to gather reader feedback on the designs and to compare the performances of the three letterform designs.

Firstly, the questionnaire was used with 102 Thai student participants, none of whom had previously learned the script, in order to establish which of the TLK designs appeared most familiar to them. Secondly, the letter recognition study was conducted with 32 participants (aged 19 to 21 years old) after they had received some training in Khom Thai. The letter recognition study compared the accuracy rate of letter identification for the three letterform designs using a method of short exposure on a computer screen. It is noted that the study in Chapter 4 does not intend to characterize these participants' performances as representative of the total Thai population. For this reason, the participants' results were used as feedback on the designs. This study did not have the goal of examining the results in the large scientific context. Rather, it provided a design framework that will enable further research in the future with more participants representing a broader demographic range.

The study's scope was determined by its use of purposive sampling. This decision was based on the nature of the practice-led research underlying this study. Purposive sampling is a type of non-probability sampling that is suitable for pilot studies that are not intended to be generalised to their entire population. This technique is also used when there is a particular problem that has not been widely studied, such as in exploratory research. In such cases, the researcher's goal is to obtain basic statistical data, identify a trend to solve a particular problem, or develop guidelines to improve a situation (Zikmund et al., 2010).

In art and design research, the use of the purposive sampling technique is applicable, because each problem is unique and cannot be generalised. Schön (1987, p.4) described such cases as "messy, indeterminate situations". The prime goal of the study in Chapter 4 is to develop directions as a signpost for future research on the relationship between familiarity and Khom Thai letter identification.

I conducted this study from a design practitioner standpoint, as the primary underlying problem required a design solution. For this reason, it would be inappropriate to use social sciences criteria to judge this work. This study did not seek to prove or disprove the validity of legibility testing methods, as did Lund's thesis (1999). Moreover, it was not a practice-led study investigating legibility in scientific contexts, as were those of Beier (2009) and Chahine (2012). Rather, as previously stated, the main purpose was to create new Khom Thai letterforms that took into account the social and historical context, and the need for Khom Thai learning materials.

The final chapter provides conclusions on the theoretical and practical aspects of the study. This includes an indication of how the three TLK designs could be used as learning materials: TLK Brahma and TLK Deva as writing models, and TLK Manussa as character mnemonics.

Mixed methodologies were adopted for this research. They were:

- 1. Secondary reading of key texts: contextual Review
- 2. Observational analysis of ancient texts
- 3. Practice portfolio review
- 4. Sketching and designing (initial drawings): practice-led approaches to the first draft designs (see details in portfolio)
- 5. Reflections on design
- 6. Interviews with palaeographers and feedback on designs
- 7. Likert scale questionnaire answered by 102 Thai participants to evaluate the first draft

- 8. Refining designs
- 9. Short exposure technique with 32 Thai participants: observational analysis of their response rate
- 10. Final designs and conclusions

Throughout the study, reflective practice integrated critical thinking, theoretical studies, and design practice without losing the connectivity between each strand. In this context, the methodological framework could be conceptually analogised as a helix model, and this model allowed me to unify different strands of design practice and theoretical academic research. For this reason, I have utilized a first-person voice in some parts of the study in which creative processes are discussed, so as to describe my personal experiences as a design practitioner engaged in the working process. In contrast, other sections of the paper that discuss theoretical perspectives employ a more formal academic tone. As a result, Chapter 2 and Chapter 4 utilize more formal third-person academic tones, whereas Chapter 3 and the portfolio employ a first-person mode from the designer perspective.

Chapter 2: Contextual Review

The purpose of this chapter is to review the relevant literature to demarcate the research field in order to provide a context for new outcomes. It critically evaluates the existing research and debates in the field of study. Moreover, the chapter also provides background information, taking into account the historical aspect, psychological factors, and knowledge related to the subject. This section also includes "a practice portfolio review", consisting of a contextual review of other relevant contemporary designers. It also helped to establish the conceptual framework for the TLK letterform designs, as well as the research methodologies and approaches. Chapter 2 helped to outline the study and its scope by distinguishing which factors were relevant and which were not.

However, the historical overview in this chapter does not claim to be a complete chronicle of the script, as not all of the major events in the script's history are relevant. Topics were selected for inclusion on the basis of their effect on Khom Thai letter perception, thus revealing the design problem. As previously emphasized, the psychological concepts discussed in this chapter are limited to those premises that type designers and typographers have investigated. It would have been beyond the scope of this research to explore the subject from a psychological perspective. This study was in the field of art and design practice-led research, and so not all psychological methodologies were applicable for resolving its design problem.

An investigation of research databases, videos, books, online magazines, and other media related to this study revealed very few documents that could be used as references for the design framework. Most texts on the Khom Thai script focus on history and linguistics and rarely provide any significant details for type designers. This is because educators, archaeologists, and linguists have written these materials, while design practitioners have not generated any works on the topic. There is a Master research on the Khmer printing history in Cambodia by a type developer (Scheuren, 2010). This study also offers examples that illustrate manuscripts from Thailand. However, it did not directly consider the Khom Thai used in Thailand. This literature underscored the need for new Khom Thai letterform designs that acknowledge cultural and historic values without disengaging from modern Thai society.

The dearth of information in the design field indicates a knowledge gap that must be bridged to understand the Khom Thai script's relevance to contemporary society. In the era of globalization, the homogenization of Western culture and literature has dominated every corner of the world. This trend is leading to a loss of cultural individuality and identity. Khom Thai, as an element of Thai cultural heritage, is an essential component of today's society, as it promotes and preserves cultural diversity and national heritage. In presenting different cultural values, it opens opportunities for self-expression and creativity, which are vital in the field of art and design. In brief, there is an increasing interest across the globe in non-Latin type design. Thus, this chapter also studies the frameworks of other non-Latin typefaces that share close similarities with Khom Thai, and these were utilized to develop the working process

described in Chapter 3.

As previously mentioned, very few guidelines exist for designing Khom Thai, since the field of study is relatively new and has not been widely explored. This study intended to fill this gap by structurally examining the topic through the lens of design. It integrated that knowledge by reviewing the literature and other design practices. This approach distinguishes this work from previous studies on the topic.

2.1 Historical overview

Numerous publications have investigated the history of the Khom Thai script, and those that are relevant to this study are listed in the bibliography. These works have reported that the Khom Thai script derived from the ancient Khmer script during the territorial expansion of the Khmer Empire (Bamrungsuk, 1994; Chucheun 1992; Coedès, 1961; Kaewklom, 1980; Ninchinda, 1999; Padungsuntraruk, 2004; Sounsaen, 2005; Punnothok¹, 2006; National Library of Thailand, 2010; Wimonkasem, 2011). Thais adopted the ancient Khmer script around the 10th century, because no official script for writing existed at the time. However, the Thai and Khmer languages differ from each other. The ancient Khmer script was not suited for writing in Thai, and so additional letterforms and letters were incorporated. This new version of the script is called "Khom" in the Thai language, meaning "Khmer". Khom Thai is also a Brahmiderived script.

In a historical study, Punnothok (2006) provided an in-depth analysis of the development of ancient Thai scripts. He indicated that the Khom Thai script has been used alongside the Thai script since the 15th century. Thais also accept Khom Thai as another form of the Thai script (Padungsuntraruk, 2004, p.133; National Library of Thailand, 2010, p.1). Studying inscriptions and ancient documents in Thailand pointed to evidence that may support this notion. Many inscriptions have been found across the country that were written in both Khom Thai and Thai, such as *Charuek Chao Phutthasakon Song* [ca. 1504], *Charuek Mae Akson Khom Khut Parot* [ca. 1747], *Charuek Maha Therasithep* [ca. 16th century], *Charuek Praditsathan Prathat* [ca. 15th century], *Charuek Wat Songkhop Sam* [ca. 1433], and *Charuek Wat Tamnak* [ca. 1480]. This evidence indicates that both of the scripts have been used side by side since the 15th century, as Punnothok proposed. However, each script is utilized in its own context. While the Thai script is used for writing non-religious documents, the Khom Thai script is mainly employed for religious purposes. Therefore, the Khom Thai script is regarded as a holy script (Sali, n.d.).

¹ Thawat Punnothok (ຈຳປັນໂລນາກ) is the standard transliteration from Thai to English based on the Royal Society of Thailand's manual (1999) or The Royal Thai General System of Transcription (RTGS). However, Punnothok's name is occasionally spelled "Tawat Punnotok" (2002). This research uses RTGS for all Thai transliterations into English, except those names spelled by the writers themselves (e.g., Phramaha Kittisak Maitreejit, Kaewklom, and Sounsaen).

In another historical study, Wimonkasem (2011) pointed out that the Khom Thai script is the most widely used ancient script in Thailand. Buddhist monks and historical scholars still intensively study the Khom Thai script. However, there are only a few experts in the field, while thousands of documents have been written in Khom Thai that are valuable pieces of Thailand's historical and religious heritage. These include Atthakatha and commentaries on the Theravada Tripitaka (the canonical texts of Theravada Buddhism), which still await transliteration into the Thai language (Sali, n.d.).

This perspective emphasises that the Khom Thai script is an integral component of Thai national identity. Learning Khom Thai is important, because it represents a significant cultural asset for the Thai people. Thus far, the literature review has established the main purpose of this research project. The goal was to design Khom Thai letterforms that took into account the historical and contemporary context. The ultimate goal was to help learners access the Khom Thai script by using these letterform designs as learning materials.

The decline of the Khom Thai script

This section focuses major factors contributing to the script's decreased usage, thus shedding light on why the Khom Thai script is unfamiliar to contemporary Thais. A number of studies have indicated that various elements played a role in the decline of Khom Thai (Bamrungsuk, 1994; Chucheun, 1992; Ninchinda, 1999; Padungsuntraruk, 2004; Punnothok, 2006; Sali, n.d.; Sounsaen, 2005; Wimonkasem, 2011).

Firstly, a change occurred in the languages in institutional Buddhism. Before the 19th century, Buddhist monasteries had been the centre of education in Thailand. Young boys often studied with monks to learn how to read and write. Since Pali is the primary language used in Theravada Buddhism, learning Pali alongside Thai was a educational requirement. Pali is a spoken language that originated in India. It has no script of its own for writing. Therefore, other scripts, such as Roman, Devanagari, and Burmese, are utilized for writing in Pali. Before the 19th century, the Khom script² was mainly used for Pali, Sanskrit, and Thai, while the Thai script was used only to write in the Thai language in Thailand.

From the 19th century onwards, use of the Khom script has dwindled, as King Rama IV (1804-1868) ordered monks to instead use the Thai script to write in Pali. Moreover, he also developed a new script named Ariyaka to replace the Khom script. In appearance, Ariyaka possesses an affinity to Roman (see Figure 1). Moreover, unlike Khom, it does not have any subscript. However, monks did not accept this new script, because they were not familiar with the letterforms. Instead, they continued to use Khom to write in Pali, and Ariyaka ultimately faded away.

When mentioning the Khom script here, it may get confusing whether the script is the same as Khom Thai. To explain further, the Khom Thai script can be also categorised as a type of the Khom script. However, the term "Khom" is used on its own to describe the script's application for writing in many languages including Pali, Sanskrit and Thai. When the Khom script is used for writing in Pali, it employs four fewer letters than are used for writing in Thai. This alteration is due to a dissimilarity in the languages' orthographic systems.



Figure 1. Ariyaka characters (above) designed by James (2010), compared with Thai characters (below) in TH Sarabun

Secondly, King Rama V (1853-1910) ordered Tripitaka to be translated from Pali into Thai (Padungsuntraruk, 2004, p.115–116). The newly published scriptures were printed in the Thai script. However, some Buddhist scriptures still await translation.

The third factor was a change to the Buddhist studies exam, the Sanam Luang test that the Theravada school in Thailand had administered since the 17th century. Traditionally, the test had required monks to translate Pali documents, written on palm leaves and utilizing the Khom Thai script, into Thai. They also had to translate in the opposite direction, all in front of a committee. This practice was replaced with a written assessment employing the Thai script.

From 1918, the Pali division of the Buddhist Association, which arranged the annual Buddhist studies exam, became concerned that the Khom Thai script would vanish. For this reason, it again included the Khom Thai script translation task on the annual examination. However, in 1945, the Ministry of Education decided to permanently cancel the test (Sali, n.d.). It made this decision on the basis of the government's nationalist and modernizing policies, which were intended to eradicate all ancient traditions regarded as obsolete. This policy change put an end to the study of the Khom Thai script at Buddhist institutes and schools. As a result, it became less necessary for monks and Thai students to learn the Khom Thai script.

Although these historical events played a significant role in Khom Thai's decline, educational policies in the 19th and 20th centuries also have some responsibilities according to Tsumura (2009). In an anthropological study on traditional Thai scripts in northeast Thailand, Tsumura (2009) pointed out that educational reforms in 1884 and 1921 were pivotal factors that worsened the situation.

Since the national policies in that period focused on centralizing political power in Bangkok, the educational system tended to disregard other regions' local knowledge, including the use of the Thum script, the Thainoi script, and the Khom Thai script.

In contrast to previous studies by Chucheun (1992), Kaewklom (1980) and Punnothok (2006) Tsumura (2009) suggested that the Thai script was not widely accepted across the country until the beginning of the 20th century when the educational reforms were adopted. It is noticeable, however, that Tsumura's study was based on a very small sample. His field study was based on interviews with 24 monks and 7 laymen (31 total participants) who used traditional scripts in only 3 villages in Khon Kaen. Therefore, it is hard to prove his point on a large scale, as he claimed.

Scheuren (2010, p.9) also made a comment in his footnotes that the Thai script had not been used until the late 19th century. According to him, before that time, Thais had used the Khmer script for writing. In fact, Thais had not only adopted the Khmer script for writing, but also used many traditional scripts, including the Pallava script, ancient Mon script, and Kawi script, before the time of the Thai script. Examples of inscriptions found in Thailand and written in these scripts are *Charuek Bon Than Praphuttharup Wat Huawiang* [ca. 1183] and *Charuek Thammikkaracha* [ca. 12th century].

Evidence from inscriptions also demonstrates the use of the Thai script across the country before the 19th century; these inscriptions include *Charuek Chao Therasithepkirimanon Nueng* [ca. 1413], *Charuek Somdet Phramahamuniratanamoli* [ca. 1420], and *Charuek Watyotkhaosamo Kalan*g [ca. 17th century]. Therefore, it is unlikely that Thais only started using the Thai script in the late 19th century, as suggested by Scheuren. However, it is observable that the new educational system solely relied on the Thai script, excluding the ancient scripts that the previous system had required students to learn, as Tsumura suggested. At that time, state schools were opened across the country to replace the former educational system, which had been based on Buddhist monasteries. Consequently, study of the Khom Thai script in the school system eventually came to an end. This researcher investigated the main Thai textbooks used in state schools in the 20th century, including those by Phraya Padungwitayasoem (1935), Khun Chitpitthayakam (1935), and Chao Phraya Thammasakmontri (1938). All of these texts were written solely in the Thai script, meaning that none were written in Khom Thai.

According to Tsumura, the year 1973 saw further education reforms. This new system emphasizes the importance of traditional knowledge. Its policies integrate local knowledge into the modern educational system, so that students in different locales can maintain a sense of pride in their regional heritage. However, the Thai script is still the only script in use at state schools across the country. Consequently, Thais do not utilize the Khom Thai script on a daily basis. However, examining the first national economic and social development plan (Government of Thailand, 1961-1966) through eleventh plan (Government of Thailand, 2012-2016) revealed that the third plan (Government of Thailand, 1972-1976) did not emphasise traditional knowledge, as Tsumura claimed. It was only with the eighth plan (1997-2001) that traditional knowledge came to the attention of the Thai government. However, studying main textbooks used in states schools in this period, including Bandai kaona (Kirathiwitthayosan, 1959), Nangsuerean pasa Thai (Sipaiwan, 1978), and Fue yanrai hai dek an ok kean dai (Raksuthi, 2010), again demonstrated that they were all written in the Thai script. This information supports Tsumura's claim that after 1973, the Thai script was the only script used at state schools.

Nowadays, Khom Thai is the topic of a required course for students of oriental palaeography in certain universities including Silpakorn University. However, it is limited accessible to ordinary Thais interested in the subject. It receives little attention from the public in general.

Overall, the historical studies presented in this section underline the reason that usage of the Khom Thai script is declining: a change in people's familiarity with it. When Khom Thai was removed from the educational curriculum in state schools, its letterforms became unfamiliar to literate Thai people. Namely, Khom Thai is no longer in regular use, as textbooks began to be exclusively published in Thai.

2.2 The exposure effect

After reviewing the historical cotext surrounding Khom Thai, this part moves on to the psychological framework that is related to the research.

"The hypothesis of habit" (as cited in Lund, 1999), "the mere-exposure effect" (Zajonc, 1968), the "familiarity effect" (as cited in Beier, 2009), and "the exposure effect" (as cited in Lidwell et al., 2010) all refer to a psychological phenomenon characterized by a fondness for familiar objects.

Lidwell et al. (2010, p.86) defined the theory as follows: "familiarity plays a primary role in aesthetic appeal and acceptance; people like things more when frequently exposed to them". Since this concept goes by multiple names, this paper uses the term, "the exposure effect", suggested by Lidwell et al. (2010).

Regarding familiarity and type design, Beier (2009) pointed out that design practitioners have long acknowledged that familiarity is an important factor that can increase the legibility of type. Regardless of the complexity of the letter structure, the legibility of type is believed to depend on the familiarity of the letterforms. The frequency of exposure to particular type styles can determine whether someone recognizes a typeface. As Licko stated, "We read best what we read most" (Licko, 1990, p.12 cited in Beier, 2009, p.47). To clarify this notion, Beier gave examples of type designers who forwarded this idea, including Dwiggins, Morrison, and Tschichold. In general, these designers suggested that typeface should be invisible during the reading process. It should not interrupt or draw any attention from readers. Beier emphasized the term "invisible", stressing that, "...in order to forget that a type is there, we must be familiar with it" (Beier, 2009, p.111).

Other designers, including Frutiger (as cited in Osterer & Stamm, 2014), Gill (1931/2013), Goudy (1940/1978) and Renner (as cited in Burke, 1998) also agreed that a new typeface should have familiar characteristics and should not be noticeable, since readers cannot always keep up with new styles.

As Zapf noted:

Only mankind's reason seems at times not to keep pace with modern development.

As the reader generally cannot distinguish between the 'old familiar faces' and the new, his question seems justified, since we ought to be able to get along

with the types already available. Finally, type designers cannot always think up

something new.

Some decades ago, the noted American type designer Frederic W. Goudy – surely the greatest type designer of recent times – came to the conclusion that the old fellows stole all of our best ideas

(Zapf, 1960/1970, p. 29).

Moreover, Licko also noted that legibility is not always static. Instead, it depends on the familiarity of typeface styles, which can change over time. To prove her point, she provided the example of Baskerville's change in recognition (Licko, 1996). Baskerville, unlike Caslon's OldStyle, has a high stroke contrast, an uncommon typographic attribute in the past. When the typeface was first released, critics said it looked too sharp. Licko stated that the typeface was rejected and labelled as illegible. However, Baskerville is one of today's most accepted typefaces. According to Licko, Time Roman was received in a comparable manner. People did not widely embrace that typeface when it first appeared. After exposure, however, Time Roman went on to become one of today's most popular typefaces. Licko pointed to Blackletter as another example, stating that, "It's the same with Blackletter, which was at one point more legible to people than humanist typefaces" (Licko, 1990, p.12).

Regarding Blackletter and the Latin type, Beier extended Licko's argument, providing additional details. Beier noted that before the Renaissance, Blackletter had been the predominant typeface across Europe. Although the Latin letterforms slowly grew in popularity in Western Europe, many Europeans, including the Dutch, were still unable to recognize the Roman script, despite the fact that it was used for writing in their native languages. Even in the early 19th century, Blackletter easily remained the dominant typeface in Germany. Beier cited Otto von Bismarck's 1882 letter, in which he claimed he could read faster in Blackletter than Roman (Beier, 2012, p. 159). However, as scholars began promoting the use of the Latin type, it eventually became the standard for writing in most parts of Europe, as it is today. Presently, people familiar with Latin letterforms thus find it more legible than Blackletter.

In Germany, both Blackletter and Latin letterforms were in use before World War II. However, Blackletter lost public acceptance in 1941 when the Nazi party announced that it had a connection with Jews. Consequently, the Roman type officially replaced Blackletter. However, the Nazis later proclaimed that the true reason behind that decision was that German speakers outside of Germany could barely read Blackletter, due to their familiarity with the Latin type, which led to communication glitches between Nazi Germany and other countries (Beier, 2012, p.160).

On the basis of these examples, Licko concluded that familiarity must play a central role in legibility, since readers can understand texts written in a particular typeface once they become accustomed to it.

However, Ole Lund (1999) argued that this conclusion is too generalized. For instance, a reader may find a text set in a common typeface more legible than a scarcely readable text. This may be because the typeface is more visible in the former text than in the latter, rather than because of the reader's familiarity with it. Moreover, it does not mean that the effect will occur under all kinds of reading conditions. Lund thought that Licko's concept was obscure and lacking sufficient proof.

In Lund's view, the question remained as to whether legibility is biologically determined or influenced by the environment. Another critique of the exposure effect is that people can become emotionally attached to unrelated or meaningless stimulants, suggesting that preferences do not develop solely on the basis of familiarity (Eysenck & Keane, 2010). Moreover, repetition can sometimes lead to boredom and reduced likability, as many psychological studies have demonstrated (e.g., Bornstein et. al, 1990; Crisp et.al, 2009).

Thus far, the discussion has revolved around the familiarity of the Latin type. Most studies on legibility and letter recognition have focused on the Roman alphabet (e.g., Friedman, 1980; Kinoshita & Kaplan; Polk & Farah, 1997; Thompson, 2009). However, Khom Thai is a non-Latin script. The literature on that topic did not contain any previous studies on Khom Thai and the exposure effect.

For other non-Latin scripts, including Arabic, there exist a number of studies that are not directly relevant to the topic of interest. For example, a study on priming and the Arabic script was published in 2012 (Carreiras et al., 2012). Priming is a psychological effect in which a person's actions are unconsciously influenced by a previous stimulus briefly presented before the individual is asked to perform a task.

In legibility research, the same-different matching task is a frequent topic of study. Such procedures can be divided into five primary stages. First, a reference letter or string of letters (probe) is presented on a computer screen for less than a second. Next, a mask, such as a hashtag sign, replaces the reference and then disappears. After this step, a letter or group of letters (prime) is briefly presented for less than a second and vanishes. Then, a target letter or group of letters is shown. Lastly, the participant is asked to identify whether the target is the same as the probe. The accuracy rate is then compared to ascertain whether the prime actually influenced the answers. This type of research predominantly focuses on lower-case and upper-case Roman letters.

Researchers (e.g., Kinoshita and Kaplan, 2008) have frequently found that that the priming effect is stronger when the prime and target pair lower-case and uppercase letters sharing common features (e.g., "y" and "Y") than when the letters do not share analogous traits (e.g., "a" and "A").

Carreiras et al. (2012) came to the same conclusion, finding that a prime with similar characteristics could more successfully influence the participant's response than could primes with dissimilar features. The difference was that Carreiras et al. used Arabic letters, and so they determined that the priming effect might be universal. Although it does not play a direct role, familiarity interestingly seems to be an important factor influencing letter identification accuracy.

However, it is questionable whether the same effect would occur with Khom Thai. Whether the priming effect is a universal phenomenon still requires further investigation.

2.3 Investigating letter recognition methods

Researchers have developed various methods for investigating type recognition. Since legibility is an essential element of type design, legibility research methods are often applied to test a typeface's performance. With the goal of identifying an appropriate technique for comparing the recognition of the Khom Thai letterform designs (see Chapter 4), this study reviewed legibility research methods. It was conducted from a design perspective, but not all legibility research approaches are an appropriate fit for practice-led research in art and design. For that reason, the scope of this review is limited to methods that type designers have employed. A search of databases, including the British Library (Ethos), University of Huddersfield Summon, the National Library of Thailand, and Google Scholar, identified at least three PhD dissertations wrote by design practitioners that investigated legibility at the time that the paper was written (Beier, 2009; Chahine, 2012; Lund, 1999). Together, these three studies outline methods for assessing legibility. The letter recognition study in Chapter 4 was based on these approaches.

There are six major approaches: threshold visibility, the search task, tests on continuous reading, eye movement, preference rating, and typeface topology studies (see details in Appendix B). Each method has its own strength and weakness, and so not every technique is suitable for every reading condition.

In the case of Khom Thai, not all the tests are applicable. According to the interview with the senior lecturers (for details, see Appendix D), beginners' main obstacle in reading the Khom Thai script is that they struggle to recognize single letters, rather than engaging in continuous reading. When students fully learn all of the characters, they can easily read the script. Thus, this study focused on the recognition of single letters, because the letterform designs in this paper will be used as writing models and learning materials. That intended use means that each character will be used separately. Moreover, single letters play a key role in reading. Without individual letters, one could not read words. As stated in the introduction, this study did not assess legibility via continuous reading tests. Therefore, this contextual review does not incorporate studies that utilized that approach. The methods summarized by Beier (2009), Chahine (2012) and Lund, (1999) indicated that the search task has not gained widespread acceptance because it cannot represent an actual reading process. Consequently, this research project did not employ that technique. In addition, Lund (1999) suggested that a wide range of scientific typeface typology studies is not based on human behavioural observations. For instance, such studies rely on computational models to mimic human vision and to observe input and output information, rather than observing actual human behaviour. This method is open to criticism, because human vision is far more complex than computers (Eysenck & Keane, 2010), which could lead to inaccurate results. The literature on threshold visibility and preference rating describes two appropriate methods for studying letter recognition.

"Threshold visibility" (see Chahine, 2012; Lund, 1999) or the "visual accuracy threshold" (see Beier, 2009) is a method using letter or word identification as a measure of typeface recognition. Commonly, this test is conducted with literate adults who have no difficulties with reading (e.g., dyslexia or eye problems). The procedure starts with the computer presents a single letter, group of letters, or word to the participant. Next, the participant is asked to name the character or word. The accuracy rate or response speed is an indicator of recognition.

Regarding the accuracy rate, the greater the participant's success in correctly identifying the letters, the more recognizable the typeface is. Likewise, when it comes to the speed of response, the less time the participant requires to recognize the typeface, the greater its legibility. This approach has two subtypes: short exposure and variable distance (Beier, 2009).

Short exposure involves flashing individual letters or words on a tachistoscope or computer screen for a short period of time (less than one second), so that the eyes cannot shift focus (Beier, 2012, p.17). The short exposure method is the best fit for examining letter recognition.

The variable distance method tests from how far participants can read a typeface. It is a fitting approach for examining display typefaces or signs (e.g., road signs) at considerable distances (Chahine, 2012, p.136; Lund, 1999, p.93). Since the TLK series consist of letterform designs intended for use as writing models and learning materials, the variable distance approach would not have been a suitable method for testing their performance.

Another method in legibility research is preference rating. In this method, the researcher asks participants to rank selected reading materials by order of preference. The limitation of this method is that it depends on personal, subjective experiences rather than objective factors. However, this study was based on design practice, and was not located in a particular scientific discipline, and so preference rating was applicable.

This study adopted two legibility methods, the short exposure technique and the preference rating, to gather information (see Chapter 4). In this study, the ultimate goal was to investigate whether familiar traits could improve the letter identification rate of Khom Thai as the analyses in Chapter 4. To do so, it was necessary to collect additional data instead of simply relying on the designer's aesthetic whims and judgements. It was important to consider the reader's experience to improve the design decision. In this case, the emphasis was on whether short extenders and narrower Khom Thai characters could affect the recognition of that script.

2.4 The practitioner-researcher role

To find suitable frameworks for this practice-led research, previous PhD studies in the Ethos database were examined as signposts. Studies were included if their contents were relevant to this analysis.

Yee's work (2006) stood out, since it provided examples of how to approach practice-led research in typography. Her research primarily focused on creating a typographic educational framework for cross-media typography, a topic that was not directly relevant to this project. However, her PhD study provided an in-depth examination of the problems surrounding practice-led research methodologies. Initially, design research did not rest on concrete principles. Therefore, researchers had to adopt methodologies from other fields (Yee, 2006, p.63). According to Yee, there was an attempt to "scientise" design research in general during the 1960s and 1970s. This early movement was based on the assumption that scientific approaches could resolve any design problem. This practice positioned the researcher as an objective and rational outside observer. Likewise, at that time, early legibility research adhered to the same positivistic trend as Lund (1999) pointed out. Studies were primarily science-based and focused on type legibility. Consequently, researchers in other fields, such as psychology, carried them out.

The main drawback was that these researchers lacked typographic knowledge. As a result, they often misinterpreted the research results. For example, Lund commented on the improper choice of stimulus materials in Pedersen and Kidmose's experiment (Pedersen and Kidmose, 1993). That study compared the reading speed of text between ITC New Baskerville and Monotype Baskerville to determine the legibility of the typefaces. The x-height was the experimental factor. It was difficult to verify that the x-height influenced the legibility of type, because ITC New Baskerville and Monotype Baskerville have different typographic properties. Therefore, that study could not conclude whether the x-height or other variables were responsible for the reading speed results.

Another criticism of the science-driven approach is that it hinders creative initiative, which is an essential component of art and design. Furthermore, scientific methods sometimes undervalue the professional knowledge of design practitioners.

For instance, Poulton's article (Poulton et al., 1965, p.48 cited by Lund, 1999, p.106) disqualified designers' knowledge, stating:

But how much is really known about the effectiveness of printed graphic design? There are plenty of opinions, plenty of guesses — but how much soundly based fact? ... there is no real body of knowledge about graphic design — slogans substitute for fact.

After the positivist movement, concern mounted regarding the limitations of scientific approaches in art and design research. Accordingly, the field's research frameworks have been reassessed. Many thinkers (e.g., Schön, 1983; Archer, 1979 as cited in Yee, 2006) have called for a new research paradigm, one that considers artistic skills as the body of knowledge. This paradigm shift has led to the development of research methodologies for practice-led research. This new shift does not imply that a theory-driven approach should be completely excluded from practice. As Yee suggested, practitioners should be aware of the importance of theory as well as practice; otherwise, research in this field will be dominated by experts from other domains.

The review of her work illustrated that Yee used mixed methods drawn from both qualitative and quantitative approaches, including reflective practice, peer reviews, questionnaires, and educational frameworks. She also compared her own work with the iterative design process that she followed to develop her educational model (prototype). Yee then solicited external feedback from in-depth interviews with educational and professional reviewers to improve the framework and identify key problems in typographic education of screen-based media. Three classroom-based action research projects were also conducted with students at Northumbria University to retest her model.

Her approach was consistent with the "practitioner-researcher role" that Gray and Malin (2016) used to describe the practitioner's stance as a researcher in the field of art and design. Inhabiting both roles requires the simultaneous integration professional knowledge and research skills. However, design work is based on personal experience, and it emphasizes learning by doing. Thus, the practitioner is the centre, a self-observer who develops creative works on the basis of inner judgements. In contrast, a researcher must look through the lens of an external observer, avoiding prejudging the research context in advance. Consequently, this process needs connections with the external world, so as to examine reality from a different angle. When a practitioner is a researcher, balancing the two roles can be challenging.

The main difficulty facing designers and artists is that they sometimes refuse to articulate their thoughts in an academic manner, out of a fear that it would cause them to lose their creativity, as Gray and Malins pointed out (2016, p.21). This problem leads to a disconnection between the role of the academic and the role of the design practitioner, and Yee tried to bridge this gap by bringing together theoretical and reflective approaches.

Beier (2009) described the situation in similar terms. Beier pointed out the absence of communication between the creative drive and the academic approach. This separation can lead to a lack of output contributing to the field of art and design. On its own, each point of view might not provide the full picture.

Regarding the study of Khom Thai, linguists and historians have conducted most of the research on the topic. It is for this reason that design issues have not been raised; the previous researchers have lacked knowledge of the typographic field. Khom Thai letterforms have not been the focus of these studies. Therefore, Khom Thai type design research has not advanced. On the contrary, design practitioners' disinterest in conveying their thoughts on design practice has led to a shortage of models for Khom Thai letterform design.

Overall, exploring the design research highlighted the need for integrated approaches in art and design research that incorporate both of the two roles. From the designer's perspective, the design object is the result of an individual construction process. This idea derives from the concept of reflective practice which has constituted a widespread research movement since the 1970s (Ferguson, 2012). This approach has frequently been cited as a means of engaging in art and design research (e.g., Yee, 2006; Gray and Malin, 2016). This practice acknowledges feelings, experiences, reflexivity, and personal involvement with the design artefact as research methods. Moreover, reflective practice can include an analysis and evaluation of how each design problem is solved.

Yee (Schön, 1987, p.115 as cited by Yee 2006, p.71) summarized the process, splitting it into the four steps in reverse order listed below:

- "4-Reflection on reflection on the design description
- 3-Reflection on the design description
- 2-Description of designing
- 1-Design"

First, the practitioner must reflect on his or her thoughts during the design process (reflecting in action). Secondly, the designer thoughtfully defines the design actions. In the next step, the pratitioner questions the suitability of the designer's description of the design artefacts or actions. The final goal is to ascertain the answers to the research questions.

In a practicum setting, according to Schön (1987), the relationship between the coach and the student is the key to nurturing the learning process of reflection-in-action. However, this research did not further pursue that concept, because the focus was on the design practice rather than on the educational context that Yee emphasised. This concept of reflective practice provided direction for both Chapter 3 and the portfolio, which represents the project's practical side. Both of them explored personal construction during the process of designing the three letterform designs. The approach involved self-communication, with the goal of understanding how each design was developed through practice. In another framework, the researcher's role, legibility research methods (short exposure technique, described in Chapter 4) and social science methodologies (questionnaires and semi-structural interviews, also discussed in Chapter 4) were adapted to assess the letterform designs from an external perspective. As a tool for viewing the designs from a different angle, this latter approach provided additional support (see Chapter 4).

2.5 Review of the practice portfolio

Since the Khom Thai script's letterforms differ from those of the Roman alphabet, the general method used to develop Roman type was not always sufficient for designing Khom Thai. For instance, the Roman alphabet does not have any subscript characters. All of its letters are written above the baseline, while some of non-Latin typefaces, including Khom Thai, require extra space for subscripts under the full letterform. Moreover, the Roman type does not have any upper and lower vowels written above the letters, while Khom Thai has these characteristics. From these differences, there is a need for further investigation into other related Asian scripts.

This section focuses on letterform analyses, especially Thai, and Khmer, which share some graphic properties with Khom Thai. The review includes studies of Khom Thai, Thai and Khmer Moul letterforms by other design practitioners. This part gives an insight into design issues that help developing the working process for the TLK letterform designs.

Existing Khom Thai typefaces

Although a considerable volume of literature has addressed the history of Khom Thai, few studies have explored design processes that type designers could use as guidelines. The databases of the Thai National Library and the Thai Library Integrated System, which compile scholarly documents, theses, and studies from most of universities and institutes in Thailand, contained only one study related to the design framework (Phramaha Kittisak Maitreejit, 1999).

This was a master's thesis by Phramaha Kittisak Maitreejit that involved designing four computer-based lessons to teach the Khom Thai script. Although the researcher created a Khom Thai typeface, KM-khomtai, as a learning resource for the lessons, it was not the focal point of the study. Rather, it was only a supporting component. Despite the fact that Phramaha Kittisak Maitreejit's research was, by nature, a practice-led study, the study nevertheless focused more on the lessons' educational framework, only briefly describing the typeface's design process.

Regarding the methodology, the researcher only named the software used to produce the typeface. There was no explanation of how the letterforms were developed or how the typeface's proportions were established. Although Phramaha Kittisak Maitreejit insisted that his typeface represented the authentic style of the script, and supported his claim by stating that the design was approved by his supervisors and experts in epigraphy, the thesis did not refer to pre-existing writing styles from ancient documents to corroborate his claim. The lack of clarification regarding the typeface development process renders this work unsatisfactory as a design guideline. Although the typeface was published in Wimonkasem's (2011) widely used textbook on Khom Thai epigraphy, KM-khomtai proved to be an inadequate writing model for students because of certain inconsistencies in the letterforms. A close observation reveals that the stroke weight (see Figure 2), x-height of the individual letters (see Figure 3) and angles (see Figure 4) are not unified. For example, there is no unity in the design of the sok or the upper component. The shapes and sizes of characters fluctuate too much. In some cases, letters that should be the same height diverge from each other (see Figure 3). These issues could mislead beginner students using this typeface as a reference.



Figure 2. Example of unrefined outlines of so suea and yo yak in KM-khomtai



Figure 3. Inconsistent heights of ko kai, to tao, cho chang, and no nu

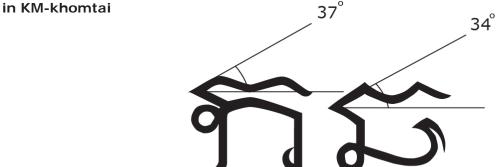


Figure 4. Different sok angles in ko kai and cho ching in KM-khomtai

Another Khom Thai typeface widely used in Thailand is Khom2004. The Office of Culture at Khon Kaen University developed this typeface in 2004. Like KM-khomtai, this typeface is inadequate as a writing model for a number of reasons. First, some of the individual letters do not follow the traditional Khom Thai script. For instance, the cursive crossbar of so ruesi, the 39th letter, faces the wrong direction, as Figure 5 demonstrates.

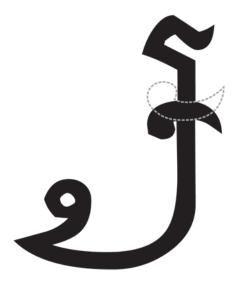


Figure 5. So ruesi in Khom2004 (the cursive crossbar in the middle is normally placed in the area indicated by the dashed lines)

This composition of Khom2004 does not follow the Khom Thai writing tradition. Finally, nearly all of the letterforms for numbers completely diverge from commonly used Khom Thai numbers (see Table 1). Again, the designers did not mention using any ancient documents as a source of inspiration or reference. The stroke weight of Khom2004 is more consistent than KM-khomtai. However, the overall outline of each character is not smooth.

Number	0	1	2	3	4	5	6	7	8	9
Design										
TLK Deva	0	ව	<u></u>	ពា	\mathcal{C}	٩	9		\gtrsim	$\mathcal{C}_{\mathcal{I}}$
Khom2004	0	9	ত্ত	Œ	C	3	5	9	2	Q

Table 1. Comparison of Khom Thai numbers in TLK Deva (representative of typical letterforms) and Khom2004

Apart from these two typefaces, no other Khom Thai typefaces were found in Thai type foundries, the Thai Library Integrated System database or the Thai National Library database. These sources housed the largest scholar databases in Thailand at the time that this paper was written. A review of both existing typefaces indicated that they are insufficient in terms of bridging the gap between Khom Thai and contemporary fonts and design methodologies. The typefaces' letterforms are not recommended writing models, since they were not designed on the basis of a comprehensive examination of ancient writing styles. These typefaces could misguide students about how to correctly write the Khom Thai script.

Khom Thai writing models

Wimonkasem's (2011) textbook about ancient scripts in Thailand is one of the major resources currently in use in the Department of Oriental Languages at Silpakorn University for studying Khom Thai. In this textbook, a writing model (Wimonkasem, 2011, pp.37-43) provides writing directions for most Khom Thai characters (Figure 7). However, that model is incomplete. For instance, the framework lacks a writing model for dependent vowels. Nevertheless, those characters can be found in small sizes in other sections explaining Khom Thai orthography (e.g., Wimonkasem, 2011, p.50). As previously discussed, the textbook's model relies on the KM-khomtai font developed by Phramaha Kittisak Meetrijit (1999) throughout that work. While the models of the National Library (2010) and Chuchuen (1992) are based on handwriting.

Inspecting the National Library's writing model (2010) and Chuchuen's model (1992) illustrated that those frameworks are also incomplete (Figures 6-7). Certain characters, such as fo fan, po pla, so sala, and so ruesi, are missing. In the National Library's model (2010), tin khu is written upside-down, thereby differentiating that framework from other writing models and Trai Phum manuscripts.

Among the three frameworks, Chuchuen's model provides very small-sized sample characters. Such minute sizes are not useful for beginners for practicing writing Khom Thai characters. These observations indicate the need for more learning materials, and especially for Khom Thai writing models, since the existing models are not sufficiently accurate.



Figure 6. Khom Thai characters written according to Chuchuen's model (1992), by Virunhaphol

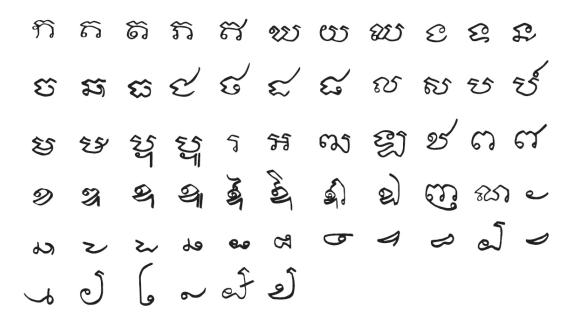


Figure 7. Khom Thai characters written according to Wimonkasem's model (2011), by Virunhaphol



Figure 8. Khom Thai characters written according to the National Library of Thailand's model (2010), by Virunhaphol

Overview of Thai typefaces

Until this point, this chapter has investigated the Khom Thai script itself. However, standards of familiarity have changed in Thailand since the 15th century, and type design is no exception. These shifts therefore make it necessary to examine the current Thai script alongside Khom Thai, so as to understand the contemporary context. At present, the Thai script is Thailand's official script. It evolved from the ancient Khmer script and the ancient Mon script into the simpler version familiar to Thai people today.

Regarding the Thai script³, more documents address its history than its design. Only few number of books are written on Thai type design (e.g., National Electronics and Computer Technology Center, 2001; Royal Society of Thailand, 1997; Suveeranont et al., 2005).

This section now turns to Thai letterforms. One resource worth mentioning is f0nt.com by Singto, one of the largest free font-providing platform in Thailand. This website also houses forums on typography and type design, which are a valuable resource for Thai design practitioners interested in sharing their design experiences. Nowadays, the forums contain too many posts to review, especially considering the timeframe of this study. For instance, posts in the forum on font criticism (not including the other four typographic forums) now number 18,187 (retrieved on 21 August 2016). Furthermore, most of these posts were not directly related to the subject of interest, and so only topics that have content relevance are discussed here.

I reviewed the history of the Thai script before its design, due to the greater availability of research materials on that subject. However, as this contextual review expanded, it became clear that the history of the Thai script was not the central focus. Nevertheless, this background information provided useful when I later constructed the design framework. Therefore, some historical background information on the Thai script was moved to Appendix A.

Apart from reviewing fonts on this website, I also assessed a wide range of materials. These included: Google's font directory, Linotype's online catalogue, Monotype's online catalogue, the directories of 5 major type foundries in Thailand (Superstore, Cadson Demak, DB font, font PSL, and Katatrad), Thai Adobe fonts, and the 13 national fonts. This initial search of current styles highlighted today's larger trends in design. In general, Thai fonts exhibit diverse shapes, sizes, and stroke weights. Fonts that have regular stroke weight are more common for running texts than other stroke weights, such as bold, italic, and light. This part examined the regular stroke weight style of current Thai fonts more than other styles because it is more frequently in use.

The findings of the literature review indicated that an official Thai typeface classification system still does not exist. Additionally, terms for describing the anatomy of Thai type are still insufficient. A classification would provide many benefits. For example, such a scheme could provide a system of use for identifying typefaces. Moreover, a classification could provide a terminology for describing graphic elements and typography, making terms understandable for the purpose of communication. That said, such a standard does not yet exist.

Nevertheless, attempts have been made to classify Thai typefaces based on looped styles as shown in Figure 9 (e.g., National Electronics and Computer Technology Center, 2001). However, it would be controversial to conclude that the Thai loop is the equivalent of the Latin serif, since the loop plays a larger role than the Roman serif in distinguishing confusing letter pairs, such as rue and lue, as Figure 10 demonstrated. Certain characters, such as pho phueng/pho phan, tho thung/pho samphao, kho khwai/do dek, rue/lue, and fo fa/fo fan, have highly similar basic skeletons, leaving the different positions of the loops as the key element for differentiating them. Without loops, separating these sets would be challenging. For this reason, the looped style is regarded as more legible than the loopless design. The looped style is commonly found in both headlines and body text. On the contrary, the loopless style is less used for body text.

Apart from the loop, many elements can also be used for distinguishing typefaces, and these include the type of upper curve and the horizontal stroke at the base (Royal Society of Thailand, 1997), as displayed in Figure 11. Therefore, using loop styles to classify Thai is not the only categorisation method.

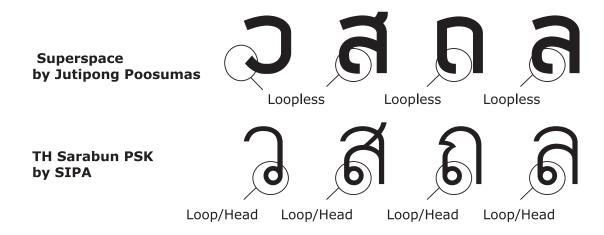


Figure 9. Loopless (above) and looped styles (below)

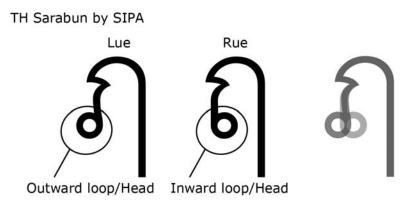


Figure 10. Lue and rue in TH Sarabun

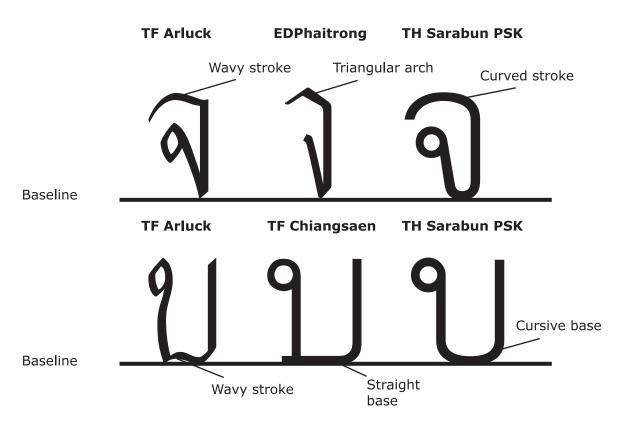


Figure 11. Upper curve types and the bases of cho chan (above) and bo baimai (below)

Seven writing models

Before moving on to the analysis of Thai types, it is also necessary to consider the writing models taught in state schools. In that regard, this paper examines main Thai writing models (Figures 12-18) used for Thai letterforms. These frameworks informed the TLK designs that were developed at a later state. According to Office of the Basic Education Commission or OBEC (1992), there are at least seven popular writing models in Thailand that have been in use since the 17th century. These are Alak's model, Phraya Padungwitayasoem's model, Rongrian Thungmahamek's model, Rongrian Sainamthip's model, Chulalongkorn's model, Khun Samritwannakan's model, and the Ministry of Education's model (Office of the Basic Education Commission, 1992).

Among these seven, Alak is the oldest writing style. The word "Alak" refers to Thai royal scribes. However, the term is also used for describing the writing style employed by those royal scribes (Figure 12).

Phraya Padungwitayasoem's model has been used since 1928 (Office of the Basic Education Commission, 1992, p. 6). A Thai textbook, *Baep hat an ko kai kho khai ko ka*, written by Phraya Padungwitayasoem (1935), contains two types—the one depicted in the writing model (Figure 18) and the book type used for the running texts in this book. In the book type, the heads of kho khai, kho rakhang, cho chang, so so, and tho montho are circular, while the heads employed in the writing model have open circular terminals. Another difference pertains to the fact that the book type is a serif typeface, unlike Phraya Padungwitayasoem's writing model.

Chulalongkorn's model was developed around 1969 (Figure 13) and used in the Faculty of Education at Chulalongkorn University. The idea of developing this model was put forth by the head of the Elementary Education Department, Professor Ampai Sucharitkun.

From 1977 onwards, Khunsamritwannakan's model (Figure 14) has been utilised as a writing model (Office of the Basic Education Commission, 1992, p. 3). Later, this framework was developed into the Ministry of Education's model (Figure 15). Rongrian Thungmahamek's model is based on Mongkon Suphanrat's handwriting (Figure 16). Monkon Suphannarat was a headmaster at Supamatphitayakhom School. His son, Surin Suphannarat, who was a headmaster at Thungmahamek School, used his father' handwriting as a writing model for students at his own school beginning in 1966. In 1967, it was adapted and further developed into Rongrian Sainamthip's model (Office of the Basic Education Commission, 1992, pp.7-8). These two writing models have shorter extenders than Alak's model. Serifs are present in none of the seven official writing models. In nearly all of the models, kho khai, kho rakhang, cho chang, so so, and tho montho have heads; the exception is Phraya Padungwitayasoem's model that the characters have open circular terminals (Figure 18).



Figure 12. Alak's model, as written by Virunhaphol

ว ๔ ษ ๙ พ พ อ ฮ ว ำ ไ ใ โ ฟ ฟ ม ม ย ธ ฮ ฮ บ า ไ ใ โ ฟ ฟ ม ม ย ธ ฮ ฮ บ า ไ ใ โ ฟ ฟ ม ม ย ธ ฮ ฮ ฮ บ า ไ ใ โ ฟ ฟ ม ม ย ธ ฮ ฮ

Figure 13. Chulalongkorn University's model, as written by Virunhaphol

กขาคคมงานชชญญฎฎฐพญ ณดตถทธนบปผฝพฟภมยรล วศษสหพือฮี-ัว-าไใโฤฦฦะา

Figure 14. Khunsamritwannakan's model, as written by Virunhaphol

Figure 15. The Ministry of Education's model, as written by Virunhaphol

Figure 16. Rongrian Thungmahamek's model, as written by Virunhaphol

กขาคคมงงน ช ช มญฎฏฐพญ ณ ๑ ๓ ๓ ๓ ๓ น บ ป ผ ฝ พ ฟ ภ ม ย ร ฉ ว ศ ษ ส ห พื่อ ฮี ว ำ ไ ใ โ ฦ ฦ ะ า เ

Figure 17. Rongrian Sainamthip's model, as written by Virunhaphol

กขขคคมงกถนบป ผฝพพภมยรถ วศษสหพือยี-ว-าไใโฦฦ;า

Figure 18. Phraya Padungwitayasoem's model, as written by Virunhaphol

Thai types

The next part moves on to analyse typographic elements of Thai types. This discussion does not claim to be a complete exploration of all Thai typefaces; instead, it addresses a selection containing type examples that had made a significant impact on the development of Thai letterforms, and this section addresses general understandings of typographic structures. Although Thai historians believe that printing production in Thailand started in the 17th century, printing began to flourish in the 19th century, as Dan Beach Bradley, an American missionary, opened a press in Thailand in 1839. One of his early typefaces was published in *Kampi kan raksa* (Bradley, 1842). The style of this typeface resembles handwriting, with inconsistencies in the letterforms, as Figure 19 illustrates.

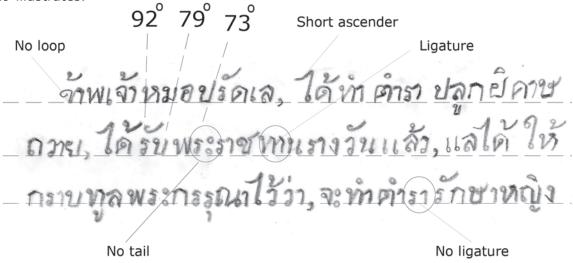


Figure 19. Analytical drawing of characters from Bradley's typeface in *Kampi kan raksa* (Bradley, 1842) at approximately 130% of the original size, drawn and analysed by Virunhaphol. Adapted from *Kampi kan raksa* (p. 3), by D. B. Bradley, 1842, Bangkok, Thailand: A.B.C.F.M. Press. Public domain.

Figure 19 contains an analytical drawing study of one of Bradley's early metal typefaces. The extenders are shorter than the handwriting in the Thonburi period. The angle stresses of ho hip, mo ma, and bo baimai is at approximately 88 degrees, 79 degrees, and 73 degrees, respectively. Kho khai lacks a loop, while cho chang, which shares certain features, does have a loop. In certain cases, the ligature of lak khang links to the former character , while in other instances, these are separated. Sara a does not have a tail, while all of the seven writing models depict sara a with that element. The vertical stems are straight.

Bradley also created further Thai typefaces for his newspaper, *the Bangkok Recorder*, between 1844–1845 and 1865-1867. That publication is considered the first Thai newspaper published in Thailand. Those typefaces have more of an upright and uniform appearance than his early works. These typefaces may be separated into subcategories on the basis of the upper arch of the characters. In general, the main differences concern the arch. The first Bradley' type has a triangular arch (see Figure 20), while the latter has a cursive arch (see Figure 21). There is a ligature links lak khang and the former letter in both of the typefaces. This feature imitates handwriting and is seen in works from the late Ayutthaya writing style to the early Rattankosin era.

Figure 20 includes an analytical drawing of Bradley's typeface in *the Bangkok Recorder*. One of the unique characteristics of that typeface is that the loop of so ruesi's crossbar is not situated in the middle of the body, as it is today. For yo ying, the descender is detached from the body, as with the modern yo ying. Cho chang has a close counter. There is no gap between the head and the tail of the letter.

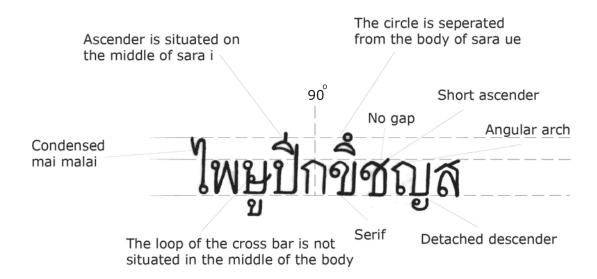


Figure 20. Analytical drawing of characters from Bradley's typeface in *the Bangkok Recorder* (1865) at approximately 200% of the original size, drawn and analysed by Virunhaphol. Adapted from *the Bangkok Recorder* (p. 1), by D. B. Bradley, 1865, Bangkok, Thailand: Bradley's Press. Public domain.

In comparison with the handwriting in the Thonburi period, the extenders of Bradley's typefaces are significantly shorter. They are serif typefaces, and the proportional dimensions of certain characters, including mai malai, are noticeably more condensed. The angle stress is at 90 degrees, unlike the handwriting, which slants to the right. Although there are differences between these typefaces and the handwriting style, as previously noted, certain characteristics of traditional handwriting also exist in Bradley's works. For instance, the ascender of sara i does not sit at the right end. The circle above sara ue is separated from the body, in contrast to the contemporaneous sara ue, which commonly features a circle attached on the right side. These are common traits of the Ayutthaya (the 14th-18th centuries) and Thonburi style (the 18th century).

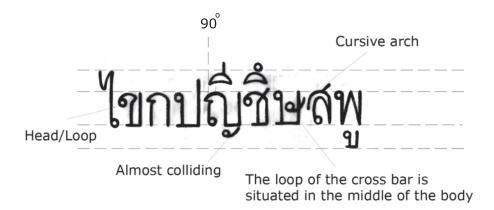


Figure 21. Analytical drawing of characters from Bradley's typeface in *Nirat muang London* (Mom Rajoday, 1881) at approximately 200% of the original size, drawn and analysed by Virunhaphol. Adapted from *Nirat muang London* (pp. 23-26), by Mom Rajoday, 1881, Bangkok, Thailand: Bradley's Press. Public domain.

Over all, this typeface is more cursive than the first style. Kho khai has a nearly close counter, while cho chang has a close counter. Loops are clearly visible. The descender of yo ying almost collides with the body above. Sara i and sara ue have the same properties as in the first style. In this typeface, the loop of so ruesi's crossbar sits in the middle of the body, as with the present-day writing model.

Thong Siam

Thong Siam is a Thai metal type used to publish a book called *Flag regulations for the kingdom of Siam* in 1899. This book concerned the specifications of the Thai flag. As indicated in Figure 22, the general forms of the characters are upright. The typeface is serif. Circular loops are significantly visible, and the extenders tend to be short. The vertical stem tends to be slightly curved at the base of the circular head and then become straighter. Sara i and sara ue bear a greater resemblance to present-day writing models. Kho khai and cho chang have different characteristics. For kho khai, there is an open counter, while cho chang has a close counter.



Figure 22. Analytical drawing of Thong Siam's characters in *Flag regulations* for the kingdom of Siam (Thailand, 1899) at approximately 200% of the original size, drawn and analysed by Virunhaphol. Adapted from *Flag regulations for the kingdom of Siam* (pp. 18-20), by Thailand, 1899, Leipzig, Germany: W. Drugulin. Public domain.

Farangset

In 1913, a metal typeface called Farangset was created by Assumption College, the first Catholic school in Thailand (Suveeranont, 2002). This typeface served as a model for later popular fonts, including Angsana UPC and DB Angkana. Farangset was the first type with a significant stroke weight contrast, and loops are clearly visible. It is a serif typeface. In comparison with Thong Siam and Bradley's typefaces, Farangset is the only one with flattened beaks, as the others have angled beaks. The ascender of sara i is moved slightly inward from the right end of the body.

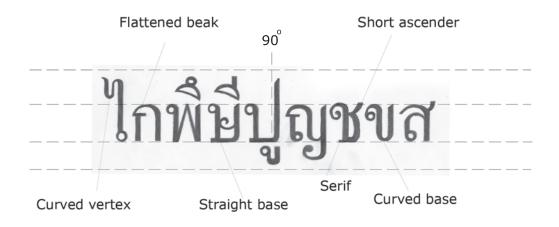
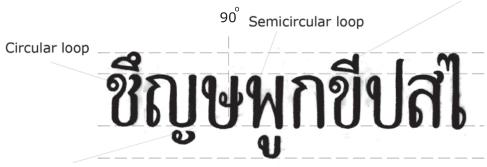


Figure 23. Analytical drawing of Farangset's characters, republished in *Sarakadee* (Suveeranont, 2002, p.69) at approximately 200% of the original size, drawn and analysed by Virunhaphol. Adapted from "10 faces of Thai type and Thai Nation", by P. Suveeranont, 2002, *Sarakadee*, 211(18), p.69.

Pong typefaces

Pongmai and Pongsae were among the first display types used for newspaper headlines in Thailand from 1917-1939 (Suveeranont, 2002). Pongmai is narrower than Pongsae (see Figures 24-25). The stroke weight of Pongmai is also thicker. Both have short extenders, and the tail of cho chang is at the x-height line. There are two types of loops in Pongmai. First, for several narrow characters, including cho chang and kho khai, the loops are circular. However, others such as pho phan and po pla have semicircle-shaped loops, while Pongsae features small loops without counters. In Pongsai, so suea's tail is attached to the slope inside the body, as depicted in Figure 24 while in Pongmai, the tail starts from the right end of the upper arch. The vertical stems are thicker than the horizontal strokes for both of the typefaces.

The vertical stem is situated at the end of sara i's body



Detached descender

Figure 24. Analytical drawing of Pongmai's characters, republished in *Sarakadee* (Suveeranont, 2002, p.71) at approximately 200% of the original size, drawn and analysed by Virunhaphol. Adapted from "10 faces of Thai type and Thai Nation", by P. Suveeranont, 2002, *Sarakadee*, 211(18), p.71.

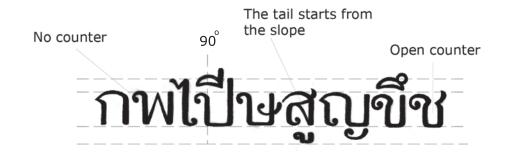


Figure 25.Analytical drawing of Pongsae's characters, republished in *Sarakadee* (Suveeranont, 2002, p.70) at approximately 200% of the original size, drawn and analysed by Virunhaphol. Adapted from "10 faces of Thai type and Thai Nation", by P. Suveeranont, 2002, *Sarakadee*, 211(18), p.70.

Tom light

Tom light is a photosetting type used in the Thairath newspaper between 1976-1987. It was designed by Thongtoem Semonsut, the head of printing production at Thairath (Suveeranont, 2002). The letterforms of Tom light are based on geometrical forms, and so the level of simplification is higher than for Bradley's typefaces, Thong Siam, and Farangset. There are serifs on several characters, including kho khai, cho chang, so so, bo baimai, and po pla. The terminals are mainly flat, the upper arch is curved, and the loop is circular. Later this typeface was developed into an OpenType font called Cordia New, which is why it has similar characteristics with Tom light.

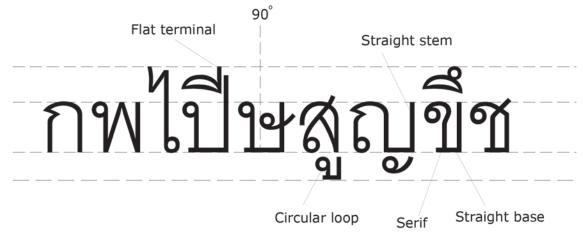


Figure 26. Analysis of Tom light's structures, represented by Cordia New

DB Erawan

DB Erawan was one of the first PostScript fonts, and it was designed in approximately 1987 by the Dear Book type foundry (DB fonts). It was one of the heaviest stroke weight font that Dear Book designed at that time. Moreover, it was one of the earliest loopless fonts in the market. The letterforms are simplified. Beaks and loops do not exist in DB Erawan. In term of letter recognition, certain characters, such as mai malai, are difficult to distinguish from other characters. In terms of form, mai malai more closely resembles to mai muan than typical mai malai, as Figure 28 demonstrates.

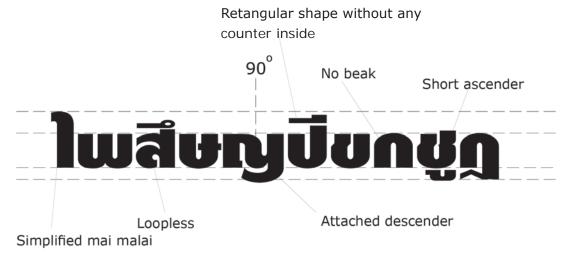


Figure 27. Analysis of Erawan's structures, by Virunhaphol



Figure 28. Comparison of DB Erawan's mai malai and TH Sarabun PSK's mai malai and mai muan (from the left)

Unity Progress, Dear Book and NECTEC's fonts

The UPC and New font families by Unity Progress are one of the early digital fonts available in Thailand since 1992 (now offered under license from Microsoft). New fonts are an improved version of UPC. Therefore, the letterforms of both families look similar. The only difference is the encoding. Cordia New (Figure 29), Browallia New (Figure 30), and Angsana New (Figure 31) by Unity Progress were among widely used fonts in government organisations until SIPA launched the national fonts in 2007 (see pp. 57-61).

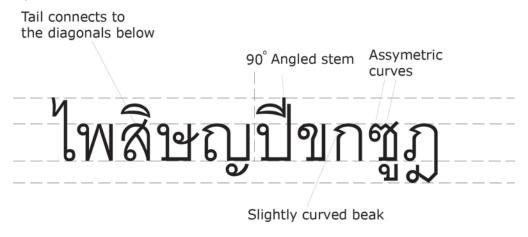


Figure 29. Analysis of Cordia New, by Virunhaphol

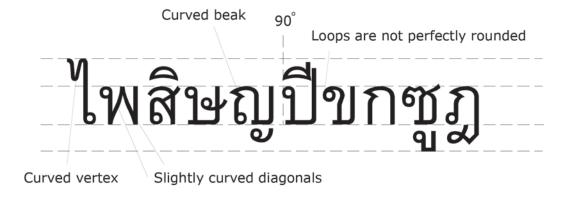


Figure 30. Analysis of Browallia UPC, by Virunhaphol

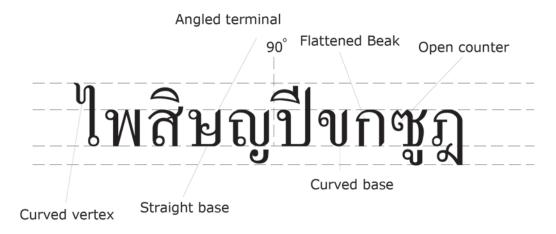


Figure 31. Analysis of Angsana New, by Virunhaphol

To prevent copyright issues stemming from the use of fonts by private companies including UPC and New font families, the National Electronics and Computer Technology Center (NECTEC) initially sought to provide public domain fonts that anyone could freely use without infringing on the copyright. Moreover, NECTEC stated that there was a lack of high-quality multilingual fonts in the market at the time. Most were incompatible, and so NECTEC intended to create new fonts to fill those gaps.

NECTEC, with the help of the Thai type foundries Dear Book and Unity Progress, launched three desktop fonts, Kinnari (Figure 32), Norasi (Figure 33), and Garuda (Figure 34) together with a book called Thai font (the National Electronics and Computer Technology Center, 2001). These three national fonts, as NECTEC called them, were quietly released in mid-2001. In term of availability, Even now they are not available to be downloaded on f0nt.com, which is considered the largest free Thai font provider in Thailand. Moreover, the fonts are no longer exist publicly on NECTEC's website anymore. For these reasons, the three fonts are not frequently used fonts among Thais in comparison with the 13 national fonts released in 2007 by SIPA.

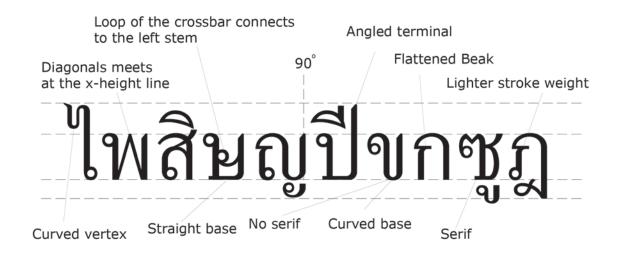


Figure 32. Analysis of Kinnari, by Virunhaphol

In term of the designs of the three fonts, Kinnari (Figure 32) was developed by Dear Book. Both Kinnari and Angsana New (Figure 31) were inspired by Farangset (Figure 23) therefore they share certain characteristics with Farangset. Some characters of Kinnari including kho khai and cho chan have curved bases like Farangset. There are serifs in certain characters such as kho khai, cho chang, so so, bo baimai and po pla.

In Thai font (2001), Nectec explained that curved base in character like cho chan is added to make the total letterform look more balance. For the same reason, serif is added for bo baimai. However, they are not necessary to add these extra structures to Thai characters in my opinion if the circular loop above is not too big to the point that make the space between the loop to the base look unbalance. Another characteristic that came from Farangset's typographic attribute is flattened beak. The stroke weight of the beak commonly lighter than vertical stems as Figure 32 shows. The loop that attaches to the crossbar of so ruesi of Kinnari connects to the left stem of the body. This characteristic also occurs in one of Bradley's typeface (the upright style) and Angsana New, but it does not exist in the seven common handwriting models. Terminals of Kinnari are angled and flat. Kinnari's loops are circular and visible while Angsana New's loops also circular, but some characters such as so so has open loop. The vertexes of Kinnari's mai malai are curved.

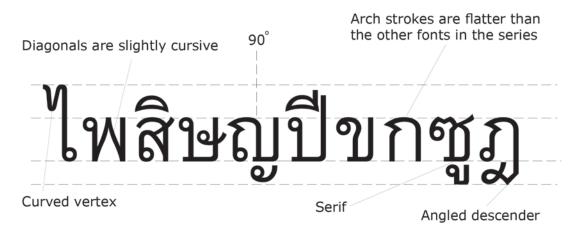


Figure 33. Analysis of Garuda, by Virunhaphol

Garuda was designed by Unity Progress. The company used Browallia UPC as a design model for Garuda. For this reason, the two fonts look very similar, as indicated in Figures 30 and 33. One of significant typographic traits is that when forming an apex, the diagonals tend to be slightly cursive. As compared to other NECTEC fonts, Garuda's arch strokes are flatter. The beak is curved, unlike in Kinnari. Again, serifs are a feature of certain characters, such as kho khai and bo baimai. The vertexes of mai malai are curved, as in Kinnari, but the stroke weight contrast is lower. Loops are circular but not perfectly rounded. The descender of sara i sits at the right end of the body, as in the present-day sara i.

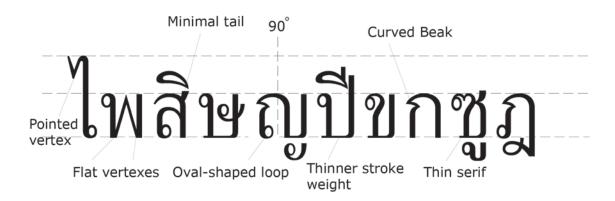


Figure 34. Analysis of Norasi, by Virunhaphol

The last font, Norasi, was developed by Wirat Sonloetlamwanit and Yannis Haralambous. As compared to other NECTEC fonts, Norasi has the highest stroke weight contrast. The angle stress is at 90 degrees. The serifs are thinner than for other fonts in the series. In addition, the vertexes are flat, the tails are mostly minimal, and the beaks are curved. The oval shape of Norasi's loops is significantly different than that seen in the other fonts.

A design issue that should be addressed concerns NECTEC's statement that all of the fonts were designed for clear reading at small sizes. However, confusing character pairs, such as cho chan and so so, are difficult to distinguish from each other at 12 pts or below. Both characters have short tails, and that feature is hardly visible at small sizes (see Figures 35-37).

40 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

36 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

30 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

24 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสมที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนใหยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

18 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

16 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๓๘๙๐

14 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๓๘๙๐

12 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

10 pt Garuda ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แลกค่างได้ดี

อีกทั้งเป็นแบบที่คนใทยเราคุ้นเคย ๑๒๓๔๔๖๙๘๙๐

กขขคคฆงจฉชชฌญฏฏฐทฒนดตถทธนบปผฝ พฟภมยรลวศษสหพอฮ

มสนที่แตกต่างได้ดี (ค) จี (ค)

Figure 35. Specimen sheet of Garuda, by Virunhaphol

40 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนทีแตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

36 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

30 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

24 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนใทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

18 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

16 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนทีแตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

14 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๙

12 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างใต้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๙

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐ 10 pt Kinnari ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนทีแตกต่างได้จั

ขฃคฅฆงาฉชชฌผูฏฏฐฑฒฌดตถทธนบปผฝ

14 pt ขชสศขชคคาใใโน

พภมยรถาศษสหพอฮ

40 pt ขชสศขชคดาไใโน 18 pt ข ช ส ศ ข ช ค ๑ จ ใ ใ โ น 24 pt ขชสศขชคดจใใโน 30 pt ขชสศขชคดาไใโน ตัวอักษรคู่สับสนของกินร<mark>ี</mark> 36 pt ขชสศขชคดาไใโน

Figure 36. Specimen sheet of Kinnari, by Virunhaphol

40 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

36 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

30 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนทีแตกต่างได้ดี

24 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างใต้ดี อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐ 18 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

16 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

14 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างได้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐

12 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนที่แตกต่างใต้ดี

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๙

อีกทั้งเป็นแบบที่คนไทยเราคุ้นเคย ๑๒๓๔๕๖๗๘๙๐ 10 pt Norasi ตัวอักษรควรมีหัวเพราะจะทำให้แยกคู่สับสนทีแตกต่างได้จั

พภมยรลวศษสหพือ รูทฒนดตถทธนบปผฝ

18 pt ២ ៦ ឥ គ ២ ៦ ค ๑ จ ไ ไ ไ น

40 pt 21 ช ส ศ 21 ช ค ด จ ไ ใ โ น 36 pt 21 ช ส ศ 21 ช ค ด จ ไ ใ โ น 30 pt ២ ៦ ឥ គ ២ ៦ គ ៣ ១ រី ំ រ ំ ែង ตัวอักษรคู่สับสนของนรสีห์

Figure 37. Specimen sheet of Norasi, by Virunhaphol

Thai national fonts by SIPA

For the same reason that NECTEC launched its fonts in 2001, the Software Industry Promotion Agency (SIPA) and the Department of Intellectual Property (DIP) released 13 national fonts in 2007. These are public domain fonts that can be freely used without any copyright infringement issues.

These national fonts are for the computer, and they have been available for download on fOnt.com as OpenType fonts since 2007. The Thai government approved TH Sarabun PSK to be the standard font for government documents, and so it replaced Angsana New in 2010. This decision was officially announced in the Royal Thai Government Gazette (Office of the Prime Minister, 2011).

In general, horizontal strokes at the bases of certain characters, including po pla, are curved, while vertical strokes are mostly straight. TH Sarabun PSK has circular loops and a minimal stroke weight contrast. The beaks are cursive, unlike in Angsana New. The terminals are flat (see Figure 38).

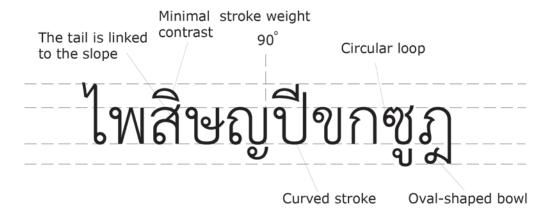


Figure 38. Analysis of TH Sarabun PSK, by Virunhaphol

Except for TH Niramit AS (see Figure 39), all the fonts in the national font series lack serifs. However, Niramit AS's serif is small. Strokes occasionally extend beyond the border of neighbouring strokes. The curves forming the head of so so are asymmetric, an atypical feature for that character. The bases of the characters are mainly straight.

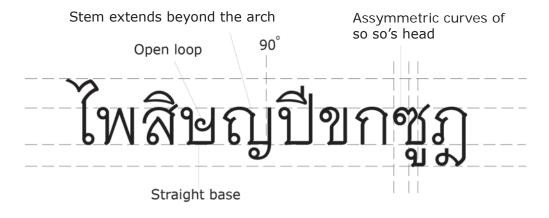


Figure 39. Analysis of TH Niramit AS, by Virunhaphol

Three fonts, TH Charm of AU (Figure 40), TH Chamornman (Figure 41), and TH Srisakdi (Figure 42), are based on Alak's handwriting. According to the designer, TH Srisakdi was based on the handwriting of the royal scribe in the Thonburi-Early Rattanakosin era. Therefore, these handwriting-based fonts have long extenders, as demonstrated in Figures 40-42. The ascenders move in both directions. The angle of stresses of the three fonts move rightward, between approximately 76-81 degrees. Loops of fonts are different. For TH Charm of AU , loops are angular and are commonly attached in the middle of the vertical stem. TH Charmonman has open loops, while TH Srisakdi has both open loops and oval-shape loops. In TH Charm of AU, the terminals are predominantly tapered. TH Charmonman and TH Srisakdi's terminals are pointed. In both of those fonts, the descenders of yo ying are attached to the body, while TH Charm of AU features detached descenders. Sara u is noticeably larger than normal in all the fonts, and especially in TH Srisakdi. Among the three, the stroke weight is the lightest.



Figure 40. Analysis of TH Charm of AU, by Virunhaphol

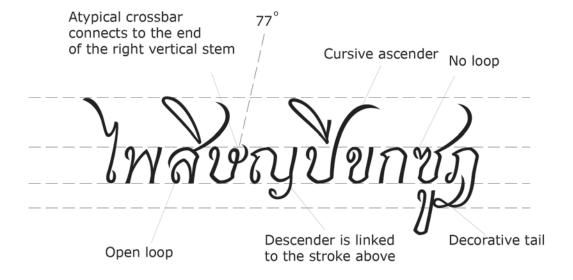


Figure 41. Analysis of TH Charmonman, by Virunhaphol

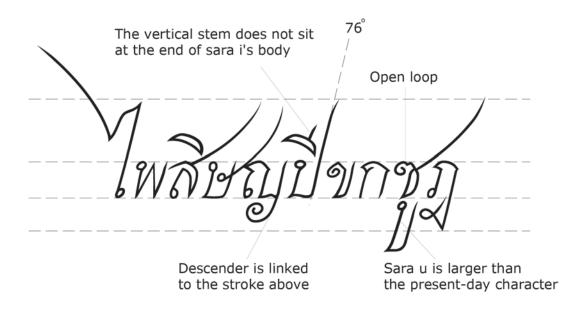


Figure 42. Analysis of TH Srisakdi, by Virunhaphol

TH Mali Grade 6 (Figure 43) is also a handwriting font inspired by a sixth-grader's handwriting. It has a moderate stroke contrast. The loops are circular and larger than those seen in other national fonts. The vertex of pho phan does not touch the x-height line.

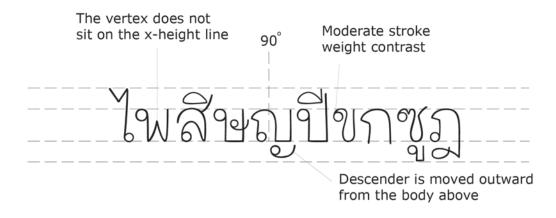


Figure 43. Analysis of TH Mali Grade 6, by Virunhaphol

TH Chakra Petch (Figure 44) is more angular than other fonts. The corners are angled—in fact, even the outlines of the circular loops are angled. Vertical and horizontal strokes are straight. The tail of so ruesi does not extend beyond the body, which is uncommon, while the terminals are mostly flat.

Straight stem

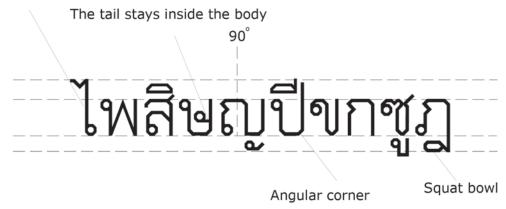


Figure 44. Analysis of TH Chakra Petch, by Virunhaphol

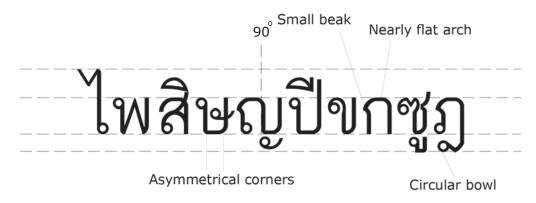


Figure 45. Analysis of Bai Jamjuree CP, by Virunhaphol

TH Bai Jamjuree CP (Figure 45) generally has nearly flat arches. The beaks are small, while the bowls and loops are circular. In most cases, characters have asymmetrical left and right corners, with a more cursive right side. The terminals are flat.

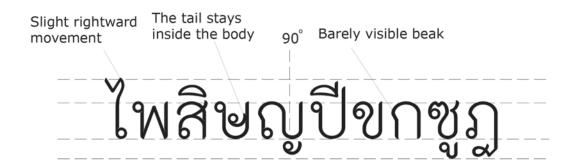


Figure 46. Analysis of TH K2D July8 by Virunhaphol

Unlike TH Chakra Petch, TH K2D July8 (Figure 46) and TH Kodchasal (Figure 47) are more cursive. The overall letterforms look more roundish than the other fonts.

TH K2D July8 has barely visible beaks. The arches of many characters, including ko kai, do dek, and yo ying, are more curved than in other national fonts.

As with TH Chakra Petch, so ruesi's tail does not extend beyond the body. The bases of characters such as so ruesi are curved.

In comparison with other TH font family, TH Kodchasal is considered a wide font. The beaks tend to move inward, the loops are oval-shaped, and the terminals are curved (see Figure 47).

As with TH Kodchasal, TH Koho has oval-shaped loops. However, it has a lighter stroke weight. TH Koho has nearly flat arches. The horizontal strokes at the base are mostly curved. TH Koho's so suea is unique because the tail moves rightward. TH Krub has open loops, and the beaks move inward, as with TH Kodchasal. It also has a curved horizontal stroke at the base.

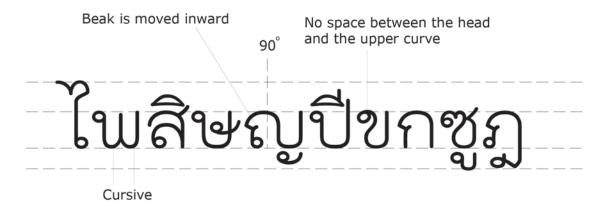


Figure 47. Analysis of TH Kodchasal, by Virunhaphol

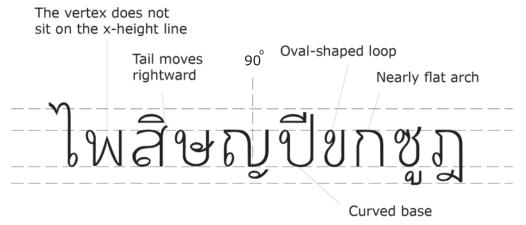


Figure 48. Analysis of TH Koho, by Virunhaphol

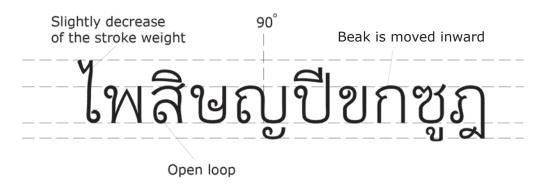
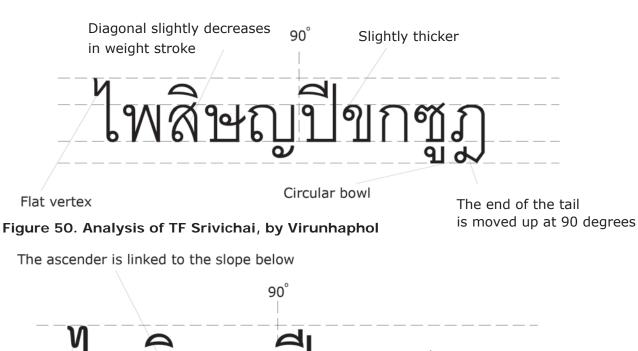


Figure 49. Analysis of TH Krub, by Virunhaphol

TF fonts

The TF font family is another collection of free fonts that is popular in Thailand. It was designed by the Thailand Printing Federation, which intends to provide public domain fonts for the Thai people. The TF fonts are desktop fonts. They had been in circulation for a long time but were fully revised in OpenType format in 2012. Many fonts in the series, including TF Srivichai, TF Pimai, and TF Pimpakarn, share close typographic similarities with the New series. In general, TF Srivichai (Figure 50) has close commonalities with Cordia New (Figure 30). However, it has a lighter stroke weight. TF Pimai (Figure 51) is nearly identical to Browellia New (Figure 30), while TF Pimpakarn (Figure 52) looks very close to Angsana New (Figure 31).



Curved vertex Angled descender

Circular loop

Figure 51. Analysis of TF Pimai, by Virunhaphol

Slightly curved diagonals

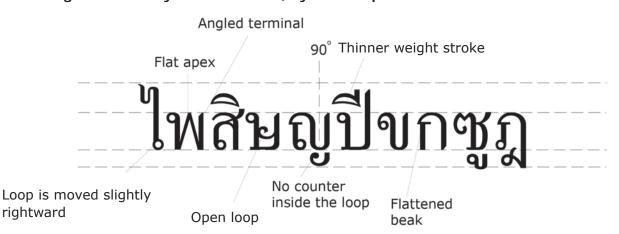


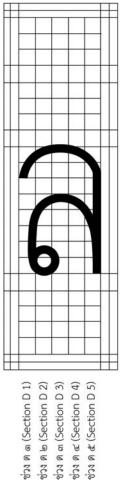
Figure 52. Analysis of TF Pimpakarn, by Virunhaphol

The Royal Society's guidelines

A review of Thai types revealed an absence of strict rules for designing Thai typefaces. However, the first serious discussion of proportional guidance for standard Thai letters emerged during the 1970s (Royal Society of Thailand, 1997). At the time, there was confusion among Thai students on how to correctly write Thai characters, since there was no standard model for students to learn (Royal, Society of Thailand, 1997, p.7). Therefore, the national linguistics academy, part of the Thai gorvernment, called "The Royal Society of Thailand" was the one that put forward the idea to establish what should consider "standard" Thai letterforms. Its primary responsibility of this organisation is regulating Thai language standards. Therefore from 1974, many attempts have been made to form groups of Thai language experts to conduct intensive research into various styles of Thai writing models including the main seven writing models that are commonly used in Thailand (see pp.41-43). After the research, The expert committees concluded that the general writing style in the early Rattanakosin period closely resembles how Thai people write today. Later, a typeface representing standard Thai letterforms was designed on the basis of Rattanakosin's handwriting. Eventually, the Royal Society of Thailand published a handbook containing standard Thai proportional guidelines in 1997. The objective of this manual was to provide standard guidelines for writing Thai characters and designing Thai computer fonts (see Figure 53).



ช่วง ร ๑๖ (Section R 16) ช่วง ร ๑๕ (Section R 15) ช่วง ร ๑๔ (Section R 14) ช่องว่าง (Space) ช่วง ร ๑๒ (Section R 12) ช่วง ร ๑๑ (Section R 11) ช่วง ร ๑๐ (Section R 10) ช่องว่าง (Space) ช่วง ร ๘ (Section R 8) ช่วง ร ๗ (Section R 7) ช่วง ร ๖ (Section R 6) ช่วง ร ๕ (Section R 5) ช่วง ร ๔ (Section R 4) ช่วง ร ๓ (Section R 3) ช่วง ร ๒ (Section R 2) ช่วง ร ๑ (Section R 1) ช่องว่าง (Space) ช่วง ร -๒ (Section R -2) ช่วง ร -m (Section R -3) ช่วง ร -๔ (Section R-4) ช่วง ร -๕ (Section R -5)



เส้น ร ๑๕ (Line R 15) เส้น ร ๑๔ (Line R 14) เส้น ร ๑๓ (Line R 13) เส้น ร ๑๒ (Line R 12) เส้น ร ๑๑ (Line R 11) เส้น ร ๑๐ (Line R 10) เส้น ร ๙ (Line R 9) เส้น ร ๘ (X-height) เส้น ร ๗ (Line R 7) เส้น ร ๖ (Line R 6) เส้น ร ๕ (Line R 5) เส้น ร ๔ (Line R 4) เส้น ร ๓ (Line R 3) เส้น ร ๒ (Line R 2) เส้น ร ๑ (Line R 1) เส้น ร o (Baseline) เส้น ร -๑ (Line R -1) เส้น ร -๒ (Line R -2) เส้น ร -๓ (Line R -3) เส้น ร -๔ (Line R -4) เส้น ร -๕ (Line R -5)

เส้น ร ๑๖ (Line R 16)

Figure 53. Dimensional proportion of lo ling, as specified in the Royal Society of Thailand's manual. Redrawn by Virunhaphol. Adapted from Mattrathan krongsang tua akson Thai chabap Ratchabandittayasathan, by the Royal Society of Thailand, 1997, p.71. Copyright 1997 by the Royal Society of Thailand.

The handbook provides basic descriptions of standard Thai letters. However, this typeface in the handbook has no name. Thus, for reasons of convenience, this paper refers to it as "RST typeface". According to the handbook, regular stroke weight is the only style accepted as a standard model. Italic, bold, lighted, narrow, condensed, and wide are not considered official.

According to the manual, the head component of each letter must be rounded, and the stroke weight needs to be consistent. Minor stroke contrast is acceptable in cursive lines and stroke reversals. The manual continues, addressing the structure of the bounding box, which matches that used in Western typography, as Figure 53 illustrates.

This area includes the upper vowel, the tone mark, the full-form letter, and the low vowel as illustrated in Figure 54. A full-form letter contains eight proportional sections, and one section is that same as a single unit of that letter. Horizontal divisional lines are "R" lines, and vertical divisional lines are called "D" lines. While R0 is the baseline, R4 is the centre line, and R8 is the x-height. Above the R8 line, the upper vowel and the tone mark extend approximately 4 and 3 units, respectively. Moreover, the lower vowel is 4 units long.

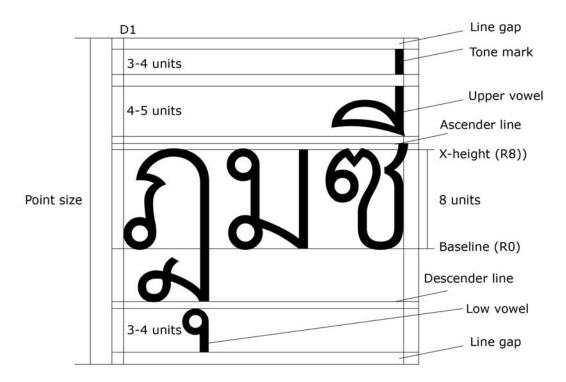


Figure 54. Dimensional proportions of a Thai word in TH Sarabun, as specified in the Royal Society of Thailand's manual

After defining the basic grids, the handbook's next section provides approximate width dimensions. These are as follows:

- No nen and tua lue are 9 units wide.
- Cho choe, yo ying, tho phuthao, tua rue, and the Thai number nine are 8 units wide.
- Cho ching, the Thai number six, and the Thai number eight are 7 units wide.

- To patak, do chada, no nu, bo baimai, po pla, pho phan, fo fan, pho samphao, tua lue, so ruesi, lo chula, the Thai number two, the number four, the number five, the number seven, and sara am are 6 units wide.
- Ko kai, kho khwai, kho rakhang, tho montho, do dek, to tao, tho thung, tho thahan, pho phueng, fo fa, mo ma, yo yak, tua rue, lo ling, so sala, so suea, ho hip, o ang, mai o, mai malai, mai muan, the Thai number zero, the Thai number one and the Thai number three are 5 units wide.
- kho khai, ngo ngu, cho chan, cho chang, so so, tho than, tho thong, ro ruea, wo waen, mai han akat, Lak khang, Phinthu i, sara i, sara ue and sara eu, mai yamok, and paiyan noi are 4 units wide
- Mai tho are 3 units wide.
- thanthakhat is 2 units wide.
- Mai na and sara ae are between 1 and 2 units wide.

Thai numbers are slightly shorter than letters. Therefore, their body height should be between 5 and 6 units. The handbook noted that the acceptable dimensional distortion is plus or minus 0.5-1 unit.



Figure 55. The Royal Society's model, as written by Virunhaphol

Comparing frequently used fonts (including TH Sarabun, Angsana New, Browallia New, Cordia New Dillenia UPC, Microsoft Sans Serif, Nina Font Family, and Tahoma [Thai]) with the Royal Society of Thailand's manual, indicated that certain characteristics of TH Sarabun match the proportional guidelines. In comparison, the other fonts have serifs (see Figure 56) while TH Sarabun has no serif. Serif is not a common typographic trait in modern handwriting from 1928 (see pp.41-43), however, it can be found generally in printing types.

Studying letterforms in old printing books in the rare book collections at Chulalongkorn University, Thammasat University, and the National Library of Thailand from between 1905-1965 (e.g., *Kot monthianban pama*, 1936; *Lamdap sakun kao bang sakun pak si*, 1937; *Nam phra prathinang nam pratu lae pom*, 1905; *Prachum pongsawadan pak song*, 1914; *Rueang kon chat Thai*, 1940; *Tamnan rueang krueang to lae thuai pan*, 1965) revealed that text types from this period sometimes had serifs. Moreover, the circular stroke terminals of certain characters, such as kho rakhang and tho montho, are sometimes missing (see Figure 56). Some typographic elements such as serif are added to compensate the space between the head above and the base of the character (National Electronics and Computer Technology, 2001, p.17). It is not a requirement to do so, but rely more on personal judgment of each designer. Like certain printing books in early of the 20th Century, Angsana New has no circular stroke terminals of kho rakhang and tho montho like Farangset as demonstrated in Figure 56.

Overall, the styles of fonts in the market are vary, and sometimes do not conform with the Royal Society of Thailand's manual. For instance, TH Sarabun is wider than RST typeface. It is a looped font with a low stroke contrast. The extenders of TH Sarabun are shorter than those of RST typeface. The base of TH Sarabun is often cursive while the RST typeface's base is straight.

However, it is stated in the handbook (p. 8) that the RST typeface is based on studies of handwriting therefore certain characteristics of printing types including open loop and serif are excluded from the manual since they are not considered as standard.

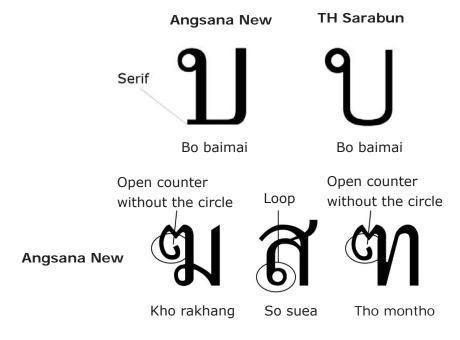


Figure 56.Comparison of bo baimai in Angsana New and TH Sarabun PSK (above), and an analysis of kho rakhang, so suea and tho montho in Angsana New (below)

The change in Thai letterforms

Padungsuntraruk (2004, p.127) claimed that the reason why Thai letterforms are more simplified today than in the past is that from 1944, the main writing models that Thais used for writing practice have been based on printing fonts rather than on handwriting. In his view, Thai letterforms in print fonts from the mid-20th century were adjusted because of typesetting constraints. (He did not state which typesetting system he thought was responsible for the change in Thai letterforms. However, hot metal typesetting was commonly used in Thailand at that time.) Due to the use of types from that period as references for writing, the letterforms of today consequent look different (e.g., shorter extenders and more symmetric forms) than handwriting.

Punnothok (1992) also pointed out that Thai letterforms from this time became smaller, shorter, and more angular in general. However, it remains questionable whether the Thai letterforms of both present-day handwriting and fonts have followed the styles of printing typefaces that were adjusted according to the typesetting technique used in the mid-20th century, as noted by Padungsunraruk (2004).

In contrast with these views, Sathirakun (Sukpinit et al., 1967) mentioned that in general, most type designs replicate handwriting, and not vice versa. This comment makes evident that early types, such as Bradley's font (1842), closely resemble handwriting. However, according to Sathirakun, printing fonts sometimes have more typographic elements than handwriting. These extra features (e.g., serifs) were added at a later date to make types more consistent and visually pleasing than handwriting. In Thai font (National Electronics and Computer Technology Center, 2001), NECTEC also commented on this issue in the same direction as Sathirakun that some elements (e.g., serifs of bo baimai, po pla, and tho thong) are added to make the letterform appear balanced.

To determine whether contemporary Thai letterforms have been influenced by printing typefaces from the mid-20th century, as Padungsuntraruk claimed, I compared the main seven writing models with printing books from 1905-1965 found in the rare books collections of the National Library of Thailand, Thammasat University, and Chulalongkorn University. The findings revealed at least three of the seven writing models, including Alak, Rongrian Thungmahamek, and Rongrian Sainamthip, are based on handwriting (Office of the Basic Education Commission, 1992, pp.5-8). In Alak's model, the ascenders tend to be very long, and the heads are mostly angular, unlike the present-day Thai writing style, which typically features roundish heads (e.g., Royal Society of Thailand's model, 1997). Nowadays, Alak's style is still in use, but not regularly. It is predominantly used for official documents, such as for handwritten copies of the Thai constitution. When Alak' style was developed is unclear, but it was already in existence in the 17th century when the Thai script's appearance first started to resemble the present-day Thai script. Studying letterforms in Thai manuscripts in Alak's style, including Mongkonlathipaniplae [ca. 1827], Nathon Samut Tang Khunnang Raiwan Pi Mamia Thosok [ca. 1870], Nithan Kumumthumon [ca. 1898], and Prasamut Traiyaphumlokwinichaikatha [ca. 1840], indicated that the characters in these manuscripts did not usually have serifs. The heads of kho khai, kho rakhang, cho chang, so so, and tho montho are visible. The writing slightly slants towards the right. Another noticeable difference in the Alak writing tradition is that the ascender of sara i is sometimes not located at the right end of the character's body, as in the present,

but is instead placed nearly at the centre. There is ligature connecting the character that Sara a is positioned after.

The other writing models also do not have serifs. There are visible heads on kho khai, kho rakhang, cho chang, so so, and tho montho in nearly all of the models, except for Phraya Padungwitayasoem's model. That is the only framework in which these characters are loopless.

Studying types from the 20th century (1905-1965) from printing books found in the rare book collections at Chulalongkorn University, Thammasat University, and the National Library of Thailand (e.g., *Kot monthianban pama*, 1936; *Lamdap sakun kao bang sakun pak si*, 1937; *Nam phra prathinang nam pratu lae pom*, 1905; *Prachum pongsawadan pak song*, 1914; *Rueang kon chat Thai*, 1940; *Tamnan rueang krueang to lae thuai pan*, 1965) demonstrated that those types also possess certain handwriting characteristics. For instance, the ascender of sara i is placed in the middle of the body instead of at the right. However, there is no ligature between sara a and the preceding character, as in the Alak style. These observations make clear that the seven models and the printing fonts do not represent a total break with the handwriting tradition.

However, in general, present-day Thai letterforms are obviously different from those found in old, handwritten manuscripts in the Alak style. Nonetheless, it remains unproven that the letterforms were changed because the writing models came to be based on printing fonts rather than on handwriting, as Padungsuntraruk suggested.

Familiarity in reading and Khom Thai

A review of script's origins indicates that the Khom Thai script and the Thai script came from the same root. The writing systems employed by both scripts are not alphabetic, but alphasyllabaries (for more information about alphasyllabary see Bright, 2000), in which a consonant and a vowel are written as a unit. In contrast with an alphabetic system, in an alphasyllabary, vowels take a supporting position relative to consonants.

Both scripts were derived from the ancient Khmer script. The Khom Thai script was developed around the 15th century, while the modern Thai script was created around the 17th century. Consequently, they share some overlapping characteristics, including letter units. The three main textbooks on the Khom Thai script (Chucheun, 1992; The National Library of Thailand, 2010; Wimonkasem, 2011) reveal that five full-form Khom Thai form letters share common elements with the Thai script. They are tho phuthao, tho montho, kho khai, ro ruea, and so suea. Interviews with lecturers at Silpakorn University's Oriental Languages Department indicated that beginner students do not struggle to identify these letters (for interview details, see Appendix D). Moreover, once students are able to remember each letter of the Khom Thai script, they can read it with little difficulty.

This key information helped to clarify this study's main problem: Orthography is not the primary obstacle for would-be readers of the Khom Thai script. Rather, the unfamiliar letterforms constitute the chief barrier. Starting from this supposition, this study addressed whether it was possible to design Khom Thai letterforms that could enable recognition of the Khom Thai characters. The conceptual frameworks for the three letterform designs were developed based on this central question, with the goal of exploring potential solutions through the design practice described in Chapter 3 and the portfolio. The graphic elements that contributed to the change in Khom Thai's familiarity require examination, since this study's goal was to re-introduce the script into mainstream usage. Consequently, the next section further elaborates on this topic.

Differences between the Khom Thai script and the Thai script

The previous section reviewed the general proportions of the present-day Thai script. This section addresses the extent to which Thai is different from Khom Thai. It also discusses the key issues responsible for contemporary Thais' inability to recognize Khom Thai. An observational analysis assessed these questions. Relevant documents were appraised, including the principal Khom Thai textbooks (Chucheun, 1992; National Library of Thailand, 2010; Wimonkasen 2011), four Trai Phum manuscripts from the National Library of Thailand's database, and the Royal Society of Thailand's handbook (Royal Society of Thailand, 1997). On their basis, I identified multiple properties of the Khom Thai script that contribute to its letterforms' lack of familiarity. These are as follows:

- 1. Overall structural differences
- 2. Proportional width
- 3. Stem
- 4. Upper elements

Figures 57–60 depict letters, vowels, and numbers in both Thai and Khom Thai. Regarding full-form letters, the five Khom Thai letters that share significant characteristics with the Thai script are enclosed in squares. Overall, the graphic elements of full-form letters, subscribed consonants, and independent vowels are different, with the exception of these five letters. However, dependent vowels, tone marks, and numbers resemble their Thai counterparts.



Figure 57. Comparison of Thai characters (TH Sarabun) by SIPA and full-form Khom Thai characters (TLK Deva) designed by Virunhaphol

Character names in order:

- 1. Ko kai; 2. Kho khai; 3. Kho khuat (obsolete); 4. Kho khwai; 5. Kho khon (obsolete); 6. Kho rakhang;
- 7. Ngo ngu; 8. Cho chan; 9. Cho ching; 10. Cho chang;
- 11. So so; 12. Cho choe; 13. Yo ying; 14. Do chada; 15. To patak;
- 16. Tho than; 17. Tho montho; 18. Tho phuthao; 19. No nen; 20. Do dek;
- 21. To tao 22; Tho thung; 23. Tho thahan; 24. Tho thong; 25. No nu; 26. Bo baimai; 27. Po pla; 28. Pho phueng; 29. Fo fan; 30. Pho phan; 31. Fo fan; 32. Pho samphao; 33. Mo ma; 34. Yo yak; 35. Ro ruea; 36. Lo ling; 37. Wo waen; 38. So sala; 39. So ruesi; 40. So suea; 41. Ho hip; 42. Lo chula; 43. O ang; 44. Ho nokhuk

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Khom Thai	√	J	(,	~ ~	, –	_ 2	} ,	ป์	ಬ	8.) _	_

Figure 58. Comparison of Thai characters (TH Sarabun) by SIPA and Khom Thai subscribed consonants (TLK Deva) by Virunhaphol

Character names in order:

1. Ko kai; 2. Kho khai; 3. Kho khuat (obsolete); 4. Kho khwai; 5. Kho khon (obsolete); 6. Kho rakhang; 7. Ngo ngu; 8. Cho chan; 9. Cho ching; 10. Cho chang; 11. So so; 12. Cho choe; 13. Yo ying; 14. Do chada; 15. To patak; 16. Tho than; 17. Tho montho; 18. Tho phuthao; 19. No nen; 20. Do dek; 21. To tao; 22. Tho thung; 23. Tho thahan; 24. Tho thong; 25. No nu; 26. Bo baimai; 27. Po pla; 28. Pho phueng; 29. Fo fan; 30. Pho phan; 31. Fo fan; 32. Pho samphao; 33. Mo ma; 34. Yo yak; 35. Ro ruea; 36. Lo ling; 37. Wo waen; 38. So sala; 39. So ruesi; 40. So suea; 41. Ho hip; 42. Lo chula; 43.O ang; 44. Ho nokhuk

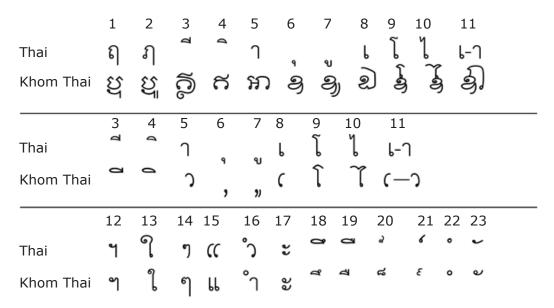


Figure 59. Comparison of Thai characters (TH Sarabun) by SIPA and Khom Thai vowels (TLK Deva) by Virunhaphol

Character names in order:

- 1. Tua rue; 2. Tua lue; 3. Sara i; 4. Phinthu i; 5. Sara a; 6. Tin yiat; 7. Tin khu; 8. Mai na; 9. Mai o;
- 10. Mai malai; 11. Sara ao; 12. Mai yamok; 13. Mai muan; 14. Paiyan noi; 15. Sara ae; 16. Sara um;
- 17. Wisanchani; 18. Sara ue; 19. Sara eu; 20. Mai tai khu; 21. Thanthakhat; 22. Nikkhahit; 23. Mai han akat

Thai $\mathbf{v} = \mathbf{v} + \mathbf{v}$

Figure 60. Comparison of Thai characters (TH Sarabun) by SIPA and Khom Thai tone marks (TLK Deva) by Virunhaphol

Character names in order
1. Mai ek; 2. Mai tho; 3. Mai tri; 4. Mai chattawa

Khom Thai's width proportions of some full-form characters are approximately 50% wider than the present-day Thai script. Of note is that the Thai letter is less cursive than Khom Thai. Figure 61 exemplifies how the Thai script and Khom Thai differ in terms of their horizontal proportions. The illustration compares the two scripts' kho rakhang letterforms using TH Sarabun and TLK Deva to demonstrate the difference. TH Sarabun's kho rakhang is commonly 400 units high and 339 units wide (using a 1,000 unit per em measuring system). These proportions were readjusted to enable a width comparison with TLK Deva.

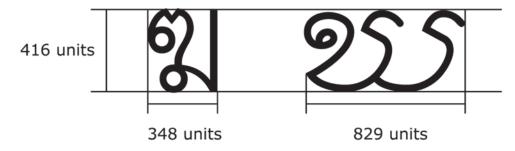


Figure 61. The SIPA's Kho rakhang in Thai (TH Sarabun), readjusting the x-height to match Khom Thai (TLK Deva), enabling a comparison between the width proportions of the two scripts

According to Noordzij (2005), the writing tool and the hand movement dictate the letterform. The Khom Thai script is traditionally written on a prepared palm leaf with a metal stylus called a "Lek Chan". The preparation of the palm leaf, according to Wiraprachak (1987), starts with selecting mature and intact leaves from deeply forested areas. Next, the leaves' edges are cut with a knife to refine them for writing. In length, the cut palm leaves should be approximately 50-75 centimetres. After this step, the palm leaves are left to be sun-dried for three days. Then, palm leaves of the same size are grouped together in bunches of approximately 20-30 leaves. After this step, the stems are cut. The leaves are folded into rolls and soaked in water overnight. In some parts of Thailand, and especially in the north, palm leaves are boiled in the water used to wash uncooked rice. Next, the palm leaves are again sun-dried for one or two days. Once the palm leaves are dry, they are unfolded and cut again. Then, a hole is punched in each palm leaf. Groups of 20-30 leaves are placed between two rectangular pieces of wood called a "Khanop". The edges of the palm leaves that extend beyond the borders of the Khanop are trimmed with the knife. After this step, 500 palm leaves are bound together using the palm leaf stems that were previously cut; these stems run through the holes in the leaves . Finally, the palm leaves are tied up with the Khanop.

Writing on a palm leaf starts with drawing three to nine lines as a guideline (five lines are most common). To draw these guides, threads are stretched with a wooden frame that is slightly larger than the size of the palm leaves themselves. An ink ball is then applied to the threads. After this step, the frame is placed above the palm leaves. The threads are pulled and released on the writing surface, creating the guidelines. When this step is finished, a "Mon Rong", another group of six or seven palm leaves that are sewed together and wrapped in cloth, is placed under the palm leaf used as the writing material. Four small and sharpened pieces of bamboo pierce through the bottom corners of the Mon Rong (two pieces at each corner). These bamboo pieces hold the writing material in place. After the preparation of the palm leaves, a Lek Chan is used for writing on the surface. Since the stylus is sharp and the palm leaf's surface can easily split, the writer must inscribe roundish letterforms to prevent severing the writing surface. Moreover, the writer cannot place his or her hand directly on the palm leaf, as Figure 62 illustrates. After this process, black charcoal or ink is applied to the surface, as Figure 63 demonstrates. Another common writing tool is a brush. Letterforms created with a brush have a higher stroke contrast than does the Lek Chan style in general.

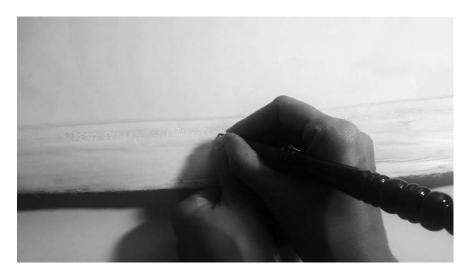


Figure 62. The technique for writing on a palm leaf, as demonstrated by Virunhaphol



Figure 63. Black ink on a palm-leaf surface, as demonstrated by Virunhaphol

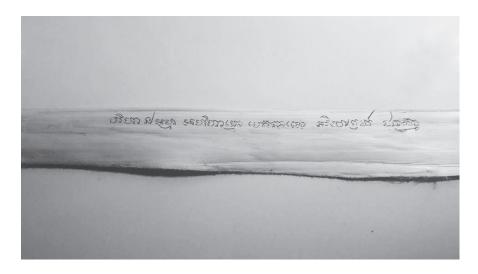


Figure 64. Visible Khom Thai letterforms after ink is applied on the surface, as demonstrated by Virunhaphol

Both of these traditional writing methods require more space than the present-day Thai script. In contrast with the Khom Thai script, the Thai script in its present grew smaller, the tails became shorter, and the distance between the upper vowel and the letter shrank. The letterforms of the Thai script today are simpler than those of the Khom Thai script (Padungsuntraruk, 2004, p.115). Because of its unique writing style, Khom Thai stems tend to be more cursive than Thai stems, as Figure 65 indicates.

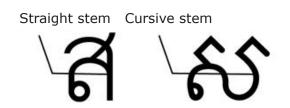


Figure 65. Comparison of so suea stems in Thai (left; TH Sarabun by SIPA) and Khom Thai (right; TLK Deva by Virunhaphol), which are representative of typical letterforms

The Thai script does not have "sok", which is an important graphic element of the Khom Thai script. However, because the Thai script does not include it, Thais are unaccustomed to this letter feature. For this reason, this study examined these elements by designing TLK letterform designs with different graphic properties to compare familiar characteristics of the Thai script with Khom Thai.

Letterform analyses of Khom Thai and Thai

This section includes letterform drawing analyses by Virunhaphol. The aim was to study Thai and Khom Thai graphic structures to help identify which graphic features of Khom Thai make that script unfamiliar to Thais in the present. That knowledge informed the design choices made at a later stage. This section thus studies handwriting from the Ayutthaya and Thonburi eras, including from nine Trai Phum manuscripts from the 17th to 19th centuries. Materials were chosen for review based on the significance of the handwriting and ability to represent these particular periods in term of beauty and authenticity. However, this study does not claim to be a complete review of Thai and Khom Thai. Rather, it constituted an initial exploration of the subject to find references for the letterform designs.

Although Lai Sue Thai developed in the 14th century and was the first Thai script, Chuchuen (1992, p.98) suggested that the Thai script called Thai Yo or Thai Ayutthaya in King Ramathibodi III's era (1633 –1688) developed in a manner closer to the present-day Thai script. Observing documents from that period, including the Siamese-Franco treaty of 1687 reprinted in "the inscriptions in Thailand database project" (Princess Maha Chakri Sirindhorn Anthropology Center, 2006), underscored that the letterforms mostly differed from those in use today. However, certain words in this treaty were readable (see Figure 66). The angle stress of the Ayutthaya handwriting style tends to slant rightward. The vertical stems are cursive, and the extenders are long. There are ligatures between the consonant characters and lak khang, a feature that is not common today. The translations of this document both in Thai and English were printed in Coedès (1921).

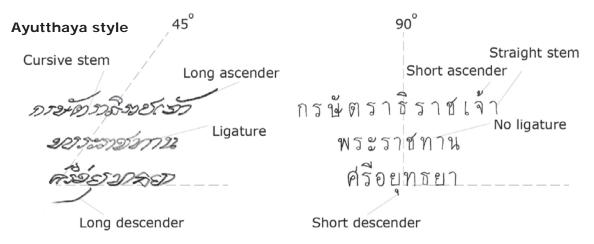


Figure 66. Thai letterform comparison of words from the Siam-Franco Treaty of 1687 (left) and the present-day handwriting style (right), written and analysed by Virunhaphol. The left image was adapted from sanya Thai-Farangset krang Somdet Phra Narai [the Siam-Franco treaty of 1687], *In the inscriptions in Thailand database project*, 2006, Retrieved October 12, 2015, from http://www.sac.or.th/databases/inscriptions/inscribe_image_detail.php?id=1205. Copyright 2006 by Princess Maha Chakri Sirindhorn Anthropology Center.



Figure 67. Thai letterform drawing analysis of Thai characters in Thonburi's style, at approximately 75% of the original size, drawn and analysed by Virunhaphol. Adapted from *Bilderhandschrift Traiphum*,1776, Staatliche Museen zu Berlin, pp. 1-2. Used under Creative Commons Attribution 3.0 Generic License: https://creativecommons.org/licenses/by-nc-sa/3.0/de/deed.en.

These unique characteristics of Thai and Khom Thai can also be seen in manuscripts from the Ayutthaya and Thonburi era .

Figure 67 contains an analytical drawing study of Thai letterforms by Virunhaphol. In the Thonburi writing style, letterforms are commonly slanted to the right. The extenders are long, and lak khang is connected to the previous character with a ligature. Unlike in the Ayutthaya style, the vertical stems in the Thonburi era were straight.

In comparison, Khom Thai is commonly wider than Thai, as Figure 68 demonstrates. The angle stress of Khom Thai is not always slanted to the right. In contrast, most Thai handwriting from these periods is rightward slanting and rarely straight (see Figures 69-79). In these manuscripts, the sara a of both Thai and Khom Thai often does not have a tail (see Figure 76).

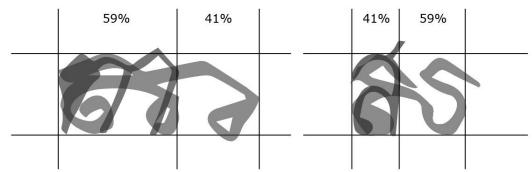


Figure 68. Comparison of Thai (darker grey) and Khom Thai (lighter grey) from a Trai Phum manuscript, redrawn and analysed by Virunhaphol

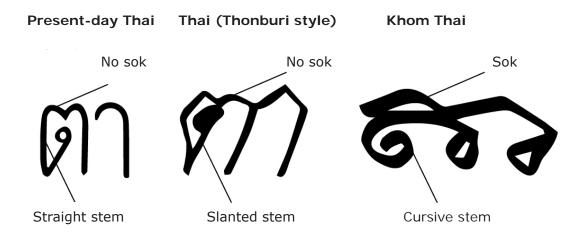


Figure 69. Comparison of a word written in present-day Thai, Thai in the Thonburi style, and Khom Thai (from the left), drawn and analysed by Virunhaphol

	73°				
าราเหล่าชื่อได้เปลา หายยา พระลา	มร่า สมิงหลกวย ได้ ตก แต่งไว้ แต่ คมี	<u>//</u>			
, Loop		<u> </u>			
- เปมภิกษในพุทธสาสมา	ครามศึกออกมาได้ เสายราชในเมือง				
Curply a tip viot. Straight tip viot		_			
Cursive tin yiat Straight tin yiat					

Figure 70. Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the eighteenth century. Adapted from *Samut pap Trai Phum chabap Tham Lanna lae akson Khom*, by Kana kammakan fai pramuan ekkasan lae chotmaihet , 2004, p. 93, Copyright 2004 by National Library of Thailand.

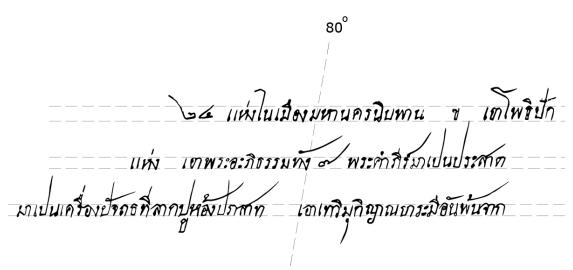


Figure 71. Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the eighteenth century. Adapted from *Samut pap Trai Phum chabap buran chabap krung Thonburi*, by Office of the Prime Minister, 1982, p. 7, Copyright 1982 by Office of the Prime Minister.

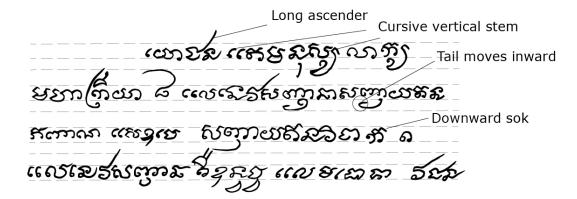


Figure 72. Khom Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the Ayutthaya era. Adapted from *Samut pap Trai Phum chabap akson Khom pasa Thai*, by National Library of Thailand, 2007, p. 78, Copyright 2007 by National Library of Thailand.

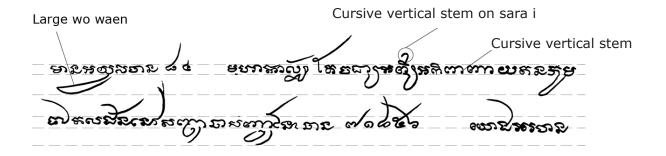


Figure 73. Khom Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the eighteenth century. Adapted from *Samut pap Trai Phum chabap Tham Lanna lae akson Khom,* by National Library of Thailand, 2004, p. 113, Copyright 2004 by National Library of Thailand.

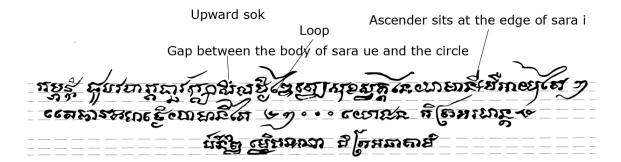
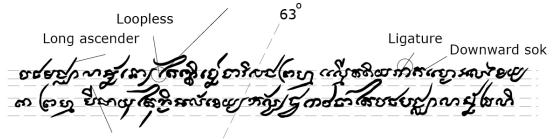


Figure 74. Khom Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the Ayutthaya era. Adapted from Samut pap Trai Phum chabap akson Khom pasa Thai, by National Library of Thailand, 2007, pp. 80-81, Copyright 2007 by National Library of Thailand.

Vertical stem moves leftward



Ascender sits at the edge of sara i

Figure 75. Khom Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the Ayutthaya era. Adapted from *Samut pap Trai Phum chabap akson Khom pasa Thai*, by National Library of Thailand, 2007, pp. 80-81, Copyright 2007 by National Library of Thailand.

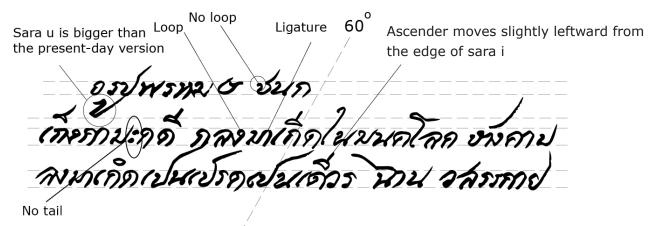


Figure 76. Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the Ayutthaya era. Adapted from *Samut pap Trai Phum chabap krung si Ayutthaya-chabap krung Thonburi*, by National Library of Thailand, 1999, p. 17, Copyright 1999 by National Library of Thailand.

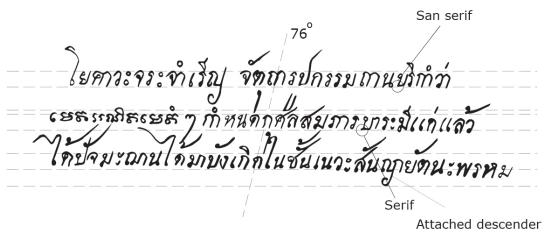


Figure 77. Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the Ayutthaya era.

Adapted from *Samut pap Trai Phum chabap krung si Ayutthaya- chabap krung Thonburi*, by National Library of Thailand, 1999, p. 113, Copyright 1999 by National Library of Thailand.

Gap between the body of sara ue and the circle

Figure 78. Thai letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript from the Ayutthaya era. Adapted from Samut pap Trai Phum chabap krung si Ayutthaya-chabap krung Thonburi, by National Library of Thailand, 1999, p. 18, Copyright 1999 by National Library of Thailand.

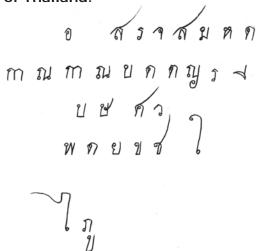


Figure 79. Letterform study of Thai characters based on a Trai Phum manuscript from the Ayutthaya era, by Virunhaphol

In the Trai Phum from Thonburi era, both of the scripts feature very long extenders. Subscribed vowels, such as tin khu (sara u), are larger than the present-day subscribed vowels (see Figure 80). Another noticeable point is that the Thai tin khu often has a horizontal stroke at the base linking two vertical stems above, while in Khom Thai, tin khu does not usually have this element (see Figure 78). It is observable that the circle of the Thai sara ue from this period is commonly detached from the body, unlike today's sara ue, whose circle is often attached at the upper right-hand side of the body (see Figure 81).

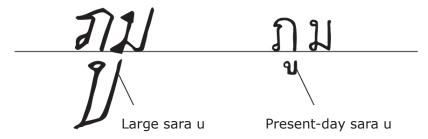


Figure 80. Comparison of sara u (tin khu) in Thonburi era (left) and the present-day sara u (right), as drawn and analysed by Virunhaphol

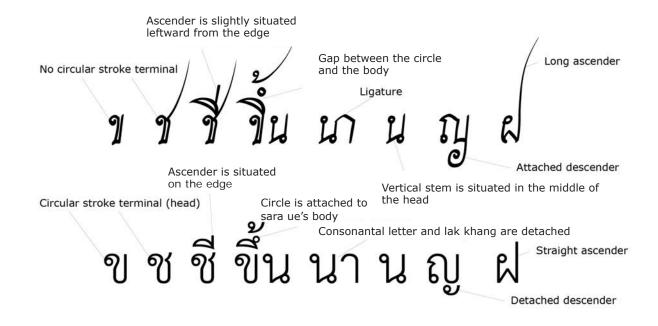
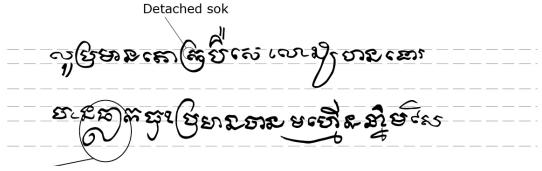


Figure 81. Comparison between Ayutthaya-Thonburi characters in SOV Jaruk (above) and modern Thai characters in TH Sarabun PSK (below)

Studying Thai letterforms from Trai Phum manuscripts made clear that there are many types of loops (e.g., open loop, circular loop, and loopless). Thai characters generally do not have serifs. However, in certain Trai Phum manuscripts from the Ayutthaya period, bo baimai and po pla have serifs, which is uncommon for handwriting (Figures 77-78). The ascender of sara i in the Ayutthaya-Thonburi period often does not sit at the right edge of the body (as in the present day) but moves further inward from the left. There is often a gap between the circle and the body of sara ue in the Ayutthaya-Thonburi period, but now this feature is usually attached to the body.

The National Library of Thailand collection contains at least one Trai Phum manuscript that was written in Khmer by Khmer Moul (Figures 82-83). The main difference that distinguishes that writing style from others is that the sok is often detached from the body, which is not the case for Khom Thai's sok. This characteristic also can be found in certain present-day Khmer fonts.



A subscribed consonant is attached to a full-form character above

Figure 82. Khmer letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript in the Khmer language found in Thailand. Adapted from *Trai Phum chabap pasa Khmer*, by Khamtho, 1987, p. 14, Copyright 1987 by National Library of Thailand.

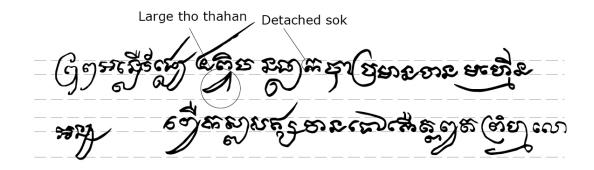


Figure 83. Khmer letterform drawing analysis, at approximately 75% of the original size, drawn and analysed by Virunhaphol. This is an example of handwriting based on a Trai Phum manuscript in the Khmer language found in Thailand. Adapted from *Trai Phum chabap pasa Khmer*, by Khamtho, 1987, p. 14, Copyright 1987 by National Library of Thailand.

Other related scripts: Khmer

As previously pointed out, Khom Thai is a type of Khmer script. Subsequently, it closely resembles the Khmer Moul script used in Cambodia, although the two are not the same. Both of these scripts are descendants of the ancient Khmer script (see the Khmer alphabet chart in Appendix E). Khmer Moul is sometimes called Mul, Khmer Mool, or Aksar Mul, and these terms can be used interchangeably. Khmer Moul and Khom Thai share many similarities, and so this section examined Khmer typefaces, and especially Khmer Moul. However, the chrieng style is not included in this part of the paper, because the chrieng letterforms share fewer common characteristics with Thai and Khom Thai than with Khmer Moul. The proportions and elements of the Khmer scripts reviewed herein helped inform the design decisions made in developing the three letterform designs at a later stage.

This study's focus was limited to the design aspect, since its objective was to identify a design framework for the TLK letterform designs. Furthermore, the scope of this research was limited to the Khom Thai script in Thailand. This research did not concentrate on Khmer scripts in Cambodia, since the TLK letterform designs were specifically created for the Thai language, and not for Khmer. A search revealed that Khmer fonts are not widely used across the globe in comparison with other non-Latin fonts, such as Arabic and Chinese. Rather, they are chiefly utilized in Cambodia and parts of Southeast Asia.

As Scheuren (2010) addressed, printing in Cambodia started much later than for other scripts. Therefore, Khmer types were first developed in the 19th century. According to him, "Kam bog' a" (later called Camboja, Pali-Siamisch, Kambodschao, and Pali-Kambodza) is the first Khmer type, and it emerged in 1844 (Scheuren, 2010, p.20). However, the typeface may not have been widely used, and so it is not generally acknowledged as the first Khmer type. Generally, many historians believe that a type cut at Imprimerie Nationale in Paris in 1877 is the first Khmer printing type in the Moul style. That type is noticeably close to handwriting, and the stroke weight is light. In general, the soks move downward. While certain soks are attached to the body, other characters have detached soks. Loops are mostly open, while horizontal strokes tend to be curved. Finally, vertical strokes can be either straight or cursive (see Figure 84).

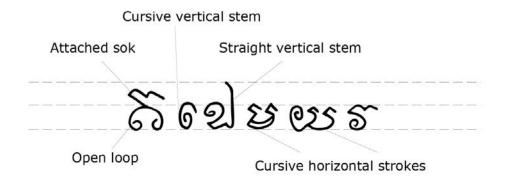


Figure 84. Letterform drawing analysis of Imprimerie Nationale Mul's characters, republished in *Khmer printing types and the introduction of print in Cambodia: 1877-1977* (Scheuren, 2010, p. 21) at approximately 130% of the original size, drawn and analysed by Virunhaphol.

Other historical Khmer types that are worth mentioning here are Deberny & Cie Mul and one of D. Stempel AG's typefaces. Derberny & Cie was a type foundry in Paris that produced Khmer type in the 20th century. The style was based on palm-leaf manuscripts; therefore, Deberny & Cie Mul closely resembles handwriting (Scheuren, 2010, p.28).

In comparison with Imprimerie Nationale Mul, the stroke weight contrast of Deberny & Cie Mul is significantly higher. The sok is detached from the body. Moreover, the type is more angular than Imprimerie Nationale Mul in general. Some loops are triangular without a counter inside. However, other loops are also open, as illustrated in Figure 85.

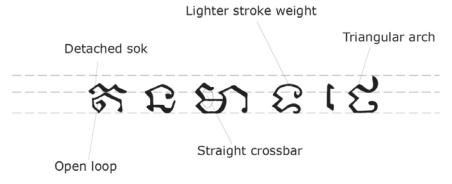


Figure 85.Letterform drawing analysis of Deberny & Cie Mul's characters, republished in *Khmer printing types and the introduction of print in Cambodia:* 1877-1977 (Scheuren, 2010, p. 27) at approximately 130% of the original size, drawn and analysed by Virunhaphol.

In 1925, D. Stempel AG launched a Khmer typeface in the Moul style (Scheuren, 2010). The stroke weight contrast of this type is higher than that of Imprimerie Nationale Mul. The horizontal strokes at the bases of certain characters are flattened. Loops are sometimes closed and circular and open in other cases, as depicted in Figure 86. The vertical stems of certain letters are cursive, while others are straight.

Apart from these three Khmer types, there are also other historical types that this review does not include. The reason is that many of them are in the chrieng style, which, as stated earlier, shares fewer common characteristics with Thai and Khom Thai than with Khmer Moul. Therefore, they have been excluded from this design review.

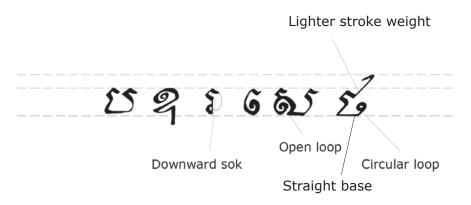


Figure 86. Letterform drawing analysis of D. Stempel AG's characters, republished in in *Khmer printing types and the introduction of print in Cambodia:* 1877-1977 (Scheuren, 2010, pp.31-32) at approximately 130% of the original size, drawn and analysed by Virunhaphol.

Moving on to Khmer fonts in the present, some educational institutes that offer Khmer courses, such as the University of Hawaii, also use these fonts as learning materials. Several websites also provide collections of Khmer fonts. One of these is Selapa's website. In this section, a review of 24 Khmer fonts from this website are included. The criteria for choosing these fonts were based on the relevance of design issues that could enable the development of the three letterform designs.

One Khmer type designer who has worked internationally to develop Khmer and other Southeast Asian fonts is Hong. In an interview with Google (2010), Hong addressed a design issue of particular relevance for this paper: the complexity of the letter formation in the Khmer script. Unlike the Roman script, in which all letters are situated above the baseline, Khmer has subscribed consonants, and lower vowels are placed under the baseline. Moreover, the upper vowels are positioned above the main letters (see Figure 87). Consequently, word formation requires more space than in the Roman script, meaning it is not a practical choice for font design. To solve the problem when creating Hanuman, a multilingual UI font he designed for Google in 2010, Hong condensed the letters' proportions so that they matched those of the Roman script. Consequently, each letter's descender and ascender are shorter than what is seen in handwriting. His design brief for this project was to create a compatible font for computers and mobile devices. At the time, certain other Unicode Khmer fonts, such as Dokchampa, were used for the Windows operating system, but these fonts were too small to read. Therefore, Hong intended to create better font hinting for user interfaces.

Hinting is "instructions added to the font that tell the character outlines how to reshape themselves at low and medium resolutions in order to create character images of maximum clarity" (Felici, 2012, p. 53).

However, by condensing Khmer letterforms, this method can cause reading problems when this typeface appears in small sizes. The short extenders are less visible, as Figure 88 demonstrates. As a result, letters that have close graphic elements, such as tho thong and pho phueng are hard to see the difference. Based on this observation, I designed a long ascender for TLK Deva and TLK Brahma, so as to allow readers to easily distinguish the characters from each other (see Figure 89).



Figure 87. Khmer word formation in Khmer Moul OS



Figure 88. Comparison of pho phueng and tho thong in a small size (18 pts) in TLK Brahma (left) by Virunhaphol, and Khmer Moul OS by Hong

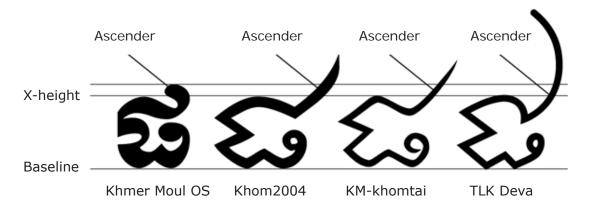


Figure 89. Comparison of pho phueng's ascender. From the left, the typefaces are as follows: Khmer Moul OS, Khom2004, KM-khomtai, and TLK Deva

In general, Khmer OS is a Unicode font family that Hong developed for user interfaces. It is multilingual, and therefore, the Khmer letter proportions match the Latin characters. The fonts in this family were intended to solve the reading problem at small sizes for cross-media platforms. Hong's modern Khmer fonts, such as Khmer OS, are more simplified than Moul-style fonts (see Figure 90). Moreover, modern Khmer fonts tend to be more angular than Khmer Moul. Like Khom Thai, Khmer Moul is roundish. The difference between the two is that Khmer Moul tends to have a high stroke contrast, since its letterforms were influenced by calligraphy.



Figure 90. Comparison of Khmer OS (above) and Khmer Moul OS

For calligraphic fonts, Hong does not usually draw a counter inside the head, as he does with his more modern fonts. From my observations, the closed counter is fitting for fonts with a low stroke width, because there is sufficient room to draw the negative space inside the head. However, for calligraphic typefaces, which have thicker stroke weights, this graphic feature usually disappears. Both TLK Deva and TLK Manussa have lighter stroke weights than TLK Brahma, and so I designed the head of TLK Deva and TLK Manussa with the closed counter inside, while I only drew a curve for TLK Brahma (see Figure 91).

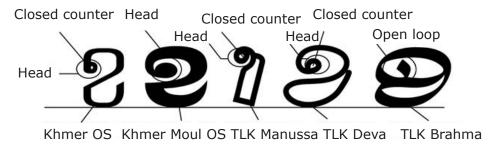


Figure 91. Comparison of the heads of a letter in Khmer OS, Khmer Moul OS by Hong, and the TLK letterform designs by Virunhaphol

Another noticeable element of Hong's work is that medium-wide letters are taller than they are wide, because he condensed the letters to meet the proportion of the Roman type. The advantage of this method is that it saves page space. However, the letterforms are distorted and difficult to read in small sizes. For Khom Thai, I examined the Trai Phum's writing style and compared it to the textbooks. I found that normal medium-wide letters had nearly equal heights and widths. Subsequently, I decided to apply these proportional dimensions to the TLK Deva and TLK Brahma designs, since those proportions represented ancient writing styles. However, TLK Manussa was based on characteristics of the Thai script in the present. Thus, it is the only letterform design in which the medium-wide letters are taller than they are wide.

A review of Khmer fonts (e.g., Khmer Moul OS) revealed another difference between Khom Thai and Khmer scripts. In some cases, the sok of Khmer is not always attached to the body of the letter. However, the letterforms in Trai Phum and the textbooks indicated that this letter element in Khom Thai is commonly attached to the body. For this reason, I decided to follow the Thai style, as illustrated in Figure 92.

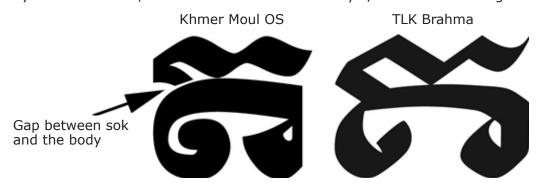


Figure 92. Comparison of the sok in Khmer Moul OS by Hong and TLK Brahma by Virunhaphol

The Khmer Moul OpenType fonts by other type designers (e.g., Kanjahn, Sovanvichet, Keo, Rithy, Sokha, Mony, and Kai) mostly of these fonts have a strong calligraphic influence, as Figures 93–104 show graphic analyses by Virunhaphol.

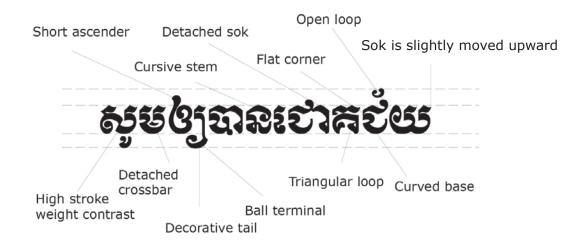
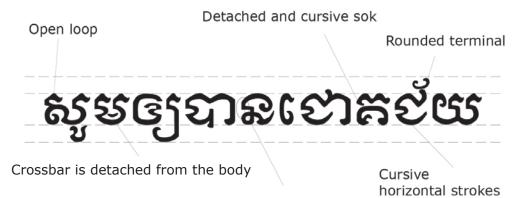


Figure 93. Typographic study of Ang TaPich designed by Keo, analysed by Virunhaphol



Sheared corner

Figure 94. Typographic study of Kh Baphnom_Old Style designed by Mr. Sovandy Mok, analysed by Virunhaphol

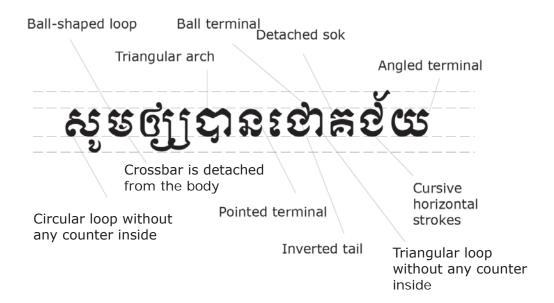


Figure 95. Typographic study of Kh Prey Veng designed by Kh Prey Veng, analysed by Virunhaphol

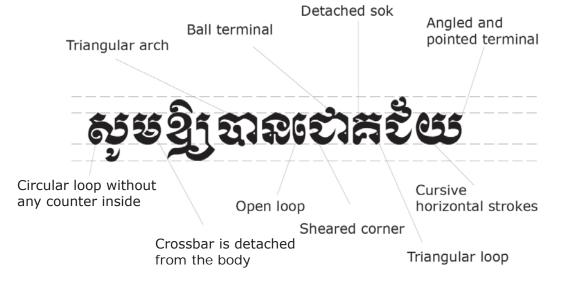


Figure 96. Typographic study of Khmer M1 designed by Lim Sovanvichet, analysed by Virunhaphol

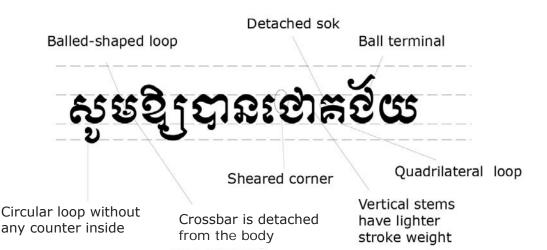


Figure 97. Typographic study of Khmer M2 designed by Lim Sovanvichet, analysed by Virunhaphol

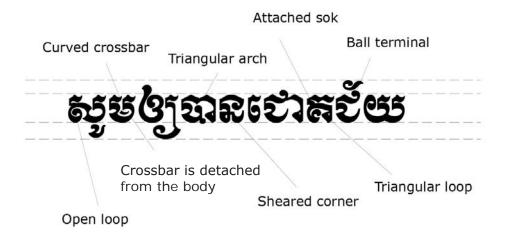


Figure 98. Typographic study of Khmer Mool designed by Top Rithy, analysed by Virunhaphol

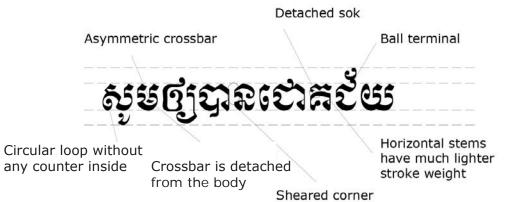


Figure 99. Typographic study of Khmer Moul designed by pen sokha, analysed by Virunhaphol

Sheared corner cut Short ascender at 90 degree angles Ball loop without counter Detached sok **រ្យុ**ធានទោកថ Pointed terminal Curved horizontal stroke Straight Small close counter vertical stroke

inside the loop

Figure 100. Typographic study of Khmer OS Moul designed by Danh Hong, analysed by Virunhaphol

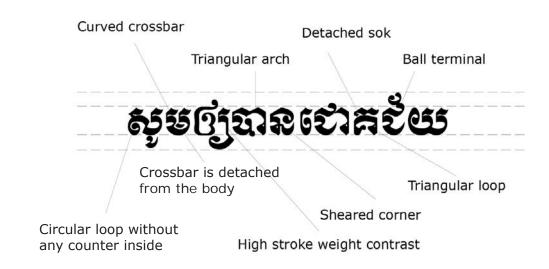


Figure 101. Typographic study of Khmer Unicode R1 designed by pen sokha, analysed by Virunhaphol

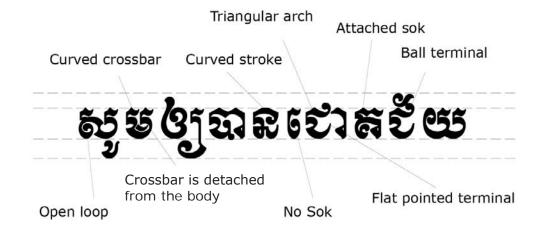


Figure 102. Typographic study of MoolBoran designed by OM Mony, analysed by Virunhaphol

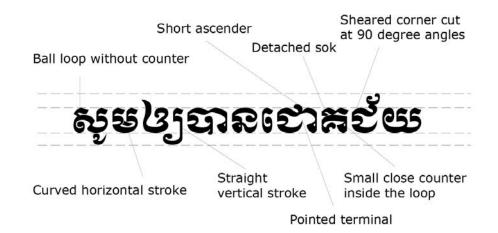


Figure 103. Typographic study of Moul designed by Danh Hong, analysed by Virunhaphol

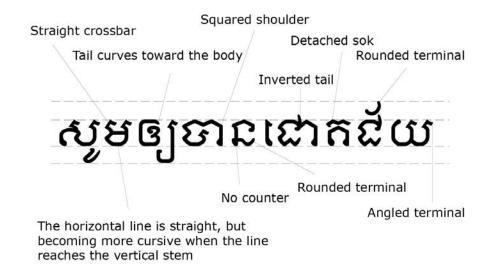


Figure 104. Typographic study of Khmer OS Muol Pali designed by Danh Hong, analysed by Virunhaphol

In addition to the Moul style and the chrieng style, the upright style is also common. Although it was adapted and is also sometimes used in place of the chrieng style, there is certainly a difference between the two regarding the angle of stress. Chrieng slants rightward, while the axis of the upright style is at 90 degrees, just as with present-day Thai and Khom Thai script. Therefore, the design review also includes fonts in the upright style. In general, upright style fonts are narrower than Moul fonts. The stroke weight contrast is often (but not always) lower. Figures 105-113 contain Virunhaphol's graphic analyses of these upright style fonts. Most of them are desktop fonts intend to be used on the computer; the exceptions are Nokia Pure S40 KHMR (Figure 115) and Khmer UI (Figure 114). Nokia Pure S40 KHMR is for mobile phone use, while Khmer UI is a user interface font.

Tapered terminal Short ascender Upward sok No sok Loopless Straight stem Detached sok Open loop

Figure 105. Typographic study of AKbalthom KhmerLer designed by AKbalthom, analysed by Virunhaphol

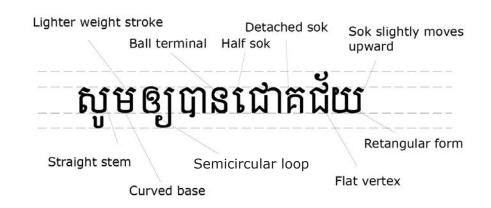


Figure 106. Typographic study of Ang DaunTeav designed by Chhun Keo, analysed by Virunhaphol

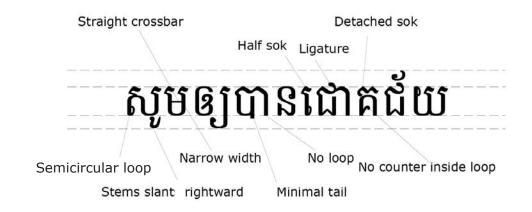


Figure 107. Typographic study of Battambang designed by Danh Hong, analysed by Virunhaphol

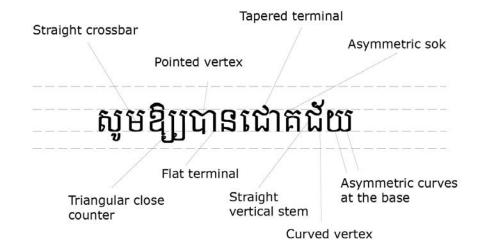


Figure 108. Typographic study of Kh Limon S1 designed by Sath SokhaMony & Chhit WornNarith (Limon Group), analysed by Virunhaphol

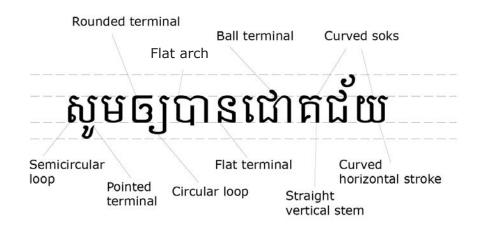


Figure 109. Typographic study of Khmer Busra designed by D. Kanjahn, analysed by Virunhaphol

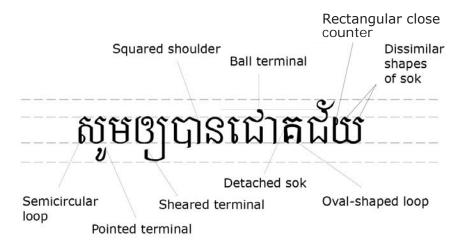


Figure 110. Typographic study of Khmer Element designed by D. Kanjahn and Mr. Samady KS, analysed by Virunhaphol

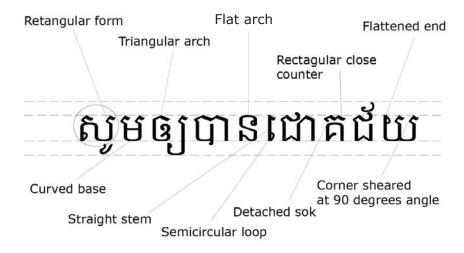


Figure 111. Typographic study of Khmer OS designed by Danh Hong, analysed by Virunhaphol

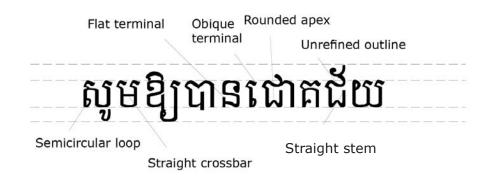


Figure 112. Typographic study of Khmer S1 designed by LIM Sovanvichet, analysed by Virunhaphol

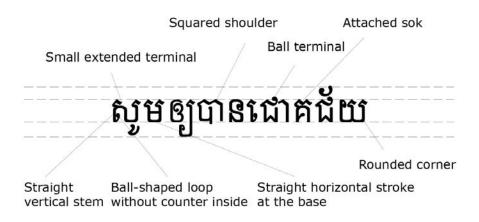


Figure 113. Typographic study of Khmer Unicode Serif designed by pen sokha, analysed by Virunhaphol

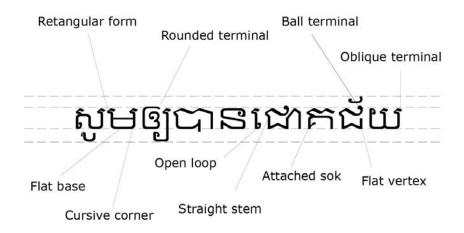


Figure 114. Typographic study of Khmer UI by Microsoft Corporation, analysed by Virunhaphol

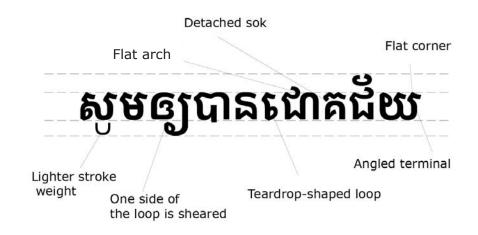


Figure 115. Typographic study of Nokia Pure S40 KHMR Bold designed by Dalton Maag, analysed by Virunhaphol

Overall, the stroke contrast of most Khmer Moul typefaces in Cambodia is higher than the stroke contrast of Thailand's Khom Thai typefaces, KM-khomtai, and Khom2004. As with typical Thai fonts, such as TH Sarabun, both of the Khom Thai typefaces do not have thick stroke weights. Common tools for writing Khom Thai and Thai are pens, pencils, brushes, and metal styluses (Wiraprachak, 1987). Letterforms written using a pencil or metal stylus consequently have a light stroke weight, and KM-Khomtai and Khom2004 represent that style. However, pen and brush can create letterforms with a higher stroke weight contrast.

This review of Khmer typefaces provided additional insights into the graphic construction of the Khmer script family. This knowledge informed the design framework discussed in Chapter 3.

Other Non-Latin scripts

Apart from Khmer and Thai, other non-Latin scripts were also examined. However, the basic structures of these other scripts, including Japanese, Chinese, and Arabic, shared few similarities with Khom Thai. Therefore, I could not use them as models for the TLK letterform design framework.

However, during this search to find a general working method for Non-Latin scripts, Frutiger and Patel's efforts regarding Devanagari (Osterer and Stamm, 2014) came to my attention, due to certain similarities between the situations facing Khom Thai and Devanagari. When Frutiger started redesigning the script in 1967, Devanagari had been also used for writing on palm leaves and stones. India's National Institute of Design commissioned Frutiger to restyle the ancient script to enable it to catch up with the Western typesetting and reproduction technique at the time (Osterer and Stamm, 2014, p.206). Like Khom Thai, there were no guidelines governing the design process. Modernising the script was not an easy task for Frutiger, since Devanagari is heavily based on calligraphic form. When he tried to simplify the letterforms, as he had done in the case of Univers, the design seemed incorrect to him.

As Frutiger stated:

What I was trying to do was a formal simplification in the sense of the shapes of Univers. While I was doing this, I noticed right away that something was wrong, but I didn't know what it was, and therefore I couldn't do anything about it first. Then I had the idea to write a classical script first using the Calam, a type of antiqua suitable for the pen (Osterer & Stamm, 2014, p.206).

Although this work is not a typeface in use Frutiger's reflections on the problem of redesigning Devanagari is an interesting point of view. It is an example of how to use reflective practice as a tool in solving design problems. The way that he decided to study the graphic structures of Devanagari by practicing writing the script with Calam [Kalam] seemed to be a logical choice, because this working method could help improve design knowledge, including regarding proportions, stroke weights, and key skeletons. The results of his reflective practice provide ideas on how to approach traditional scripts, improve creativity through practice, and identify design possibilities.

In the first stage, the initial sketches of TLK Brahma and TLK Deva also followed this approach, albeit rather loosely. The experimental drawings helped informed the basic structures of both of the letterform designs that were later redesigned with the computer.

Apart from Frutiger's Devanagari typeface, Arabic were also investigated. An exploration of similar problems in Arabic typography highlighted an interesting issue related to designing multilingual typefaces. As Ross (Ross & Shaw, 2012) noted, that process can be challenging, because two scripts can have different graphic elements, such as the stroke modulation, counters, and x-height. Ensuring cooperation between Arabic and Latin letterforms is a difficult task, as Balius (2013) pointed out that the two are largely different. For instance, Arabic is unicase, unlike Latin characters. Therefore, it is not necessary to determine the cap height for Arabic.

One of the main issues that needs to be considered regarding multilingual letterforms is that adjusting non-Latin characters to match the proportions of Latin might not be the best design solution. As Nemeth (2006) pointed out, there have been many criticisms of this practice. This is due to the face that Arabic and Latin have different structures and do not generally conform to each other. Adjusting the Arabic dimensional proportions to fit the Latin x-height to make Latin and Arabic equally appealing could ruin the authenticity of Arabic. Furthermore, the readjustment of the letterforms could destroy Arabic word shapes, making it harder to read the script. Therefore, each designer must make a careful decision as to which graphic features can be compromised and which cannot. The discussion surrounding the matchmaking of Arabic and Latin is not directly relevant to Khom Thai and Thai. However, it suggested design problems that can occur when readjusting the proportions of one script to match those of another.

In the case of TLK Manussa, which characterises the modern Thai script, five letters share common graphic elements: kho khai, tho montho, tho phuthao, ro ruea, and so suea. I started designing these Khom Thai letters first, since they seemed to closely resemble their Thai counterparts. However, as Balius pointed out, this task was not simply a matter of mimicking the Thai script. Therefore, I adapted the letterforms according to Khom Thai's main structures. As Figure 116 illustrates, in TLK Manussa, kho khai was angled slightly rightward, as in Khom Thai. Its letter elements, however, were simpler and more angular than is typical of Khom Thai. Moreover, I extended tho thong's ascender past the length of the Thai letter. I adjusted tho phuthao's finial to include the sok at the end. However, since the Thai script inspired TLK Manussa, the sok is smaller than in other letterform designs that I designed, more closely resembling the Thai version. For pho samphao, the height of the shoulder was decreased to create enough space to draw the sok above it. The other letters pictured (tho montho, ro ruea, and so suea) follow the main outlines of Khom Thai. However, I reduced the width proportions in accordance with the Thai script.

As Nemeth acknowledged, very little empirical research has examined the matchmaking and legibility of non-Latin typefaces. Further investigation aimed at confirming that harmonisation is not the best design practice requires more study on this subject. The main problem is that a change to the word shape can impede recognition of the script. If this is the case, the design of TLK Deva and TLK Brahma must work better in letter recognition than TLK Manussa, since the characters of both letterform designs were not created based on the Thai script, as was the case with TLK Manussa. Chapter 4 will further investigate into this issue.

Letter name	Kho khai	Tho montho	Tho phuthao	Ro ruea	So suea
TLK Manussa	7	ಇ	ប្រា	Ĵ	ស
TH Sarabun	ဈ	M	M	วี	ส

Figure 116. Comparison of Thai letters in TH Sarabun and Khom Thai letters in TLK Manussa

Key points:

- 1. Khom Thai is a type of Khmer script with its origins in the Khmer Empire. The Khom script was developed around the 15th century to write in the Thai language, Sanskrit and Pali in Thailand. This study only focused on the Khom script that is used for the Thai language.
- 2. The exposure effect is a psychological phenomenon characterized by people's tendency to like objects that are familiar to them. In type design, typefaces with features familiar to readers are believed to be more recognizable. The research question built on this concept, and it asked whether graphic features of the Thai script that are familiar to contemporary could improve recognition of Khom Thai.
- 3. The contextual review indicated that the Thai script and Khom Thai differ in three main ways. First, they diverge in terms of the width of their letters. In general, some Khom Thai letters are wider than Thai letters nearly by half. The second issue is that the Thai script does not have subscribed consonants, while Khom Thai features subscribed consonants written below the full letterforms. This means that, in general, Khom Thai requires more interline space than the Thai script. Lastly, the letter shapes of the Thai script are more angular than those of Khom Thai. On the basis of these observations, I developed the design concepts for the three letterform designs. Chapter 3 describes this process in further detail.

Chapter 3: The Design Framework

This chapter describes the design methodology used to develop the TLK letterform designs. The abbreviation TLK means "Trai Loka", or "three worlds", in the Thai language. It has the same meaning as "Trai Phum". In the Trai Phum manuscript, the three worlds refer to the Buddhist cosmological realms that are home to many beings, including humans, devas, and Brahma. This ancient manuscript inspired the TLK Brahma and TLK Deva designs.

This study employed a combination mixed approaches, which ranged from sketching by hand to designing letterforms with a computer, to achieve its research goals. The first part of this chapter explains the conceptual framework, and as well as how the initial versions of the letterforms were implemented. Later, these preliminary designs were presented to three Khom Thai lecturers at Silpakorn University. These lecturers were interviewed, and their design feedback, which represented the Khom Thai palaeographer perspective, helped to improve the letterforms.

Finally, the designs were polished on the basis of the questionnaires and my own experience. Since there was no standard terminology for Khom Thai, the graphic terms used to describe the letterforms elements were partially based on those employed in Cole (2012). However, the terms for Roman script could not explain all Khom Thai letter features. When no substitute word was available in English, this paper uses the original terms in the Thai language, along with an English explanation of them.

3.1 The design methodology

The first step in the design process was exploring various Khom Thai documents from the archives of the National Library of Thailand, inscriptions in Thailand Database, and the British Library to find inspiration for the TLK letterform designs as reviewed in Chapter 2. This process gave me the opportunity to explore Khom Thai writing styles, with the aim of identifying logical references for the letterforms.

This search revealed a Khom Thai manuscript entitled Trai Phum, which was significant in terms of the beauty and authenticity of the letterforms (The National Library of Thailand, 2007, p.6). Trai Phum is considered one of the oldest works of Thai literature, and it dates back to the 13th century. However, only copies from the 17th to 19th centuries that have survived to the present day. The archives of the National Library of Thailand contained at least nine versions of Trai Phum. The most intact manuscript was Trai Phum Ayutthaya no. 7, which was also the only text written entirely in Khom Thai. In term of the writing style, the handwriting in this book was delicate, and graphic elements were clearly visible. Therefore, I chose Trai Phum Ayutthaya no.7 as the primary design reference. In Thai, this type of manuscript is called "Samut Thai", which literally means the "Thai notebook". The term refers to Thai books made from the pulp of the "Khoi tree", a type of tree from the Urticaceae family (National Library of Thailand, 2007). This Trai Phum manuscript contained two writing styles. In the first style, the stroke weight was very low contrast. Moreover, the letterforms were generally roundish (see Figure 118). The second style was characterised by its high stroke contrast and pointier letterforms (see Figure 117).

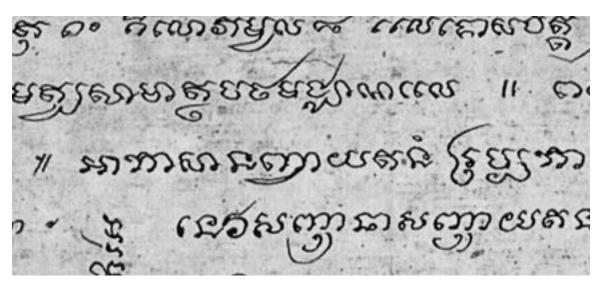


Figure 117. Details of the first writing style in Trai Phum Ayutthaya no.7 at 100% of the original size. Adapted from *Samutpap Trai Phum chabap akson Khom pasa Thai*, by Kana kammakan fai pramuan ekkasan lae chotmaihet, 2007, p. 69, Copyright 2007 by National Library of Thailand.

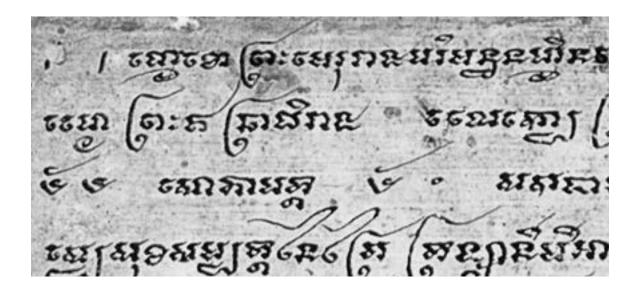


Figure 118. Details of the second writing style in Trai Phum Ayutthaya no.7 at 100% of the original size. Adapted from *Samutpap Trai Phum chabap akson Khom pasa Thai*, by Kana kammakan fai pramuan ekkasan lae chotmaihet, 2007, p. 81, Copyright 2007 by National Library of Thailand.

The three TLK letterform designs

The three letterform designs aimed to help facilitate the learning of the script. These designs could be used at a later date to teach students to write and identify each Khom Thai character in accordance with Thai alphabetic units, preparing them for further stages of reading the script. These letterform designs are named TLK Manussa, TLK Deva, and TLK Brahma.

I designed these three letterform designs on the basis of the research question, which addressed whether familiar characteristics could improve the script's letter recognition. To answer the research question, I needed to compare today's familiar script style and the traditional style used in ancient times.

Thus, I designed TLK Manussa on the basis of familiar characteristics of contemporary Thai script. This letterform design therefore represents an attempt to bridge the gap between the past and the present. Consequently, the goal was for TLK Manussa to embody a unique style that would both seem familiar for contemporary Thais and capture the authenticity of Khom Thai. This Thai script is currently condensed, and it features a low stroke contrast when writing with a pencil. Like the Thai script, TLK Manussa also possesses these attributes. Moreover, it features simpler letterforms than the other letterform designs.

Traditionally, there are main ways to write the Khom Thai script: (1) using a metal stylus to write on a palm leaf, and (2) using a pen or brush to write on paper. Both TLK Deva and TLK Brahma were designed on the basis of these calligraphic styles. These letterform designs were developed with goal of preserving the characteristics of traditional Khom Thai writing, which Thais no longer use on a regular basis. The difference between the two designs is that TLK Deva was based on the metal stylus style, while TLK Brahma was based on the brush stroke. As a result, TLK Brahma is wider, and it features a thicker stroke weight than TLK Deva. Furthermore, TLK Brahma's stroke contrast is higher than the other letterform designs, because of the influence of the calligraphic form.

These three TLK letterform designs aim to be learning materials, and they are therefore not for everyday use. I reviewed the pre-existing fonts, KM-Khomtai and Khom2004 (see Chapter 2), but they proved to be insufficient as writing models. Therefore, TLK Brahma and TLK Deva can fill this gap, since they are both based on traditional styles that are more accurate than the two fonts commonly used for studying Khom Thai in Thailand. Additionally, the few Khom Thai writing models in existence are incomplete, as discussed in Chapter 2.

For TLK Manussa, although it does not follow common Khom Thai styles used as writing models like the other two designs, it may be presented as character mnemonics for students in accordance with authentic Khom Thai characters. Since TLK Manussa possesses graphic attributes of the familiar, contemporary Thai script, it may facilitate the learning process (see the portfolio, pp.162-163).

TLK letterform styles

The next step was implementing the TLK letterform design practices. Before describing the design methods, however, it is crucial to discuss the styles of the three designs, which helped them to communicate in a precise manner. Letterform design, like humans, have various personalities. The three designs all served different purposes, and so their characteristics were grounded in the distinctions between the new style

and the old style. While TLK Manussa integrates the style that is familiar today, TLK Deva and TLK Brahma follow traditional calligraphic styles. As a design practitioner, crafting TLK Manussa posed the greatest challenge, since it represents a style that other type designers have not yet explored. This does not mean that I developed TLK Deva and TLK Brahma without any complications. Both of these letterform designs also demanded significant attention to the design details. The next sections introduce the concepts and principles underlying each of the three typefaces that I created.

TLK Deva

Figure 119. Full-form letters in TLK Deva

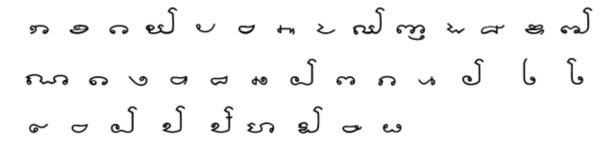


Figure 120. Subscribed consonants in TLK Deva

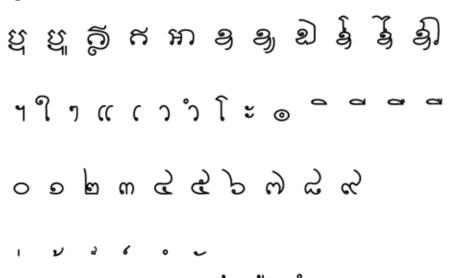


Figure 121. Vowels, numbers, tone marks, and symbols in TLK Deva

As the beginning of this chapter noted, the Khom Thai script was traditionally written in different ways. The first method involved using a metal stylus to write on palm leaves. This writing style is called "Sen Chan". In Thai, "Sen" refers to the stroke, and "Chan" means writing on palm leaves with a metal stylus (Phra Akkaradet Yannatecho, 2015). I designed TLK Deva by basing the letterforms on this writing style. In comparison, the letterforms of contemporary Thai script are more angular than the Sen Chan style. The Sen Chan letterforms are rounded due to the peculiar writing method.

In general, letters are written from left to right, as in the Roman script. However, with Sen Charn, the hand position for writing is completely different. Normally, the edge of the left thumbnail is trimmed into a notch. The right hand positions itself above the left hand, while the metal stylus rests against the notch. Both hands move along the lines. Since a palm leaf can easily split horizontally, the writer must inscribe roundish shapes to avoid damaging its surface (Calderhead & Cohen, 2011, pp.149-151). It is for this reason that Khom Thai requires more width space than the Thai script as discussed in Chapter 2. These chirographic differences make it difficult for today's Thais to recognise Khom Thai.

Two key aspects shaped the overall appearance of TLK Deva. Firstly, this letterform design should appear roundish, and it is wider than the Thai script. In comparison with TLK Manussa, the stems of TLK Deva are more cursive. This design was intended to preserve the rounded letterforms. Secondly, TLK Deva features long extenders, because it follows the traditional Khom Thai writing style (see Figures 119–121). These chirographic features should not be compromised to the point at which the visibility of the letterforms suffers. The only resemblance between the Sen Charn style and the Thai script is that both feature a low stroke contrast. Therefore, I assigned the same stroke weight to both TLK Deva and TLK Manussa. From these general specifications, I began by designing the key letters, a process to which the next section returns.

TLK Brahma

Figure 122. Full-form letters in TLK Brahma

Figure 123. subscribed consonants in TLK Brahma

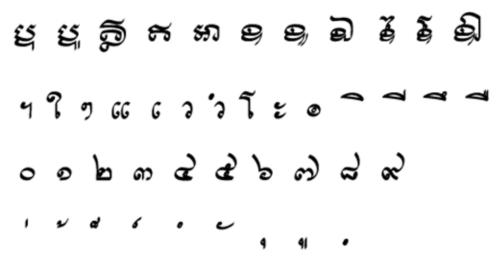


Figure 124. Vowels, numbers, tone marks, and symbols in TLK Brahma

As previously discussed, there are two traditional methods for writing in Khom Thai. The second style that will be examined in this section is "Sen Chup". The term "Sen Chup" contains two separate Thai words. As previously noted, "Sen", means the brush stroke, while "Chup" in Thai is for "to dip". In this case, the term refers to the way in which a pen or quill is dipped in ink and then utilized for writing on paper. In addition, brushes made from mouse whiskers or horsehair are sometimes also used for writing in Khom Thai (Phra Akkaradet Yannatecho, 2015).

A review of the letterforms in Trai Phum found that the stroke contrast is higher for Sen Chup than Sen Chan, because the former style is strongly influenced by calligraphic brushstrokes. Furthermore, the sok does not always point downward. I followed these rough parameters to develop TLK Brahma (see Figures 122–124). Although I based TLK Brahma on the Sen Chup writing style, no proportional principles existed that governed its application. For this reason, I formed this design's proportional dimensions on the basis of my observations and sketching experiments. The details regarding how I designed these letterforms are in the working process and the portfolio.

TLK Manussa



Figure 125. Full-form letters in TLK Manussa



Figure 126. subscribed consonants in TLK Manussa

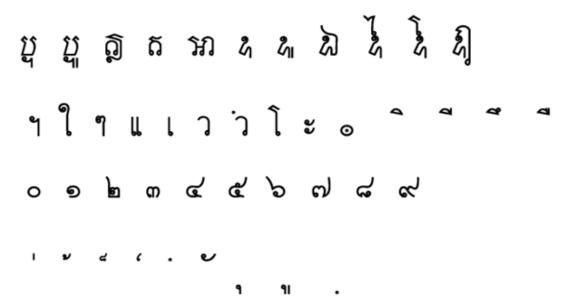


Figure 127. Vowels, numbers, tone marks, and symbols in TLK Manussa

The design concept underlying TLK Manussa was the idea that Khom Thai might be more accessible if the letterforms take into account the style that is commonly used today. This letterform design is read like Khom Thai, but it seeks to express the personality of the Thai script. Balancing the two concepts was challenging, because only a few Khom Thai characters share common graphic elements with the Thai script. Of all the letterform designs, TLK Manussa posed the most demanding design challenge. With few design references on which to draw, I had to employ a more innovative approach. For this reason, I studied the letterforms of the Thai script to ascertain how the proportions had been developed and how the general Thai typeface designs appeared in Chapter 2. The main issue in crafting this design was the proportional difference between Khom Thai and the Thai script. In general, some Khom Thai characters are wider than the Thai script nearly 50%. This disparity made it necessary to reduce the width of TLK Manussa. To some extent, however, some letters still had to be wider to appear to be Khom Thai (see Figures 125-127).

In the end, I decided to use the Royal Society of Thailand's (1997) proportional guidelines as a source of inspiration, because they offered clear direction on the design process. I did not use the NECTEC (2001) guidelines, because that organisation has not conducted any studies on handwriting, unlike the Royal Society of Thailand. Instead, NECTEC only studied fonts on the market in 2001 to develop its guidelines, and therefore, the book is not appropriate to use for developing writing models.

To overcome the design obstacle, I adapted the Khom Thai skeletons to fit the Thai proportions that the Royal Society of Thailand's manual outlined. I then individually adjusted each letter in accordance with the appearance of Khom Thai. These alterations were based on my experience rather than on a strict reading of the handbook. This was because the manual provided guidance for Thai type design, but not for Khom Thai type design. Consequently, it did not contain enough information to make it a useful resource for designing complete TLK Manussa characters. However, the handbook helped me define the general style and concept for TLK Manussa. It constituted a starting point for the letterform design, which is simple and contemporary.

Proportional considerations for TLK Deva and TLK Brahma

After I determined the styles for the three letterform designs and the general proportional dimensions for TLK Manussa, the next step was establishing the proportions for the other two letterform designs, TLK Brahma and TLK Deva. The three major textbooks for teaching Khom Thai did not contain any proportional guidelines for Khom Thai type design (Chucheun, 1992; The National Library of Thailand, 2010; Wimonkasem, 2011). Only Wimonkasem (2011) attempted to define its graphic elements, including the writing direction. However, in contrast to the Thai script, insufficient details were available on the design of Khom Thai.

For this reason, the proportions for TLK Deva and TLK Brahma were based on my close observation of the writing styles in Trai Phum, rather than on the textbooks and my experimental sketches. I commenced the design process by establishing the general proportions of the full-form letters, since these are the main characters written on the baseline. Since no previous systems of Khom Thai type design existed, I selected no nu as the letter defining the x-height of each letterform design. Cho chang is a letter with a long ascender, and so I used it as a reference for the ascender height. The next step was defining the descender height. Commonly, the full-form letters do not have long descenders, because there are subscripts beneath the baseline. On a full-form letter, a long descender can interrupt the subscript underneath it. Therefore, I sought to control this graphic feature. I selected tho montho as a key letter for determining the descender height.

For the subscribed consonants, they are usually shorter than full-form letters by approximately 50%. The subscribed consonant's ascender usually ends at the x-height of the full-form letter.

According to manual published by the Royal Society of Thailand (1997), the x-height is commonly set at 8 units. I used this value as the x-height of my three letterform designs. All three designs featured the same x-height, which later enabled me to use that factor as a constant control variable in the letter recognition testing (see Chapter 4). However, the letterform designs varied in width, because this is a factor that contributed to the unfamiliarity of the Khom Thai script, as previously discussed. Overall, I classified the letters into five categories: thin, narrow, medium, wide, and ultra-wide.

I began by first defining the widths of the narrow and medium letters, because these two groups contained the majority of the letters. In Trai Phum, medium letters had approximately similar widths and heights. For TLK Deva, I decided to set the width of the medium letters at approximately 8 units. However, TLK Brahma features slightly wider letters, because it has a higher stroke modulation. Narrow letters of both TLK Deva and TLK Brahma were about half as wide as the medium letters. In TLK Manussa, the medium letters are between 4-6 units wide, while the narrow letters are half as wide.

After determining the rough proportions for my letterform designs, the next step was analysing the anatomy of Khom Thai. This allowed me to place letters with common graphic features into groups. This was a practical approach to the design process, since I could use the base letters to design other characters in the group at the same time.

3.2 The anatomy of Khom Thai

As Ross (2013) indicated, no standard terms exist that describe the letterforms of non-Latin scripts. The Khom Thai script is structurally different from the Roman alphabet. Thus, I gathered terms that were fitting choices for describing Khom Thai letter compositions from a wide range of sources. Some of these terms have also been applied to Roman type, while others are the original Thai description, accompanied by explanations in English.

When researching the anatomy of Khom Thai, I surveyed textbooks including those by Cheng (2005), Punnothok (2006), The National Library of Thailand (2010) and Wimonkasem (2011).

This section includes details on each character's graphic elements, and it also provides illustrations that highlight the structure of Khom Thai. Therefore, it is more visual than previous chapters. Graphics have been included, because they describe the constructions more clearly than words alone. This section's objectives are to provide useful information on Khom Thai letterforms and features that other design practitioners can use as design guidelines. Moreover, by examining these elements of Khom Thai, I gained a deeper understanding of its letterforms, which helped me further develop my letterform designs.

Types of Khom Thai letters

Figures 129-131 present three sets of characters: (1) full-form letters (Figure 129), (2) subscribed consonants (Figure 130), and (3) vowels and numbers (Figure 131). As further clarification, Khom Thai characters generally change their appearance when the letters that combine to form a word shift positions. When used as an initial consonant, a letter appears above the baseline. This type of Khom Thai letterform is called "tua tem", which can be literally translated as "full form". When a letter appears as the final consonant in a word, it is smaller, positioned under the initial consonant. This type of Khom Thai letter is called "tua choeng", or a subscribed consonant.

The Thai script contains are 44 consonants (2 of which are now obsolete), 32 vowels, and no subscribed consonants. The letterforms of initial and final consonants in a word are the same in the Thai script. In contrast, Khom Thai comprises 42 full-form letters (initial consonant letters). When these are used as final consonants, the number of characters decreases to 37 subscribed consonants. While the Thai script has only one type of vowels (32 characters), Khom Thai has two kinds of vowels. First, it contains independent vowels, which can be written alone. The second type of vowel, the dependent ones, must combine with consonants to form words. Khom Thai features 12 independent vowels and 22 dependent vowels. This information helped me to establish the number of characters that would be involved in the next stage.

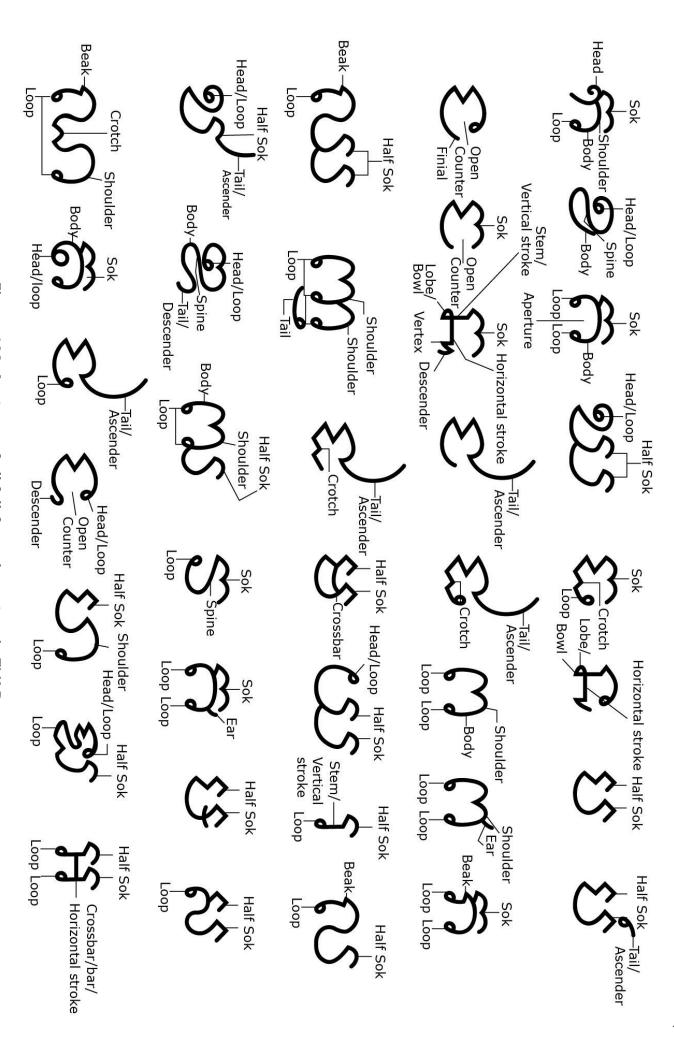


Figure 128. Anatomy of all full-form characters in TLK Deva

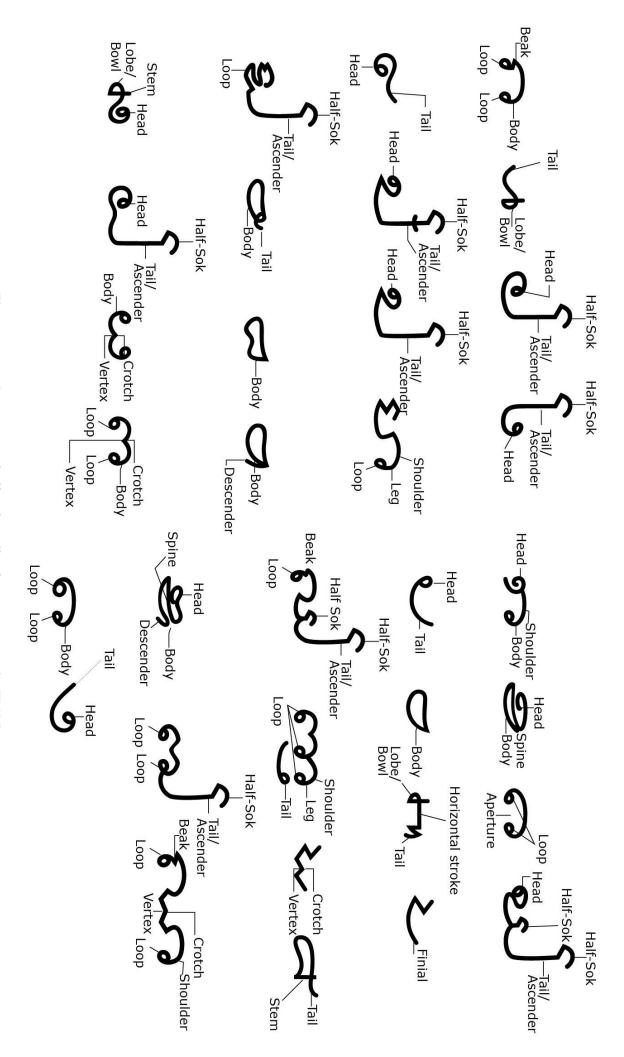


Figure 129. Anatomy of all subscribed consonants in TLK Deva

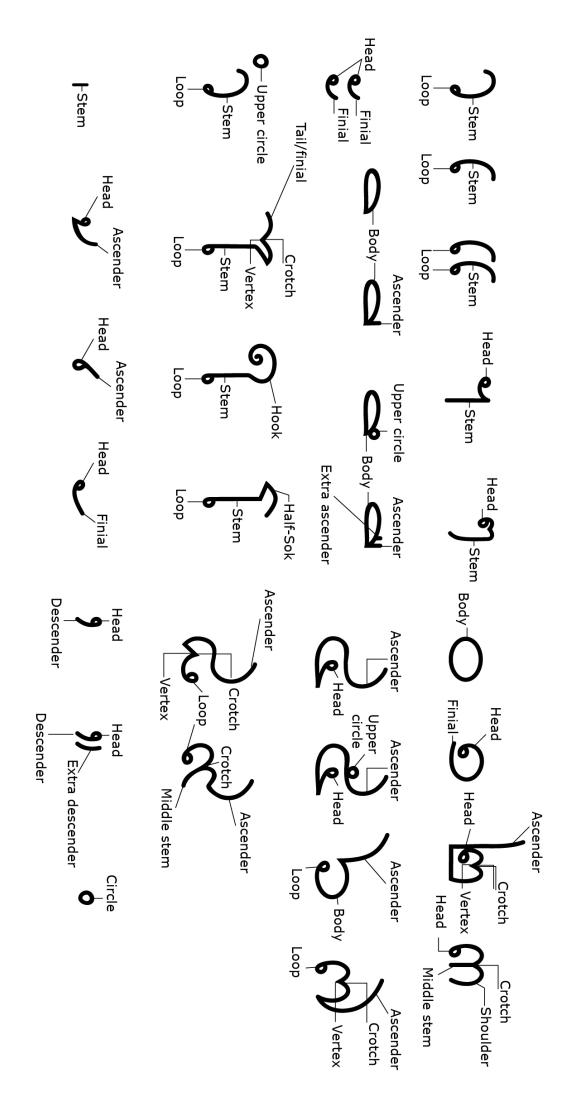


Figure 130. Anatomy of all vowels, symbols, tone marks, and numbers in TLK Deva

Sok

Next, I investigated the sok, an essential element. This feature is an upper component that is attached to the letter's body. In general, the sok takes the form of a continuous wavy line with a notch in the middle. This type of sok is called the "sok tem", or "full sok" (see Figure 131). However, Khom Thai also contains another common type of sok: the half-sok (Wimonkasem, 2011). A half-sok contains only a portion of a full sok. However, other letters, such as kho khai, do not have any of these elements.

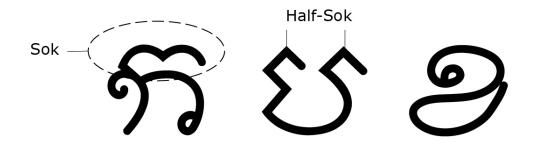


Figure 131. Example of a sok, a half-sok and a letter without sok (from the left) in TLK Deva

3.3 The working process

After studying the anatomy of type, I gained basic understand of what Khom Thai look like. The next step was moving into the practice of design. In brief, I started the design process by sketching some key letters. I did not follow a specific letter order at this stage, because I wanted to understand how hand movements and writing materials could affect the letterforms before actually designing all of the characters.

As the contextual review noted, Thai people have traditionally used several different materials for writing in Khom Thai. I therefore experimented with three types of paper: common paper, palm leaf paper, and mulberry paper. At first, I also endeavoured to find Koi paper, which was a commonly used paper in the past. However, it was no longer for sale in Bangkok. On the other hand, mulberry paper was easier to locate. As it also had a history of being used for writing in Khom Thai, I decided to use it in Koi paper's place. The next step was finding palm leaf paper on the market, which again proved difficult. In the end, I went to Ayutthaya, Thailand's former capital city, where I found a vendor still selling it. I also struggled to find a Lek Chan, or ancient metal stylus, in the capital, and so I procured it from Uttaradit, a city in north of Thailand.

After gathering all of the ancient writing materials, I started experimenting with hand drawing to get the feel for the calligraphic styles. As previously mentioned, I used Trai Phum as my writing model, since it is elegant and authentic. Then I started categorizing characters into groups to make it easier for me to design each letter. Next, I drew by hand one letter from each group as a model for other letters.

After I designed all of the characters, I printed them to examine the details. My observations occasionally revealed the need for minor changes to individual letters. For instance, the open counter was too wide, and so I redrew each letter by hand when I thought that adjustments were necessary. After redrawing the letterforms by hand,

I again drew the letterforms on a computer. Like most designers, I first created a bounding box for each of letter. I designed the letterforms in Adobe Illustrator CS6. For vector graphics, letterforms are scalable. Therefore, I later imported the letterforms to FontLab 5 to refine the outlines. I also adjusted the size of each character to fit the unit system of 1,000 units per em (1,000 UPM). In this project, 52 units of 1,000 units per em equalled 1 of the Royal Society of Thailand's units. The portfolio includes the dimensional proportions of the two systems so that other design practitioners can use them as guidelines. In this paper, the Royal Society of Thailand's unit is used to describe the design process in Chapter 3.

My design system on the computer was simple. I selected one letter from each group to design first. These characters were used as key designs for the other letters their respective groups. I used their primary proportions, including the width, x-height, descender height, and ascender height, as references for the other letters. I designed TLK Deva first, because it is a regular style of Khom Thai. I developed TLK Brahma next, because its proportional dimensions are generally quite close to those of TLK Deva. The last that I designed was TLK Manussa. In short, this was how I created my letterform designs. The next sections address how each group of letters was crafted.

After designing the letterforms on the computer, I enlarged each character (x-height=10 centimetres) to view them more carefully. I then printed out the drafts to check whether the letterforms needed further adjustments. After this step, I returned to the computer and refined the letterforms again.

The above explanation describes my working process in general terms. I now discuss each step in detail to further clarify how I designed my letterforms. Moreover, my portfolio also illustrates my work process from the beginning, and so it can be read in conjunction with this section.

Categorizing letterforms

At some points, the design process on the computer became confusing. To make the process of designing each design more manageable, I first organized the full-form letters with similar graphic elements into subgroups. This categorisation was useful for organising the design process. In particular, repeating and adjusting each letter to conform with the others in the group made the process of creating each character faster and more harmonious.

However, all type designers may have different design methodologies, since there is no single way to design letterforms. It is not a requirement, but rather a suggestion that other design practitioners first evaluate the graphic elements of each character before designing it. The approach will ensure that the letterforms are unified into a whole. Unlike the Roman script, Khom Thai's letter shapes cannot be divided on the basis of geometric shapes (e.g., square, triangular, or circular), as in Cheng's system (2005). Thus, I instead grouped the letters by height, width, and type of sok. This was a more feasible approach than using geometric forms to categorize the Khom Thai letters.

This categorization was primarily based on my observations after reviewing the three principal textbooks and the Trai Phum manuscripts. The letter categorisation system is depicted below in Figures 132-134.

Figure 132. Categorisation of full-form letters in TLK Deva

Figure 133. Categorisation of subscribed consonants in TLK Deva

Figure 134. Categorisation of independent vowels and Thai numbers in TLK Deva

Full-form characters

Group 1 full-form characters: Tho than, cho chang, to patak, tho thung, and pho phueng

Letter name	Tho than	Tho thung	Cho chang	To patak	Pho phueng
Design			`		`
TLK Deva	25)	\mathcal{E}_{j}	$\mathcal{E}_{)}$	$\mathfrak{S}_{)}$	£ ,
TLK Brahma	ಶ ಬ	S	2	2	ವ್ರ
TLK Manussa	y)	Σ_{j}	Σ	Σ_{j}^{r}	Σ_j^*

Table 2. Comparison of Group 1 full-form characters across TLK letterform designs

The first group consisted of the five letters with long ascenders as shown in Table 2. The difficulty in designing these letters was determining the ascender height. As Chapter 2's contextual review pointed out, Hong tended to keep the ascender short to conserve the interline space. However, when using a small-sized typeface, this feature is hardly recognized. The key question here addressed the extent to which the ascender could be reduced while remaining both visible and workable in real-life situations. Each of my letterform design has its own ascender height, since they were all based on different writing styles. Due to its similarities with the Thai script, TLK Manussa has the shortest ascender height. In contrast, the other two letterform designs required a generous amount of space to accommodate this graphic feature. The ancient manuscript Trai Phum demonstrated that ascenders sometimes are very long. This style is an ornamentation of the writing, but it would not be compatible with contemporary writing systems. For this reason, I drew the letter shapes and tested them as a unit by forming a pseudoword as illustrated in Figure 135. This allowed me to calculate the ascender height for each letterform design.



Figure 135. Example of a pseudoword used to determine the ascender height

In Group 1, the first letter that I created was cho chang, because it had the simplest structures. Specifically, cho chang only has two primary components: the body and the ascender. For characters in this group, the body height was set at 8 units. After experimenting with various heights, I set aside 17 units for the ascender height in TLK Deva. Such ascenders were long enough to be visible without interrupting with the upper vowels. For TLK Brahma, I set the ascender height at 16 units, since that letterform design's strong calligraphic influence meant that it required more space than TLK Manussa. The Royal Society of Thailand's manual (1997) set cho chang's ascender height at 9 units. At this height, Khom Thai ascenders were barely visible, however, since the x-height was fixed at 8 units. Therefore, I slighted increased the ascender height to 12 units for TLK Manussa.

Regarding widths, I aimed to give each letterform design its own measurements, since each represented a different writing style. The medium width of TLK Deva's letters was set at 9 units. This proportional dimension meant that the letters' body widths seem to balance to their x-heights. For TLK Brahma's letters, I assigned a slightly longer width of 11 units, since the thicker stroke weight required more space. In contrast with the other letterform designs, TLK Manussa's letters are narrower. I set established their medium width at 6 units, so as to bring to mind the Thai script.

The first version of TLK Manussa was heavily based on elements of the Thai script. Consequently, the letterforms were not roundish, as they appear in the final version. However, my revisions improved these letters, adding more of a curve to the stems so that they more closely resembled Khom Thai. After designing the letters in Group 1, I used the proportional dimensions as guidelines for the other groups. Another adjustment that the final draft incorporated was that cho chan's vertex was repositioned at the midpoint of the body height. This caused the upper and lower elements to look more balanced than in the first draft (see also the portfolio, pp. 38-39; pp. 103-104; pp. 167-168).

Group 2 full-form characters: Bo baimai, po pla, ho hip, mo ma, and so ruesi

Letter name	Bo baimai	Po pla	Ho hip	Mo ma	So ruesi
Design					
TLK Deva	ಟ	టీ	ಟಾ	ಆ	23
TLK Brahma	25	ર્ક	ಟಾ	೪	E
TLK Manussa	٢٢	ĵ	បា	ប្	<u> </u>

Table 3. Comparison of Group 2 full-form characters across TLK letterform designs

The second group of full-form letters was easier to design, since most of them (with the exception of po pla) did not have any extended elements the reached above the x-height as shown in Figure 136. All of these were medium-width letters, and so the x-height almost equalled the width. In most cases, the letters bodies looked the same. I designed yo yak first, and then mo ma since it was the only letter with a crossbar horizontally splitting the body. Thus, I used the crossbar to divide the upper and lower elements, making it easier to define the body proportions.

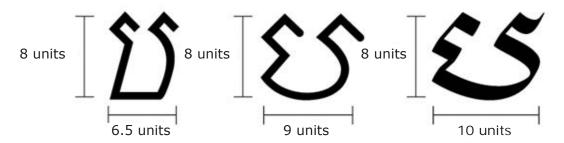


Figure 136. Mo ma's dimensions in TLK Manussa, TLK Deva and TLK Brahma (from left to right)

A design issue that arose when I was designing these characters was that they resembled Thai script characters that were not the alphabetic units they were intended to represent in Khom Thai. For instance, bo baimai in Khom Thai looks similar to yo yak in the Thai script. For this reason, in my first attempt at designing TLK Manussa, I straightened the stems, which are normally cursive for yo yak. As a result, the bo baimai design moved closer to the Thai version (see Figure 137). However, it seemed to lose certain Khom Thai characteristics in the process. Thus, I again redesigned the character, increasing the angle of the curves on both of the stems. The final result was a letter that bore a resemblance to the Thai script while also maintaining Khom Thai letter shapes (see Figure 138).

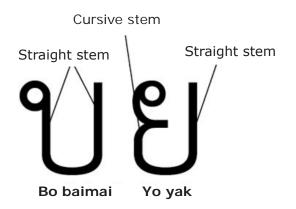


Figure 137. Comparison of bo baimai and yo yak in TH Sarabun

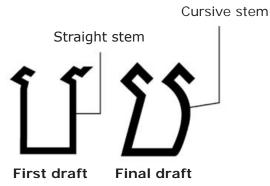


Figure 138. Two drafts of bo baimai in TLK Manussa

When designing TLK Deva, I used bo baimai as the key letter on which the others were based. I fixed the bodie height of the Group 2 letters at 8 units. This proportional dimension made this letterform design appear symmetrical and roundish, like traditional Khom Thai.

For TLK Brahma, Group 2 characters had a more calligraphic appearance. Thus, I set aside 10 units for the body width, since the stroke modulation of the letter shapes required more space (see also the portfolio, pp. 40-41; pp. 105-106; pp. 169-170).

Group 3 full-form characters: Kho khwai, so sala, to tao, ko kai, and pho samphao

Letter name	So sala	Kho khwai	To tao	Ko kai	Pho samphao
Design					
TLK Deva	ಣ	ಣ	බි	ห	ភ
TLK Brahma	हर	ಣ	85	85	F
TLK Manussa	ពិ	<mark></mark>	ä	ñ	ភិ

Table 4. Comparison of Group 3 full-form characters across TLK letterform designs

The third group consisted of full-form letters with a full sok as shown in Table 4 (see also the portfolio, pp. 42-43; pp. 127-128; pp. 171-172). As previously explained, a sok is a wavy line above a letter's body, and it is a common feature of Khmer scripts. However, not all letters have this element. Only eight Khom Thai characters had a full sok, and five of shared common characteristics. Therefore, I grouped these five characters together so that I could develop their skeletons at roughly the same time. All of these characters were medium-wide letters. Although no letter elements extended past the x-height, I designed the sok to be approximately 0.2 units higher than the x-height, so as to guarantee adequate space for the shoulder beneath the sok. For TLK Manussa, The major change in the final design regarded the sok. At first, I had designed the sok's finial as angled upwards. However, interviews with three Khom Thai lecturers indicated that this element commonly points downwards. For this reason, I redrew the sok and eliminated its finial as illustrated in Figure 139.

Upward sok Downward sok



Figure 139. Comparison of the first draft (left) and final draft (right) of to tao in TLK Manussa

In TLK Deva, I adjusted the sok, rendering it more cursive than in the other letterform designs. In contrast with TLK Deva, TLK Brahma's sok is angled slightly upwards. I kept the sok's upward finial, because I had noted that Trai Phum featured this ornamentation of the brushstroke. Since different writing tools influenced each letterform design, I designed their soks to also be unique. In general, to tao and kho khwai's letterforms are resemble, with the exception of each letter's head. To distinguish between the two, I enhanced to tao's left circle, making it more visible.

Another graphic element unique to TLK Brahma was the heads of the letters. For the other letterform designs, I drew a full circle for the head. In contrast, since TLK Brahma was strongly influenced by calligraphic form, the end of the head curls upwards (the loopless style) like a brush stroke (see Figure 140) in that letterform design.

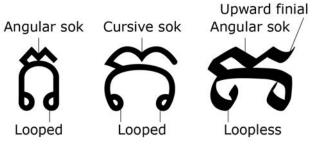


Figure 140. Comparison of kho khwai in TLK Manussa, TLK Deva, and TLK Brahma (from left to right)

Group 4 full-form characters: No nen, cho choe, lo ling, and so suea

Letter name	No nen	Cho choe	Lo ling	So suea
Design				
TLK Deva	NS	Ω	N	న
TLK Brahma	राइड	ಣ	25	5 5
TLK Manussa	ឈ	្សា	ល	ស៌

Table 5. Comparison of Group 4 full-form characters across TLK letterform designs

The fourth group brought together those letters with a half-sok as shown in Table 5. So suea was the only letter that did not share key graphic elements with others, and I assigned it to Group 4 because it has a half-sok, like other the members of the group. Although so suea's left elements did not correspond with those of the other group members, its right elements did bear a relationship with them. For this reason, I used lo ling's height-to-width ratio to design so suea, and this ensured that it could harmoniously blend with other letters. In addition, developing so suea in TLK Manussa

also proved challenging because of its half-sok. This character's left sok should have originated from the middle of the lower slope. However, in this position, the line was not parallel with the right sok, and so they were not synchronized with each other. In contrast, if so suea's left stem and the right sok are positioned at the same angle, the left sok is not situated in the middle of the lower slope (see Figure 141). Deva and TLK Brahma. As both of those letterform designs are roundish, they provided adequate space. To preserve the correct distances between the elements in TLK Manussa, I straightened the left sok's stem, allowing it to be placed in the middle of the slope. This problem did not occur when I was designing TLK Deva and TLK Brahma.



Figure 141. Comparison of the first draft (left) and final design (right) of so suea in TLK Manussa

The other three letters in this group bore a close resemblance to yo ying in the present-day Thai alphabet. For this reason, I initially adjusted the proportions of the Thai letter to fit the dimensions of Khom Thai. However, a further investigation of both scripts revealed that yo ying's beak was angled further inwards in the Thai alphabet than in Khom Thai. Moreover, unlike in the Thai script, in Khom Thai, lo ling's stems are not straight. Usually, they are angled slightly rightward. Consequently, I redesigned this element again, ensuring that it adhered to the proportions of Khom Thai. To compensate for the counter space, I positioned yo ying's middle stem further to the right in TLK Deva and TLK Brahma, creating more negative space on the inside. However, I kept the stems straight in TLK Manussa, in accordance with the Thai script (see Figure 142).

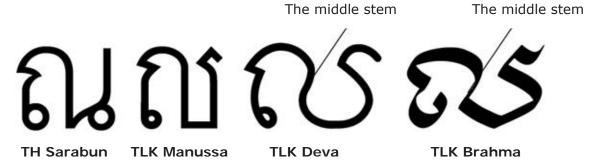


Figure 142. Comparison of no nen (TH Sarabun) and lo ling in the TLK series

Another design challenge pertained to the fact that two letters in the group, cho choe and no nen, were ultra-wide characters. They needed more space than the others, but the exact dimensions were uncertain, since no contemporary Thai letters could be used as a reference. Although the left element of Khom Thai yo ying is close to yo ying in the present, an extra component on the right-hand side required more space in Khom Thai than in the Thai version (see Figure 143). On the basis of my observations, I roughly estimated that the ratio of width of the body of the Thai character is narrow than the x-height around one third.

While the Thai character did not contain a Khom Thai-style extended right element, in Khom Thai, the extension was approximately the same width as the Thai character itself. I used this guideline to design the Khom Thai characters. Lo ling served as the foundations for the other letters in the group. Cho choe was based on lo ling. The right tail of chor choe replicated lo ling's right sok.

However, each letterform design had its own personality. For this reason, I made the Group 4 characters narrower when I designed TLK Manussa. The TLK Brahma letters were the widest, so as to provide sufficient space for the thicker stroke weight (see also the portfolio, pp. 44-45; pp. 109-110; pp. 173-174).

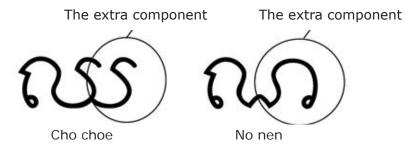


Figure 143. Extra graphic elements of cho choe and no nen

Group 5 full-form characters: Tho phuthao, fo fan, yo ying, and pho phan

Let	ter name	Tho phuthao	Fo fan	Yo ying	Pho phan	
De	sign					
TL	(Deva	M	M	W	\mathbb{C}	
TL	(Brahma	ns	n	ಣ	n	
TLŁ	(Manussa	ជា	U	ឃឹ	Ω	

Table 6. Comparison of Group 5 full-form characters across TLK letterform designs

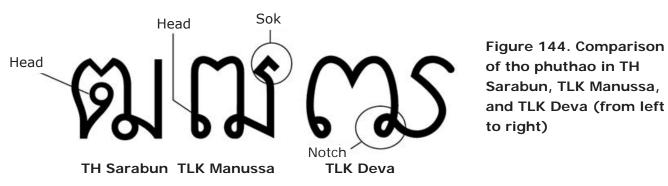
I compiled the fifth group on the basis of their close appearances. All of these characters shared the same letter shape, and so I designed them as a group, adding some minor graphic features to each of them. Group 5 was the easiest to construct, because the letters were mostly symmetrical. The letters in this group were medium-wide characters as shown in Table 6 (see also the portfolio, pp. 46-47; pp. 111-112; pp. 175-176).

I started by developing tho phuthao, because it bore a close resemblance to the corresponding character in the Thai alphabet, with similar main structures. One of the few differences was related to the position of the head. In Khom Thai, the head is situated at the baseline. In the Thai version, however, this feature is commonly positioned in middle of the body.

Moreover, in Khom Thai, there is a half-sok continuing to the end of the finial, while

this feature is absent from the Thai form. Apart from these dissimilarities, tho phuthao is structured quite similarly in Khom Thai and Thai.

For TLK Manussa, I used the Thai alphabet's proportional guidelines to design of this letter. After drawing the skeletons, I added the half-sok to the finial and repositioned the head to be at the baseline. When designing this character in TLK Deva, I began by drawing the left cursive stem and then reflected this element to create the right stem. Next, I added the notch. The process of crafting tho phuthao in TLK Brahma closely mirrored the TLK Deva design steps. Yet, when I designed the first draft of tho phuthao in TLK Brahma, I employed stems to save horizontal space. However, tho phuthao's body appeared too static. I wanted TLK Brahma's calligraphic strokes to suggest movement, since they were intended to reflect brushstrokes. I therefore readjusted the stems and made them more cursive. After finishing tho phuthao, I replicated its letterforms to design the skeletons of the other characters. I then individually adjusted each of these letters (see Figure 144).



For yo ying, I began by linking the notch and the right shoulder. However, the interviews indicated that these elements should not be joined with a single line. Therefore, I separated them in the final draft (see Figure 145).

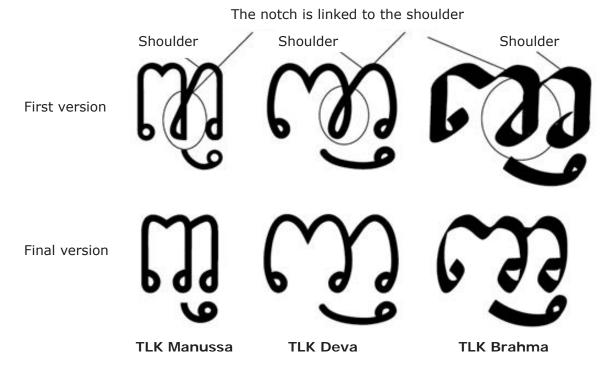


Figure 145. Revision of yo ying

Group 6 full-form characters: Cho chan, cho ching, no nu, and tho thong

Letter name	Cho chan	Cho ching	No nu	Tho thong	
Design					
TLK Deva	\mathbb{S}	Γ		\mathfrak{S}	
TLK Brahma	\mathfrak{C}	F,	R	E	
TLK Manussa	$\hat{\Sigma}$	<u> </u>	£	Σ	

Table 7. Comparison of Group 6 full-form characters across TLK letterform designs

Three of the letters in Group 6 featured a full sok as shown in Table 7 (see also the portfolio, pp. 48-49; pp. 113-114; pp. 177-178). The only letter without this element was no nu. Although no nu did not share common features with the other letters in Group 6 (apart from its lower element, including a short ascender), it was a medium-wide letter, like the other group members. This letter's proportions matched the Roman "x", and so I used no nu to define the x-height of my letterform designs. I designed the other characters in the group on the basis of no nu.

In general, the characters in this group contained three key components: the upper component, the body, and the ascender. For this reason, I began by drawing a curve to indicate the boundaries of the upper feature. Next, I created the stem. Later I drew the descender of no nu. The ascenders featured by these characters are not a common element of full-form letters. This component needed to be short to prevent it from colliding with the lower vowel or the subscribed consonant. For no nu, the descender's finial was angled upwards to preclude it from interrupting the lower space. In contrast, cho ching had a longer ascender, which dipped beneath the baseline. I permitted cho ching's ascender to dip beneath the baseline by 1 unit as illustrated in Figure 146. At this length, the ascender was visible but did not overlap with the characters beneath it.

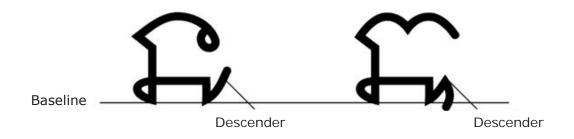


Figure 146. Comparison of no nu and cho ching's descenders

Designing these characters in TLK Manussa proved the most challenging, since the Khom Thai characters do not share any common graphic features with their Thai counterparts. For this reason, I focused on adjusting their height-width ratios to match general Thai proportional guidelines. The end result was narrower Khom Thai characters with a more simplistic appearance than the other letterform designs.

The primary concern in designing TLK Brahma was that the stroke contrast affected the shape of the sok. I moved the vertex slightly left of centre, so that the sok would appear balanced on both sides as shown in Figure 147.

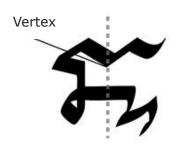


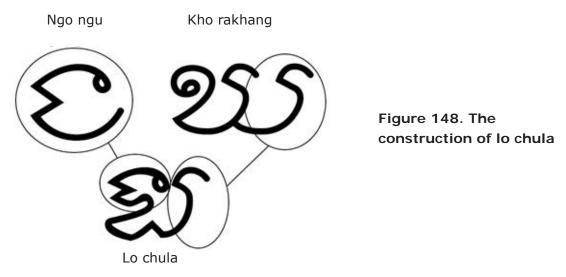
Figure 147. Cho ching's slightly asymmetric sok in TLK Brahma

Group 7 full-form characters: Yo yak, kho rakhang, and lo chula

Letter name	Yo yak	Kho rakhang	Lo chula	
Design				
TLK Deva	CS5	25.5	Ŋ	
TLK Brahma	শ্ৰ	255	Ş	
TLK Manussa	C)	ర్పు	Ŋ	

Table 8. Comparison of Group 7 full-form characters across TLK letterform designs

The seventh group posed the greatest design challenge, since they were not closely related to present-day Thai characters. All of these were ultra-wide characters as shown in Table 8, meaning that they required ample horizontal space (see also the portfolio, pp. 50-51; pp. 115-116; pp. 179-180). To unify the design of each letterform design, the width of the letters in Group 7 approximated that of the letters in Group 4, since nearly all of characters were ultra-wide letters. Within Group 7, lo chula was the most problematic, because its unique proportions required extra space beneath the baseline. After a close examination of lo chula's letterform, I noted that the character combines elements of ngo ngu and kho rakhang. The half-sok on lo chula's right-hand side bore a resemble to kho rakhang. In addition, the left-hand side of lo chula, including the head, resembled ngo gnu as shown in Figure 148. Thus, I designed kho rakhang and ngo ngu first, which allowed me to replicate their graphic elements at a later stage when I was developing lo chula.



Yo yak had the largest counter of any letter in the group. Kho rakhang's left element tends to be narrower than the corresponding component of yo yak. In addition, the heads of these two characters twisted at different angles. The head of kho rakhang moved clockwise, while yo yak's head was angled in the opposite direction. Since the curved structure of kho rakhang on the left bowed outward, and so yo yak's head had more space, meaning it was also more cursive (see Figure 149). However, I designed these two letters together, since their main skeletons were quite similar. I started by drawing an oval to determine the width, and then I split it in half to create the middle stem. Next, I took the half-sok that I had designed for so suea and added it to the middle stem and the right stem. I then redrew the curves, connecting the main structures together.



Figure 149. Yo yak and kho rakhang feature different gaps between the heads and a central sok

Group 8 full-form characters: Ro ruea, wo waen, and o ang

Letter name	Ro ruea	Wo waen	O ang	
Design				
TLK Deva	S	5	H	
TLK Brahma	5	3	55	
TLK Manussa	Ĵ	5	ĥ	

Table 9. Comparison of Group 8 full-form characters across TLK letterform designs

The eighth group consisted of three letters of varying widths as shown in Table 9 (see also the portfolio, pp. 52-53; p. 117; pp. 181-182). The element that unified these characters was that their main skeletons bore a resemblance to each other. I started by examining ro ruea, because it was the simplest character. To rueau is narrow letter with three components. The head is attached to the stem, and there is a half-sok at the end of the stem as illustrated in Figure 150. As this was the narrowest letter of all, I set its width as equal to that of a half-sok.

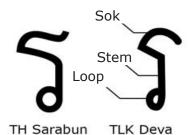


Figure 150. Comparison of ro ruea in TH Sarabun, representing the Thai letter, and TLK Deva, representing Khom Thai

The next step was designing wo waen, which had similarities with ro ruea. I adjusted ro ruea's vertical stroke by adding a degree of curvature. After this step, I added a full sok above the stem as illustrated Figure 151. In Thai, wo waen is a narrow letter, but it is a medium-wide letter in Khom Thai. Since the structures of the letter are different in the two scripts, readers of Thai struggle to recognize wo waen and frequently confuse it with ro ruea. To distinguish between two letters, I needed to increase the width of wo waen to match that of the other medium-wide letters. Wo waen and ro ruea were adjusted in all three of the letterform designs. The end result was that a wo waen that was obviously wider than ro ruea, which resolved the confusion between the two letters.

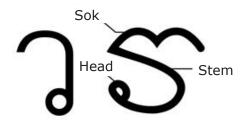


Figure 151. Comparison of wo waen in TH Sarabun, representing the Thai letter, and TLK Deva, representing Khom Thai

O ang and ro ruea contained identical components. I copied ro ruea's letterform to create the right side of o ang. After kerning the distance between the two letterforms, I added a crossbar.

Group 9 full-form characters: kho khai and tho montho

Letter name	Kho khai	Tho montho	
Design			
TLK Deva	9	99	
TLK Brahma	9	S	
TLK Manussa	2	ସ	

Table 10. Comparison of Group 9 full-form characters across TLK letterform designs

The ninth group contained two letters, kho khai and tho montho as shown in Table 10, both of which were rounded (see also the portfolio, p. 54; p. 118; p. 183). These characters are related to the corresponding modern Thai lettewrs as illustrated in Figure 152. For this reason, it was easy to design them, since I was familiar with the letterforms.

However, the ratio between their upper and lower elements was different. In Khom Thai, kho khai is angled further to the right than the Thai letter. Moreover, Khom Thai's tho montho has a larger head than the Thai character. These disparities meant that I had to adjust each letter accordingly. The main structure of both kho khai and tho montho is elliptical. In other words, the width is greater than the height. I started by drawing two ellipses to determine the area of each letter's head and body. The bodies of both the letters are relatively close in appearance. However, kho kai has a closed counter, and its axis tilts rightward. In addition, tho montho is less geometric than kho khai, and so I began by designing the latter letter.



Figure 152. Comparison of the months and kho khai in TH Sarabun, representing the Thai letters, and TLK Deva, representing Khom Thai

Group 10 full-form characters: Ngo ngu and tho thahan

Letter name	Ngo ngu	Tho thahan
Design		
TLK Deva	\mathbb{C}	\mathcal{E}
TLK Brahma	2	E,
TLK Manussa	Σ	Σ,

Table 11. Comparison of Group 10 full-form characters across TLK letterform designs

The last group of full-form characters included two letters: ngo ngu and tho thahan as shown in Table 11 (see also the portfolio, p. 55; p. 119; p. 184). Although the two characters are nearly identical, tho thahan has a short descender. In addition, tho thahan's open side is slightly larger than that of ngo ngu, because tho thahan's tail moves in direction of the baseline. When designing these characters, I started with ngo ngu. I then copied the form to design tho thahan. Both TLK Deva and TLK Brahma featured fuller curves than TLK Manussa.

The main consideration in designing TLK Brahma was that the diagonal strokes needed to be sheared, similar to Trai Phum's calligraphic style. Since the modulation was high, the diagonal strokes had a slightly lower contact point in TLK Brahma than in the other letterform designs as illustrated in Figure 153.

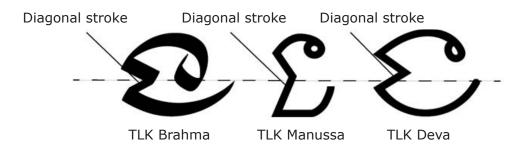


Figure 153. Comparison of the contact point of ngo ngu's diagonal stroke

Subscribed consonants

After analysing and roughly designing the first draft of my full-form characters, the next step was classifying the subscribed consonants. As with the full-form letters, characters with closely related graphic forms were organized into groups. In general, I categorized the subscribed consonants by height. For instance, I grouped the letters with long ascenders, as well as characters that only featured body parts. After classifying the letters, I chose a key letter in each group to serve as the master design for the other group members.

Creating the subscribed consonants was more complex than designing the full-form letters, because the modern Thai script does not have any consonantal subscripts. However, most of subscribed consonants share some structural elements with their full-form version, and so I adapted the full-form letters to craft each subscribed consonant. In Khom Thai in general, the main difference between the two formats was that the subscribed consonants were more dynamic than the full-form characters. For example, they featured longer ascenders and descenders. Consequently, the subscribed consonants needed to harmoniously blend with the characters above them, which meant that some subscribed consonants needed to be wider than their full-form counterparts. Otherwise, their ascenders would have collided with the character above.

I used the dimensions of the lower vowel as a guide for determining the distance between the host letter and the subscribed consonant. This type of dependent vowel is usually written below the baseline. Commonly, these vowels are less than half as tall as the x-height. The subscribed consonants in Khom Thai are similar in height to the lower vowels. For this reason, I fixed the subscribed consonants' height at 4 units. As with the full-form letters, the width varied on the basis of each character's unique letterform.

The following sections explain how I designed each group. Further details on the design process are available in the portfolio.

Group 1 subscribed consonants: Yo yak, tho phu thao, so ruesi, so suea, lo chula, kho rakhang, cho choe, and ro ruea

Letter name	Yo yak	Tho phuthao	Lo chula	So suea	So ruesi
Design					
TLK Deva	ી	ကေါ်	a	J	
TLK Brahma	5	a)	હ્યું	5	5
TLK Manussa	•	ล์	E)	و	, Ĵ

Table 12. Comparison of Group 1 subscribed consonants across TLK letterform designs

Letter name	Bo baimai	Cho choe	Kho rakhang	Ro ruea
Design				
TLK Deva	مآ	શ્ય	ಲ್	G
TLK Brahma	مح	ಬ್	22)	
TLK Manussa	ح	ณ์	2 5	b

Table 13. Comparison of Group 1 subscribed consonants across TLK letterform designs

The first group of the subscribed consonants consisted of letters with long tails as Tables 12-13 (see also the portfolio, pp. 56-59; pp. 120-122; pp. 185-188). In general, most of these letters had three elements in common: the tail, the body, and the head. I started by designing the tail, because this element that determines the height of each letter. When forming a word with both a subscribed consonant and a full-form letter, the tail of the subscribed consonant should be synchronized with the full-form letter above it, and it should not interrupt the upper vowel. For this reason, I established the height of the subscribed consonants (including the tail) at approximately the full-form letters' x-height as illustrated Figure 154. The width of each subscribed consonant was based on that of the full-form version. In this group, lo chula's body was taller than other characters by 1 unit, because of the complexity of the letterforms.

I designed a tapered ascender for TLK Brahma. In contrast to the other letterform designs, this vertical stroke was cursive, due to the influence of penmanship. I created the body's axis to tilt slightly to the right. Moreover, I crafted so ruesi's crossbar to be slightly asymmetrical, in accordance with the stress angle as illustrated in Figure 155. Like the full-form version, I formed cho choe's beak to be cursive in TLK Brahma, unlike the sharp beak in the Thai script as illustrated Figure 156.

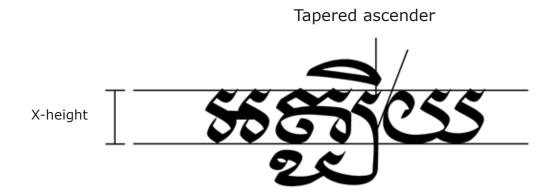


Figure 154. Pseudoword used to determine the ascender height for the subscribed consonants

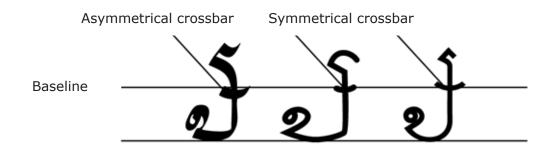


Figure 155. Comparison of so rusei's crossbar across TLK letterform designs

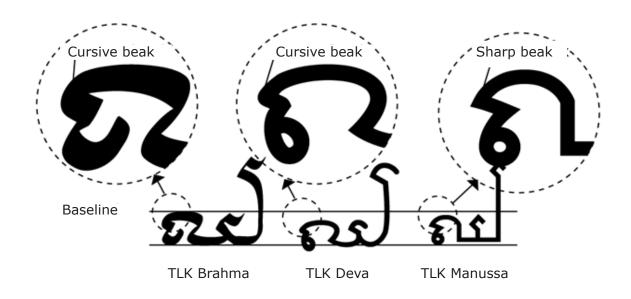


Figure 156. Comparison of beaks across TLK letterform designs

Group 2 subscribed consonants: Pho phan, yo ying, no nen, ho hip, and pho phueng

Dla a vala va a a	Dla a vala a va	Va vila a	I I a da la	NI
Pno pnueng	Pno pnan	Yo ying	Ho nip	No nen
6.9	67	ണ	20	೯೩೩
	0 0		O v	0 22 0
ಲ	००	ಯ	S	್ತಾ
હ	ങ	ങ	មា	ഹ
		G		
		ಲ ಣ ಬ ಣ	ಟ ಣಣ	ස ස භූ භ ස භූ භූ

Table 14. Comparison of Group 2 subscribed consonants across TLK letterform designs

The characters in this group were medium-wide letter as shown in Table 14, and their skeletons were less complex than those of the first group. Yo ying was the only letter with a short descender.

The subscribed consonants of pho phan, yo ying, ho hip, and no nen were related to their full-form counterparts as illustrated in Figure 157. However, the angle of the slope needed to be greater, due to the limited space for the shoulders.



Figure 157. Comparison of full-form characters (above) and subscribed consonants (below) in TLK Deva

Pho phan constituted the key design for other letters, because it contained the chief shapes that formed those characters. After designing pho phan, I inverted it to create pho phueng. The body of yo ying is identical to that of pho phan. The difference between the two is that yo ying has a tail beneath the body. The yo ying subscribed consonant was a modified version of its full-form character. For this reason, its tail is slightly shorter. In addition, I copied pho phan's right shoulder to create the shoulders of both no nen and ho hip. For the left element of each letter, I redesigned the full-form letter to fit within the subscribed consonant grid.

The main design issue that emerged for TLK Deva and TLK Brahma was the stems. If I kept the stems straight, there was not enough space to draw the upper body. To solve this, problem, I designed the vertical stems to be more cursive (see also the portfolio, pp. 60-61; pp. 123-124; pp. 189-190).

Group 3 subscribed consonants: Tho than, tho thong, tho thahan, wo waen, and o ang

Letter name	Tho than	Tho thong	Tho thahan	Wo waen	O ang
Design					
TLK Deva	à	8	Ø	O	o
TLK Brahma	♂	\boldsymbol{arphi}		e	8
TLK Manussa	ø	Ø	۵	Ø	8

Table 15. Comparison of Group 3 subscribed consonants across TLK letterform designs

Although the letters in the third group did not share many graphic features with their full-form counterparts, they were the easiest to design, because their shape was based on a half-circle. The main structure of these letters consisted of a horizontal stroke and a curve. I could form this structure by drawing a half circle to use as a guide. I crafted wo waen first, since the other letters' graphic structures were based on it. In terms of width, the subscribed consonants in this group equalled their full-form equivalents, because they did not require extra space for any extended graphic elements. Therefore, these subscribed consonants did not need to be wider, as was the case with the letters in the first group, which had long ascenders (see also the portfolio, pp. 62-63; pp. 125-126; pp. 191-192).

Group 4 subscribed consonants: Kho khwai, to tao, pho samphao, and ko kai

Letter name	Kho khwai	To tao	Pho samphao	Ko kai
Design				
TLK Deva	6	ေ	ត	9
TLK Brahma	0	n	57	90
TLK Manussa	ഒ	ဓ	ស	ന

Table 16. Comparison of Group 4 subscribed consonants across TLK letterform designs

Designing the subscribed consonants in the fourth group was straightforward, due to their simple structures. The lack of an ascending stem meant that the each letter's body was approximately the same height. I started by drawing a symmetrical arch, adjusting the details of each letter at a later stage. As was true for the full-form letters, the kho khwai and to tao subscribed consonants had very similar structures. The only component that differentiated them was that to tao had a larger circle. The main problem regarding the body of these subscribed consonants was that there was not much space for the letterforms, meaning that the circle needed to be large enough to be visible at small sizes. To solve this problem, I used a cursive left stem, rather than a straight line, to construct the body. This element allowed a larger counter inside the letterform, where the head of to tao situates (see also the portfolio, pp. 64-65; pp. 127-128; pp. 193-194).

Group 5 subscribed consonants: Cho ching, cho chang, to patak, no nu, and mo ma

Letter name	Cho ching	Cho chang	To patak	No nu	Mo ma
Design					
TLK Deva	₽,	ک	₹~	49	√
TLK Brahma	← 1	٤	•		✓
TLK Manussa	ا ک	ک	&	ro	u

Table 17. Comparison of Group 5 subscribed consonants across TLK letterform designs

Most of the characters in the fifth group featured some of the elements of their full-form equivalents, and so I grouped them together as shown in Table 17 (see also the portfolio, pp. 66-67; pp. 129-130; pp. 195-196). When working on the first draft, I utilized the graphic features of the full-form letters as a guideline as illustrated in Figure 158. I then adjusted each letter's proportional dimensions to fit inside the subscribed consonant bounding box.

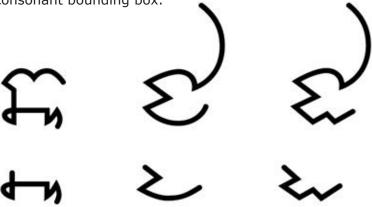


Figure 158. Comparison of full-form letters (above) that share common characteristics with subscribed consonants, in TLK Deva

Group 6 subscribed consonants: Tho thung, ngo ngu, and lo ling

Letter name	Lo ling	Ngo ngu	Tho thung
Design			
TLK Deva	~	$oldsymbol{arphi}$	9
TLK Brahma	~		©
TLK Manussa	~	€/	৩

Table 18. Comparison of Group 6 subscribed consonants across TLK letterform designs

The sixth group was straightforward to design, due to the simple letterforms. As shown in Table 18 these subscribed consonants featured two primary elements: a head and a tail. I started by drawing a curve and adding the head at its end. After this step, I adjusted the letterforms according to my different letterform designs' styles. I drew ngo ngu first, because it had the simplest form. Afterwards, I flipped it upside-down to design the other letters in the group.

In TLK Brahma, the subscribed consonants' horizontal lines were slightly cursive, and this was especially true for tho thung. The finials of lo ling and ngo ngu were pointed, while tho thung's finial which has an angled terminal. I made this distinction to emphasis the unique hand movements that create these characters. For lo ling and ngo ngu, the starting point was the head, while tho thung started from the left terminal (see also the portfolio, p. 68; pp. 131-132; p. 197).

Group 7 subscribed consonants: Kho khai and tho montho

Letter name	Kho khai	Tho montho
Design		
TLK Deva	9	
TLK Brahma	9	
TLK Manussa	2	නු

Table 19. Comparison of Group 7 subscribed consonants across TLK letterform designs

In terms of proportions, the two letters in the last group were more condensed than their full-form counterparts because of the limited interline space. Since both subscribed consonants were shorter versions of the full-form letters, I started by scaling down the full-form characters to design the subscribed consonants. However, the letterforms need to be adjusted to fit the smaller space beneath the baseline. For this reason, the stroke of these characters was slightly lighter than the full-form versions, which made visible the negative space on the inside (see also the portfolio, p. 69; p. 133; p. 198).

Numerals

The characters of Khom Thai numbers are completely unlike the Roman equivalents. Although the numeric system is the same, the graphic structures of Khom Thai are far more complex. Khom Thai numbers resemble Thai and Khmer numbers, and they feature long ascenders. Khmer numbers have shorter tails and are narrower than Thai numbers. Khom Thai numbers commonly incorporate graphic attributes of the Thai script, and so I used Thai numbers as a guideline for designing the Khom Thai digits. I started by splitting the numbers into three groups.

Group 1 numerals: Zero, one, six, and eight

Number	Zero	One	Six	Eight
Design				
TLK Deva	0	<u></u>	ک	\gtrsim
TLK Brahma	0	Ø	٦	ವ
TLK Manussa	0	ව	6	2

Table 20. Comparison of Group 1 numbers across TLK letterform designs

The first group consisted of round characters as shown in Table 20. In Khom Thai, zero resembles the Roman character, although is commonly wider. I widened it so that it would harmonize with the other numbers and be easily distinguished from the typical zero. One was the next character that I developed, because its structure was close to that of zero. However, unlike zero, one has a small gap on the open side, between the head and the tail. Because of these nuanced graphic structures, zero and one could not utilize the same curve. Rather, zero had a slightly wider curve, and I modified one's upper curve by positioning the head beneath it as illustrated in Figure 159.



Figure 159. One (grey) overlaid on top of zero (black), demonstrating the proportional differences between the two characters

To design six, I sliced off half of zero and joined the ascender at the open end. Eight was the most difficult number in the group, since it did not share many elements with the others. I included this character in Group 1, because the basic form of eight could be established by drawing a circle to determine the position of the body as illustrated in Figure 160. I fixed the length of eight's tail at the ascender height that I used for six. In TLK Brahma, both six and eight had calligraphic, angled terminals that were influenced by the rightward stress (see also the portfolio, p. 70; p. 134; p. 199).



Figure 160. Structural construction of eight

Group 2 numerals: Four, five, and nine

Number	Four	Five	Nine
Design			
TLK Deva	2	٩	65)
TLK Brahma	2	æ	8
TLK Manussa	ک	<i>&</i>	lpha

Table 21. Comparison of Group 2 numbers across TLK letterform designs

The second group of numbers consisted of three characters as shown in Table 21. Obviously, four and five were almost identical. The only difference was that five had a circle attached to the ascender, and so I began by designing number four. Four's letterform was asymmetrical. Therefore, I did not rely on geometric shapes to construct its skeleton. Instead, I drew the character by hand and then adjusted it on the computer. I positioned the head approximately in the middle of the body to give the character a sense of balance. Of all the characters, nine was perhaps the most sophisticated character, due to its highly dynamic letterform. This number features a two-storey form linked with a curve. In my opinion, this character looks best when the right shoulder is slightly higher than the left (see also the portfolio, p. 71; p. 135; p. 200).

Group 3 numerals: Two, three, and seven

Number	Two	Three	Seven
Design	,		
TLK Deva	<u></u>	ന	ന
TLK Brahma	þ	၈ာ	(r)
TLK Manussa)en	ന	ബ
TLK Brahma	E	ന ന	1

Table 22. Comparison of Group 3 numbers across TLK letterform designs

Seven and two were derived from three, and I constructed three first. I started by splitting it into two parts. Next, I drew a curve to create the left stem. After this step, I copied the stem and inverted it to create the right stem. Afterwards, I complete the key skeleton by adding the head and the middle stem as illustrated in Figure 161 (see also the portfolio, p. 72; p. 136; p. 201). For two, the right stem of three was straightened. I then shortened the middle stem and drew the base. Later, I adjusted the position of the head and finished by creating the ascender.

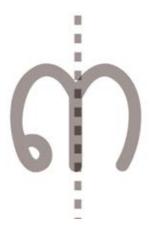


Figure 161. Structural construction of three

When three was finished, I then formed seven. Seven had the same body, apart from the middle stem. Moreover, I added a tail to the right stem. For two, I scaled down three's body to create the upper graphic features, and I then added an ascender on the left. Two differed from the other numbers in that its tail was mostly straight. However, the end of the tail sometimes angled leftward.

Vowels and tone marks

After finishing the main characters of the three letterform designs, I next turned my attention to vowels, symbols, and tone marks. This stage was somewhat easier, because I could use the existing characters as key designs. The dependent vowels, symbols, and tone marks were identical to their Thai counterparts, and so I did not struggle to design them. The only category that differed from the Thai alphabet was the independent vowels.

However, these vowels shared close graphic similarities with some of the Khom Thai consonant letters that I had already designed. Therefore, I replicated letter features that I had already created for full-form letters to create the independent vowels. The dimensional proportion of each character can be found in the portfolio (pp.73-85; pp. 137-150; 202-214).

3.4 Feedback from Khom Thai specialists

After finishing the first draft of the letterform designs, I wanted to elicit feedback on any design issues that I could improve. Moreover, I desired for this advice to come from an individual able to read the script well enough to point out any unusual design elements. Thus, I searched for palaeographers and lecturers in the field, since they would be knowledgeable regarding reading Khom Thai. Moreover, these individuals would understand the chief learning difficulties that beginner students sometimes face. As the introductory chapter pointed out, very few institutes provide Khom Thai courses. One of the oldest that does so is Silpakorn University, the only educational institute in Thailand with a Faculty of Archaeology. Moreover, Khom Thai is one of the core subjects taught in the Department of Oriental Languages. This department has collaborated with Princess Maha Chakri Sirindhorn Anthropology Centre to develop "the Inscriptions in Thailand Database Project", one of the main digital resources on Thai ancient manuscripts, including those in the Khom Thai script.

I interviewed three lecturers from the department to gather comments on my designs. These lecturers were experts on the Khmer language, the Thai language, Khom Thai, Thai ancient literature, and palaeography (Department of Oriental Languages, retrieved 2016). Their publications also included studies on ancient stelae in the Sukhothai era, which is the period during which Trai Phum emerged. That text was written during *the Sukhothai era*, around the 14th century, and so I had a particular interest in interviewing these lecturers and seeking their feedback on my designs.

I supplemented the semi-structured interviews by gathering their comments on whether the three letterform design designs were readable. Interviewing represented a practical means of re-examining my designs from the perspective of palaeography. The goal was to identify design problems and find solutions to them to improve the letterform designs.

The interviews addressed five key topics:

- 1. Common difficulties in learning Khom Thai
- 2. The development of Khom Thai proportions
- 3. The historical background of Khom Thai
- 4. Factors that influence Khom Thai letterforms
- 5. The general method of teaching Khom Thai at the Department of Oriental Epigraphy (see the summary of the interviews in Appendix D)

After discussing these topics, I asked the lecturers to give their opinions of the TLK letterform designs. Their comments suggested that all the letterform designs were legible. However, the interviewees are also noted three major areas for improvement. The first issue was related to the terminus of the sok in TLK Manussa. According to the lecturers, the finial should not be angled upward as illustrated in Figure 162. However, brushstrokes can sometimes influence this graphic element, resulting in altered letterforms. Since TLK Manussa did not represent a brush style of writing, the lecturers advised against the inclusion of this feature.

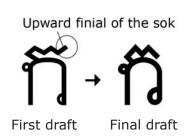


Figure 162. Comparison of the sok in TLK Manussa between the first draft and the final draft

The second issue was that some letters in TLK Manussa (including tho than, cho chang, to patak, and pho phueng) did not closely adhere to Khom Thai letterforms. The main problem was that the letters were based too closely on the structure of the Thai script as shown in Figure 163. Consequently, they were more angular than traditional Khom Thai letterforms.



Figure 163. Development of tho than, cho chang, to patak, and pho phueng in TLK Manussa

The last suggestion noted that the contact point between the middle loop and the shoulder of yo ying was not in the correct position. These elements should be separated therefore I did not connect these two lines together as previously drew from the first draft as shown in Figure 164.

Notch linking the shoulder and the middle loop

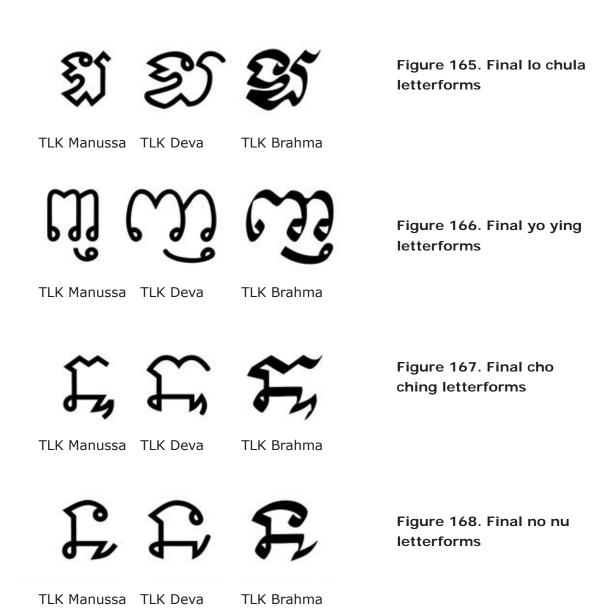
Shoulder

First draft

Final draft

Figure 164. Development of yo ying in TLK Manussa

In addition, the lecturers found that their first-year students at Silpakorn University struggled to remember four of the letters. These were lo chula (see Figure 165), tho phuthao (see Figure 166), no nu (see Figure 167), and cho ching (see Figure 168).



Before conducting the letter recognition study, I gave the final draft of the letterform designs to the lecturers for review. They re-examined them to ascertain if additional design issues existed (see the transcript summaries in Appendix D). After collecting feedback from the interviews, I again modified the letterforms of the TLK letterform designs. The portfolio further demonstrates how the letterforms developed.

Key points:

- 1. A examination of key Khom Thai textbooks and Trai Phum ancient manuscripts revealed the main traditional styles for writing in Khom Thai: (1) a metal stylus, called a "Lek Chan", (2) a brush or a pen. Therefore, The first style results in rounded letterforms, thanks to the writing materials utilized. In contrast, the second is strongly influenced by brushstrokes. I designed TLK Deva on the basis of the first writing style, while TLK Brahma represents the latter. Finally, TLK Manussa was the only letterform design that did not follow traditional sources. This letterform design incorporates characteristics of the Thai script. In general, TLK Manussa is narrower than the other two letterform designs, and the ascender and the descender are also shorter, as with Thai letters.
- 2. No existing proportional guidelines described the design of Khom Thai. In conjunction with the portfolio, this chapter can fill that gap. Since these references detail the process of designing the three letterform designs, other practitioners can study them as an example of Khom Thai design solutions to further the development of their own projects. Although design practitioners employ a diverse range of tools, this work offers potential dimensional proportions for each Khom Thai character. Individual projects can adjust these depending on the designer's judgement at a later stage.

Chapter 4: The Rating Preference and the Letter Recognition Study

As pointed out in Chapter 2, there are a variety of methods for investigating letter recognition. Each of these approaches has particular advantages and drawbacks and are therefore suitable for different purposes.

This chapter has two goals. The first identifies the letterform design that was the most familiar and preferable to participants who could read the Thai script, but did not know Khom Thai characters. The second section investigates which letterform design was the easiest to identify for participants trained in Khom Thai. To achieve these objectives, it was crucial to ask for feedback from the study participants on the TLK letterform designs. This approach was more comprehensive than designing the types solely on the basis of my personal experiences would have been.

Readers' perspectives were gathered via two approaches. First, structural questionnaires determined preferences and familiarity regarding the three letterform designs (see the example questionnaires in Appendix C). Secondly, the short exposure technique was also applied to compare the letterform designs. This method was an efficient weans of examining letter recognition, since it focused on individual letters rather than on continuous reading. According to Tinker (1963, pp.12-14), the short exposure technique is for assessing the legibility of printed typefaces. It has been one of most popular methods from the 1960s until the present day (e.g., Fiset et. al., 2009; Chastain, 1988; McClelland, 1977; Carreiras et. al., 2012; Cohen, 2007; Kinoshita & Kaplan, 2008; Beier, 2009; Fiser & Biederman, 2001; English, 1944; Zachrisson, 1965; Harris, 1973; Suen & Komoda, 1986). This study's methodology was adapted from the procedures used by Beier (2009).

This study used purposive sampling to select participants and descriptive statistics helped to analyse the data (Babbie, 2007). Purposive sampling is a kind of non-probability sampling in which the researcher selects the research participants. This method is an appropriate fit for mixed-methods research, exploratory research, and qualitative research when the goal is not generalizing the findings to the larger population. As a design practitioner, my primary goal was achieving the best design solution through practice therefore I adopted these methods because of their suitability to my topic of study. Statistical data represented one approach to articulating the design issues that arose from the design practice. For this reason, it helped to more clearly compare the performance of the three letterform designs.

4.1 Questionnaire

The rating preference method that was used in this study was adopted the questionnaire technique to gather data. The three letterform designs sought to remedy the problems caused by the letterforms' unfamiliarity during the early stages of learning. Thus, it was crucial to select participants with no prior knowledge of the subject, in order to avoid bias caused by prior exposure.

This study recruited 102 students from the Visual Communication Design Department at Rajabhat Suan Sunandha University. The selection criteria for the research participants ensured that they had attained homogeneous educational levels and that they were participating on a voluntary basis.

The participants' demographics were as follows:

- 1. They ranged in age between 18 and 22 years old.
- 2. Fifty-five participants were female, while 47 were male.
- 3. All were Thai.
- 4. All of the participants were studying in a bachelor's programme in the Visual Communication Design Department at Rajabhat Suan Sunandha University.
- 5. Twenty-six students were in the first year of the programme, 12 students were in the second year, 28 students were in the third year, and 36 students were in the fourth year.

Prior to this project, none of them had any experience in reading the script. All of the participants signed ethical consent forms (see Appendix E).

Initially, I approached students from the Thai Epistolography Department at Silpakorn University. However, the department was only home to a very small number of students. In general, there are approximately 10 students engaged in that programme per year (Hutangkun & Phayaksri, 2012), and they were not all available at the time this research was conducted. For the reasons of availability, students from Rajabhat Suan Sunandha University were chosen instead. A set of questionnaires, along with letterform design specimens displaying all of the letters in alphabetic order, was provided to the participants. These letterform designs examples provided the Thai forms above each Khom Thai letter (see the specimens in Appendix C). Therefore, the participants knew which Khom Thai letter represented each Thai letter.

The questionnaire employed a five-point Likert scale. Participants were asked to indicate whether five sentences in each letterform design appeared agreeable to them.

The questionnaire results were analysed to yield the mean score of the agreement. The standard deviation (SD) is also provided with the mean scores, and it measures whether the results were distributed close to the means. A low SD (e.g., 3≥SD) signifies more reliable data, with results grouped more closely around the mean (Dowdy et.al, 2004). The summaries of agreement in Tables 23-27 were based on the concept of "The Level of Scale Measurement" in Statistics (see Babbie, 2007, pp. 170-171; Zikmund et al., pp. 296-334).

Design	М	SD
TLK Manussa	3.57	0.59
TLK Deva	2.47	0.67
TLK Brahma	2.40	0.68

Table 23. Mean scores and SDs indicating agreement with sentence 1: "I can easily identify the characters"

The table above (Table 23) illustrates the mean scores and SDs for each letterform design regarding agreement with the statement, "I can easily identify the characters". As Table 23 demonstrates, there were noticeable differences among the letterform designs, with TLK Manussa eliciting a positive respond on this question. While that letterform design scored the highest, there were no significant disparities between TLK Deva and TLK Brahma. This finding is in alignment with the exposure effect, since TLK Manussa was the only letterform design that incorporated elements of the modern-day Thai script.

Design	М	SD
TLK Manussa	3.72	1.74
TLK Deva	2.45	0.71
TLK Brahma	2.39	0.73

Table 24. Mean scores and SDs indicating agreement with sentence 2: "This letterform design has familiar appearance"

For the sentence, "This letterform design has familiar appearance", TLK Manussa again scored the highest, with the two other letterform designs scoring relatively lower as shown in Table 24. The results, depicted in Table 24, indicated that the participants found TLK Manussa to be more familiar than the other two designs.

TLK Manussa 3.22 0.78 TLK Deva 2.29 0.75 TLK Brahma 2.23 0.70	Design	М	SD
	TLK Manussa	3.22	0.78
TLK Brahma 2.23 0.70	TLK Deva	2.29	0.75
	TLK Brahma	2.23	0.70

Table 25. Mean scores and SDs indicating agreement with sentence 3: "I would always use this letterform design if given the option"

The participants did not agree with the statement, "I would always use this letterform design if given the option", for any of the letterform designs as shown in Table 25. One participant commented, "These letterform designs are useful for a specific purpose, but they are not suitable for everyday use, since they are not in the Thai script".

Design	М	SD
TLK Manussa	3.82	0.70
TLK Deva	2.65	0.78
TLK Brahma	2.54	0.83

Table 26. Mean scores and SDs indicating agreement with sentence 4: "this letterform design contains characteristics close to those of the Thai script"

For the statement, "this letterform design contains characteristics close to those of the Thai script", participants rated TLK Manussa and TLK Deva as neutral as shown in Table 26. Although the scores only differed very slightly difference, TLK Manussa still received the highest score of the three. Both TLK Manussa and TLK Deva retained elements similar to those found in the Thai script, including the low contrast stroke weigh. On the contrary, TLK Brahma did not share any common features with the Thai script.

Design	М	SD
TLK Manussa	3.23	0.67
TLK Deva	2.20	0.68
TLK Brahma	2.12	0.64

Table 27. Mean scores and SDs indicating agreement with sentence 5: "This letterform design has characteristics that are easy to remember"

Regarding the statement, "This letterform design has characteristics that are easy to remember", participants again assigned a neutral score to TLK Manussa as shown in Table 27. That letterform design generated the highest score, followed by TLK Deva and TLK Brahma, respectively. One individual commented that, "all the letterform designs are hard to remember". This was not surprising, since none of the participants had experience in reading the script at this stage. Therefore, remembering the letterforms for a short period of time would likely be challenging.

Overall, TLK Manussa scored the highest on each question. Specifically, the respondents agreed with both sentences 1 and 2 for that letterform design. These sentences addressed whether TLK Manussa was easily identifiable and whether the letterform design was familiar to the participants. The results for these two questions support the conclusion that TLK Manussa was the most familiar of the three letterform designs.

However, statements 3, 4, and 5 yielded neutral responses for TLK Manussa. The third statement, "I would always use this letterform design if given the option", drew a comment from one of the participants, highlighting that since all of the letterform designs are in Khom Thai, most of the students will not use them regularly relative to Thai typefaces. Initially, the goal of this statement was to determine which letterform design the participants preferred. However, the ambiguous wording means that the participants might have misconstrued it. Consequently, the participants did not agree with the statement for any of the designs.

The results of statement 4 ("This letterform design contains characteristics close to those of the Thai script") demonstrated that the participants seemed to lack a strong opinion for TLK Manussa and TLK Deva, while they disagreed with the statement for TLK Brahma. Returning to a basic comparison of Thai and Khom Thai letterforms indicates that, in general, Khom Thai letters do not share many graphic elements with Thai. Despite the fact that TLK Manussa was designed to bear a resemblance to the Thai script, only five of its characters had a similar appearance to the Thai letters.

This distinction was reflected in the results for statement 4, since the participants did not communicate agreement with the statement for any of the design. However, the results still provided crucial information, implying that TLK Manussa and TLK Deva were more similar to the Thai script than TLK Brahma. As mentioned TLK Brahma was designed to have a higher stroke contrast than the others. This property is unusual for Thai, and the results to statement 4 confirmed that.

Regarding the fifth statement ("This letterform design has characteristics that are easy to remember") TLK Manussa again received a neutral score. At this stage, the participants had not yet been trained to read the script, and so they still struggled to remember Khom Thai letters. Despite the participants' lack of agreement with this statement, TLK Manussa received more positive results than the other letterform designs, suggesting the participants indeed found it the easiest to identify (see Appendix C for more details).

This set of questionnaires helped in determining which familiar factor was used as an experimental variable in the letter recognition study.

Among the five sentences, sentence 1 was the most important, since it directly asked which letterform design was the most familiar for the participants. As expected, TLK Manussa scored significantly higher than other designs. The exposure effect would predict that the subsequent recognition study would again classify TLK Manussa as the easiest letterform design to recognise in the letter identification task. The next section explores this hypothesis.

4.2 Letter Recognition Study

Prior to participating in the letter recognition study, the students received 24 hours of training (8 sessions) at Rajabhat Suan Sunandha University in reading the Khom Thai script. This course was based on an intensive-study syllabus for laypeople that the Department of Oriental Languages at Silpakorn University had developed. Wimonkasem's (2011) textbook was utilized for teaching.

At the end of the course, the participants were asked to take a test, which involved in pairing Khom Thai letters with the Thai alphabet (see Appendix C). Those who passed with a grade of 80% were selected to continue with the letter identification task. Since the next phase of the study compared the TLK letterform designs, the participants needed enough knowledge to successfully identify Khom Thai letters so that the results from the short exposure technique reflect on the design. In total, 32 from 102 students were eligible to continue with the study. All of them confirmed via self-report that they did not have any eye problems. Of these participants, 11 were men, while 21 were women. They ranged in age between 19 and 21 years old. Twenty-seven of the participants were second-year students, while five were third-year students.

As noted, the remaining 70 students were excluded, because they could not recognize Khom Thai letters. Eleven students from the eliminated group said that a 24-hour course did not provide sufficient time to learn the script. However, it was not the goal to explore whether course duration affects learning, because this was not an education study. Therefore, the teaching method was not the focal point; rather, the letter recognition rate was the variable of interest. This study only replicated a course on Khom Thai that is widely accepted in Thailand. The goal of this part of the study was to prepare the students for the next phase.

The short exposure technique

As mentioned earlier, the short exposure technique was adapted from Beier's research (2009). The materials used for the investigation consisted of TLK Brahma, TLK Deva, TLK Manussa, the National Library's typeface (NLB typeface), Khom 2004, and KM-khomtai. The characters that were selected for the test were all full-form letters (37 characters), all subscribed consonants (32 characters), and all independent vowels (11 characters). Dependent vowels, tone marks, and numbers were excluded from this study, because Khom Thai and Thai are the same in that regarding, and therefore the shapes of the letterforms did not differ.

The designs were presented on a Macbook Pro 13-inch, Mid-2012. Adobe Flash CS6 was used to create SWF files. The screen resolution was 1440 x 900 px. The distance between the participant and the computer screen was approximately 50 centimetres. The light was standard office lighting.

Procedures

The participants were randomly divided into two groups of 16. The general procedures were the same for both groups. These were as follows:

- 1. The participant was asked to look at the computer screen and focus on the centre. When ready, participant clicked the "next" button.
- 2. A single character was presented in the middle of the screen for approximately 50 ms, followed by a hashtag for another 50 ms. The x-height of the letter and the hashtag were both 45 px.
- 3. The participant was asked to name the letter he or she had seen.

The only procedural difference between the two participant groups involved the order in which the materials were presented. For the first group, the designs were presented in the following sequence:

- 1. NLB typeface (full-form characters)
- 2. NLB typeface (subscribed consonants)
- 3. NLB typeface (independent vowels)
- 4. Khom 2004 (full-form characters)
- 5. Khom 2004 (independent vowels)
- 6. Khom 2004 (subscribed consonants)
- 7. KM-khomtai (subscribed consonants)
- 8. KM-khomtai (independent vowels)
- 9. KM-khomtai (full-form characters)
- 10. TLK Brahma (subscribed consonants)
- 11. TLK Brahma (full-form characters)
- 12. TLK Brahma (independent vowels)
- 13. TLK Deva (independent vowel)
- 14. TLK Deva (full-form characters)
- 15. TLK Deva (subscribed consonants)
- 16. TLK Manussa (independent vowel)
- 17. TLK Manussa (subscribed consonants)
- 18. TLK Manussa (full-form characters)

For the second group, the designs were presented in the reverse order. The sequences for the two groups were based on the "counterbalancing" method. Counterbalancing is a practice used for controlling the order of influences that may arise during a study. It works by switching the order in which research materials are presented to different groups (Jain, 2015). Before the test, I randomly selected the order in which the characters in each category were presented.

4.3 Results and analysis

Full-form characters

There were 37 full-form characters in this category. The focus was on how many of the 37 characters in the 6 different letterform designs the 32 participants could identify. The mean correct identification rates for the full set of 37 characters are presented in Table 28 (below).

Design	М	SD
TLK Manussa	19.38	2.47
TLK Deva	22.13	2.59
TLK Brahma	29.63	2.66
NLB typeface	20.53	2.46
Khom2004	20.00	1.87
KM-khomtai	19.56	1.92

Table 28. Mean identification rates for full-form letters (37 characters)

It stands out from the table that TLK Brahma had a recognition rate of 29.63 out of 37. In fact, TLK Brahma scored higher than the other letterform designs, while TLK Manussa came in last place at 19.38 out of 37. The other letterform designs scored in approximately the same range, with no significant differences between them. In percentages, TLK Brahma had a considerably high response rates, at 80.07%. The other letterform designs scored in the same range, as follows: TLK Deva (59.80%), NLB typeface (55.49%), Khom2004 (54.05%), KM-khomtai (52.87%), and TLK Manussa (52.36%).

Subscribed consonants

This category consisted of 32 subscribed consonants. Here, the focus was on the correct identification of the 32 characters across the 6 designs for all 32 participants.

Design	М	SD
TLK Manussa	9.78	1.96
TLK Deva	14.78	2.11
TLK Brahma	12.75	1.93
NLB typeface	14.38	1.76
Khom2004	13.00	2.46
KM-khomtai	11.69	1.64

Table 29. Mean identification rates for subscribed consonants (32characters)

For the subscribed consonants, TLK Deva had the highest mean identification rate, at 14.78 out of 32 (46.19%), while TLK Manussa ranked last at 9.78 out of 32 (30.56%) as shown in Table 29. In general, the TLK Deva characters were wider than the other characters. This property might have enhanced the visibility of TLK Deva, helping it to attain its first-place score. Likewise, for TLK Manussa, the results might have been due to the narrow width of that letterform design, which rendered it less visible. Notably, analysis revealed that participants correctly identified fewer than 50% of the subscribed consonants (TLK Deva: 46.19%, NLB typeface: 44.94%, Khom2004: 40.62%, TLK Brahma: 39.84%, KM-khomtai: 36.53%, and TLK Manussa: 30.56%). These results might have reflected the participants' lesser familiarity with the subscribed consonants relative to the full-form letters. In the interview, the lecturer reported that students at Silpakorn University were also confused by the subscribed consonants. Those students had told the lecturer that subscribed consonants were more difficult to remember (see the transcript in Appendix D).

Independent vowels

Design	М	SD
TLK Manussa	10.06	0.76
TLK Deva	10.06	0.88
TLK Brahma	8.25	1.27
NLB typeface	9.75	0.88
Khom2004	9.16	1.14
KM-khomtai	9.40	1.01

Table 30. Mean identification rates for independent vowels (11 characters)

In contrast to the earlier sentences, TLK Manussa scored the highest mean identification rate for independent vowels as shown in Table 30. Of the letterform designs tested, TLK Manussa most closely approximated the proportions of Thai vowels. All of the letterform designs received higher scores for independent vowels than full-form letters and subscribed consonants. In Khom Thai, independent vowels share similarities with Thai vowels. This might have increased letter recognition, as the exposure effect theory would suggest. The highest percentage of correct responses was 91.48%, shared by TLK Manussa and TLK Deva.

Individual letters

Surprisingly, the overall results did not support the exposure effect's hypothesis. The next step was examining the results for five individual letters shown in Table 31 that share common characteristics with the Thai script and reviewing their scores on the letter recognition task. These letters were kho khai, tho montho, tho phuthao, ro ruea, and so suea.

	TLK Manussa	TLK Deva	TLK Brahma	NLB typeface	Khom2004	KM-khomtai
Letter name	_					
Kho khai	100.00%	100.00%	100.00%	100.00%	100.00%	93.75%
Tho montho	90.63%	75.00%	87.50%	12.50%	31.25%	15.63%
Tho phuthao	84.38%	56.25%	100.00%	100.00%	100.00%	96.88%
Ro ruea	90.63%	87.50%	100.00%	96.88%	93.75%	87.50%
So suea	68.50%	75.00%	78.13%	75.00%	65.63%	65.63%

Table 31. Identification rates for five familiar letters, as percentages

As Table 31 demonstrates, most participants correctly identified kho khai. It had a 100% recognition rate, except for the National Library typeface, which scored 93.75%. For tho montho, the TLK letterform designs had higher recognition rates than the other designs, which TLK Manussa coming in first place at 90.63%. Noticeably, in NLB typeface, Khom2004, and KM- khomtai, tho montho garnered very correct responses, at 12.5%, 31.25%, and 15.63%, respectively. In my opinion, the basic structure of TLK Manussa's tho montho most closely approximated the Thai letter, which is why it had the highest recognition rate.

For ro ruea and so suea, all of the letterform designs performed in the same range. However, when it came to tho phuthao, TLK Brahma, NLB typeface, and Khom2004 scored 100%, even higher than TLK Manussa (84.38%). In contrast, TLK Deva followed at 56.25%. In conclusion, the results were mixed for the five familiar individual letters. Therefore, the results did not confirm an association between familiar characteristics and letter recognition, as the exposure effect theory has suggested.

4.4 Discussion

The letter recognition study and questionnaires were conducted solely at Suan Sunandha Rajabhat University. As a result, the framework in Chapter 4 only represents one pattern of data, which cannot be generalized to the entire Thai population. However, as previously stated, the questionnaire and short exposure test were means of testing the three letterform designs. The data gathered through those approaches was not the primary outcome of the research, and it instead played a supporting role. Rather, the designs themselves are the primary end product, and these can be used as a signpost for future research in the field.

Overall, the results of the letter recognition study did not indicate that TLK Manussa was the easiest to recognize, as the exposure effect would predict. In fact, TLK Manussa did not receive higher scores than the other TLK letterform designs. Like the Thai script, TLK Manussa has shorter extenders. Moreover, it was the narrowest letterform design tested.

A possible explanation for this contradiction might be that familiarity is not the only determinant of letter recognition; rather, visibility might also play a role to here (i.e., the clarity of the letterform). Noticeably, the TLK Brahma full-form characters, which were wider than the other letterform designs, received high scores. Moreover, TLK Brahma featured a higher stroke contrast than the other designs.

These properties made it more visible than its competitors. Additionally, TLK Deva, which had the longest ascenders, had the highest score in the subscribed consonant category. This feature might have contributed to its first-place finish.

These findings suggest that the design solution commonly employed to craft Khmer scripts, compressing the extenders, is not always the best choice, since this approach decreases the visibility of the letterform design. As the contextual review noted, Khmer scripts, including Khom Thai, require more interline space than the Roman script. In addition to the full-form letters written above the baseline, Khmer words need additional space for the upper vowel, the lower vowel, and the subscribed consonant. However, distorting the letterforms to fit the Roman proportion means that the letters feature short descenders and ascenders. Moreover, the resultant script is more condensed than handwriting. These graphic properties make it challenging to identify the individual letters, as this study's results for TLK Manussa demonstrated. These findings are significant in that other type designers creating Khom Thai or other Khmer letterform designs can use them as a reference. This is the first study on Khom Thai type design to integrate a systematic letter recognition study and design practice that other designers can use as a model.

Key points

- 1. Questionnaires gathered feedback from 102 participants with no prior knowledge of the three letterform designs. The overall results demonstrated that TLK Manussa was scored the highest in terms of familiarity.
- 2. The short exposure technique is a legibility research method that used to investigate letter recognition. In this research project, 32 students participated in the letter recognition study. The procedures involved flashing a picture of each character on a computer screen for each participant for approximately 50 ms. Next, each participant was asked to identify the letter he or she had seen. The accuracy rate was later compared across the three letterform designs.
- 3. Unlike the questionnaire, the short exposure tests for letter recognition did not favour TLK Manussa. This letterform design had the shortest ascenders and descenders of the three designs developed for this study. In comparison with the other TLK letterform designs, the TLK Manussa characters were the smallest, rendering it less visible than others. These results suggested that Khom Thai letterforms not be compromised to conform to the proportions of the Roman script. Modifying the characters in this way makes it harder to identify them.

Chapter 5: Conclusion

Summarised contributions to knowledge

- 1. This paper is based on practice-led graphic research in the field of the Khom Thai script, producing three new letterform designs for Khom Thai, and thus advancing the study of non-Latin type design.
- 2. This research project was the first to establish a design process for Khom Thai letterform designs and to conduct initial tests of these letterform designs in terms of familiarity.
- 3. This work provides a design framework and methodology for Khom Thai letterform design that other type designers can use as a point of reference. As this paper gives the dimensional proportions of the individual characters in the portfolio, other practitioners could further develop their own designs in the future based on the TLK letterform designs.

The aim of this research project was to create three Khom Thai letterform designs as a contribution to the field of non-Latin type design. The broader goal was to enable audiences in the present to read and access ancient Thai scripts by creating well-researched letterform designs that can be used as writing models and learning materials. The study was prompted by the question of whether letterforms could be designed that would be familiar and easy to recognize for readers of modern Thai, whilst also retaining a close connection to the historical script. The specific objective was to create two designs (TLK Brahma and TLK Deva) that would maintain a close connection to the proportions and writing style of the historic script, and a third (TLK Manussa) that would look more familiar to readers of Thai today. Taking into account the historical and current social contexts, the study established a new graphic design process. Further development in this area will benefit heritage and conservation studies, as well as non-Latin type design.

This project thus followed a researcher-practitioner model, which permitted me to study the subject from different standpoints. Specifically, this design-led research project incorporated theoretical, historical, and contextual knowledge into the design process.

Chapter 2, the contextual review, identified the three primary design issues that affected this project. First of all, scripts in the Khmer family require extensive interlinear space as per other Indian scripts, because of the complex word formation process.

Hong has suggested a design solution for this obstacle. In his interview with Google (2010), he described the process of designing one of his fonts, Hanuman. To manage the complexity of Khmer word formation, Hong compressed the proportions of each Khmer letter to fit the Roman measurements. Therefore, his design was simpler than traditional Khmer handwriting. This design method was a logical choice, because Hanuman is a multilingual font. Therefore, Roman and Khmer letters must work together.

In contrast, the TLK letterform designs are not multilingual. Rather, TLK Deva and TLK Brahma were developed to be authentic Khom Thai designs representing traditional writing styles. Therefore, distorting the letterforms in these two letterform designs was not an option. On the other hand, TLK Manussa had a different purpose, as it integrated characteristics of modern Thai letters.

Another design issue that Chapter 2 addressed was the difference between the Khom Thai letterforms and the modern-day Thai script. Examining Thai writing styles from old manuscripts and printing books published from 1905-1965 found in the rare books collections of the National Library of Thailand, Thammasat University, and Chulalongkorn University indicated that extenders of present-day Thai characters are significantly shorter than in the past. This characteristic may be a result of a design solution that attempted to save interlinear space. Nonetheless, whether this method is the best solution for Khom Thai writing models remains questionable, since it would require significantly compressing the letterforms. From my observations, however, it is challenging to distinguish those letters that share common characteristics in small sizes if the letterforms are distorted. To investigate this design issue, I assigned different proportions to each TLK letterform design to explore the most appropriate options for Khom Thai, as Chapter 2 described.

The last main design issue that Chapter 2 addressed was the fact that Khom Thai includes many graphic features that do not have an equivalent in the Thai script, such as an upper element called a "sok". Only five Khom Thai characters have the same structure as their contemporary Thai counterparts. Therefore, most Thais are not accustomed to reading Khom Thai. If familiarity is the key to recognition, as most type designers have suggested (e.g., Licko, 1990), the letterforms from the Latinized version of the Thai script might improve recognition of Khom Thai. On the basis of the familiarity effect (see Chapter 2), I developed the concept behind TLK Manussa. I then tested this letterform design via questionnaires and the letter recognition study in Chapter 3.

Overall, Chapter 2 addressed those design problems requiring further investigation. Moreover, it also provided frameworks for Chapters 3 and 4, since it reviewed the historical, psychological, and design aspects of the Khom Thai script. Chapter 3 examined the design process for the TLK letterform designs. Along with the portfolio, that chapter provided design details, from sketching to polishing. I began the design development process by studying Khom Thai letterforms from Trai Phum manuscripts, the RST's manual on the proportional dimensions of the Thai type (1997), and the three major Khom Thai textbooks (Wimonkasem, 2011; The National Library, 2010; Punnothok, 2006). I started by sketching the letterforms on palm leaves, mulberry pulp paper, and white paper before moving on to computer.

By experimenting with different materials during the drawing stage, this research project identified key differences responsible for the script's lack of familiarity. Firstly, different tools are used to write the Khom Thai script than the Thai script. Some Indic scripts, including Sinhala and Burmese, when shaped on palm leaves by a metal stylus tend to be roundish (Calderhead & Cohen, 2001, p. 149-154). In the Khom Thai script derived from a South Indian script, Pallava, the vertical stems of certain full-form characters, excluding the Sok, are therefore mostly cursive unlike the modern Thai script. Secondly, Khom Thai letterforms written by brush tend to have a high stroke contrast, which is not a common trait in the Thai script. Lastly,

some characters of the Khom Thai script is nearly 50% wider than the Thai script. Consequently, the Khom Thai script requires more horizontal space. By identifying these key dissimilarities, I established the design framework (see Chapter 3) based on my study of Khom Thai letterforms. This chapter also furthered knowledge of the Khom Thai script by analysing its graphic elements and providing a set of terms to specify the anatomy of Khom Thai. These contributions provide deeper insights into Khom Thai letterform construction. Moreover, I grouped the characters with common elements. The working process detailed in this chapter contributes a model for type designers wishing to create Khom Thai letterform designs.

After designing all of the letterform designs, the next step was refining the letterforms and consulting with lecturers with expertise regarding the Khom Thai script. In addition, 102 students from the Visual Communication Design Department at Suan Sunandha Rajabhat University completed a set of questionnaires. The questionnaire results demonstrated that TLK Manussa received the highest scores regarding preferences and familiarity.

Next, Chapter 4 moved on to the letter recognition study. To compare the performances of the different letterform designs, I selected the short exposure technique as a means of assessing letter recognition. This approach was a logical means of observing how readers perceived each letterform design. Each letter of the three letterform designs was shown on a computer screen, with the participant asked to identify the individual letters. Overall, TLK Manussa did not score highly in terms of letter recognition accuracy. In contrast with the exposure effect theory, TLK Brahma garnered the highest scores on the letter identification task, even though it did not contain familiar characteristics. Rather, this letterform design had a higher stroke contrast than the other two. Additionally, it was the widest design. These graphic elements might have enhanced the visibility of TLK Brahma, resulting in participants recognising it more easily than TLK Manussa. "Visibility" refers to the level of clarity at which the eye view a letter. Likewise, "familiarity" refers to the fact that people feel accustomed to a certain style of letterform design (here, the proportions and angularity of the modern Thai script).

Returning to the question of whether the Latinized characteristics that are familiar today would be the best solution for Khom Thai type design, the results of this study do not support that option. As the Khom Thai letterforms were condensed for TLK Manussa, they grew less visible than other letterform designs. In this study, TLK Brahma was the most visible letterform design, since it was wider and had a thicker weight than the other letterform designs. It scored the highest overall.

Surprisingly, this study found that the visibility of the type was a determining factor in Khom Thai letter recognition. In contrast, the case of Blackletter (see Chapter 2) seemed to imply that familiarity plays an important role in reading perception. In this study, however, familiar characteristics of the Thai script did not significantly enhance the letter recognition of TLK Manussa. These results prompted me to carefully re-examine the notion of familiarity. I recommend that other design practitioners avoid distorting Khom Thai letterforms (as occurred with Latinised Thai) if the goal is to improve the visibility of letters. However, in term of filling the gap left by cultural changes, the questionnaire indicated that TLK Manussa might be most successful. This letterform design integrated characteristics of the modern Thai script, thus assisting the young participants, while TLK Brahma and TLK Deva remained faithful to the traditional calligraphic forms of the past.

However, the findings from Chapter 4 do not claim to be scientific, since the purpose of the study was only to examine the letterform designs in relation to the type design process under these particular conditions. The outcomes are not intended to represent the larger Thai population. Rather, the goal was to gather information to enable designers to create a more accessible Khom Thai script through graphic revisions. As emphasized from the outset, the main contribution of the research project is the TLK letterform designs. The letter recognition study served as a supporting component that allowed me to examine the letterform designs' performance.

Although the study's results were mixed and inconclusive, they offer new insights into the relationship between familiarity, visibility, and Khom Thai letterforms. These findings suggest that more legibility research is required to determine whether visibility or familiarity is more important for letter recognition.

The primary data in this research are the design of the TLK letterforms; analyses of Thai, Khom Thai, and Khmer letterforms in Chapter 2; the interviews with Khom Thai specialists; the questionnaires completed by 102 students at Suan Sunandha Rajabhat University; results from the letter recognition in Chapter 4; and the portfolio.

This framework and methodology used a model from legibility research to explore design possibilities for Khom Thai. The question of which letterform design could help young readers to better recognise Khom Thai characters prompted this study to create three letterform designs. In term of their usability, TLK Deva and TLK Brahma are intended as writing models for beginners, since the existing learning materials—including the three Khom Thai writing models, KM-khomtai, and Khom2004—proved to be inadequate, as Chapter 2 pointed out.

TLK Manussa is not appropriate for this purpose. However, the questionnaires demonstrated that TLK Manussa gained the highest scores for every sentence. This indicated that the participants agreed that that letterform design possessed the most familiar characteristics of the three options. This significance in terms of familiarity may help students to learn Khom Thai. This finding implies that TLK Manussa may be developed into types of learning materials other than writing models, such as character mnemonics (see the portfolio, pp.162-163). Potential uses for TLK Manussa are demonstrated in the portfolio. Future research should explore whether TLK Manussa is a suitable tool for this purpose. Moreover, additional legibility studies such as continuous reading could also focus on Khom Thai, since so few studies are dedicated to the topic.

The portfolio provides the dimensional proportions of each character, and other designers can use these as a point of reference in designing Khom Thai letterforms. This also could be extended to Khmer Moul design as well, since there are many similarities between Khom Thai and Khmer Moul. The short exposure testing procedure could be adapted for Khmer and Thai, since they share certain common graphic structures. This approach could be extended into legibility research on the two scripts. For instance, testing the letter identification and accuracy rates of Khmer or Thai across different designs via short exposure testing could determine which one is the most recognisable. As the conclusion suggested, adjusting the letterforms by reducing the extender height may not be the best solution to improve visibility and letter recognition. Other designers might want to further explorer this suggestion by designing works and making comparisons of designs with different ascender heights to examine whether shorter extenders lead to a letter identification problem. Moreover, this research could be extended by examining other ancient scripts in Thailand, such as the ancient Mon script and the Thum Lanna script, which were used in the same context as Khom Thai.

Appendices

Appendix A

An overview of the history of ancient scripts in Thailand

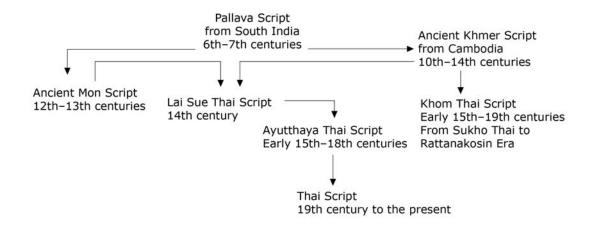


Figure 169. Development of ancient scripts in Thailand

The contents of Appendix A grew out of my interest in the history of Khom Thai. While reading historical documents as a reference for Chapter 2, it came to my attention that the roots of the Khom Thai script are multifaceted, drawing from many sources in Asia. To trace the origins of the script, this appendix offers a comprehensive picture of its history. Its relevance to this research project lies in the fact that it helps to underscore why the Thai script and Khom Thai have distinct appearances.

The 6th - 13th centuries

In the 6th century, the Thais did not have a national script, and so they widely adopted Indian scripts, such as Pallava and Tamil. In addition, the Kawi script of Java (part of present-day Indonesia) also spread to the south of Thailand.

When the Khmer Empire emerged in the 9th century, the Khmers invented a new script called "the ancient Khmer script". This script was influenced by the Pallavas script from India. From the 9th to the 15th centuries, the Khmer Empire extensively expanded its territories in Southeast Asia. Eventually, part of present-day Thailand was annexed to the empire between the 10th and 13th centuries (Sounsaen, 2005, pp.1-4). During the Khmer occupation, Thais embraced the ancient Khmer script as their own official script (Punnothok, 2006, 129- 132).

Separate from the Khmer rule, a Mon kingdom, called Hariphunchai, also reigned the in north. The Mons invented a new script derived from the Pallava script of India. The ancient Mon script and the Khmer script were equally popular among Thais until the Khom Thai script and the Thai script were born (Wimonkasem, 2011, p.2).

The 13th - 19th centuries

The 13th century marked a turning point in Thai history, because the first Thai state, Sukhothai, was founded by King Sri Indraditya at this time. This does not mean that Thai people did not exist before then. Thais had numbered among the tribes of Southeast Asia for a long time, but the Thai state only emerged in the 13th century (Padungsuntraruk, 2004, p.45). After declaring independence from the Khmers, the king discouraged Thais from using the Khmer script. Nevertheless, his attempts were not successful, and so the Khmer script remained common (Ninchinda, 1999, p. 40).

Around the 15th century, Thais adjusted the ancient Khmer script to enable writing in the Thai language (Wimonkasem, 2011, p.15). As a result, the script evolved into the Khom Thai script as it is now known. This script has been used for writing in Thai, Pali, and Sanskrit in Thailand ever since. The Khom Thai script closely resembles Aksar Mul or the Khmer Moul script in Cambodia. However, some letters are not the same. The Khom Thai letterforms have not changed significantly from the Sukhothai era until today (Padungsuntraruk, 2004, p.138).

Thais simultaneously made use of the Tham Lanna script, the Fakkham script, the Thai Nithet script, and the Tham Isan script. However, the Khom Thai script was the most widely used of the ancient scripts found in Thailand (Wimonkasem, 2011, p.24–25).

The 20th century – the present

Khom Thai's position as a holy script has not been changed through the present day. Buddhist monks, practitioners of magic, and scholars still use the Khom Thai script in certain rituals. For example, it is used to create yantras (see Figure 170), pieces of paper or cloth used for magical protection (Punnothok, 2006, p.144). However, the number of people who can read the script dramatically decreased after the Second World War, for the reasons mentioned in Chapter 2.



Figure 170. Example of a Khom Thai yantra, Luangpu Thut, from Wat Chang Hai (1997) at 75% of the original size, owned by Virunhaphol. Adapted from "Luangpu Thut", by Wat Chang Hai, 1997, Copyright 1997 by Wai Chang Hai.

The birth of the Thai script

The Thai script was developed in the 14th century by King Ram Khamhaeng, and it therefore slightly preceded the Khom Thai script. This first version of the Thai script is called "Lai Sue Thai". This script derived from the ancient Khmer script and the ancient Mon script. Unlike its predecessors, the Lai Sue Thai script does not contain subscribed consonants. It is more convenient to write in this script, because every letter is on the same line. Moreover, the script is narrower than the ancient Mon and Khmer scripts. Consequently, it conserves horizontal space (Chuchuen, 1992, p.96).

However, during King Lithai's reign in the late 14th century, literate individuals refused to write in Lai Sue Thai, because they were still familiar with the Khmer script. For this reason, the Lai Sue Thai script was again adapted, with the vowels positioned above or below the consonants, as in the ancient Khmer script (Padungsuntraruk, 2004, p.53–61). After the Sukhothai Kingdom was annexed to the Ayutthaya Kingdom in the 16th century, the Lai Sue Thai script was again embraced and developed. The new version of the Thai script crafted during the Ayutthaya era closely resembles the modern Thai script. However, the identity of the script's developer remains unknown, because Burmese armies burned down Ayutthaya twice, once in 1563 and once in 1767. Thus, few documents from the Ayutthaya era have survived to the present day.

The printing era

Unlike the Khom Thai script, the Thai script's appearance has changed significantly since the 15^{th} century. In particular, the printing process has immensely influenced its letterforms.

The development of the Thai script during the printing era was indeed complex. However, the basic facts are clear. The French are credited with having establishing printing houses in Thailand. In the early 17th century, a Jesuit bishop from France, Louis Laneau, came to Thailand as a missionary. To promote Christianity in Thailand, he opened a printing house to produce Bibles. However, there was no Thai type, and so the Roman alphabet was utilized to print the Thai alphabet. Inspired by the French, King Narai also opened two printing houses in Ayutthaya and Lopburi. Nevertheless, when the next King, Phetracha, was crowned, he adopted a policy of seclusion and closed all of the printing houses. The French were exiled from Ayutthaya, putting an end to printing production in the country (Padungsuntrarak, 2004, p.112). During this Ayutthaya period, the printing process did not influence the Thai script's letterforms, because Thais still wrote the script by hand. The Thai script in use from Narai's reign to the end of the Ayutthaya era was closer to the present-day Thai script than to the script from the Sukhothai period. However, the letterforms were slanted to the right, like italic letters as shown in Figure 171-172.

PLATE V

Figure 171. Example of Ayutthaya's handwriting at 150% of the original size. Adapted from sanya Thai-Farangset krang Somdet Phra Narai [the Siam-Franco treaty of 1687], *In the inscriptions in Thailand database project*, 2006, Retrieved October 12, 2015, from http://www.sac.or.th/databases/inscriptions/inscribe_image_detail.php?id=1205. Copyright 2006 by Princess Maha Chakri Sirindhorn Anthropology Center.

विकास का प्रमाण के का का का का का का का का

Figure 172. Example of Ayutthaya's handwriting at 150% of the original size. Adapted from Banthuek raiwan khong Phra Winsutthasunthon (Kosa Pan) na hok dan nueng [Page six of Kosan Pan's diary], *In the inscriptions in Thailand database project*, 2006, Retrieved October 12, 2015, from http://www.sac.or.th/databases/inscriptions/inscribe_image_detail. php?id=3987. Copyright 2006 by Princess Maha Chakri Sirindhorn Anthropology Center.

Approximately 200 years later, another French bishop, Arnaud-Antoine Garnault, arrived in Thailand in 1796 to promote Christianity. Printing houses again opened their doors. Since a Thai typeface still did not exist, the missionary printing houses relied on Roman fonts to print Romanized Thai (Padungsuntraruk, 2004, p.115).

It was not until the early 19th century that the first Thai font was created in Myanmar by a missionary couple from America, Reverend Adoniram Judson and Ann Hazeltine Judson. Ann Hazeltine Judson learned Thai from Thai prisoners in Myanmar. The type was then created with the help of a printer named George H. Hough (Witthawutthisak, 1986).

In 1783, Hough's printing house closed because of the political conflict in Myanmar, and so he moved to Kolkata, India. The Thai font and the printing press were brought to India with Hough. The font was again employed in 1828 to publish a Thai grammar book by Captain James Low, who was part of the Madras Native Infantry (Figure 173). Letterforms of this type closely resemble handwriting. However, the type is difficult to read as compared with the Alak style.

Later, this font was sold to a printing house in Singapore. It was then purchased by The American Board of Commissioners for Foreign Missions (ABCFM). Finally, in 1835, Dan Beach Bradley, an ABCFM doctor, brought the Thai font and a printing machine to Thailand for the first time. Since the first font was based on handwriting, printing it proved impractical. Consequently, the proportions of the Thai script were adjusted to more symmetrical shapes (see Figure 174). New versions of Thai fonts were created based on these new proportions that were more unified. Following the example of the French printing houses, King Rama IV also founded a printing house in the palace to compete with Bradley in 1858. This is considered to be the first Thai printing house owned by Thais. Over time, more printing houses opened and eventually, copying documents by hand became obsolete.

ยจจมีผู้สายคลนี้จก่อ?ขกราขทุนกัขงงที่ว่า

"There was [a] a certain man, he (or who) went to complain to a king, (and) said," &c.

There the is the sign of the masculine.

ผู้หยิงงามเล่ามีคนนางพ้า

"A woman beautiful as the queen of heaven."

Here we is the mark of the feminine gender.

ญียชาวิจเจา

"The wife of your slave, (a reply)." Meea a w is wife.

ผลเมียริปพัจตากแล้ง

"The husband and wife went to hear the (religious) discourse."
Here žaže p,hoa meea mean lit. man and wife.

เลกผู้ชายและเลกผู้หยิงภีอผาจึงงานแม่ใช่งัดผลง

"The boy and girl tucked up their clothes: then ran and followed their mother to the temple." Here and dek is rendered masculine by the p,hochaee, and feminine by the p,hooyeeng.

ลูกขางและลูกสาวแขกขเมมเท่มกากตามพ่อใชวัด**พ จัเท**ต

"The young woman, and lad, followed their father to the temple, in order to hear instruction, and bearing [on their shoulders salvers filled with] confections." Here sown and some are terms

[a] Yang mee properly signifies " there is."

Figure 173. The first Thai font printed in Low's grammar book at 100% of the original size. Adapted from *Grammar of the Thai or Siamese Language* (p.23), by James Low, 1828, Calcutta, India: Baptist Mission Press. Public domain.

๑หนังสือจกหมาย เหตุ ๆ

THE BANGKOK RECORDER.

V.c.11 เล่ม ๑ บางกอก เกี่ยน หก ขึ้นเจ็กค่ำ จุลศักภาช ๑๒๒๔ March 1st 1865. คริศศักภาช ๑๔๖๕ ใบ ๑ No. I.

หนังสือ หลวง

๑ ชื่อ วัก, ชื่อ บ้าน, ชื่อ เมือง, ที่ มี อยู่ใน แผ่น ถินไทย. าง แห่ง ก็เปน คำ ไทย แท้, ลาง แห่ง ก็เปน คำ สังสกฤฎ แท้, เงแห่ง ก็เปน คำ สังสกฤฎ แท้, เงแห่ง ก็เปน คำ เชมร. ก็ คำ ราษฎร เรียก ทั่วไป นั้น, มัก ยก คาม คำ คน มาก, แล สั้น ๆ ง่าย ๆ. แต่ ใน ราชการ คือ นังสือ ท้อง บัก ใบ ครา มัก เรียก ยาว ๆ. แล เปน คำ สังสกฤฎ โทย มาก. ถึง คำ สังสกฤฎ ก็ เรียก เคม. ผ่าย ราษฎร แม้น ้ำ คำ สังสกฤฎ, ก็ เรียก ผิก ๆ ไป. ชะ

 เมือง หนึ่ง มี ซื้อ สอง อย่าง สาม อย่าอ, ฤๅ วัก หนึ่ง มี ซื้อ สองอย่างสามอย่าง, คามคำหลวงแลคำวาษฎว, แลคำ เมือง ที่ เปน เมือง หลวง เมือง ไทย บัก นี้, แต่ ้ คืม เป็น หัว เมือง ซื้อ ชนบุรี, เป็น ภาษา สังสกุฤฏ. ครู ที่ เขา แปลง สังสาสญ เปน นังสือโวม ทั้ง นี้. Dhanapuri. แต่คำนี้ใช้ใน หนังสือ ระเชียน อย่าง สียง ใหย อ่าน ไม่ ได้. วาชการ, แต่กำ คลาดเรียกเมือง บางกอก ทั้ง นั้น, ภุว ลาง คำ เรียก สั้น ๆ, ว่า เมือง ธน, คู่ กับ เมือง นน. ถ้าเมือง นน นั้น. คาม ราชการ เรียกว่า นั้นทบุริ, เชียน เปน สังสกฤฏ อย่าง ที่โครู เขา แปลง เปน หนังสือ โรม, เขา เขียน คั้ง นี้, แต่ใน หนังสือ ยาว เชียน คริมหาสมุท ค่อ ท้าย เช้า ทั้ง สอง เมือง. หรื มหาสมุท เขียน ตาม สังสกฤฏ, กาม ครู ที่ เขา แปลง เปน หนังสือโมม, เซาเซียน กังนี้, Sri Maha Samudd คน ทั้ง บ้าน ทั้ง เมือง. เมือง นน ก็ เรียก ว่า ตลาด จานี. เมือง ธน ก็ เรียก ว่า บางกอก. ค่อ ผู้ กิ ขึ้น มา น้อย, จึง เรียก ว่า เมือง นนเมือง ขน. ที่เรียก เคม, ้เชียน เคม คำ สังสกฤฏ อย่าง ว่า นั้น, มีแค่คำ กรายทูล ใน หลวง อย่าง หนึ่ง, เชียน ใน ท้อง ยัก ใบ ทราชย่าง หนึ่ง. คำ เรียก ไม่ ใกร่ นี้

ก็ที่เรียก บางกอง นั้น, คือ แต่ เดิม ลำ น้ำ ใหญ่, แต่
 วัง นำ ลง มา ขน ถึง วัง กรมหลวง วงษา ไม่ มี, เปน แผ่น คืน. แม่

น้ำ เข้าไป พรงน่า วังน่า, แล้ว ไป เลี้ยว ลง วัก ขึ้ เหลก คลึง ชัน, แล้ว เลี้ยว มา ถึง ย้อม วัง กรมหลวง วงษา. เรือ แจว มาแค่ วัง น่า, ถึง วัง กรมหลวง วงษา, พางแค่ เช้า จน เยน, เวลาเซ้า พุงเข้า อยู่น่า วังน่า ลิมม่อ ให้ใจ, ล่องเรือ มา ถึง น่า วัง กรมหลวง วงษา, จะ หุง เข้า เยน กิน, นึกให้ว่า ล็ม ม่อไว้, จะกเรือเข้าเดิน บกไป, เอา ม่อ มา หุง เข้า เยน กิน ทันใค้. ที่ รีม บ้อม วัง กรมหลวง วงษา นั้น, มีคลอง หนึ่ง ปาก คลองเข้าไปเข้าง เหนือ, แล้ว คก เคี้ยว ไปใน สวน วน เวียน อยู่, แล้ว ปลาย คลอง ไป ทะลุ ออก ที่ น่า วัง หลัง. ก็ ปาก คลอง ข้าง ล่าง นั้น ชื่อ บางกอก ใหญ่, ช้าง บน ชื่อ บางกอก น้อย. บาง นั้น แปล ว่า คลอง คลอง ยน กับ คลอง ล่าง เรียก บางกรก เหมือน ก้าง:เปรียบเคี้ยวนี้. เหมือน กับ ปาก ลัก แล บาง กรวย, ปกลัดก็เรียกว่า ปกลัดบน, ปกลัดล่าง. ที่ ยาง กรวย นั้น ปาก ที่ ออก แม่ น้ำใหญ่ เรียก บาง กรวย นอก, ปาก ที่ รอก แม่ น้ำ น้อย เรียก บาง กรวยใน. ถึง ปาก เครง ก็เหมื่อน กัน นั้น ฉัน ใด, บางกอก น้อย บางกอก ใหญ่ ก็เปน เช่น นั้น แต่ ลำแม่น้ำนั้น อ้อมไป.

- ๑ ก็เมื่อแผ่น ดิน พระเจ้า มหาจักรพรรด์, โปรด ให้ อุด บาง กอก ใหญ่ บาง กอก น้อย, ให้ ตลุย ถึง กัน เปน แม่ น้ำ, แล้ร สร้าง เมือง ถง รักษา ที่ อุด ลัก, เหมือน อย่าง แผ่นดิน พระบาท สมเดจ์ พระพุทธ เลิศหล้า นภาไลย, สร้าง เมือง นคร เชื่อนชันธ์, เชียน เปน สังสกฤภู แต่ Nagar แต่ เชื่อนชันธ์ นั้น เปน คำ ไทย, จะ เชียน เปน คำ ไทย ก็ได้ ทั้ง เดียว นี้ เรียก ร่า เมือง ปากลัด นั้น.
- ๑ ครั้น สร้าง เมือง ลง ที่ บางกอก ขุด ลัก แล้ว นั้น, ทั้ง ชื่อ ว่า เมือง ชนบุรี. การ ที่ ขุด อย่างนี้ ถึง นาน กว่า สาม ร้อย บี้ มา แล้ว คู ก็ เหน จรึง คอก, ค้วย ลำ น้ำ ก็ ยัง แคบ กว้า ข้าง บน ข้าง ล้าง ไม่ ใช่ ฤๅ, กว้าง เพียง สิ่ เส้น เสศ ไม่ ถึง ท้า เส้น. ครั้น ทาง ลัก มี ขึ้น แล้ว, น้ำ ลง เสีย ทาง ลัก, แม่ น้ำ เก่า ก็ แห้ง ไป

Figure 174. Early metal type printed in the first Thai newspaper at 35% of the original size. Adapted from *The Bangkok Recorder* (p.1), by D.B. Bradley, 1865, Bangkok, Thailand: Bradley's press. Public domain.

From the 19th century onwards, handwriting became less important, because printing simplified the publishing process. For this reason, they became smaller, with shorter tails, and the distance between the upper vowel and the letter shrank. Another change prompted by printing was the alphabet's position relative to the baseline. Traditionally, the Thai script and the Khom Thai script were written beneath the baseline. When the printing press arrived, however, the Thais followed the Western example and positioned the alphabet on the baseline (Figure 175).

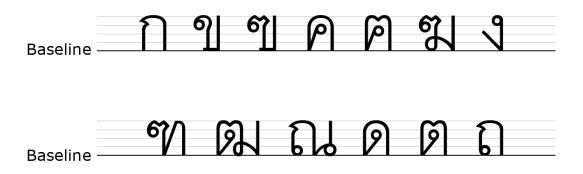


Figure 175. Examples of Thai characters in TF Srivichai written above the baseline, by Virunhaphol

Appendix B

Methods for investigating legibility and letter recognition

As mentioned at the beginning of the literature review letter recognition studies are a branch of legibility research. Sometimes, letter identification can also be used to determine the legibility of texts (Chahine, 2012, p. 139). Constructing the letter recognition study first required an examination of legibility research methods. This exploration identified feasible and appropriate methods for comparing individual letters from the TLK series.

Various approaches have been employed, and, as Lund pointed out, it would not be possible to assess every study on this topic (Lund, 1999, p. 10). Since research can follow a myriad of approaches, the methods listed summarize methods from the early 19th century (the beginning of legibility research in the West) to 2012 (Tinker, 1963; Ole Lund, 1999; Beier, 2009; Chahine; 2012). Although this does not constitute a comprehensive review of legibility research, the studies were significant enough that other researchers have repeatedly quoted them. Tinker's work on the legibility of type summarized methods used in early legibility research through the 1960s. Lund's work reviewed the literature from the 19th century through 1997, while Beier and Chahine summarized working methods until 2009 and 2012 respectively. Their summaries intersected in places, and so this section grouped together similar approaches.

Threshold Visibility

Threshold visibility (Chahine, 2012; Lund, 1999), sometimes referred to as the visual accuracy threshold (Beier, 2009), is a method that relies on letter or word identification to measure type visibility. The procedure starts with the presentation of a single letter, group of letters, or word to the participant. Next, the participant is asked to name the characters. The accuracy rate or the time duration of responses is an indicator of legibility. In other words, the more accurately or quickly the participant can identify the letters, the more legible the typeface is. This approach has two variants, the first of which is the speed of perception (Tinker, 1963), also known as the variable time of exposure, (Lund, 1999) or as short exposure (Beier, 2009). The second approach is variable distance.

Short exposure

This method entails flashing individual letters or words on a tachistoscope or a computer screen for a short period of time (generally less than one second) so that the eyes cannot switch focus (Tinker, 1963, p.12; Beier, 2012, p.17). The short exposure method is a suitable approach for examining letter recognition, and especially individual letter recognition. However, this method is limited that it might be inappropriate for investigating type visibility in the context of continuous reading.

Variable distance

The second type of visibility threshold is called variable distance (Lund, 1999; Beier, 2009) or perceptibility at a distance (Tinker, 1963). This method involves in measuring at how far of a distance the eye can clearly see the presented letters or words. This means that typefaces that can be seen from further away are more legible. This is a

feasible approach for examining display typefaces or signage (e.g., road signs) at long distances. In some cases, this method also incorporates other variables, such as light. For example, a study might consider the source of the light or distance between it and the participant. This adapted technique is called the illumination threshold method (Chahine, 2012, p.136; Lund, 1999, p.93).

The search task

This method is not widely used in legibility research. It involves in measuring the time that required by the reader to search for target letters or words or, in some cases, spelling errors in a text. It is assumed that the faster the reader can identify such elements, the more legible the typeface (Beier, 2009, p.29; Lund, 1999,p.30; Chahine, 2012, p. 136). Beier pointed out that the search task more accurately measures scanning skills, rather than actual reading, explaining its lack of popularity a research method (Beier, 2012, p.15). In my opinion, the problem with this method is that readers might find the target words or errors by chance rather than because of the influence of specific typeface elements. Moreover, the reader is presented with the target before the text, and so this knowledge might influence performance.

Continuous reading

Reading speed

In this approach, speed is an indicator of legibility. Researchers frequently employ this technique in investigations of continuous reading. Normally, the reader is given short paragraphs and asked to read them. The number of words read and the reading speed are then measured. The more quickly a typeface can be read, the higher the recognition rate. Sometimes, the reader might be asked to read aloud. In such cases, the number of errors is measured, along with the speed (Tinker, 1963, pp. 6-7; Chahine, 2012, p. 28; Beier, 2009, pp. 27-28; Lund, 1999, p.23).

Blink rate

Measuring the blink rate during reading is another proxy for legibility (Chahine, 2012, p. 136). It is believed that a higher blink rate leads to greater eye fatigue, thus decreasing legibility. However, this method, which Lukiesh and Moss extensively applied, was criticized by Tinker as questionable (as cited in Lund, 1999, p. 27; Tinker, 1963, p.7).

Fatigue in reading

Tinker, a prominent legibility researcher, concluded that measuring fatigue in reading is an ineffective method (Tinker, 1963, p.7). Instead of focusing on the accuracy rate and reading speed, this approach uses reductions in the reader's performance as an indication of poor legibility. However, Tinker argued that reductions in performance (e.g., slower reading) do not imply that the reader has visual fatigue, and they therefore do prove that a typeface is less legible.

Eye movement

This method tracks the oculomotor movement of the eyes, which is not a component of lens expansion or contraction, while reading. This approach measures the maximum number of words that the vision span can perceive in one fixation, the duration of the

fixation, and the regression rate. The less time needed to fixate on a particular text is, the more legible it is. Moreover, the regression rate is expected to be lower for more legible texts. In addition, the more words that the vision span can perceive, the more legible typeface is (Chahine, 2012, p.136; Lund, 1999, pp. 24-25).

Preference rating

This method asks the participants to rank provided reading materials in order of preference. Paterson and Tinker pointed out that preferences play a key role in subjects' performances when typefaces of similar legibility are compared (as cited in Lund, 1999, p. 31). However, a drawback of this method is that it depends on personal experience, and so results should not be generalized to the larger population (Beier, 2012, p.20).

Typeface topology studies

Other scientific studies do not examine human behaviour and instead study elements of each typeface's letterforms. For instance, Legros and Grant (as cited in Beier, 2012, p.35) claimed the legibility of typeface could be determined by overlaying letters together to see how many shared units between characters are left. The more overlapped space between the characters, the more legible the typeface is. In their study, they superimposed letters on top of each other calculate the area of the overlapped structures. Another example is Abbamonte and Evan's study (as cited in Lund 1999, p.33). Instead of using human subjects, they built a computer model that mimicked human vision. They used this model to predict how human vision would react when encountering inputted information of letterforms.

The letter matching test, the questionnaires and raw data

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จับคู่ตัวอักษรไทยกับตัวอักษรขอม

1.Full-form letters

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2.Subscripts

จับคู่ตัวอักษรไทยกับตัวอักษรขอม

Match Thai and Khom Thai letters

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Independent vowels

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จับคู่ตัวอักษรไทยกับตัวอักษรขอม Match Thai and Khom Thai letters

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TLK MANUSSA (full-form characters)

ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	ตัวอักษรไทย Thai character (TH Sarabun)
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TLK MANUSSA (consonantal subscripts)

ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	ตัวอักษรไทย Thai character (TH Sarabun)	
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TLK MANUSSA (numbers and tone marks)

วรรณยุกต์ Tone mark (TLK Manussa)	ารรณยุกต์ Tone mark (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Manussa)	เลข Number (TH Sarabun)
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TLK MANUSSA (vowels and symbols)

สระขอมไทย (สระจม) Khom Thai dependent vowel and symbol (TLK Manussa)	สระไทย Thai vowel (TH Sarabun)	สระขอมไทย (สระจม) Khom Thai dependent vowel (TLK Manussa)	สระขอมไทย (สระลอย) Khom Thai independent vowel (TLK Manussa)	สระไทย Thai vowel (TH Sarabun)	
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Feedback Questionnaire on TLK MANUSSA

แบบสอบถาม TLK MANUSSA

Please give your opinion on the design of TLK Manussa by reading each sentence.
and put \checkmark in the box that indicates your agreement with the sentence.
แบบสอบถามนี้มีจุดประสงค์เพื่อสอบถามความคิดเห็นเกี่ยวกับแบบตัวอักษรขอมไทย
TLK Manussa กรุณาเติมเครื่องหมายถูก 🥒ในช่องแบบสอบถามที่ท่านเห็นด้วยกับประโยคดังต่อไปนี้

Questions คำถาม	Strongly disagree ไม่เห็นด้วยอย่างยิ่ง	Disagree ไม่เห็นด้วย	Neutral เป็นกลาง	Agree เห็นด้วย	Strongly agree เห็นด้วยอย่างยิ่ง
1. I can easily identify the characters. ข้าพเจ้าสามารถบอกลักษณะเจาะจง ตัวอักษรชุดนี้ได้อย่างง่ายดาย					
2. This typeface has a familiar appearance แบบตัวอักษรนี้มีลักษณะกุ้นเคยกับที่ ข้าพเจ้าเคยเห็นมาก่อน					
3. I would always use this typeface if given the option. ข้าพเจ้าจะใช้ตัวอักษรนี้เป็นประจำ เมื่อมีโอกาส					
4. This typeface contains characteristics close to the Thai script. ตัวอักษรชุดนี้มีลักษณะใกล้เคียง ตัวอักษรไทย					
5. This typeface has characteristics that are easy to remember. ตัวอักษรชุดนี้มีลักษณะที่ง่ายต่อการจดจำ					

Any suggestion on the design? มีข้อเสนอแนะอะไรบ้างไหมเกี่ยวกับกา	รออกแบบตัวอักษ	บรชุดนี้ -		

TLK DEVA (full-form characters)

ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	ตัวอักษรโทย Thai character (TH Sarabun)
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TLK DEVA (consonantal subscripts)

ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	ตัวอักษรไทย Thai character (TH Sarabun)
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TLK DEVA (numbers and tone marks)

วรรณยุกที่ Tone mark (TLK Deva)	วรรณยุกต์ Tone mark (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Deva)	เลข Number (TH Sarabun)
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TLK DEVA (vowels and symbols)

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								o	٩	a	_3	อื	_e	e	สระไทย Thai vowel (TH Sarabun)
ļ	Ĩ	Ĭ	3	Q	Q	66	~	~ >	^	y	•	0	0	ی	สระขอมไทย (สระจม) Khom Thai dependent vowel (TLK Deva)
<u>₹</u> \$	TC;	(M)	1	[]	1	Ì	$\emptyset \!$	₽	્છ	٧	Q	2 2 2 2 3 4 8	N	H	สระขอมไทย (สระลอย) Khom Thai independent Қ vowel (TLK Deva)
ह्य	<u>_</u>	le)	91	@ <u>*</u>	ಲ್ಲಾ	ල	_	ē	಄	േ	_@	<u>ල</u> ා	ලා	ല	สระไทย Thai vowel (TH Sarabun)

Feedback Questionnaire on TLK DEVA

แบบสอบถาม TLK DEVA

Please give your opinion on the design of TLK Deva by reading each sentence.
and put 🗸 in the box that indicates your agreement with the sentence.
แบบสอบถามนี้มีจุดประสงค์เพื่อสอบถามความคิดเห็นเกี่ยวกับแบบตัวอักษรขอมไทย
TLK Deva กรุณาเติมเครื่องหมายถูก 🗸 ในช่องแบบสอบถามที่ท่านเห็นด้วยกับประโยคดังต่อไปนี้

Questions คำถาม	Strongly disagree ไม่เห็นด้วยอย่างยิ่ง	Disagree ไม่เห็นด้วย	Neutral เป็นกลาง	Agree เห็นด้วย	Strongly agree เห็นด้วยอย่างยิ่ง
1. I can easily identify the characters. ข้าพเจ้าสามารถบอกลักษณะเจาะจง ตัวอักษรชุดนี้ได้อย่างง่ายดาย					
2. This typeface has a familiar appearance แบบตัวอักษรนี้มีลักษณะคุ้นเคยกับที่ ข้าพเจ้าเคยเห็นมาก่อน					
3. I would always use this typeface if given the option. ข้าพเจ้าจะใช้ตัวอักษรนี้เป็นประจำ เมื่อมีโอกาส					
4. This typeface contains characteristics close to the Thai script. ตัวอักษรชุดนี้มีลักษณะใกล้เคียง ตัวอักษรไทย					
5. This typeface has characteristics that are easy to remember. ตัวอักษรชุดนี้มีลักษณะที่ง่ายต่อการจดจำ					

ตัวอักษรชุดนิมิลักษณะที่ง่ายต่อการจดจำ			
Any suggestion on the design? มีข้อเสนอแนะอะไรบ้างไหมเกี่ยวกับการออกเ	แบบตัวอักษรชุดนี้		

TLK BRAHMA (full-form characters)

พัวอัก Kho (TLI	พัวอั Tha (Tr	ตัวอัก Kho (TLI	ตัวอั Tha (Th	ตัวอัก Kho (TLK	ที่วอ็ Tha (TH
ตัวอักษรขอมไทย Khom Thai character 😝 (TLK Brahma)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Brahma)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Brahma)	ตัวอักษรไทย Thai character (TH Sarabun)
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		3	2	ĸ	800

TLK BRAHMA (consonantal subscripts)

ตัวอักษรขอมไทย Khom Thai character (TLK Brahma)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Brahma)	ตัวอักษรไทย Thai character (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Brahma)	ตัวอักษรไทย Thai character (TH Sarabun)
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TLK BRAHMA (numbers and tone marks)

วรรณยุกต์ Tone mark (TLK Brahma)	วรรณยุกต์ Tone mark (TH Sarabun)	ตัวอักษรขอมไทย Khom Thai character (TLK Brahma)	ເຄ _ື Number (TH Sarabun)
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		8	9

TLK BRAHMA (vowels and symbols)

Feedback Questionnaire on TLK BRAHMA

แบบสอบถาม TLK BRAHMA

Please give your opinion on the design of TLK Brahma by reading each sentence.
and put 🗸 in the box that indicates your agreement with the sentence.
แบบสอบถามนี้มีจุดประสงค์เพื่อสอบถามความคิดเห็นเกี่ยวกับแบบตัวอักษรขอมไทย
TLK Brahma กรุณาเติมเครื่องหมายถูก 🗸 ในช่องแบบสอบถามที่ท่านเห็นด้วยกับประโยคดังต่อไปนี้

Questions คำถาม	Strongly disagree ไม่เห็นด้วยอย่างยิ่ง	Disagree ไม่เห็นด้วย	Neutral เป็นกลาง	Agree เห็นด้วย	Strongly agree เห็นด้วยอย่างยิ่ง
1. I can easily identify the characters. ข้าพเจ้าสามารถบอกลักษณะเจาะจง ตัวอักษรชุดนี้ได้อย่างง่ายดาย					
2. This typeface has a familiar appearance แบบตัวอักษรนี้มีลักษณะคุ้นเคยกับที่ ข้าพเจ้าเคยเห็นมาก่อน					
3. I would always use this typeface if given the option. ข้าพเจ้าจะใช้ตัวอักษรนี้เป็นประจำ เมื่อมีโอกาส					
4. This typeface contains characteristics close to the Thai script. ตัวอักษรชุดนี้มีลักษณะใกล้เคียง ตัวอักษรไทย					
5. This typeface has characteristics that are easy to remember. ตัวอักษรชุดนี้มีลักษณะที่ง่ายต่อการจดจำ					

Any suggestion on the design? มีข้อเสนอแนะอะไรบ้างไหมเกี่ยวกับก	ารออกแบบตัวอัก	าษรชุดนี้		

Agreement	Lower limit	Upper limit	Midpoint (x)
Strongly disagree	1	1.7	1.35
Disagree	1.8	2.5	2.15
Neutral	2.6	3.3	2.95
Agree	3.4	4.1	3.75
Strongly agree	4.2	4.9	4.55

Table 32. The class width of the questionnaire

Class width=(max-min)/class number = 0.8

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly	20	1.35	27	-1.05	22.05
disagree					
Disagree	36	2.15	77.4	-0.25	2.25
Neutral	40	2.95	118	0.55	12.10
Agree	6	3.75	22.5	1.35	10.935
Strongly	0	4.55	0	2.15	0
agree					
Total	102		244.9		47.34

Table 33. Sentence 1 for TLK Manussa

X-bar = 2.40 Variance = 0.4641 SD = 0.6812

Agreement	Frequency	Midpoint	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)	(x)			
Strongly	24	1.35	32.4	-1.04	25.96
Disagree					
Disagree	32	2.15	68.8	-0.24	1.84
Neutral	38	2.95	112.1	0.56	11.92
Agree	8	3.75	30	1.36	14.7968
Strongly	0	4.55	0	2.16	0
agree					
Total	102		243.3		54.52

Table 34. Sentence 2 for TLK Manussa

X-bar = 2.39

Variance = 0.5345

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly	31	1.35	41.85	-0.88	24.0064
disagree					
Disagree	34	2.15	73.1	-0.08	0.2176
Neutral	33	2.95	97.35	0.72	17.1072
Agree	4	3.75	15	1.52	9.2416
Strongly	0	4.55	0	2.32	0
agree					
Total	102		227.3		50.5728

Table 35. Sentence 3 for TLK Manussa

X-bar= 2.23

Variance= 0.4958

SD= 0.7041

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly	23	1.35	31.05	-1.19	32.5703
disagree					
Disagree	24	2.15	51.6	-0.39	3.6504
Neutral	38	2.95	112.1	0.41	6.3878
Agree	16	3.75	60	1.21	23.4256
Strongly	1	4.55	4.55	2.01	4.0401
agree					
Total	102		259.3		70.0742

Table 36. Sentence 4 for TLK Manussa

X-bar= 2.54

Variance= 0.6870

SD= 0.8289

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly	34	1.35	45.9	-0.77	20.1586
disagree					
Disagree	39	2.15	83.85	0.03	0.0081
Neutral	28	2.95	82.6	0.83	19.2892
Agree	1	3.75	3.75	1.63	2.6569
Strongly	0	4.55	0	2.43	0
agree					
Total	102		216.1		42.1128

Table 37. Sentence 5 for TLK Manussa

X-bar= 2.12

Variance= 0.4129

Agreement	(1)	(2)	(3)	(4)	(5)	Mean score of	SD
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree	agreement	
Question 1	0	4	30	53	15	3.57	0.5918
Question 2	0	8	18	46	30	3.72	1.735
Question 3	6	11	35	42	8	3.22	0.7801
Question 4	0	5	20	38	39	3.82	0.7005
Question 5	6	12	35	38	11	3.23	0.6729

Table 38. The conclusion of TLK Manussa from the questionnaire

Agreement	Frequency	Midpoint	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	17	1.35	22.95	-1.12	21.3248
Disagree	34	2.15	73.1	-0.32	3.4816
Neutral	44	2.95	129.8	0.48	10.1376
Agree	7	3.75	26.25	1.28	11.4688
Strongly					
agree	0	4.55	0	2.08	0
Total	102		252.1		46.4128

Table 39. Sentence 1 for TLK Deva

X-bar= 2.47

Variance= 0.45503

SD= 0.67456

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	21	1.35	28.35	-1.11	25.87
Disagree	29	2.15	62.35	-0.31	2.7869
Neutral	44	2.95	129.8	0.49	10.5644
Agree	8	3.75	30	1.29	13.3128
Strongly					
agree	0	4.55	0	2.09	0
Total	102		250.5		52.5382

Table 40. Sentence 2 for TLK Deva

X-bar= 2.46

Variance = 0.5151

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	32	1.35	43.2	-0.94	28.2752
Disagree	26	2.15	55.9	-0.14	0.5096
Neutral	38	2.95	112.1	0.66	16.5528
Agree	6	3.75	22.5	1.46	12.7896
Strongly					
agree	0	4.55	0	2.26	0
Total	102		233.7		58.1272

Table 41. Sentence 3 for TLK Deva

X-bar= 2.29

Variance= 0.5699

SD= 0.75490

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	14	1.35	18.9	-1.30	23.66
Disagree	29	2.15	62.35	-0.50	7.25
Neutral	43	2.95	126.85	0.30	3.87
Agree	13	3.75	48.75	1.10	15.73
Strongly					
agree	3	4.55	13.65	1.90	10.83
Total	102		270.5		61.34

Table 42. Sentence 4 for TLK Deva

X-bar= 2.65

Variance= 0.6014

SD= 0.7755

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	31	1.35	41.85	-0.85	22.3975
Disagree	37	2.15	79.55	-0.05	0.0925
Neutral	31	2.95	91.45	0.75	17.4375
Agree	3	3.75	11.25	1.55	7.2075
Strongly					
agree	0	4.55	0	2.35	47.135
Total	102		224.1		94.27

Table 43. Sentence 5 for TLK Deva

X-bar= 2.20

Variance= 0.4621

Agreement	(1)	(2)	(3)	(4)	(5)	Mean score of	SD
	Strongly	Disagree	Neutral	Agree	Strongly	agreement	
	disagree				agree		
Question 1	17	34	44	7	0	2.47	0.6746
Question 2	21	29	44	8	0	2.46	0.7177
Question 3	32	26	38	6	0	2.29	0.7549
Question 4	14	29	43	13	3	2.65	0.7755
Question 5	31	37	31	3	0	2.2	0.6798

Table 44. The conclusion of TLK Deva from the questionnaire

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	20	1.35	27	-1.05	22.05
Disagree	36	2.15	77.4	-0.25	2.25
Neutral	40	2.95	118	0.55	12.10
Agree	6	3.75	22.5	1.35	10.935
Strongly					
agree	0	4.55	0	2.15	0
Total	102		244.9		47.34

Table 45. Sentence 1 for TLK Brahma

X-bar= 2.40 Variance= 0.4641 SD= 0.6812

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	24	1.35	32.4	-1.04	25.96
Disagree	32	2.15	68.8	-0.24	1.84
Neutral	38	2.95	112.1	0.56	11.92
Agree	8	3.75	30	1.36	14.7968
Strongly					
agree	0	4.55	0	2.16	0
Total	102		243.3		54.52

Table 46. Sentence 2 for TLK Brahma

X-bar= 2.39

Variance= 0.5345

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	31	1.35	41.85	-0.88	24.0064
Disagree	34	2.15	73.1	-0.08	0.2176
Neutral	33	2.95	97.35	0.72	17.1072
Agree	4	3.75	15	1.52	9.2416
Strongly					
agree	0	4.55	0	2.32	0
Total	102		227.3		50.5728

Table 47. Sentence 3 for TLK Brahma

X-bar= 2.23 Variance= 0.4958 SD= 0.7041

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	23	1.35	31.05	-1.19	32.5703
Disagree	24	2.15	51.6	-0.39	3.6504
Neutral	38	2.95	112.1	0.41	6.3878
Agree	16	3.75	60	1.21	23.4256
Strongly					
agree	1	4.55	4.55	2.01	4.0401
Total	102		259.3		70.0742

Table 48. Sentence 4 for TLK Brahma

X-bar= 2.54

Variance= 0.6870

Agreement	Frequency	Midpoint (x)	f(midpoint)	(x-x bar)	f(x-xbar)square2
	(f)				
Strongly					
disagree	34	1.35	45.9	-0.77	20.1586
Disagree	39	2.15	83.85	0.03	0.0081
Neutral	28	2.95	82.6	0.83	19.2892
Agree	1	3.75	3.75	1.63	2.6569
Strongly					
agree	0	4.55	0	2.43	0
Total	102		216.1		42.1128

Table 49. Sentence 5 for TLK Brahma

X-bar= 2.12

Variance= 0.4129

Agreement	(1)	(2)	(3)	(4)	(5)	Mean score	SD
	Strongly	Disagree	Neutral	Agree	Strongly	of agreement	
	disagree				agree		
Question 1	20	36	40	6	0	2.4	0.6812
Question 2	24	32	38	8	0	2.39	0.7311
Question 3	31	34	33	4	0	2.23	0.7041
Question 4	23	24	38	16	1	2.54	0.8289
Question 5	34	39	28	1	0	2.12	0.6426

Table 50. The conclusion of TLK Brahma from the questionnaire

Typeface	TLK Manussa	TLK Deva	TLK Brahma	NLB typeface	Khom2004	KM-khomtai
S 1	20	24	30	24	21	22
S 2	21	23	28	22	22	20
S 3	22	22	29	21	19	21
S 4	17	19	30	19	23	20
S 5	19	24	32	24	18	18
S 6	20	23	31	20	20	19
S 7	20	22	36	19	21	17
S 8	21	20	31	23	18	16
S 9	23	28	30	17	20	15
S 10	19	27	30	19	23	19
S 11	18	23	31	17	21	23
S 12	20	20	22	24	18	20
S 13	17	24	24	18	17	21
S 14	16	25	28	20	19	18
S 15	14	25	29	24	20	20
S 16	21	23	30	23	19	19
S 17	22	24	25	22	18	20
S 18	15	24	30	23	22	21
S 19	20	18	32	18	20	20
S 20	18	20	33	20	19	19
S 21	19	24	32	17	21	18
S 22	16	20	33	16	22	20
S 23	15	17	30	18	17	21
S 24	19	21	31	20	18	22
S 25	20	24	30	21	16	23
S 26	21	22	29	22	20	21
S 27	22	21	28	22	21	22
S 28	23	20	30	23	23	18
S 29	24	23	28	24	21	17
S 30	18	20	27	20	20	19
S 31	20	20	29	18	21	18
S 32	20	18	30	19	22	19
Mean	19.375	22.125	29.625	20.531	20.00	19.563
SD	2.472	2.587	2.661	2.462	1.867	1.917

Table 51. Total number of correct answers for each typeface

S=participant code

For the letter codes, see Figures 6–9.

Letter code	Total number of	Percentage of correct
	correct answers	answers
	(of out of 32	
1	participants) 1	3.13
2	32	100.00
3	1	3.13
4	28	87.50
5	5	15.63
6	2	6.25
7	27	84.38
8	28	87.50
9	29	90.63
10	28	87.50
11	29	90.63
12	17	53.13
13	29	90.63
14	27	84.38
15	2	6.25
	1	3.13
16		
17	30	93.75
18	2	6.25
19	1	3.13
20	30	93.75
21	31	96.88
22	3	9.38
23	3	9.38
24	31	96.88
25	5	15.63
26	8	25.00
27	27	84.38
28	24	75.00
29	29	90.63
30	5	15.63
31	27	84.38
32	20	62.50
33	4	12.50
34	22	68.75
35	16	50.00
36	11	34.38
37	5	15.63

Table 52. Correct answers for individual full-form letters in TLK Manussa for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	10	31.25
2	32	100
3	8	25
4	25	78.125
5	31	96.875
6	9	28.125
7	32	100
8	28	87.5
9	29	90.625
10	32	100
11	28	87.5
12	32	100
13	24	75
14	18	56.25
15	27	84.375
16	3	9.375
17	29	90.625
18	18	56.25
19	27	84.375
20	25	78.125
21	8	25
22	28	87.5
23	3	9.375
24	32	100
25	28	87.5
26	23	71.875
27	5	15.625
28	10	31.25
29	28	87.5
30	4	12.5
31	16	50
32	8	25
33	5	15.625
34	24	75
35	4	12.5
36	4	12.5
37	11	34.375

Table 53. Correct answers for individual full-form letters in TLK Deva for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	28	87.5
2	32	100
3	26	81.25
4	29	90.63
5	30	93.75
6	28	87.5
7	31	96.88
8	29	90.63
9	29	90.63
10	31	96.88
11	25	78.13
12	29	90.63
13	28	87.5
14	32	100
15	29	90.63
16	28	87.5
17	30	93.75
18	24	75
19	26	81.25
20	22	68.75
21	28	87.5
22	27	84.38
23	22	68.75
24	31	96.875
25	25	78.125
26	32	100
27	26	81.25
28	28	87.5
29	32	100
30	25	78.13
31	16	50
32	25	78.13
33	12	37.5
34	25	78.13
35	13	40.63
36	8	25
37	7	21.88

Table 54. Correct answers for individual full-form letters in TLK Brahma for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	27	04.20
1	27	84.38
2	32	100
3	29	90.63
4	29	90.63
5	29	90.63
6	17	53.13
7	28	87.5
8	18	56.25
9	10	31.25
10	31	96.88
11	14	43.75
12	23	71.88
13	4	12.5
14	32	100
15	20	62.5
16	17	53.13
17	2	6.25
18	27	84.38
19	4	12.5
20	29	90.63
21	4	12.5
22	3	9.375
23	3	9.375
24	32	100
25	22	68.75
26	31	96.88
27	15	46.88
28	6	18.75
29	31	96.88
30	6	18.75
31	14	43.75
32	24	75
33	4	12.5
34	24	75
35	7	21.88
36	3	9.38
37	6	18.75

Table 55. Correct answers for individual full-form letters in NLB typeface for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	14	43.75
2	32	100
3	24	75
4	25	78.13
5	11	34.38
6	23	71.88
7	9	28.13
8	4	12.5
9	25	78.13
10	15	46.88
11	4	12.5
12	32	100
13	10	31.25
14	32	100
15	28	87.5
16	13	40.63
17	2	6.25
18	15	46.88
19	5	15.63
20	28	87.5
21	26	81.3
22	20	62.5
23	10	31.25
24	30	93.75
25	15	46.88
26	29	90.63
27	17	53.13
28	16	50
29	30	93.75
30	12	37.5
31	23	71.88
32	5	15.63
33	5	15.63
34	21	65.63
35	8	25
36	5	15.63
37	17	53.13

Table 56. Correct answers for individual fullform letters in Khom2004 for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	24	75
2	30	93.75
3	23	71.88
4	27	84.38
5	26	81.25
6	23	71.88
7	13	40.63
8	26	81.25
9	20	62.5
10	30	93.75
11	23	71.88
12	20	62.5
13	5	15.63
14	31	96.88
15	18	56.25
16	16	50
17	2	6.25
18	18	56.25
19	6	18.75
20	27	84.38
21	10	31.25
22	2	6.25
23	1	3.13
24	31	96.88
25	20	62.5
26	25	78.13
27	16	50
28	7	21.88
29	28	87.5
30	5	15.63
31	19	59.38
32	12	37.5
33	5	15.63
34	21	65.63
35	8	25
36	2	6.25
37	6	18.75

Table 57. Correct answers for individual full-form letters in KM-khomtai for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	2	6.25
2	27	84.38
3	26	81.25
4	1	3.13
5	28	87.5
6	26	81.25
7	1	3.13
8	1	3.13
9	1	3.13
10	28	87.5
11	1	3.13
12	1	3.13
13	1	3.13
14	30	93.75
15	23	71.88
16	1	3.13
17	27	84.38
18	2	6.25
19	23	71.88
20	1	3.13
21	17	53.13
22	1	3.13
23	17	53.13
24	1	3.13
25	1	3.13
26	1	3.13
27	19	59.38
28	1	3.13
29	1	3.13
30	1	3.13
31	1	3.13
32	1	3.13

Table 58. Correct answers for individual subscribed consonants in TLK Manussa for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	10	31.25
2	32	100
3	10	31.3
4	20	62.5
5	25	78.13
6	32	100
7	16	50
8	5	15.625
9	32	100
10	24	75
11	5	15.63
12	31	96.88
13	4	12.5
14	32	100
15	29	90.63
16	27	84.38
17	27	84.38
18	11	34.38
19	7	21.88
20	1	3.13
21	26	81.25
22	7	21.88
23	3	9.38
24	22	68.75
25	14	43.75
26	8	25
27	5	15.63
28	2	6.25
29	2	6.25
30	1	3.13
31	1	3.13
32	2	6.25

Table 59. Correct answers for individual subscribed consonants in TLK Deva for the 32 participants

Letter code	Total number of correct answers	Percentage of correct answers
	(out of 32	
	participants)	
1	6	18.75
2	29	90.63
3	31	96.88
4	18	56.25
5	31	96.88
6	28	87.5
7	26	81.25
8	22	68.75
9	3	9.38
10	21	65.63
11	3	9.38
12	28	87.5
13	3	9.38
14	2	6.25
15	27	84.38
16	3	9.38
17	24	75
18	6	18.75
19	3	9.38
20	2	6.25
21	24	75
22	12	37.5
23	19	59.38
24	2	6.25
25	1	3.13
26	2	6.25
27	15	46.88
28	1	3.13
29	1	3.13
30	2	6.25
31	7	21.88
32	6	18.75

Table 60. Correct answers for individual subscribed consonants in TLK Brahma for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	10	31.25
1		
2	16	50
3	28	87.5
4	26	81.25
5	12	37.5
6	14	43.75
7	27	84.38
8	9	28.13
9	2	6.25
10	8	25
11	9	28.13
12	30	93.75
13	13	40.63
14	32	100
15	4	12.5
16	31	96.88
17	26	81.25
18	30	93.75
19	19	59.38
20	26	81.25
21	21	65.63
22	18	56.25
23	8	25
24	12	37.5
25	8	25
26	11	34.38
27	2	6.25
28	2	6.25
29	1	3.13
30	2	6.25
31	2	6.25
32	1	3.13

Table 61. Correct answers for individual subscribed consonants in NLB typeface for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	9	28.13
2	18	56.25
3	25	78.13
4	24	75.13
5	11	34.38
6	13	40.63
7	26	81.25
8	9	28.13
9	5	15.63
10	8	25
11	4	12.5
12	29	90.63
13	11	34.38
14	28	87.5
15	5	15.63
16	8	25
17	28	87.5
18	24	75
19	16	50
20	28	87.5
21	24	75
22	12	37.5
23	4	12.5
24	8	25
25	9	28.13
26	12	37.5
27	3	9.38
28	6	18.75
29	5	15.63
30	1	3.13
31	2	6.25
32	1	3.13
	l	1

Table 62. Correct answers for individual subscribed consonants in Khom2004 for the 32 participants

Letter code	Total number of	Percentage of
	correct answers	correct answers
	(out of 32	
	participants)	
1	17	53.125
2	20	62.5
3	28	87.5
4	23	71.88
5	7	21.88
6	8	25
7	24	75
8	6	18.75
9	7	21.88
10	5	15.63
11	1	3.13
12	23	71.88
13	8	25
14	25	78.125
15	4	12.5
16	6	18.75
17	27	84.38
18	28	87.5
19	11	34.38
20	23	71.88
21	21	65.63
22	11	34.38
23	3	9.38
24	2	6.25
25	5	15.63
26	10	31.25
27	5	15.63
28	4	12.5
29	6	18.75
30	2	6.25
31	3	9.38
32	1	3.13

Table 63. Correct answers for individual subscribed consonants in KM-khomtai for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	31	96.875
2	32	100
3	26	81.25
4	31	96.875
5	30	93.75
6	30	93.75
7	30	93.75
8	30	93.75
9	32	100
10	27	84.375
11	23	71.875

Table 64. Correct answers for individual independent vowels in TLK Manussa for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	30	93.75
2	31	96.88
3	27	84.38
4	32	100
5	31	96.88
6	31	96.88
7	32	100
8	31	96.88
9	21	65.63
10	30	93.75
11	26	81.25

Table 65. Correct answers for individual independent vowels in TLK Deva for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	30	93.75
2	27	84.38
3	12	37.5
4	31	96.88
5	32	100
6	32	100
7	31	96.88
8	31	96.88
9	18	56.25
10	11	34.38
11	9	28.13

Table 66. Correct answers for individual independent vowels in TLK Brahma for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	32	100
2	30	93.75
3	26	81.25
4	31	96.88
5	28	87.5
6	32	100
7	32	100
8	32	100
9	22	68.75
10	27	84.38
11	20	62.5

Table 67. Correct answers for individual independent vowels in NLB typeface for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	30	93.75
2	31	96.88
3	24	75
4	27	84.38
5	25	78.13
6	32	100
7	21	65.63
8	30	93.75
9	26	81.25
10	25	78.13
11	22	68.75

Table 68. Correct answers for individual independent vowels in Khom2004 for the 32 participants

Letter code	Total number of correct answers (out of 32 participants)	Percentage of correct answers
1	31	96.88
2	32	100
3	27	84.38
4	25	78.13
5	26	81.25
6	32	100
7	22	68.75
8	31	96.88
9	31	96.88
10	24	75
11	20	62.5

Table 69. Correct answers for individual independent vowels in KM-khomtai for the 32 participants

Appendix D

Summary of the interviews (translated from Thai transcriptions)

First interview (S1)

Virunhaphol: Hi. Would you please kindly describe your experience?

S1: Well, I have been teaching Khom Thai courses for nearly 30 years at universities. Apart from teaching Khom Thai, I also teach other ancient scripts, including Khmer, Thum Lanna, and Thum Isan. I works closely with the National Library and other organizations to translate Khom Thai documents.

Virunhaphol: Why are you especially interested in Khom Thai?

S1: First of all, it grows from my personal interest in the Thai language. And then, I moved on to study Thai palaeography. That was when I became interested in Khom Thai. It is the most widely used script of the ancient scripts in Thailand, so there are more things to study, like palm-leaf documents, stone inscriptions, and so on. Moreover, it is a script that was used in nearly every part of the country, unlike others that were more regional scripts [for example, Thum Lanna is used mainly in the north]. It is fascinating to see how each script has been developed. They tell stories about who we were in the past.

Virunhaphol: What is Khom Thai's current position in Thailand?

S1: It is obvious that the script is not regularly used by Thais in general. However, it's not dead, fortunately. I think the situation is more or less improving, since there are more national policies that support the learning of traditional knowledge. However, there there have not been many significant changes to the situation. Learning is still limited to scholars and those who have a special interest in the subject. Maybe it is because the Thai script is simpler to read than Khom Thai. There is no subscribed consonant. So, it is harder to read Khom Thai. We are not trained to read subscribed consonants like in the past. Of course, we must feel it is harder, right?

Virunhaphol: Is it hard for you to read the script?

S1: In the past, yes, back in those days when I was a student. But nowadays, there is no problem.

Virunhaphol: Does your department currently have enough staff?

S1: Hard to say. It's about the supply and demand. The more people want to learn, the more needs for lecturers. However, the number of students is still low ,so there are a fewer number of lecturers in my department in comparison with other departments. However, if you ask me whether it is enough now, I would say yes.

Virunhaphol: What are the main problems in learning Khom Thai at the beginner level?

S1: Students are not able to associate the letterforms of Khom Thai with the Thai alphabetic units. They look different, and that's the problem.

Virunhaphol: Are there enough Khom Thai learning materials for your classes?

S1: In this university, of course. We are one of the best. But I would love to see new materials coming out.

Virunhaphol: What are the common ways to teach Khom Thai to students?

S1: Repeatedly write each Khom Thai letter down along with the Thai letters. They are gradually learned that way.

Virunhaphol: How long does it take to learn the script?

S1: It depends on how hard the students work on each assignment. It's hard to say how long. But, at the end of the semester, they can read the script fairly well.

Virunhaphol: What are the benefits of learning Khom Thai?

S1: In terms of cultural value, it helps us identify who we are, where we came from. It is a way to communicate with our past, making the connection between now and then. Virunhaphol: Why isn't Khom Thai popular nowadays?

S1: Well, there are many factors. One of the reasons is that nowadays the Thai script is the standard. Khom Thai is more optional, so most of the documents are written in the Thai script rather than Khom Thai. I think it is not important whether Khom Thai is popular or not. It is a kind of script that has it own place. The value of the script does not lie in the popularity. In my opinion, the true value of the script is that it is a tool in covey messages from the past. Without it, those words would be lost forever. Of course, it is also important to bring it back to the present so that young generations can study it. Don't get me wrong, but my point is that it may not be popular now, but it is still worthwhile to preserve the script.

Virunhaphol: Would you please kindly give your opinion on the design of the three letterform designs?

S1: I think they look all right to me. I like this one the most [TLK Brahma].

Virunhaphol: Is there any particular reason?

It looks...[pause]. I don't know. It looks ancient to me, compared to the others. I like the brushstroke, and that's all.

Virunhaphol: In your opinion, are there any graphic elements that needed to be improved?

S1: This one [TLK Manussa]. The sok should not point downward like that. The overall shape looks too angular for me. I think it looks too close to the Thai letters.

Virunhaphol: What about TLK Brahma? It has upward sok, too.

S1: I think it looks fine, since it represents calligraphic stroke. And the finial is not too long. Another thing I want to mention is the beak of this letterform design [TLK Manussa]. Commonly, it shouldn't move inward like the Thai script.

Virunhaphol: Would you consider them authentic styles?

S1: TLK Deva and TLK Brahma look all right to me. But this one, I'm not sure. It [TLK Manussa] is not traditional Khom Thai, for sure.

Virunhaphol: Are they readable and legible?

S1: Of course, all of them. I have no problem reading them.

Virunhaphol: Any further suggestions?

S1: With TLK Manussa, make sure you base your design more on the Khom Thai script. Otherwise, it does not closely represent the script.

Second interview (S1)

Virunhaphol: I have been working on the design of the letterform designs. Would you please kindly give your opinions on the revised version of the letterform designs?

S1: It all looks good to me. Much better than the first draft.

Virunhaphol: Would you consider them authentic styles?

S1: For TLK Deva and TLK Brahma, I would say yes.

Virunhaphol: Are they readable?

S1: All of them are readable.

Virunhaphol: Which one do you think has the closest characteristics to the Thai script?

S1: TLK Manussa.

Virunhaphol: Which one do you think is the easiest to read?

S1: Hard to say. I can read them all. I've been trained to read Khom Thai, so the styles don't affect me much.

Virunhaphol: Which one do you prefer?

S1: TLK Brahma. I think it's the most beautiful.

Virunhaphol: Any further suggestions?

S1: I would love to see which one works best for students.

First interview (S2)

Virunhaphol: Would you please kindly describe your experience?

S2: Like many staff members in this faculty, my expertise is in Khom Thai and the Thai language. My publications revolve around these subjects. I am also interested in Thai literatures as well.

Virunhaphol: Why are you especially interested in Khom Thai?

S2: It's an ancient script that that was equally used with the Thai script. There are so many documents to study that can be traced back to Sukhothai [the 13th century]. That period is considered to be the starting point of the Thai historical era. Examining Khom Thai stone inscriptions from that era provides significant information about people's way of life during that time.

Virunhaphol: What is Khom Thai's current position in Thailand?

S2: I think it's kind of stable now after the reformation of education during 70s. There are certain kinds of people who are interested in the subject, like historians and scholars. Back in the old days, it was also used by root doctors, magical practitioners, and monks. So, there is a feeling that the script is sacred because of the context around it.

Virunhaphol: Is it hard for you to read the script?

S2: No, I have no problem. I've been studying the script for a long time. But, for beginners, I think it is hard for them at first. Then, after they can remember Khom Thai letterforms, there isn't any problem.

Virunhaphol: Does your department currently have enough staff?

S2: Judging from the number of students, I think there are.

Virunhaphol: What are the main problems in learning Khom Thai at the beginner level?

S2: It's hard for students to remember Khom Thai letters at first. The appearance of Khom Thai and Thai are mostly different, but there're also some similarities. It's probably like learning to write Greek when you have already learned Roman. That's maybe not the best comparison, however, that's the closest I can come up with right now. Let's say the alphabetic order of Khom Thai and Thai are the same, so it doesn't take long for students to figure out which one [Khom Thai letter] represents the Thai letter. So, once students are able to link the odd letterforms of Khom Thai to the Thai alphabetic unit,

reading the script is no longer a problem. That said, the orthographies [of Khom Thai and Thai] are not exactly the same, but they can make a guess and gradually learn to read. Remembering Khom Thai letterforms is the beginning of learning. I think those that share similarities, like kho khai, ro ruea, and tho phuthao, are the easy ones. They look very close to the Thai version. Students with no experience in reading the script can identify those letters with no effort. But, for a letter like lo chula, it probably takes more time, since there is no similarity at all.

Virunhaphol: Are there enough Khom Thai learning materials for your classes?

S2: Now, there are many databases, such as the Inscriptions in Thailand Database Project, that provide some digitized ancient documents that students can access. It's still growing, so the more, the better.

Virunhaphol: What are the common ways to teach Khom Thai to students?

S2: Commonly, there are textbooks [Wimonkasem, 2010; The National Library of Thailand, 2011] that our departments have been using for quite some time. There are writing models provided in these books, so students can use them as references for practicing writing in Khom Thai.

Virunhaphol: How long does it take to learn the script?

S2: There isn't much time in class to teach everything all at once, so students need to work hard as well if they intend to master this skill. We also provide an eight-week training in Khom Thai for anybody who is interested in learning. Normally, what we do in class is asking students to first write each letter. They can do assignments at home as well. Practicing is the key. After they learn all the characters, then there's no problem in reading the script.

Virunhaphol: So you mean the main difficulty in reading the script occurs because students cannot remember the letterforms for each letter? After learning all of the letters, reading is less of a problem?

S2: If we're speaking about Khom Thai, the Khom script that is used for the Thai language, not Pali and Sanskit, then I would say yes. Although, of course, there are some differences in orthography between the present-day Thai and Khom Thai, still there are a lot of similarities. I think the most difficult part is remembering the letterforms of each letter. Reading running texts is not going to be a problem when you learn all the characters. What I found is that the subscribed consonants usually confuse the students because there is no subscribed consonant in the present-day Thai script. Subscribed consonants are harder to remember. They [students] have always complained about how hard it is for them to learn subscribed consonants in my classes. With letters like tho phuthao, tho montho, kho khai, ro ruea, and so suea [full-form], they are very easy for students to learn. They are nearly the same as the present-day version. There are so many ancient documents, however, and there are still only very few people who can read the script. Promoting learning should improve the situation.

Otherwise, this cultural heritage will be lost.

Virunhaphol: What are the benefits of learning Khom Thai?

S2: For pleasure. For personal interest. For training your brain. There are many benefits. But the most important is that learning the script makes its legacy lives on. It is something that has been passed down from one generation to the next.

Virunhaphol: Why isn't Khom Thai popular nowadays?

S2: I think the nationalist policies during 1945 played a significant role. When Khom Thai programs were shut down, there was no place to learn the script for Thais in general. Only a few communities still teach their children to read and write the script. However, in the big picture, there aren't many places that provide Khom Thai courses. Virunhaphol: Would you please kindly give your opinion on the design of the three letterform designs?

S2: This one [TLK Manussa] looks strange to me. Why is it so condensed?

Virunhaphol: I'm trying to come up with something new. I want to avoid being too cliché with my design.

S2: Right. I think this one need some improvements. It looks somewhat like...I don't know. It's odd at this point. Are you trying to make it look modern?

Virunhaphol: Yes, that's the intention.

S2: Be careful about that. I have no problem with compromising the new and the old styles, but you have to bear in mind that you're designing an ancient script. It's kind of losing the sense of traditional taste.

Virunhaphol: Can you be more specific?

S2: I think you based your design on the modern style too much. For example, this one [bo baimai], I can barely see the wavy line in the middle of the body. It looks too much like the Thai letter. And this part is too long [the finial of the sok].

Virunhaphol: In your opinion, are there any graphic elements that needed to be improved?

S2: I think TLK Deva and this one [TLK Brahma] are OK. TLK Manussa need more work, for sure. Try to look at references of Khom Thai, then adjust the letter elements accordingly. Otherwise, it's not going to look like Khom Thai.

Virunhaphol: Would you consider them authentic styles?

S2: TLK Deva and TLK Brahma are all right. As for TLK Manussa, I'm not sure.

Virunhaphol: Are they readable and legible?

S2: I can read them all. That's not a problem.

Virunhaphol: Any further suggestions?

S2: Comparing your designs and the writing models in textbooks may be a good way to improve your work.

Second interview (S2)

Virunhaphol: I have been working on the design of the letterform designs. Would you please kindly give your opinions on the revised version of the letterform designs?

S2: I'm all right with them. TLK Manussa is improved. Now, it looks like Khom Thai.

Virunhaphol: Would you consider them authentic styles?

S2: These [TLK Deva and TLK Brahma] could represent traditional writing styles. But the purpose of this one [TLK Manussa] is different, isn't it?

Virunhaphol: Are they readable?

S2: I would say yes.

Virunhaphol: Which one do you think has the closest characteristics to the Thai script?

S2: I would say TLK Manussa.

Virunhaphol: Which one do you think is the easiest to read?

S2: For me, I think TLK Deva, since it look simple and not condensed.

Virunhaphol: Which one do you prefer?

S2: TLK Deva.

Virunhaphol: Any further suggestions?

S2: I think on your future projects you could work on designing Thai letterform designs that feel like the Khom Thai script as well. I know it's like a reversal of what you are doing right now, but I think it would be interesting for modern Thai users.

First interview (S3)

Virunhaphol: Would you please kindly describe your experience?

S3: Apart from being a lecturer and a researcher, I'm also a Khmer translator.

Virunhaphol: Why are you especially interested in Khom Thai?

S3: There are a lot of things in common between Khmer and Thai. This is because there was a lot of cultural exchange during the Khmer Empire. I think Khom Thai is like a bridge between the two cultures. It's a fusion, and that makes it interesting.

Virunhaphol: What is Khom Thai's current position in Thailand?

S3: It's a small community of people who study the script, while there are piles of ancient documents waiting to be translated. It's not a match when it comes to the number of people who can read the script and the number of ancient documents. Now, we still discover more and more ancient inscriptions, but few can read them.

Virunhaphol: Is it hard for you to read the script?

S3: Of course not.

Virunhaphol: Does your department currently have enough staff?

S3: I won't say there's a lack of manpower in my department, since we have enough lecturers. But, I would love to see more and more people who are interested in learning Khom Thai.

Virunhaphol: What are the main problems in learning Khom Thai at the beginner level?

S3: I would say the letterforms. Khom Thai look closer to Khmer than Thai. Actually, it is nearly the same as Khmer Moul. Therefore, it's not familiar to Thais. However, both of the languages [Khmer and Thai] came from the same root, so they aren't completely different. I think students need to first grow accustomed to Khom Thai letterforms and then move on to reading.

Virunhaphol: Are there enough Khom Thai learning materials for your classes?

S3: We don't have any shortage, but we are also open to new things that are coming out. There's always room for improvement.

Virunhaphol: What are the common ways to teach Khom Thai to students?

S3: Practice writing Khom Thai letters over and over. We also provide them with a learning CD so that they can do their homework at home as well as in class. Virunhaphol: How long does it take to learn the script?

S3: It depends on what level you are expecting. If you want to be competent enough to translate difficult documents, then I would say a couple of months. But, if you want just to read ordinary texts, then a couple of weeks will be enough. It also depends on how hard you study. Some people may take weeks, and some may take years. Who know? Virunhaphol: What are the benefits of learning Khom Thai?

S3: It would benefit those in the field of history the most, since it is the area that they are focusing on.

Virunhaphol: Why isn't Khom Thai popular nowadays?

S3: It's hard to read for general Thais. The way it forms a word is confusing for most people. But, in the end, it's not too hard if you put effort into it.

Virunhaphol: Would you please kindly give your opinion on the design of the three letterform designs?

S3: This one [TLK Manussa] looks funny to me. It's not bad, but different from what I've seen for Khom Thai. The first issue that I think needed to be improved is the terminal of the sok in TLK Manussa. It should not move upward. The second thing is these letters [tho than, cho chang, to patak, and pho phueng] do not closely follow Khom Thai letterforms. Isn't that right? Tho than looks too close to the Thai version. They are too angular, in my opinion. The contact point of the middle loop of this letter [yo ying] shouldn't connect to the shoulder. You should separate them.

Virunhaphol: I know. I want it to be more contemporary.

S3: Okay. It looks like the present-day Thai script. However, I still think that it looks too close to the Thai letters.

Virunhaphol: Yeah. What about the other two?

S3: They are all right. TLK Brahma is beautiful.

Virunhaphol: Why you like it?

S3: It's what I've seen a lot in ancient texts. The style looks elegant and sophisticated. I like it.

Virunhaphol: In your opinion, are there any graphic elements that needed to be improved?

S3: They are alright for me. That's all I can say.

Virunhaphol: Would you consider them authentic styles?

S3: TLK Deva looks like Sen Chan, and TLK Brahma looks like Sen Chup. Yes, I think they are authentic styles.

Virunhaphol: Are they readable and legible?

Yes, they are legible.

Virunhaphol: Any further suggestions?

S3: At this point, I think what you can do is ask for more opinions from students as well. I'm an experienced Khom Thai reader, so my taste may not reflect what students like today.

Virunhaphol: I'll do that after I finish designing my letterform designs. Thanks.

Second interview (S3)

Virunhaphol: I have been working on the design of the letterform designs. Would you please kindly give your opinions on the revised version of the letterform designs?

S3: I still like TLK Brahma the most. I think it's the most charming one.

Virunhaphol: Would you consider them authentic styles?

S3: Yes, for these two [TLK Deva and TLK Brahma], I would say so.

Virunhaphol: Are they readable?

S3: Yes.

Virunhaphol: Which one do you think has the closest characteristics to the Thai script?

S3: TLK Manussa.

Virunhaphol: Which one do you think is the easiest to read?

S3: In term of reading, I think there aren't many differences between the letterform designs.

Virunhaphol: Which one do you prefer?

S3: TLK Brahma.

Virunhaphol: Any further suggestions?

S3: No, I have no further comment.

Appendix E Other documents

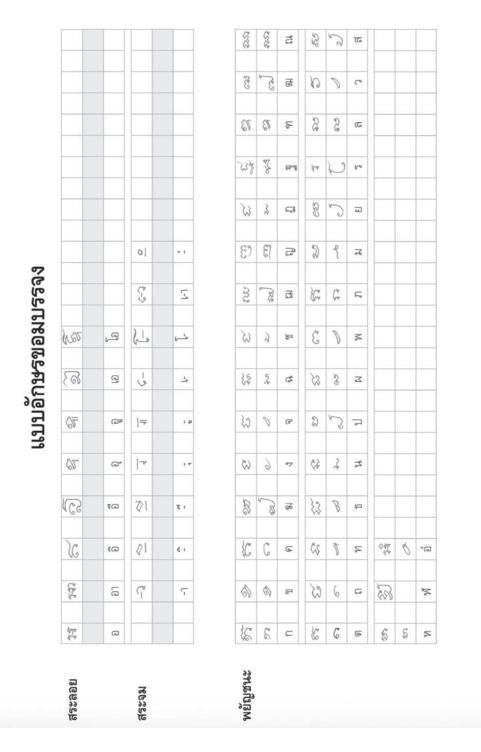


Figure 176. National Library of Thailand's writing model at 80% of the original size. Adapted from *Kumue thaitot akson Khom*, by National Library of Thailand, 2010, p.4. Copyright 2010 by National Library of Thailand.

The letterforms from this National Library's writing model were what I referred to as the NLB typeface.



Figure 177. Comparison of full-form characters and subscribed consonants in Thai, Khmer upright, Khmer Moul, and Khom Thai, by Virunhaphol

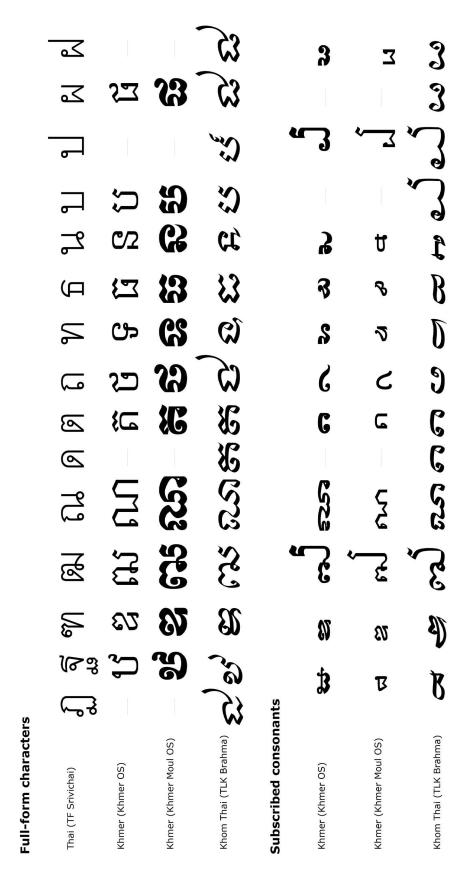


Figure 178. Comparison of full-form characters and subscribed consonants in Thai, Khmer upright, Khmer Moul and Khom Thai, by Virunhaphol

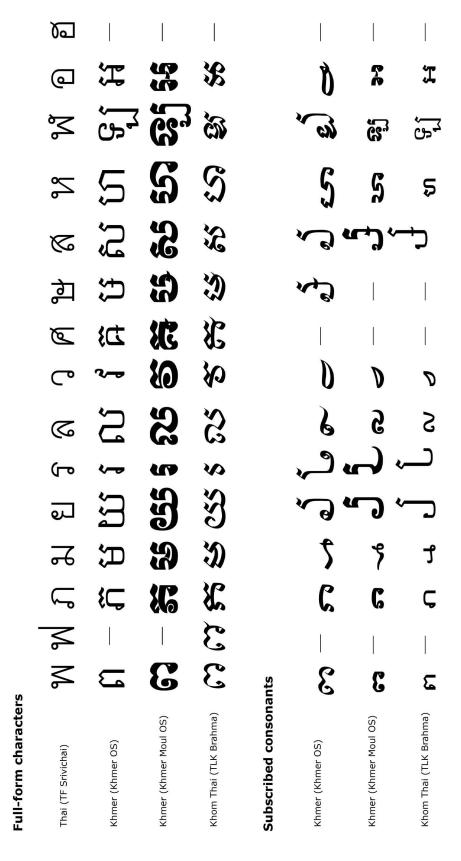


Figure 179. Comparison of full-form characters and subscribed consonants in Thai, Khmer upright, Khmer Moul and Khom Thai, by Virunhaphol



Figure 180. Comparison of numerals and independent vowels in Thai, Khmer upright, Khmer Moul and Khom Thai, by Virunhaphol

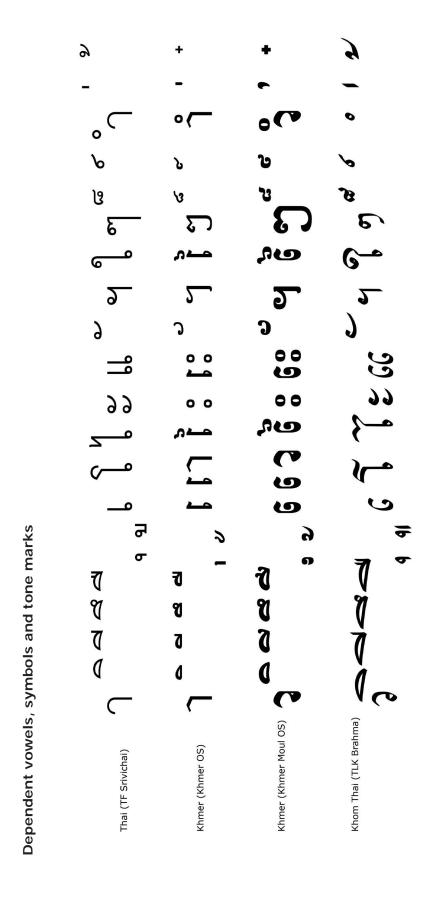


Figure 181. Comparison of dependent vowels, symbols and tone marks in Thai, Khmer upright, Khmer Moul and Khom Thai, by Virunhaphol

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This form is used for confirming an agreement between the researcher and the participant to collect data for this research.

This form consists of two parts:

1. Information Sheet

This part gives you information about the research process to help you make the decision whether or not to participate in this research.

2. Certificate of Consent

If you choose to participate, you will be asked to sign your name, indicating that you have provided your permission for using the data provided that you provide in the study.

A copy of this informed consent form will be given to you as an agreement between the researcher and yourself.

แบบฟอร์มนี้ใช้เพื่อยืนยันข้อตกลงระหว่างนักวิจัยและผู้เข้าร่วมการวิจัยเพื่อเก็บ ข้อมูลในงานวิจัยชิ้นนี้

แบบฟอร์มนี้ประกอบด้วยสองส่วน ได้แก่:

- 1.ส่วนแรกให้ข้อมูลเกี่ยวกับขั้นตอนในการวิจัยเพื่อช่วยในการตัดสินใจเข้าร่วม หรือไม่เข้าร่วมงานวิจัยในครั้งนี้
- 2.ใบประกาศความเห็นชอบในการเข้าร่วม ในกรณีที่คุณเลือกที่จะเข้าร่วมในการให้ข้อมูลในงานวิจัย คุณจะถูกขอให้เซ็นต์ ชื่อเพื่ออนุญาตการใช้ข้อมูลนี้ประกอบงานวิจัย คุณจะได้รับสำเนาของแบบฟอร์มนี้หนึ่งฉบับเพื่อเป็นคู่สัญญาระหว่างกัน

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Part I: Information Sheet ส่วนที่หนึ่ง : ใบแจ้งข้อมูล

Introduction ส่วนนำ

My name is Farida Virunhaphol. I have been a PhD candidate at University of Huddersfield since 2013.

Currently, I am conducting research on designing typefaces in the Khom Thai script, with the goal of facilitating learning. Your opinion will be valuable input that will help me to improve my design, if you decide to participate.

ข้าพเจ้า นางสาว ฟาริคา วิรุฬหผล เป็นนักศึกษาระคับปริญญาเอก ณ มหาวิทยาลัยฮัคเคอร์สฟิลค์ตั้งแต่พ.ศ.2556

ในขณะนี้ข้าพเจ้ากำลังคำเนินการวิจัยเกี่ยวกับการออกแบบตัวอักษรขอมไทยซึ่งมุ่งหวังเพื่อเสริมสร้างการเรียนรู้อักษรชนิคนี้ ความคิคเห็นของคณจะเป็นข้อมลสำคัญต่อการออกแบบตัวอักษรเป็นอย่างยิ่งหากท่านเลือกที่จะเข้าร่วมงานวิจัย

Purpose of the research จุดประสงค์ของงานวิจัย

This research aims to study the impact of the mere-exposure effect on the letterforms of Khom Thai script via typeface design.

Mere-exposure, or the familiarity effect, is a psychological phenomenon in which people tend to recognize familiar objects better than unknown artifacts.

งานวิจัยชิ้นนี้มีจุดประสงค์เพื่อศึกษาผลกระทบของทฤษฎีว่าด้วยความเคยชินที่มีผลต่อรูปทรงของตัวอักษรขอมไทยโดยผ่าน การเปรียบเทียบรูป ทรงของการออกแบบตัวอักษร ทฤษฎีความคุ้นเคยเป็นทฤษฎีทางจิตวิทยาว่าด้วยพฤติกรรมของมนุษย์ที่ จะจดจำสิ่งที่ตนคุ้นเคยได้ดีกว่าสิ่งของที่ไม่เคยพบเห็นมาก่อน

Procedures ขั้นตอนในการเก็บข้อมูล

You will be provided three questionnaires. These three questionnaires will ask for your level of agreement with sentences describing the TLK typefaces series.

คุณจะได้รับแบบสอบถามสามชุคซึ่งจะให้คุณเลือกประโยคที่คุณเห็นด้วยมากที่สุดในการอธิบายลักษณะของชุคตัวอักษร TLK series

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Part I: Information Sheet Participant Selection การเลือกผู้เข้าร่วมในงานวิจัย

I would like to invite you to participate in this research, because your expertise in Thai paleography could contribute valuable knowledge on the historical aspect of Khom Thai script.

ข้าพเจ้าขอเชิญท่านผู้ทรงคุณวุฒิเข้าร่วมในงานวิจัยชิ้นนี้เพราะความรู้ความเชี่ยวชาญของท่านทางค้านจารึกของไทยจะเป็นความรู้อันเป็น ประโยชน์ทางค้านประวัติศาสตร์ของอักษรขอมไทย

Voluntary Participation ความสมัครใจในการร่วมงานวิจัย

Your participation in this research is entirely voluntary. If you do not want to participate in this research, you can freely decide against signing this form.

การเข้าร่วมงานวิจัยของคุณนั้นเป็นความสมัครใจทั้งสิ้น ในกรณีที่ท่านรู้สึกว่าไม่อยากเข้าร่วมในงานวิจัยนี้ คุณสามารถปฏิเสธที่จะเซ็นต์ เอกสารชคนี้ได้อย่างอิสระ

Confidentiality การรักษาความลับ

All the information that is provided by you will be protected and reported without any distortion. The information that is given to the researcher will be kept private. Your name will be anonymous.

The typefaces in the TLK series belong to the University of Huddersfield. You must not share any materials from this research with anyone to avoid any copyright infringements.

ข้อมูลทั้งหมดที่กุณได้ให้ไว้กับนักวิจัยจะได้รับการกุ้มกรองและรายงานโดยไม่มีการบิดเบือน ข้อมูลจะถูกเก็บเป็นความลับ โดยชื่อของ ชื่อของกุณจะไม่มีการะบุ

อักษรในชุด TLK เป็นลิขสิทธิ์ของมหาวิทยาลัยฮัดเดอร์สฟิลด์ คุณจะต้องไม่เปิดเผยเอกสารใด ๆ ที่ได้จากการวิจัยนี้ให้ใครทราบ เพื่อหลีกเลี่ยงการละเมิดลิขสิทธิ์ใด ๆ

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Part I: Information Sheet Contact information ข้อมูลในการติดต่อ

If you wish to ask questions later, you can contact me as follows: ถ้าคุณต้องการจะถามคำถามใดๆในภายหลัง คุณสามารถติดต่อนักวิจัยได้ดังต่อไปนี้

Ms. Farida Virunhaphol นางสาว ฟาริคา วิรุพหผล PhD candidate/Lecturer นักศึกษาปริญญาเอก/อาจารย์

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Part II: Certificate of Consent
รับรองความยินยอม
Statement by the participant
ถ้อยแถลงโดยผู้เข้าร่วม
I have read all of the above information, and I acknowledge all the terms and conditions.
I have had the opportunity to freely ask any question about participating.
I voluntarily consent to be a participant in this research without being forced or deceived to sign this form.
I permit the researcher to use all the information provided by me in her research.
ข้าพเจ้าได้อ่านข้อมูลทั้งหมดข้างต้นและรับทราบข้อกำหนดและเงื่อนไขทุกอย่าง ข้าพเจ้าได้รับโอกาสที่จะถามกำถามใด ๆ
เกี่ยวกับการมีส่วนร่วมในงานวิจัยครั้งนี้ได้อย่างอิสระ ข้าพเจ้าสมัครใจยินยอมที่จะมีส่วนร่วมในการวิจัยครั้งนี้ได้โดยไม่ได้ถูกบังกับ
หรือหลอกให้ลงนามในแบบฟอร์มนี้ ข้าพเจ้าอนุญาตให้นักวิจัยที่จะใช้ข้อมูลทั้งหมดที่ได้มาจากข้าพเจ้าในงานวิจัยของเธอ
Print Name of Participant (ชื่อตัวพิมพ์ของผู้เข้าร่วมวิจัย)
Signature of Participant (ลงนามชื่อของผู้เข้าร่วมวิจัย)
Date (วันที่)
Day/month/year (วันที่/เดือน/ปี)
Zaymenan yan (an mano m Z)
Statement by the researcher
ถ้อยแถลงโดยผู้วิจัย
I confirm that there has no deceptions have been involved in this research.
The participant gave his or her consent voluntarily, without being deceived or being coerced.
A copy of this form has been provided to the participant as an agreement to participate in this research.
ข้าพเจ้ายืนยันว่าไม่มีการหลอกลวงใดๆในการวิจัยนี้ ผู้เข้าร่วมให้ความยินยอมของพวกูเขา
ด้วยความสมัครใจโดยไม่ถูกหลอกหรือถูกข่มขู่ ผู้เข้าร่วมได้รับสำเนาของแบบฟอร์มนี้เป็นข้อตกลง
ที่จะมีส่วนร่วมในงานวิจัยนี้ร่วมกัน
Print Name of Researcher (ชื่อตัวพิมพ์ของนักวิจัย)
Signature of Researcher (ลายเซ็นต์ของนักวิจัย)

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Introduction

This portfolio collects my drawings and letterform designs from 2013 to 2016. I have submitted it as part of my practice-led research project, and the intention is for it to be read in conjunction with the thesis. The main purpose of this portfolio is to demonstrate how the TLK letterform designs were developed. The TLK letterform design family consists of TLK Manussa, TLK Deva, and TLK Brahma. To begin, TLK Manussa was inspired by present-day Thai letterforms. It integrates characteristics of the modern Thai script, so as to appeal to younger Thais. In contrast, TLK Deva and TLK Brahma follow traditional Khom Thai writing styles. This portfolio is divided into two main sections. The first part contains progress sketches. It consists of my hand-drawn illustrations and computer sketches, which preceded the final designs. The second part describes the three letterform designs. It provides the specifications for the design of the TLK letterforms, and it also explains how each character was crafted. As the accompanying thesis has addressed, very few guidelines govern the design of Khom Thai letterform designs. This portfolio details the Khom Thai design process, and the community of non-Latin design practitioners can utilize it as a reference.

SELECTION SERVING SERV

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Sketches

The initial goal of this project was quite simple: to design Khom Thai s to help students learn Khom Thai more effectively. Two factors motivated me. These were my personal struggles to learn the script and interviews with three lecturers (see Appendix D in the thesis) that underscored that the letterforms' complexity constitutes the primary hurdle for students of Khom Thai. From my experience, it occurred to me that I could not able to remember the Khom Thai characters, especially those with different typographic features than the present-day Thai characters.

My first attempt was quite impractical. After a lengthy exploration of theories on design and learning, the theory of anthropomorphism initially attracted me. This concept relies on the idea that assigning human characteristics to objects might attract people's attention more easily than other forms¹ (DiSalvo and Gemperle, 2003). Thus, I tried to associate the Khom Thai structures with human forms. However, after reviewing key works from the literatures, I could not find any strong evidence in support of this notion. Moreover, there were no connections between the Khom Thai script and anthropomorphic shapes.

Nonetheless, my primary concern was that it would be challenging to create digitized versions of the letterforms, since they are complex and barely legible. After sketching some letters, I eventually realized that anthropomorphism was not the solution to my design problem. Therefore, I examined other possibilities for developing Khom Thai s.

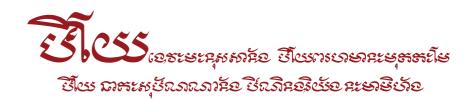
I identified a factor that could potentially assist students in learning the Khom Thai characters. In contrast to the Roman alphabet, each Thai letter (as well as each Khom Thai character) has its own meaning. For instance, one letter is called "ko kai", which means "chicken" in the Thai language.

Therefore, my next attempt focused on trying to associate the Khom Thai letterforms with these meanings. For example, I drew a picture of a tiger for the letter so suea (in the Thai language, "so suea" means "tiger"). Again, the letterforms were illegible and impractical. The design was too extreme, and it had completely broken away from conventions to the point of being unrecognizable.

I grew frustrated that I was unable to identify an appropriate design solution. As much as I wanted to create something new, certain limitations hindered me from doing so. My s needed to be recognizable as Khom Thai, and they also needed to be readable.

Therefore, my next step entailed searching for commonalities between the past and the present. There are five Thai characters that obviously resemble Khom Thai. In general, however, the two scripts differ from each other in terms of appearance.

It was at this point that I started writing Chapter 2 of my thesis. Thus, I observed the two scripts side-by-side and noted that the Khom Thai letterforms are generally wider. As I explained in Chapter 23 I started incorporating characteristics of the modern Thai script into my TLK Manussa sketches. This approach provided some direction regarding the design of the other s. At this stage, I experimented with calligraphic pens, pencils, and a metal stylus, before I began sketching on the computer. Although my final designs were not strictly based on these initial sketches, that process expanded my creativity and offered me insights into the working process.



¹ DiSalvo, C., & Gemperle, F. (2003). From seduction to fulfillment: the use of anthropomorphic form in design. Paper presented at the the 2003 International Conference on Designing Pleasurable Products and Interfaces, Pittsburgh, USA.



Figure 1. Anthropomorphic Khom Thai sketches inspired by Mayan, Egyptian, and Rongorongo scripts, designed by the author

This is one of my initial sketches of the letters, ko kai and kho kwai. The design is no longer recognisable as Khom Thai.

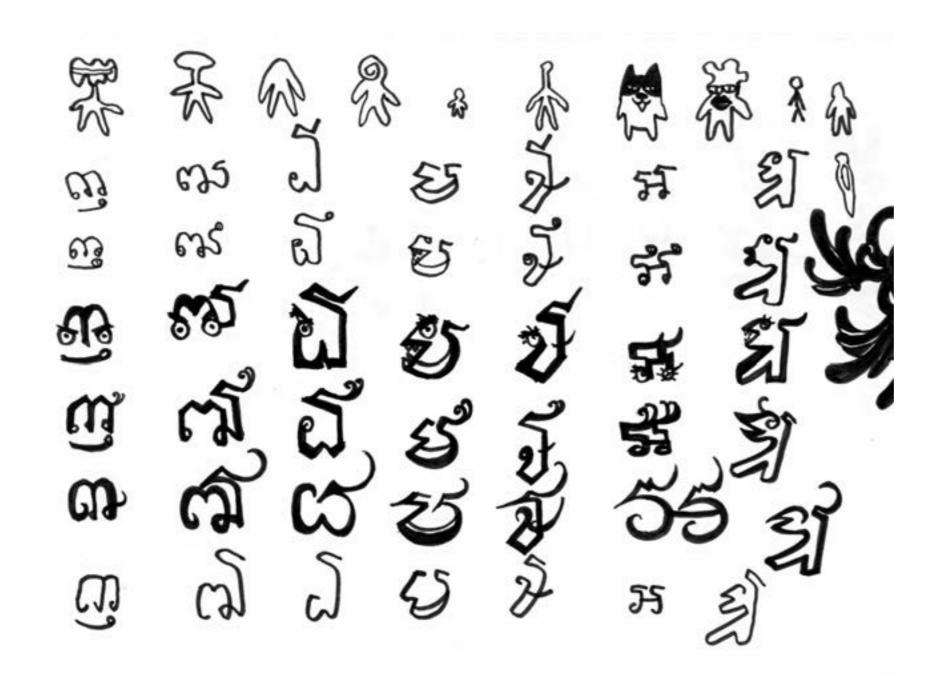


Figure 2. Anthropomorphic Khom Thai sketches inspired by Mayan, Egyptian, and Rongorongo scripts, designed by the author

This sketch represents a further attempt to impart some human characteristics to the Khom Thai letters. While the characters are more legible than in Figure 1, they are still difficult to recognize as Khom Thai.



Figure 3. Anthropomorphic Khom Thai sketches inspired by Mayan, Egyptian, and Rongorongo scripts, designed by the author

In this attempt, instead of using the entire human body, an eye, lip, and hand were assigned to the Khom Thai letterforms.

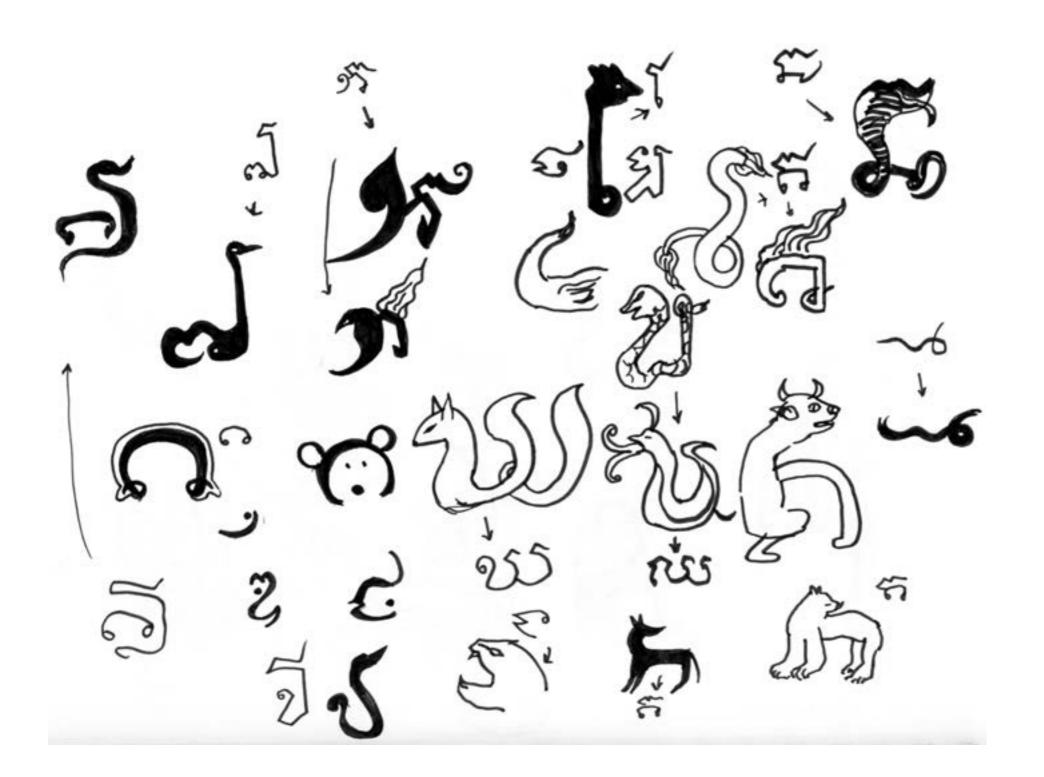


Figure 4. Zoomorphic Khom Thai sketches, designed by the author

I also experimented with zoomorphic letterforms. No particular theory informed this approach, although certain Thai letters have meanings associated with animals. Thus, I was interested in exploring whether it would be possible to use animal shapes in the letterform designs. Again, the letterforms are very illegible.



Figure 5. Zoomorphic Khom Thai sketches, designed by the author



Figure 6. Anthropomorphic and zoomorphic Khom Thai sketches, designed by the author

Apart from using animal and human features as references, I also tried to integrate traditional Thai patterns into the designs. The result was complex letterforms that would be highly impractical.

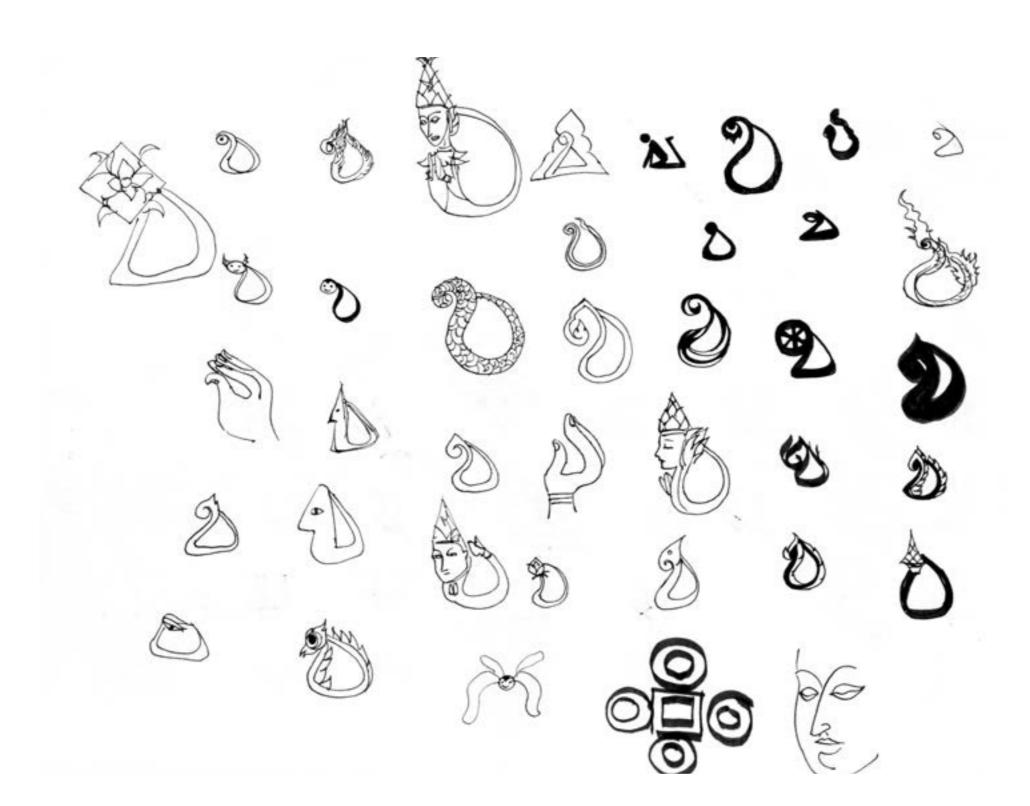


Figure 7. Anthropomorphic Khom Thai sketches, designed by the author



Figure 8. Khom Thai characters, designed by the author

I created this set of characters to study basic Khom Thai structures. The simpler the letterforms, the easier they were to read.

Figure 9.A traditional Thai pattern, "Kanok", sketched by the author

In one attempt to make my letterform designs unique, I relied on *Kanok*, a traditional Thai pattern, as a design reference. However, Kanok had many complex structures that were not a suitable fit for the letterform design, and so I eventually dropped this idea.

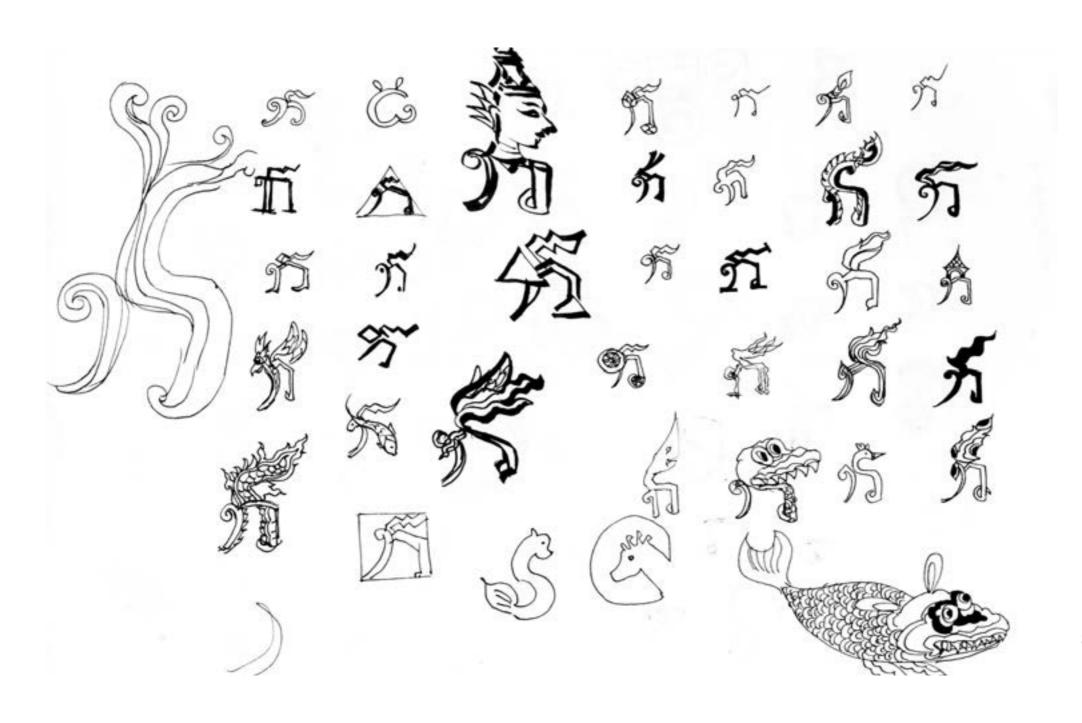


Figure 10. Anthropomorphic and zoomorphic Khom Thai sketches, designed by the author

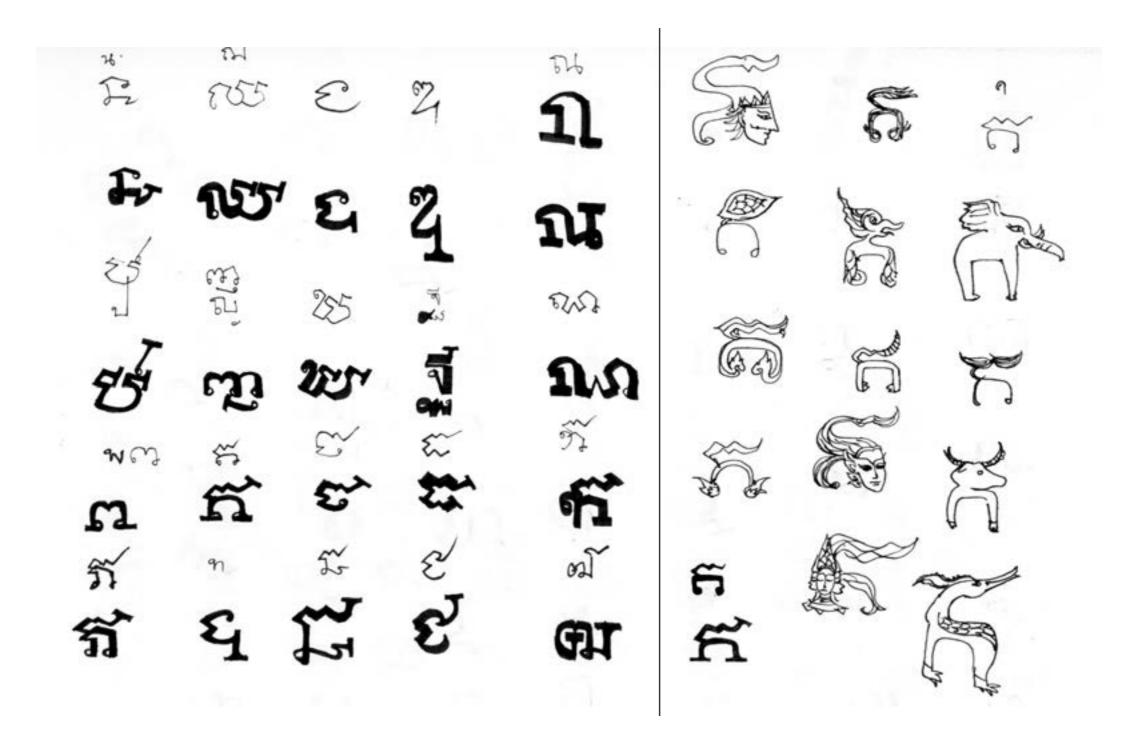


Figure 11. Khom Thai characters with serifs, designed by the author

One of the main debates in Western legibility research focuses on whether serifs make a letterform design more legible. After reviewing the literature on legibility (see Chapter 2 of my thesis), I sketched some serifs for Khom Thai. This feature seemed to be unnecessary, however, since Khom Thai already has loops that are somewhat comparable to serifs.

Figure 12. Anthropomorphic and zoomorphic Khom Thai sketches, designed by the author

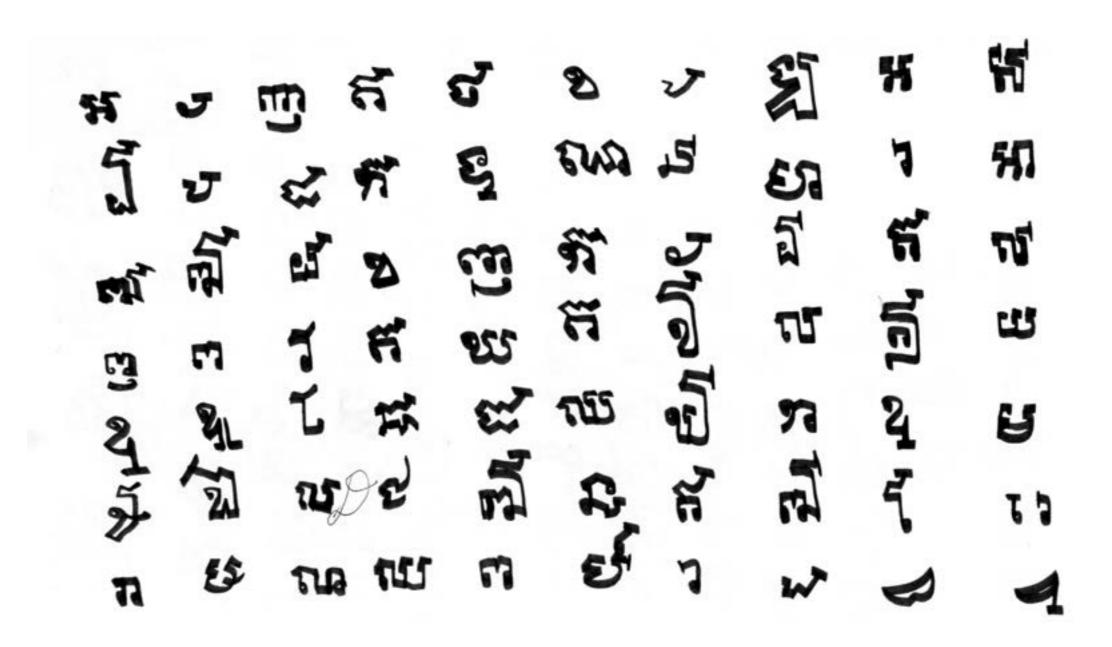


Figure 13. Khom Thai characters with serifs, designed by the author

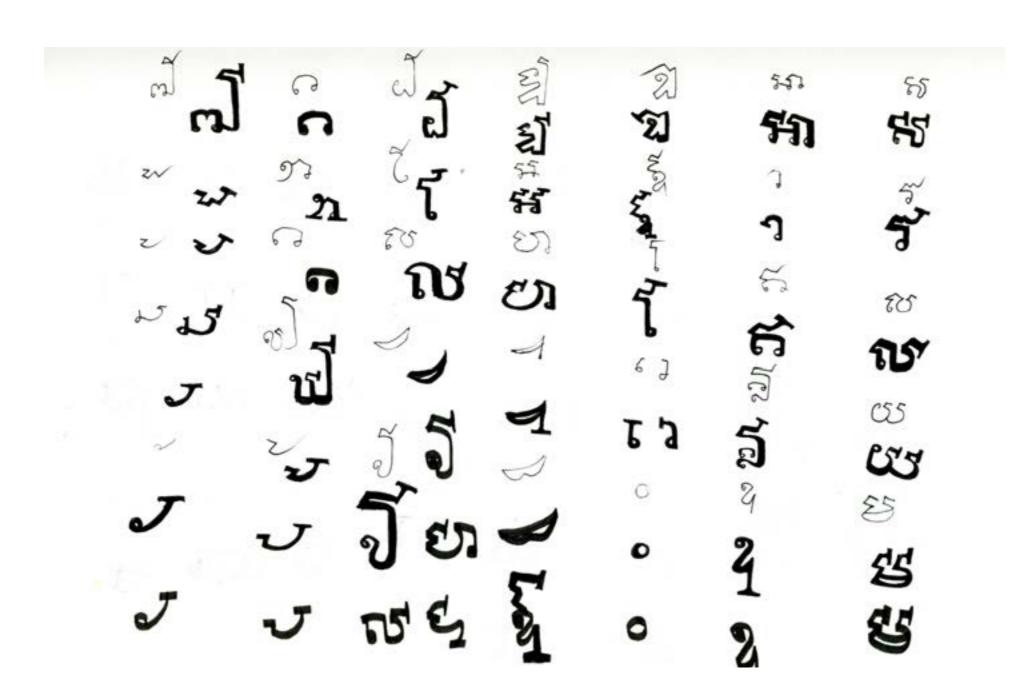


Figure 14. Khom Thai characters with serifs, designed by the author

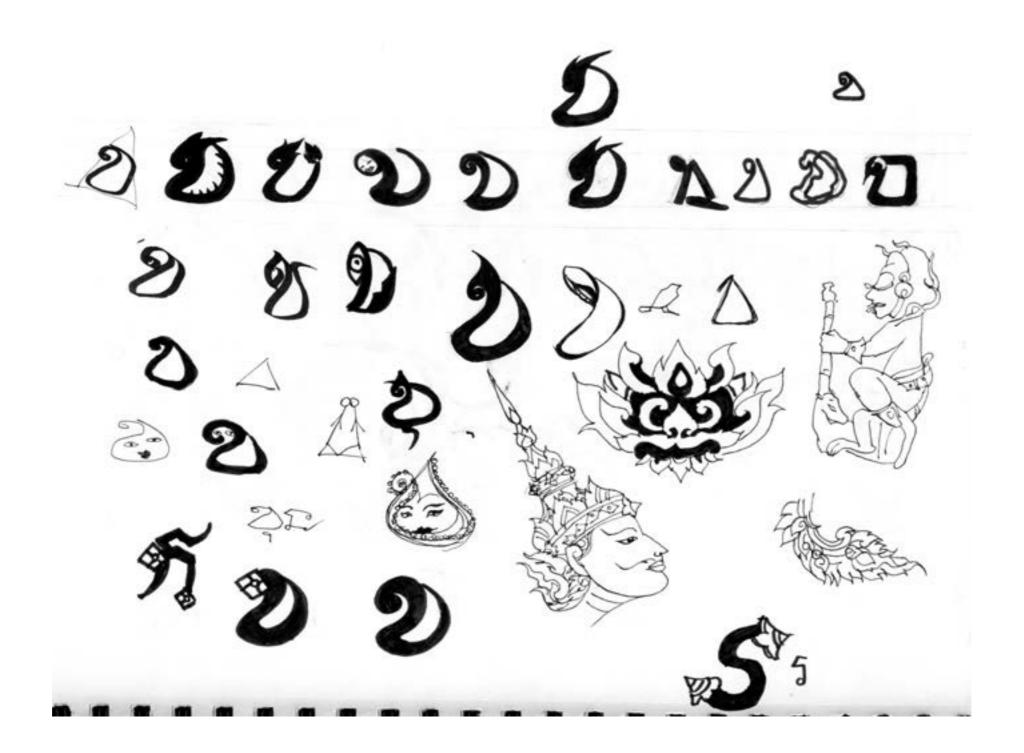


Figure 15. Anthropomorphic and zoomorphic Khom Thai sketches, designed by the author

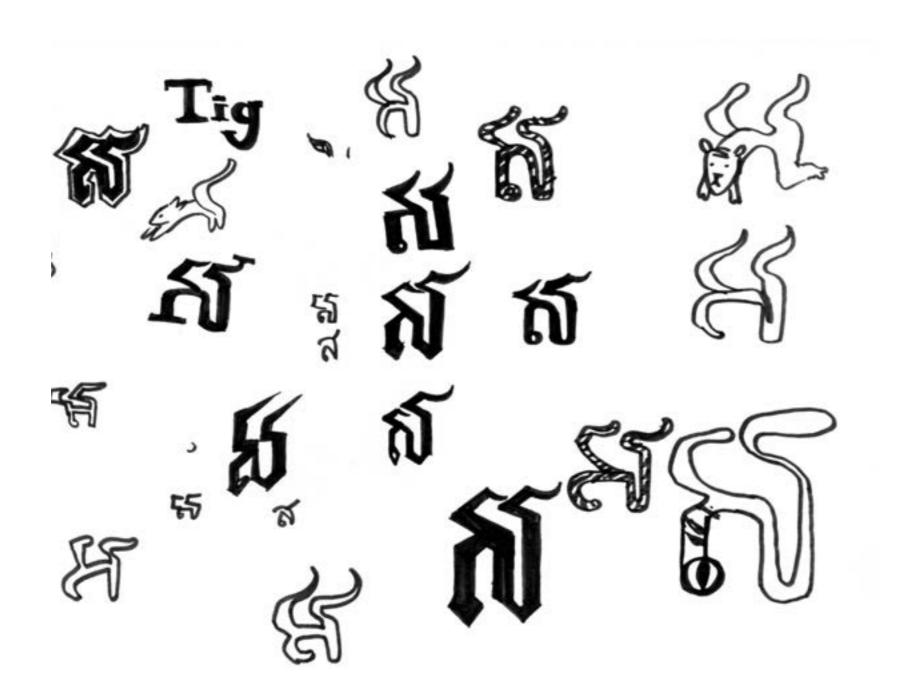


Figure 16. Zoomorphic sketches of the Khom Thai letter, so suea, designed by the author

Figure 17. Sketches of three Khom Thai characters (tho phuthao, cho choe, and so suea), sketched by The author and inspired by the RST's type design model

After studying the Khom Thai letterforms, I introduced the proportions of the present-day Thai script in sketches. The characters grew more legible. However, at this stage, I was still exploring the concept of zoomorphism. While the results were more readable than the previous drawings, they still featured a strange appearance.



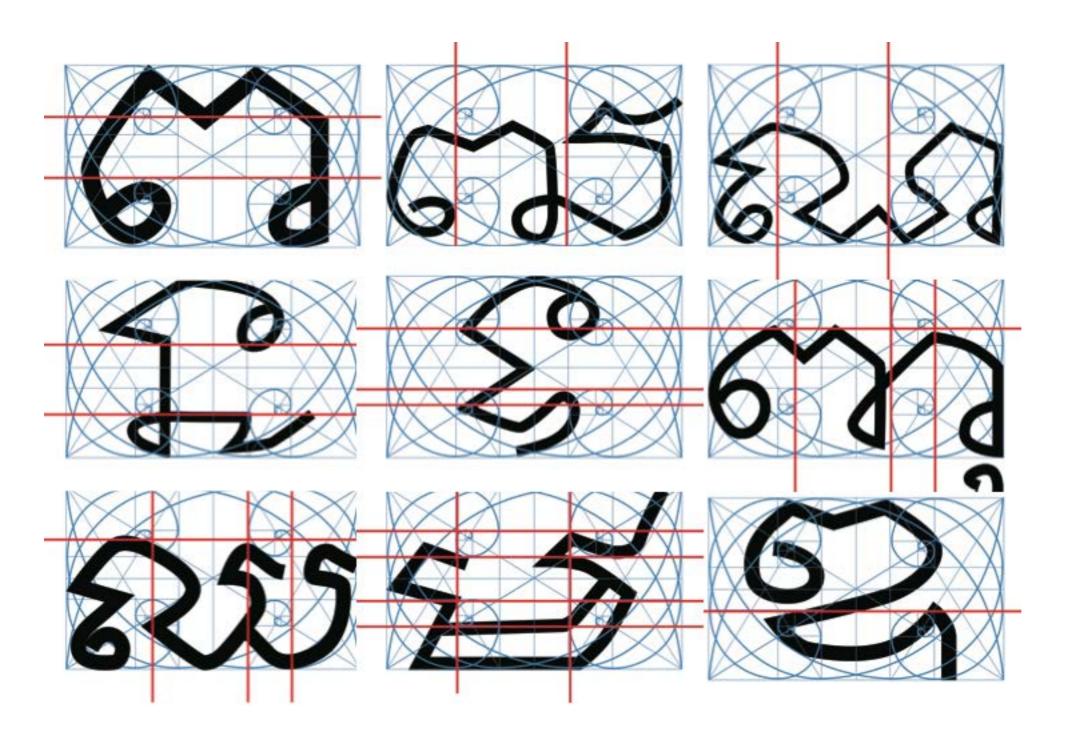


Figure 18. Sketches of Khom Thai characters, designed by The author and inspired by the National Library of Thailand's writing model

Since my initial sketches had met with limited success, I returned to the computer and started to roughly sketch a few letterforms, using the National Library's model as a model. I did not have many guidelines, and so I created a bounding box based on the golden ratio. These sketches were in closer alignment with the appearance of traditional Khom Thai, and they later inspired the concepts behind two of my letterform designs, TLK Deva and TLK Brahma.

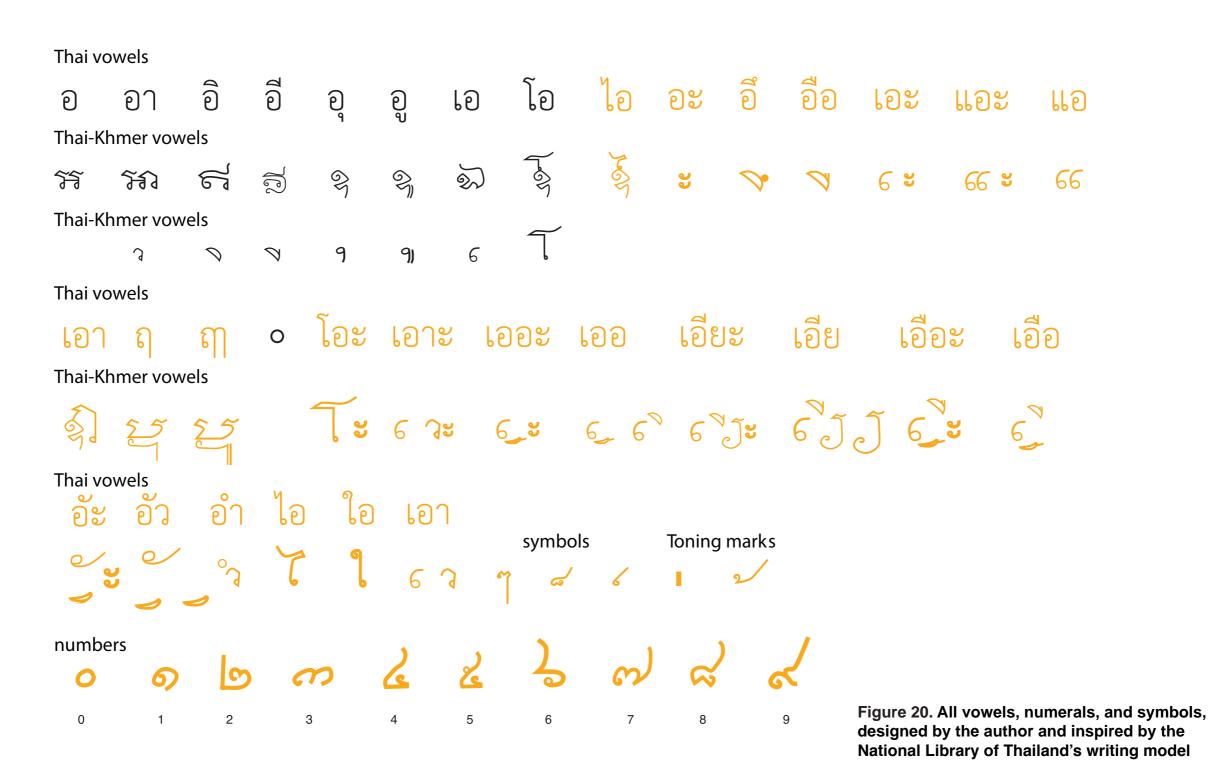
ก/k/ ข/kh/ข/kh/ค/kh/ค/kh/ฆ/kh/ง/ng/จ/ch/ฉ/ch/ช/ch/ซ/s//ฌ ch/ญ/y//ฏ d/ ฏ/d/ Thai-Khmer Script (initial consonants) - 25 C T FF Z RUS AN 677 Thai-Khmer Script (final consonants) 2 Standard Thai Alphabet ฐ /th/ฑ /th/ฒ /th/น n/ ด /d/ ต /t/ ถ /th/ท /th/ ธ /th//น n/ บ /b//ป p/ ผ /ph/ ฝ /f/ พ /ph/ Thai-Khmer Script (initial consonants) as anger of som a so so Thai-Khmer Script (final consonants) Standard Thai Alphabet ฟ/f/ ฦ/ph/ฆ/m//ย y/ ร/r/ ล/l/ ว/w//ศ s/ ษ/s//ส s/ ห/h/ ฬ/l/ อ /o//ฮ Thai-Khmer Script (initial consonants) Thai-Khmer Script (final consonants) Figure 19. All full-form letters and consonantal

Standard Thai Alphabet

After crudely sketching some characters, I developed all of the full-form characters and consonantal subscripts.

subscripts, designed by the author and inspired by the National Library of Thailand's writing

model



22

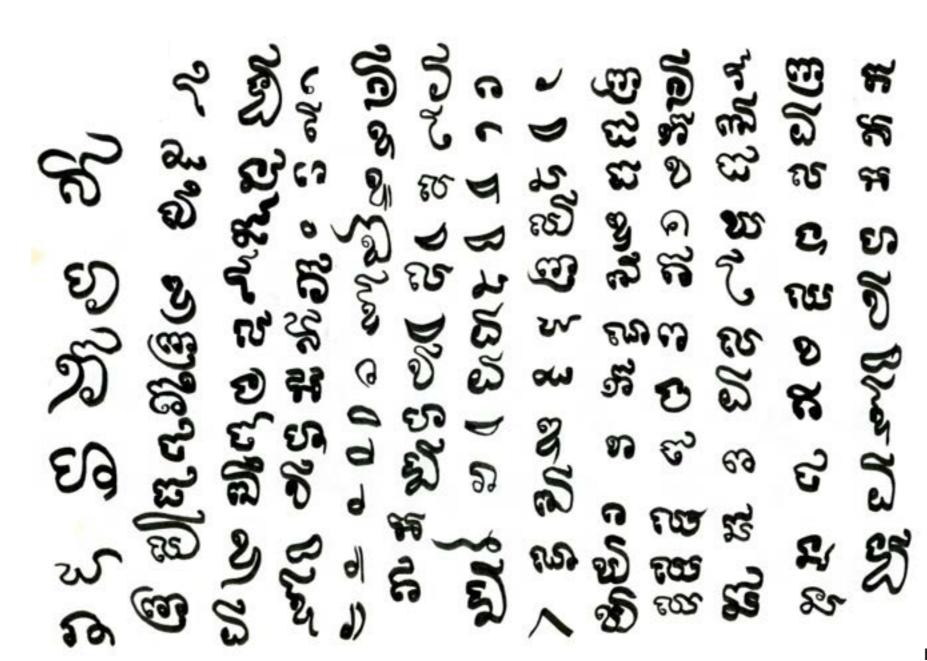


Figure 21. Sketches of Khom Thai characters, designed by the author

I continued sketching, but I abandoned human and animal forms, due to their lack of connections with Khom Thai. Rather, I experimented with a pen, and I tried to draw high stroke contrast letterforms. These later evolved into the TLK Brahma design.

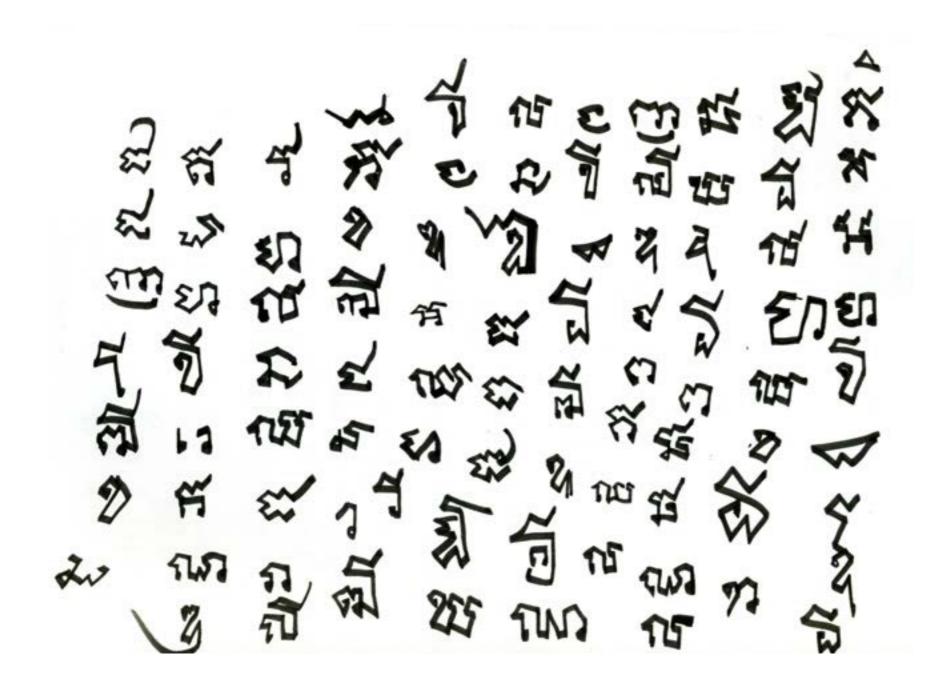


Figure 22. Sketches of Khom Thai characters, designed by the author

This sketch represent my attempt to make the characters more angular. However, as Chapter 2 indicates, Khom Thai letterforms are actually roundish.

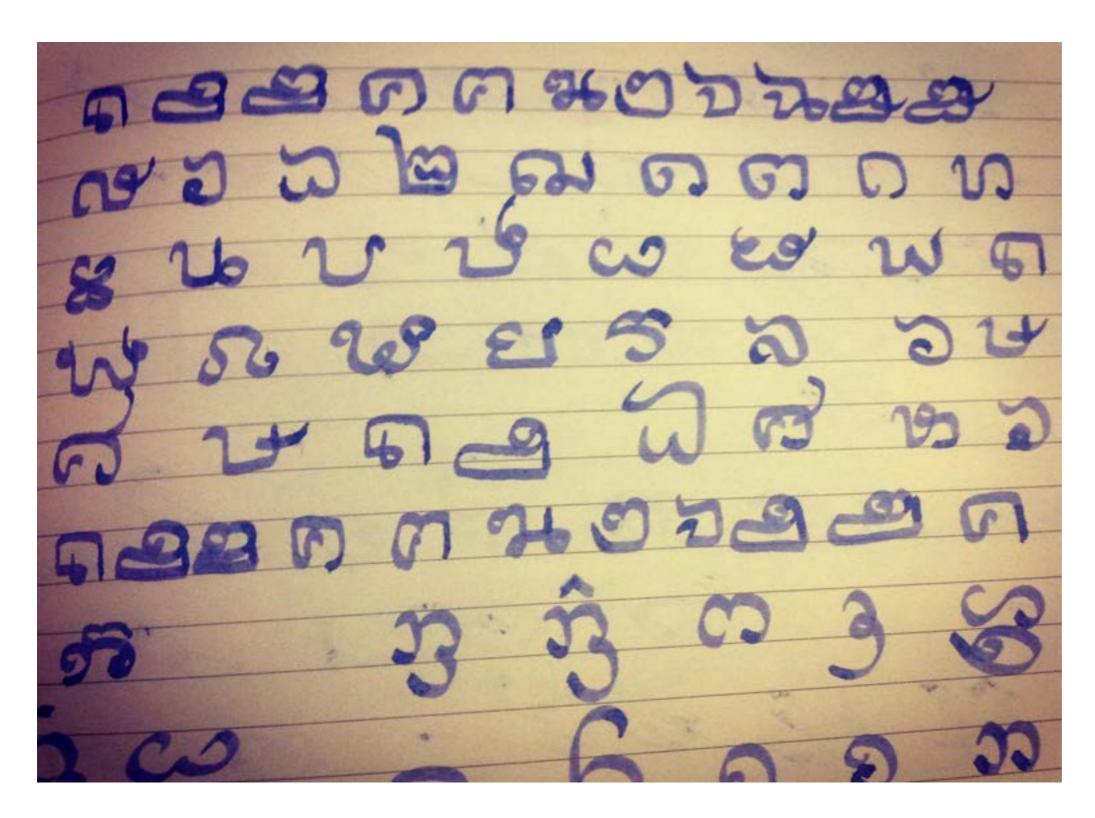


Figure 23. Sketches of Thai characters, designed by The author

This sketch illustrates a reverse process. Initially, I had tried to incorporate the characteristics of the present-day Thai script into Khom Thai. Here, I instead sketched a group of Thai characters and gave them Khom Thai-style typographic features as an experiment.



Figure 24. Writing on a palm leaf, by the author

The next method that I explored was adopting traditional writing techniques. Writing on a palm leaf was more challenging than I had expected, as its surface was slippery. The traditional hand position made it difficult to control my hand while writing. Another obstacle revolved around the fact that I could not see the letterforms, since they were inscribed on the surface without the use of ink.

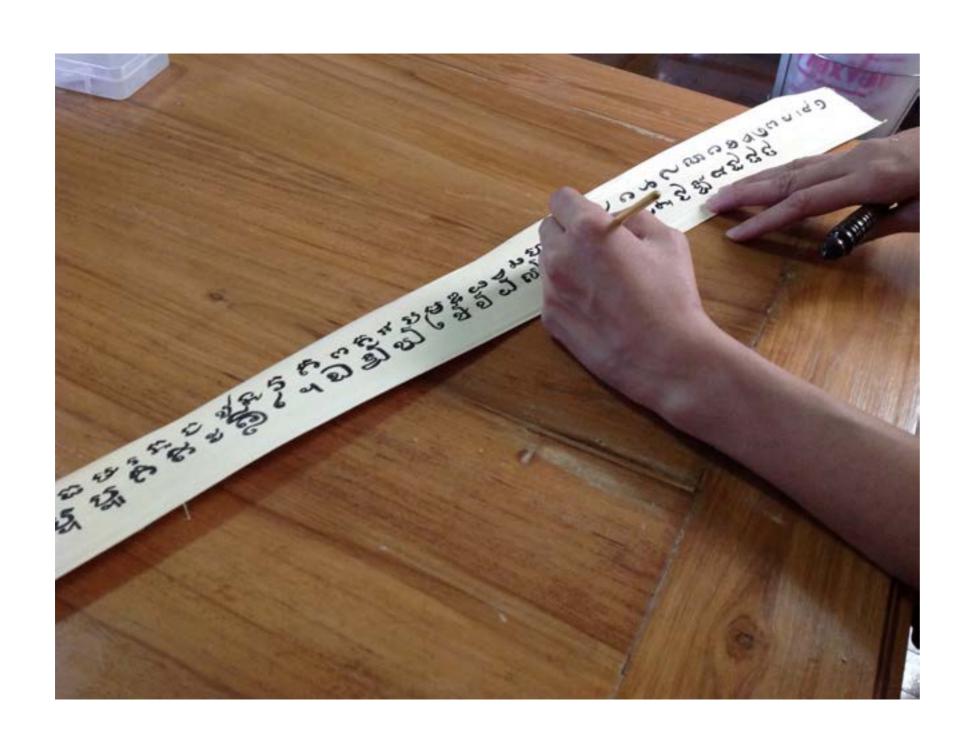


Figure 25. Writing on a palm leaf, by the author

I tried another approach: using a brush and ink on a palm leaf. In contrast to my earlier attempt, the letterforms were visible. However, since I am left-handed, I needed to carefully ensure that the ink was dry before I sketched each character. If the ink had not dried, my left hand would have smeared the wet ink, creating messy letterforms. Traditionally, Khom Thai letterforms are smaller than the characters that I drew. However, I struggled to control my hand, since the palm leaf was quite slippery, and so I needed to practice by writing larger characters.

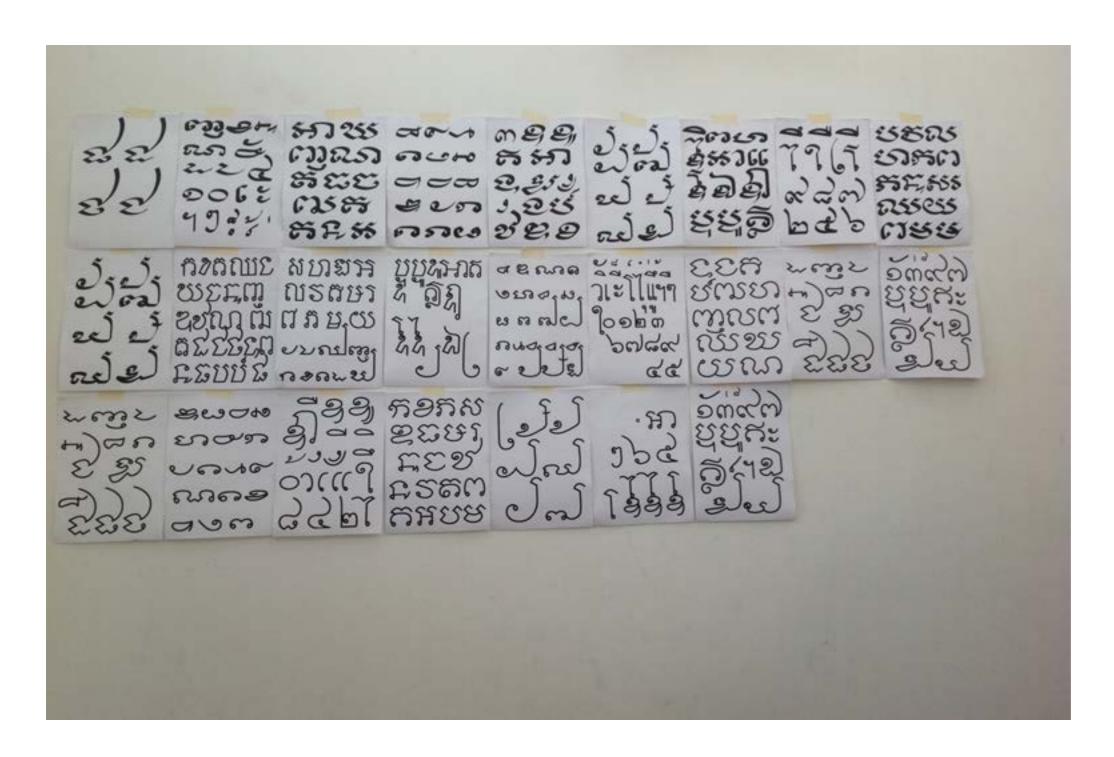


Figure 26. Sketches on the computer, by the author

After I had studied Khom Thai letterforms through hand sketching, I had a better understanding of their main structures and features. I used Trai Phum as a reference as I developed TLK Deva and TLK Brahma on the computer. I printed out all the letterforms to view the details of my initial designs.

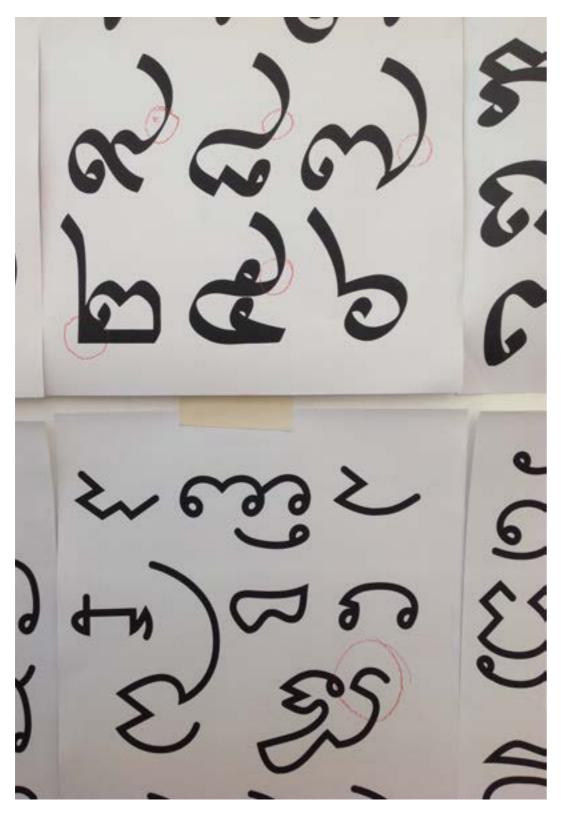


Figure 27. Initial corrections (marked in red) on the TLK Deva and TLK Brahma sketches, by the author

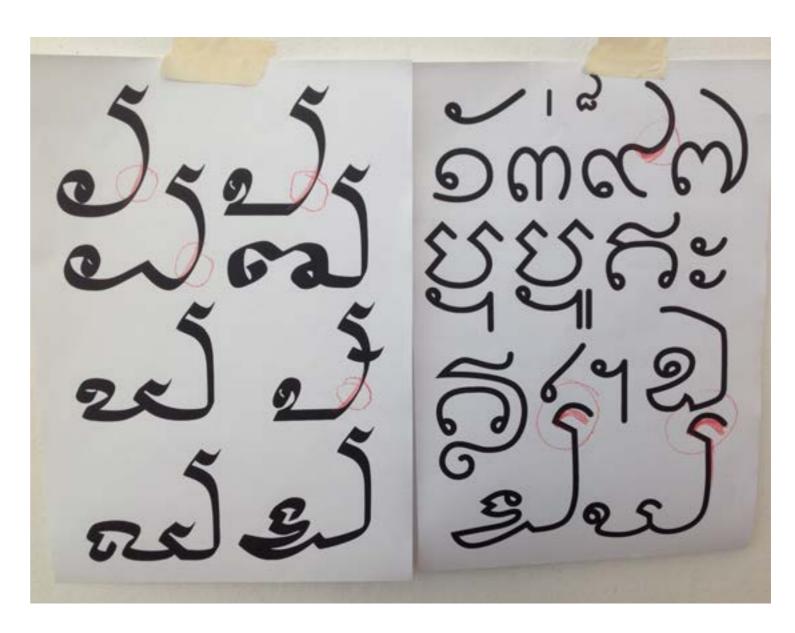


Figure 28. Initial corrections (marked in red) on the TLK Deva and TLK Brahma sketches, by the author

When creating the first draft of TLK Brahma, the main problem that I encountered involved the stroke contrast of some of the thinner stems. The contrast seemed too high, and so I later adjusted it.

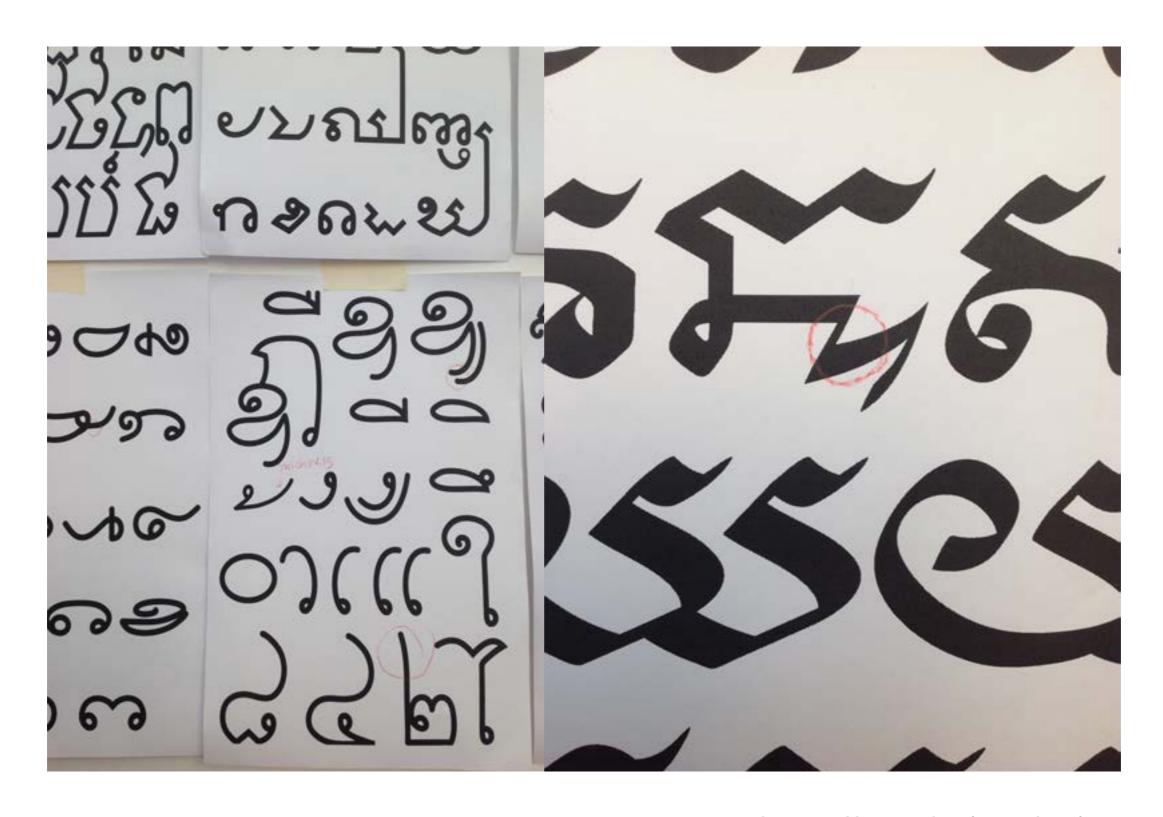
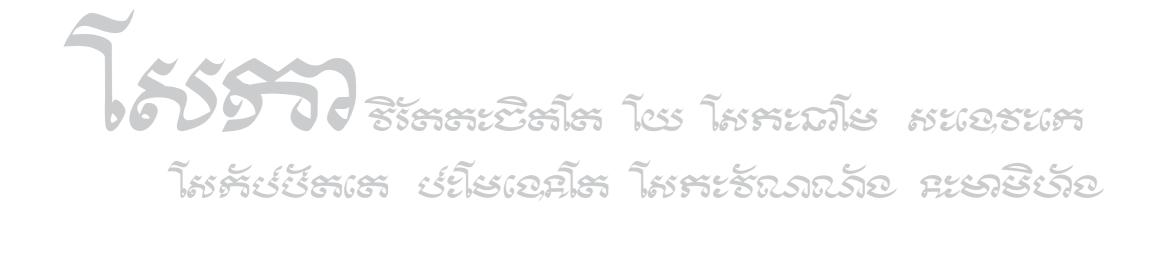


Figure 29. Initial corrections (marked in red) on the TLK Deva and TLK Brahma sketches, by the author

The development of the three letterform designs

Chapter 3 of my thesis described each 's development and my working processes. The portfolio complements that information by recording my role in designing the three letterform designs. It contains my reflections on the process of creating the TLK letterform designs. Moreover, it provides proportional dimensions and specimen sheets for each letterform design. I adjusted the TLK letterform designs in three major times. Therefore, in the section describing the development of each character, I provide both the initial designs and the final version. Each character of TLK letterform designs are intended to be used separately. The reason is: TLK Deva and TLK Brahma are writing models while TLK Manussa will be developed into character mnemonics therefore they are not fonts or typefaces. The measurement units that are used here are the Royal Society of Thailand's system (written in black), however, corresponding values according to a system of 1000 units per em have been added (written in red) in order to provide a reference for type designers wishing to work with a 1000-unit system. The grid shown in these illustrations is based on the Royal Society of Thailand's system.



TLK Brahma อีแหณะยถย่อ

TLK Brahma as a writing model



TLK Brahma is a letterform design that is intended to be used as a writing model based on the Sen Chup style. This style has a high stroke weight contrast, as illustrated in Figure 30.

The working method of TLK Brahma started with examining the general letterforms and formed the overall structures of certain key letters. Then, I tried to find references for individual letters in the manuscript and adjusted each character's letterforms accordingly. However, when I could not find a model for an individual letter, I instead used the other characters in the group.

Figure 30. Details of the second writing style in *Trai Phum Ayutthaya no.7* at 25% of the original size. Adapted from *Samutpap Trai Phum chabap akson Khom pasa Thai*², by Kana kammakan fai pramuan ekkasan lae chotmaihet, 2007, p. 81, Copyright 2007 by National Library of Thailand.

Figure 31. Khom Thai characters written in accordance with TLK Brahma's model, by Virunhaphol

² Kana kammakan fai pramuan ekkasan lae chotmaihet. (2007). *Samutpap Trai Phum chabap akson Khom pasa Thai* [Trai Phum manuscript: Khom Thai version]. Bangkok, Thailand: National Library.



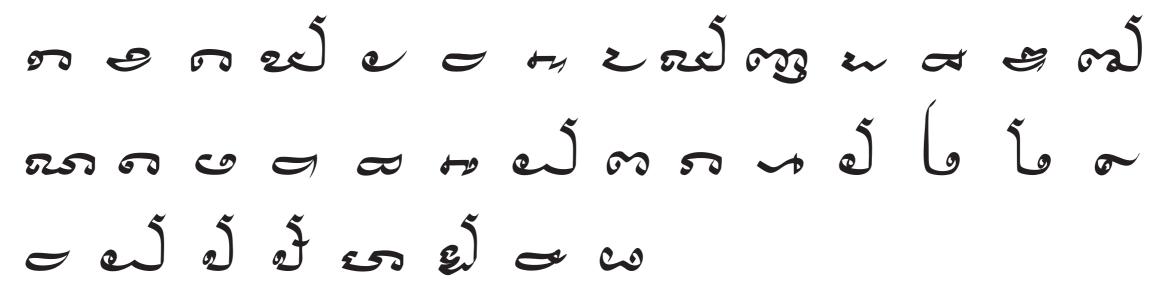
Figure 32. Examples of Khom Thai characters at 100% and written in accordance with TLK Brahma's model, by Virunhaphol

TLK Brahma Characters

Full-form characters

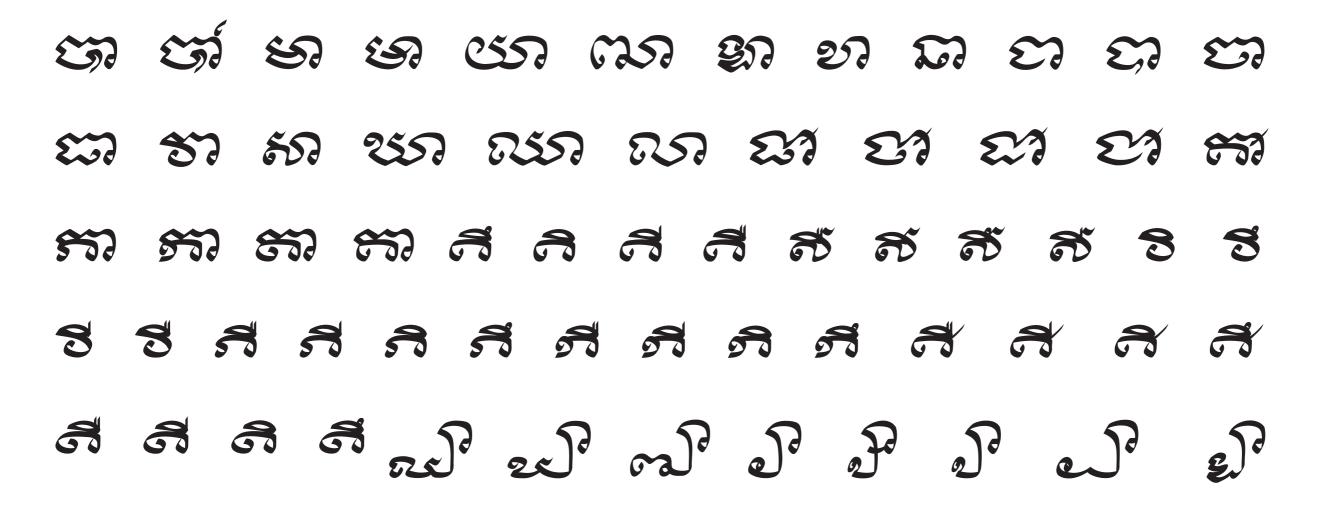


Consonantal subscripts



TLK Brahma Characters

Ligatures



TLK Brahma Characters

Independent vowels



Dependent vowels and symbols



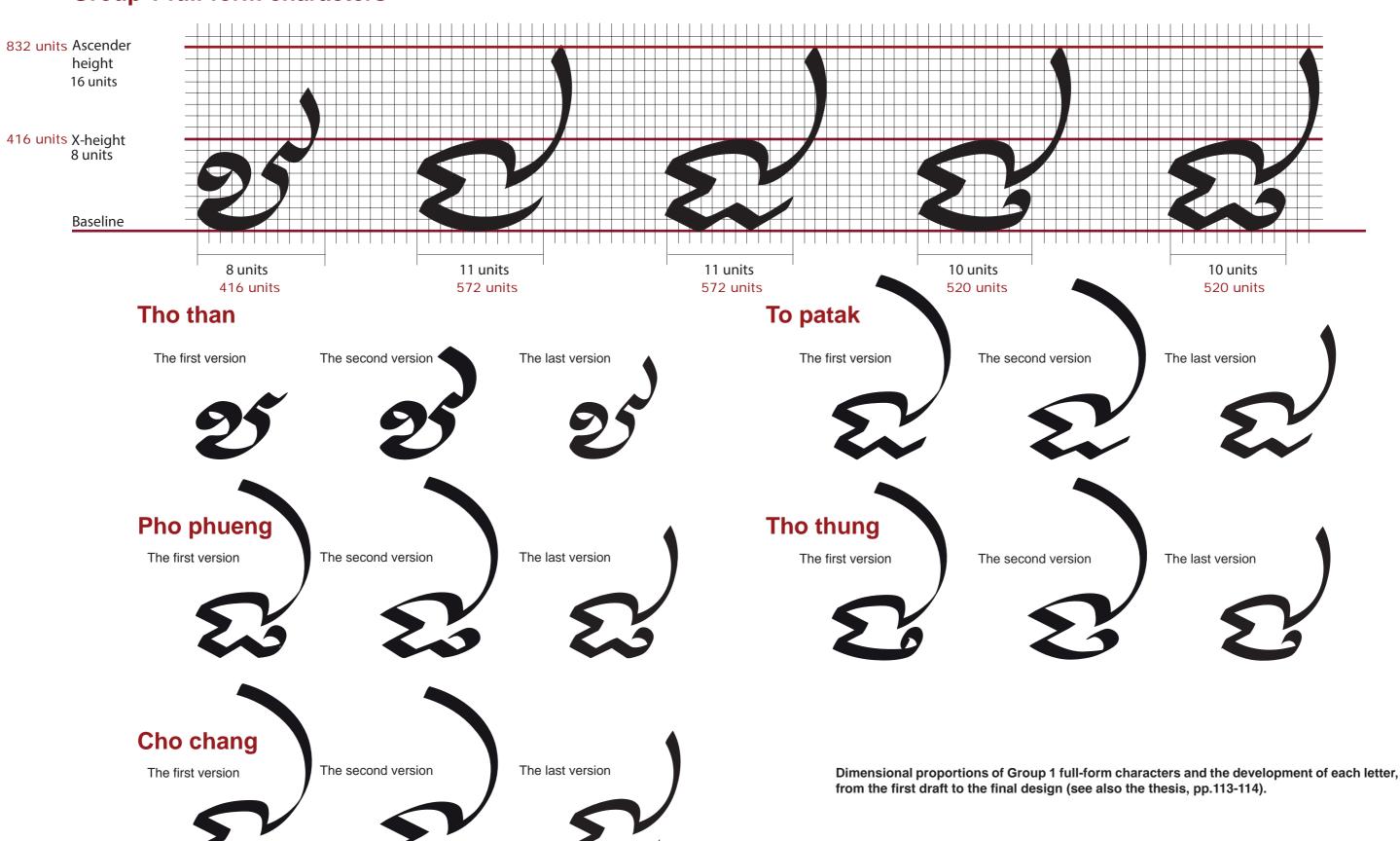
Numbers



Tone marks

ر ا

Group 1 full-form characters



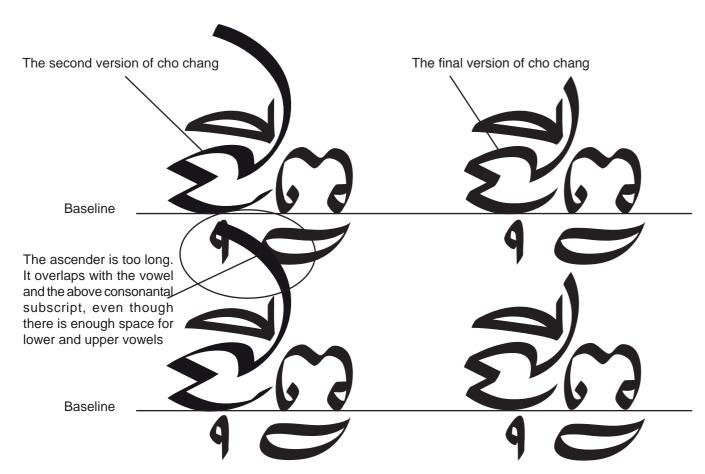


Figure 33. Comparison of cho chang in a pseudoword used for determining the ascender height

Figure 34 contrasts the second version (left) of cho chang with the final draft (right). Noticeably, in the first and the second drafts (left), the ascender is too long. There was barely enough interline space for the lower vowel and the consonantal subscript in the upper line without creating an overlap with the line below. I could chose from several solutions to remedy this problem. First, I increased the interline space. However, after testing a group of pseudowords (see Figure 34), I found that a massive amount of interline space was required to prevent the ascender from overlapping with above characters. Such a long ascender did not seem practical. The second solution was reducing the length of the ascender. Therefore, I tested various length and ultimately decided to to set the ascender height (16 units) at double the x-height (8 units).

To patak, tho thung, pho pheung, and cho chang boast nearly identical letterforms. The main issue that I needed to consider when designing them was the ascender height. It was difficult to decide how long the ascenders should be, and so I tested cho chang with other characters, Figures 33 illustrate. Cho chang was the key character in its group, and so I used its ascender height to determine the heights of the other ascenders.

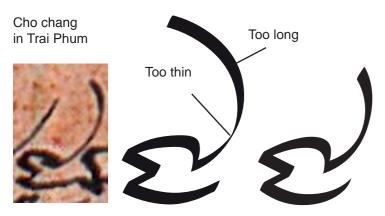


Figure 34. Comparison of cho chang between the first draft (left) and the final design (right)

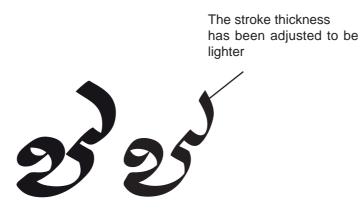


Figure 35. Comparison of the than between the first draft (left) and the final design (right)

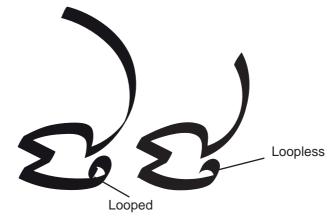
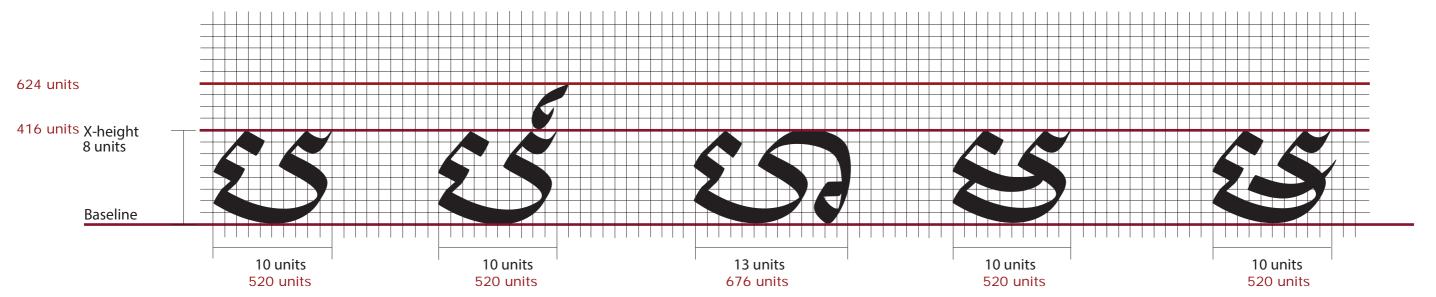


Figure 36. Comparison of tho thung between the first draft (left) and the final design (right)

Group 2 full-form characters



Bo baimai

The first version

The second version

The last version



Mo ma

The first version

The last version



The second version



Ho hip

The first version



The second version

The last version



So ruesi

The first version



The second version The last version



Po pla

The first version



The second version



The last version



Dimensional proportions of Group 2 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.114-116).

Ho hip in Trai Phum

Mo ma in Trai Phum



Figure 37. Comparison of ho hip between the first draft (left) and the final design (right)

Shorter ascender. This adjustment was made so that this letter would not collide with the upper character.

25 25

Figure 38. Comparison of po pla between the first draft (left) and the final design (right)



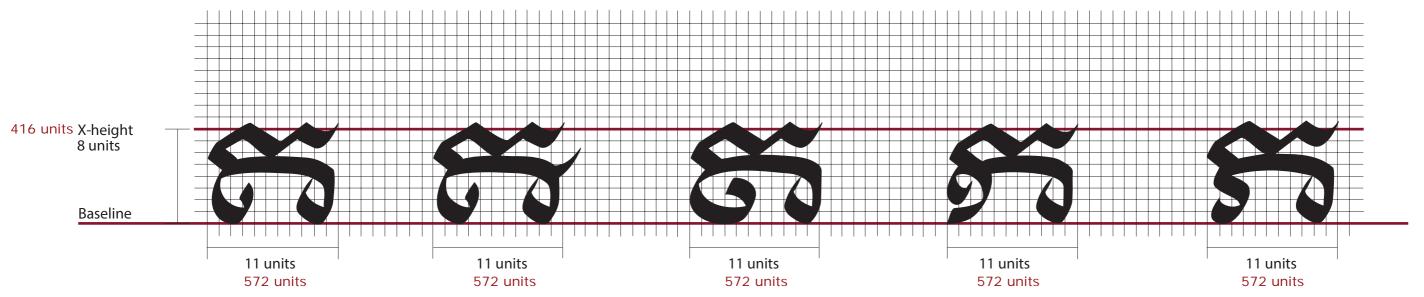
Figure 39. The final version (grey) of yo yak overlaid on top of the first version (black) to demonstrate the proportional differences

Figure 40. Example pseudowords constructed by Group 2 full-form characters



The first time I saw these characters, they reminded me of yo yak in modern Thai. However, the Thai letter has a loop, while these Khom Thai letters (with the exception of ho hip) are loopless. Based on this similarity, I first drew (the Thai) yo yak as a reference and compared it to Trai Phum. Later, I adjusted each letter, bringing them closer to Khom Thai. My final modification of the character consisted of adjusting the thickness of the stroke.

Group 3 full-form characters



Kho khwai

The first version

The second version

The last version





Pho samphao

The first version

The second version

The last version



To tao

The first version





So sala

The first version

The second version

The last version



The second version

The last version













Ko kai

The first version

The second version

The last version







Dimensional proportions of Group 3 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.116-117).



Figure 41. Comparison of to tao between the first draft (left) and the final design (right)



Figure 42. Comparison of ko kai between the first draft (left) and the final design (right)



Figure 43. Comparison of pho samphao between the first draft (left) and the final design (right)



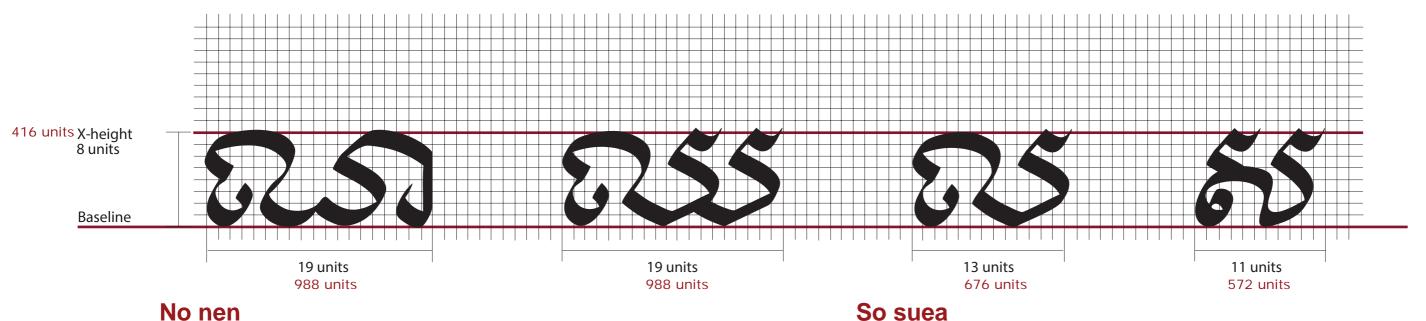
Figure 44. The final version (grey) of to tao overlaid on top of the first version (black) to demonstrate the proportional differences

Figure 45. Example pseudowords constructed by Group 3 full-form characters



Although all of the characters in the group are clearly almost the identical, this is not true of their bodies. I started by drawing a sok and a curve. Afterwards, I adjusted the body of each characters to correspond with the reference. Ko kai and pho samphao formed a sub-category, as their left bodies share some close similarities. The right stems of the characters are identical. Additionally, the body widths of both characters are nearly the same, and so I developed them together.

Group 4 full-form characters



No nen

The first version The second version The last version









The first version



The second version



The last version



Cho choe

The first version

The second version

The last version







Lo ling

The first version

The second version

The last version







Dimensional proportions of Group 4 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.117-119).



Figure 46. A comparison of cho choe between the first draft (left) and the final design (right)

Unlike no nen, I decided to keep this element cursive because it seemed to harmonize with the cursive beak. Trai Phum did not contain many references to this letter, and so I designed it on the basis of lo ling and cho choe.



Figure 47. A comparison of no nen between the first draft (left) and the final design (right)



Figure 48. Comparison of lo ling between the first draft (left) and the final design (right)



Figure 49. A comparison of so suea between the first draft (left) and the final design (right)

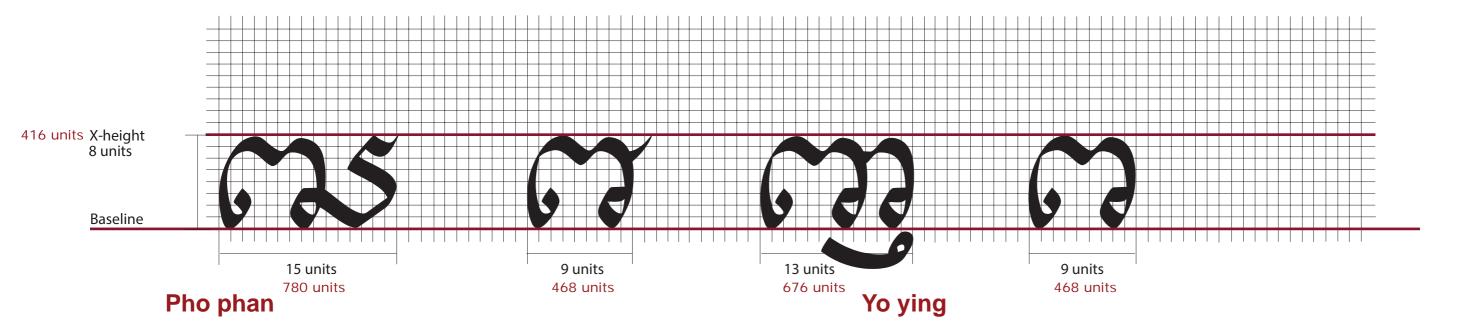
This part was adjusted to be more angular, in accordance with Trai

Figure 50. Example pseudowords constructed by Group 4 full-form characters



As I crafted the first and the second drafts of the characters, my primary problem revolved around the width proportions. These characters are wider than most of letters. In the end, I decided to narrow each letter slightly and adjust the stroke thickness. So suea was the only one in this group for which I drew a loop. Although Trai Phum sometimes depicted that character as loopless, I cross-referenced its illustrations with the textbooks' writing models and noted the presence of a loop.

Group 5 full-form characters



The first version

The second version

The last version

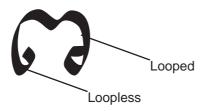
The first version

The second version

The last version









Tho phuthao

The first version





Fo fan

The first version

The second version

The last version

ras

The second version

The last version



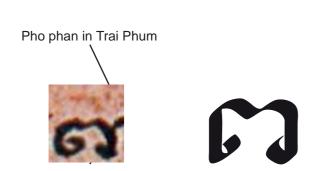








Dimensional proportions of Group 5 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.119-120).



The stems were designed to be more cursive, in accordance with *Trai Phum*



Figure 51. A comparison of pho phan between the first draft (left) and the final design (right)

I did not link the right loop and the right shoulder in the last draft, as per the interviewees' feedback



Figure 52. A comparison of yo ying between the first draft (left) and the final design (right)



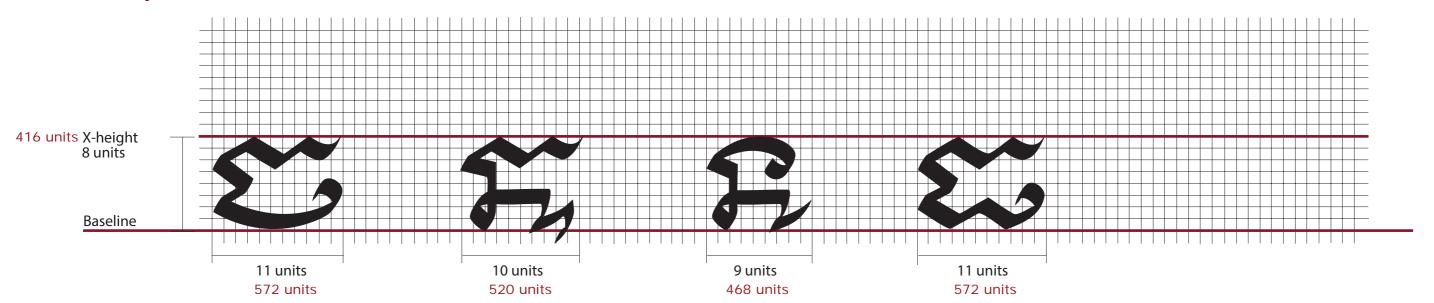
Figure 53. Comparison of the phuthae between the first draft (left) and the final design (right)





Most of TLK Brahma's full-form characters are loopless. However, there is a link between the right knot of tho phuthao and the right sok, and so I designed a loop instead on the right side of the characters in this group so that they would work together harmoniously.

Group 6 full-form characters



Cho ching

The first version

F

The second version



The last version

No nu

The first version



The second version



The last version



Cho chan

The first version



5

The second version

2

The last version

Tho thong

The first version



The second version



The last version



Dimensional proportions of Group 6 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.121-122).

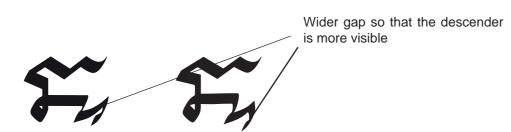


Figure 55. Comparison of no nu between the first draft (left) and the final design (right)

No nu from Trai Phum

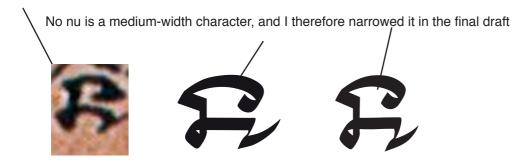


Figure 56. Comparison of no nu between the first draft (left) and the final design (right)



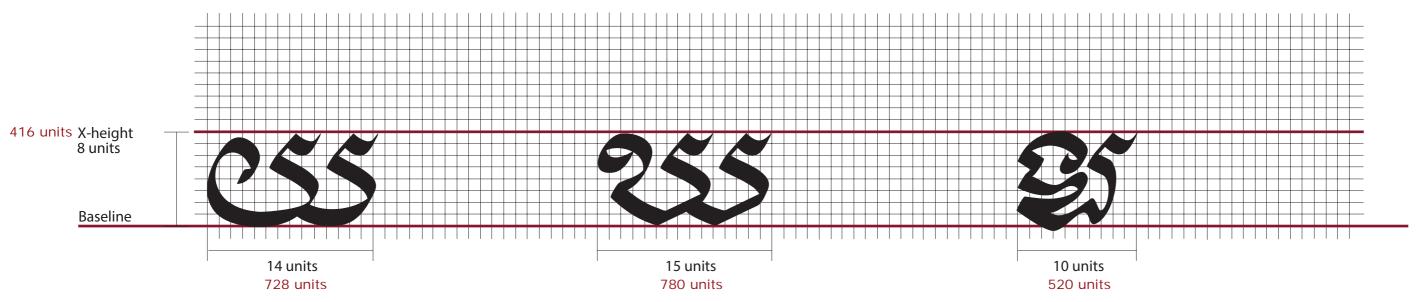
Figure 57. The final version (grey) of no nu overlaid on top of the first version (black) to demonstrate the proportional differences

Figure 58. Example pseudowords constructed by Group 6 full-form characters



I personally liked TLK Brahma's no nu, and so I used this letter to determine the x-height of all the characters. It does not share many typographic features with other letters, except for cho ching. However, I still categorized it in this group, because I employed no nu's lower structure to create cho ching. With their short descenders, both letters are quite uncommon. However, I found that the descender height was easier to be determine than the ascender height, because the former is short and does not significantly interrupt the line beneath. Approximately 0.5–1 units from the baseline were sufficient for the descender.

Group 7 full-form characters



Lo chula

The first version

The second version

The last version

35

25

Yo yak

The first version



The second version The last version



Kho rakhang

The first version

The second version

The last version







Dimensional proportions of Group 7 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.122-123).

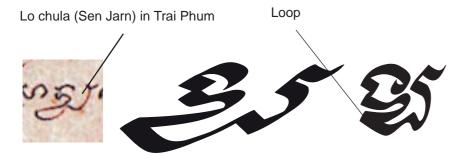


Figure 59. Comparison of lo chula between the first draft (left) and the final design (right)

I adjusted the low curves to be more angular, so that the character could be easily distinguished from yo yak.



Figure 60. Comparison of kho lakhang between first draft (left) and the final design (right)

Yo yak in Trai Phum



the first version

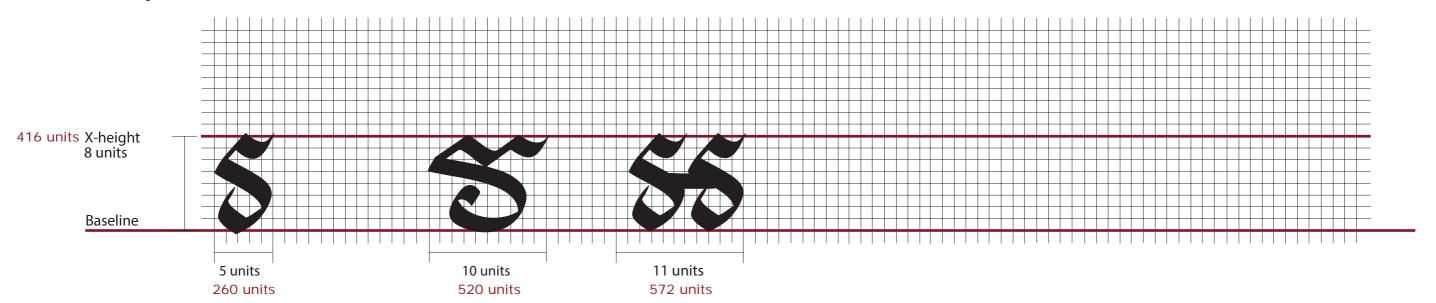
Figure 61. Comparison of yo yak between the first draft (left) and the final design (right)

Figure 62. An example of pseudo words constructed by the full-form characters in Group 7



Out of all of the characters, lo chula was the most difficult to design. Few references existed that I could use as guidelines. I could not find lo chula represented in the second style of Trai Phum writing. However, Trai Phum's first writing style did depict this letter. Therefore, I used it as a starting point. In my first draft of this letter, the loop is long. However, when forming a pseudoword, lo chula was too complicated. Therefore, I looked to other references, including the National Library's writing model. In that source, the loop was shorter than in Trai Phum. For this reason, I decided to reduce the size of lo chula's loop, making it more practical.

Group 8 full-form characters



Ro ruea

The first version

The second version

The last version

O ang

The first version

The second version

The last version







Wo waen

The first version

The second version

The last version







Dimensional proportions of Group 8 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.123-124).

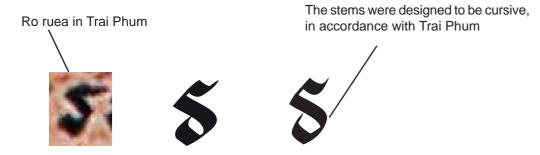


Figure 63. Comparison of pho phan between the first draft (left) and the final design (right)



Figure 64. Comparison of wo waen between the first draft (left) and the final design (right)



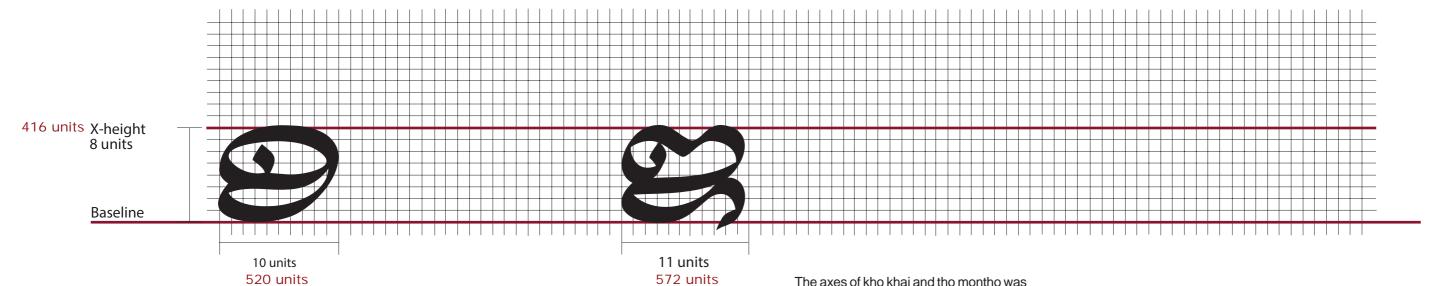
Figure 65. The final version (grey) of wo waen overlaid on top of the first version (black) to demonstrate the proportional differences

Figure 66. An example of pseudo words constructed by the full-form characters in Group 8



The Khom Thai ro ruea resembles its Thai counterpart, and so I began by designing that letter. There is not drastic change of ro ruea and o ang from the first to the final drafts. Wo waen required a significant amount of effort on my part, since it was the only letter in the group that with a full sok. Initially, I could not decide whether the sok should be wider than the lower part of the letter. In the end, I decided to narrow wo waen, since it was already a narrow character.

Group 9 full-form characters



572 units

Kho khai

The first version Kho khai in Trai Phum





The second version



The last version

Tho montho

Tho montho in Trai Phum The first version



The second version



The last version



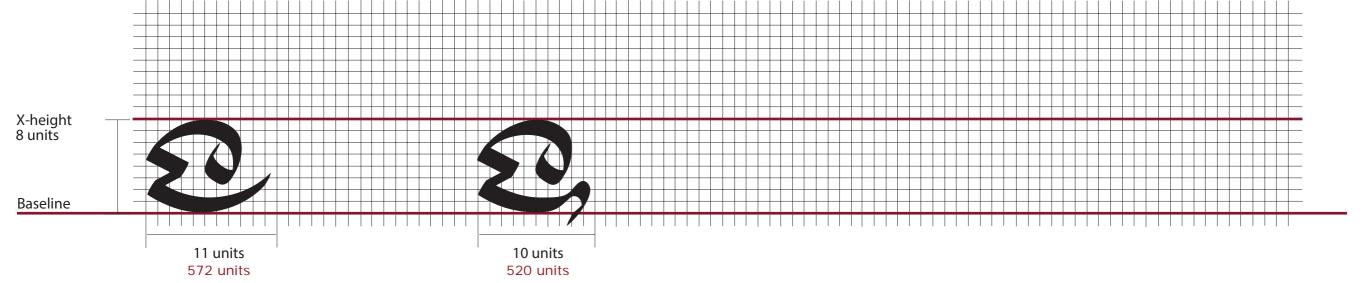
The axes of kho khai and tho montho was modified to be straighter, in accordance with Trai Phum.



Figure 67. Example pseudowords constructed by Group 9 full-form characters

Dimensional proportions of Group 9 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.124-145).

Group 10 of full-form characters.



Ngo ngu

Ngo ngu in Trai Phum

416 units

The first version

The second version

The last version











Tho thahan in Trai Phum

The first version

The second version

The last version









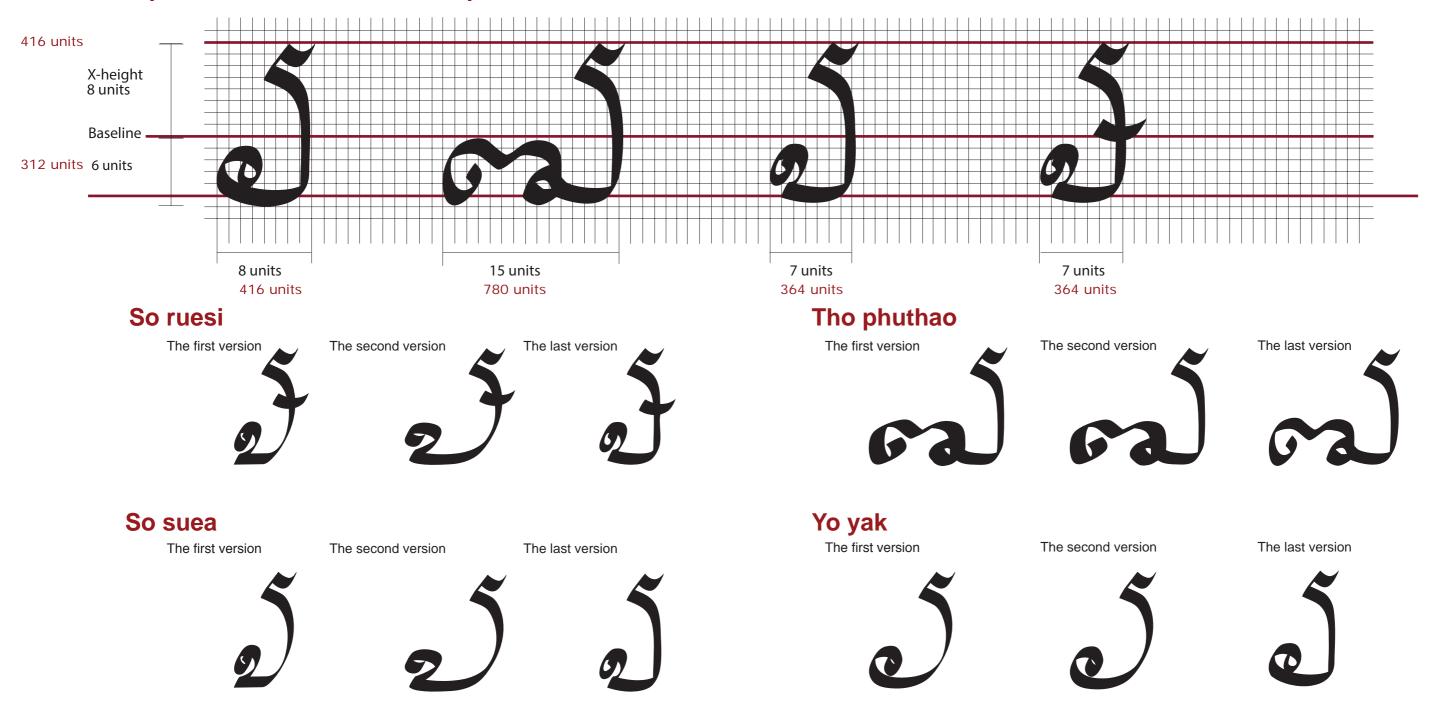


Figure 68. Example pseudowords constructed by Group 10 full-form characters

Dimensional proportions of Group 10 full-form characters and the development of each letter from the first draft to the final design (see also the thesis, pp.125-126).

The two characters in the group can be distinguished from each other as follows: Tho than has a short descender at the end of the finial. At first, I kept this feature above the baseline. However, it was challenging to tell the two letter apart, and so I lengthened tho than's tail, allowing it to extend beneath the baseline.

Group 1 the consonantal subscripts



Dimensional proportions of Group 1 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, pp.127-128).

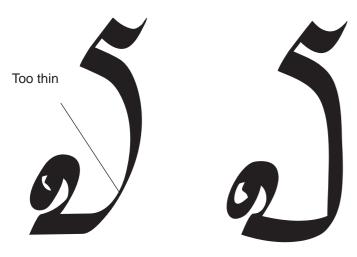


Figure 69. Comparison of so suea between the first draft (left) and the final design (right)

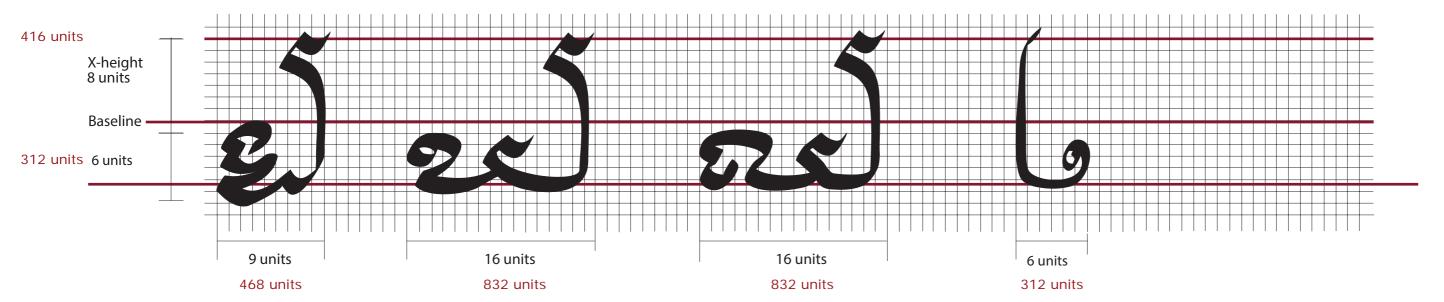
Figure 70. Example pseudowords constructed by Group 1 characters



The main consideration in designing these characters was the ascender height. As explained in Chapter 3 of the thesis, the body height of the consonantal subscripts is approximately 4–5 units. I designed the body of each character first and placed it in random pseudowords, as the next page illustrates. Later, I determined the height of the ascender. In the first draft, the ascender was cursive. However, I decided to straighten it, because there was too much negative space when consonantal subscripts and full-form letters were placed next to each other.

Figure 71. Example pseudowords constructed by Group 1 characters

Group 1 consonantal subscripts



Lo chula



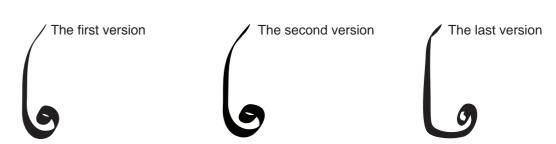
Cho choe



Bo baimai



Ro ruea



Kho rakhang



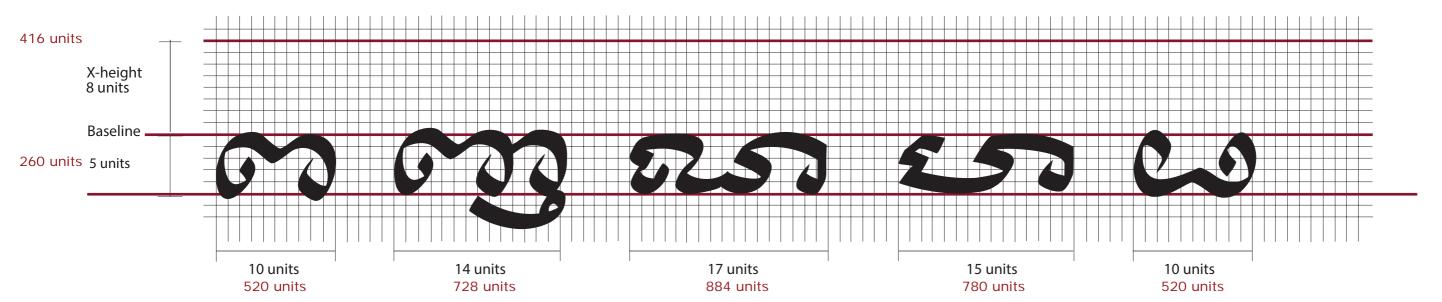
Dimensional proportions of Group 1 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, pp.127-128).

Figure 72. Example pseudowords constructed by Group 1 characters



Figure 74. Example pseudowords constructed by Group 1 characters

Group 2 consonantal subscripts



Pho phan

The first version

The second version

The last version

Pho phueng

The first version

The second version

The last version













Yo ying

The first version

The second version

The last version

300

The first version

No nen

The second version

The last version

Ho hip

The first version

The second version

The last version









Dimensional proportions of Group 2 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, pp.129).

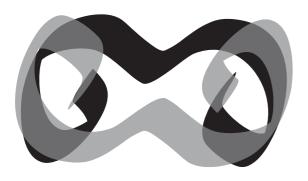
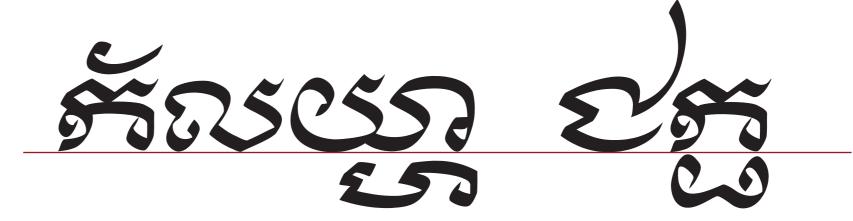


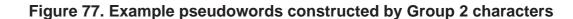
Figure 75. The final version (grey) of pho phueng overlaid on top of pho phan (black) to demonstrate the proportional differences

Figure 76. Example pseudowords constructed by Group 2 characters



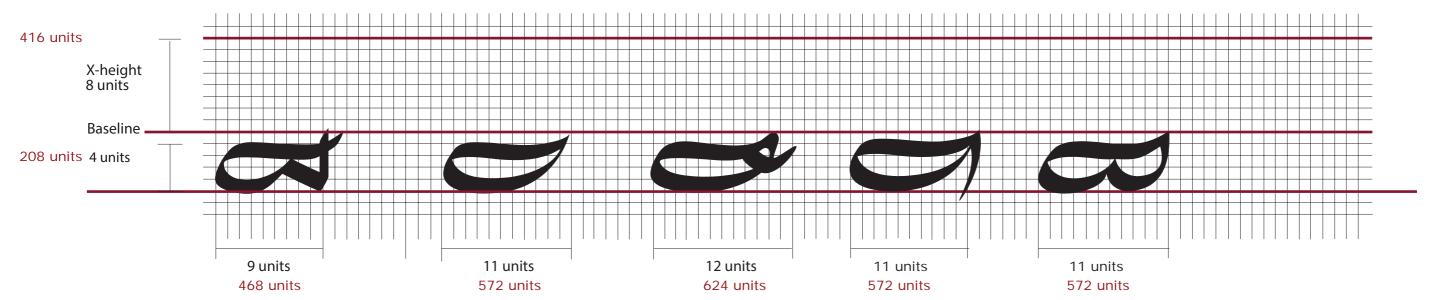
The first and the second drafts of these characters featured a thicker stroke weight. With their shorter body relative to their full-form counterparts, these consonantal subscripts appeared overly condensed. When the stroke weight was lightened in the final version, the characters became easier to read.





TLK Brahma

Group 3 consonantal subscripts



Wo waen

The first version

The second version

The last version

Tho than

The first version

The second version

The last version













Tho thahan

The first version

The second version

The last version



The first version

The second version

The last version













Tho thong

The first version

The second version

The last version







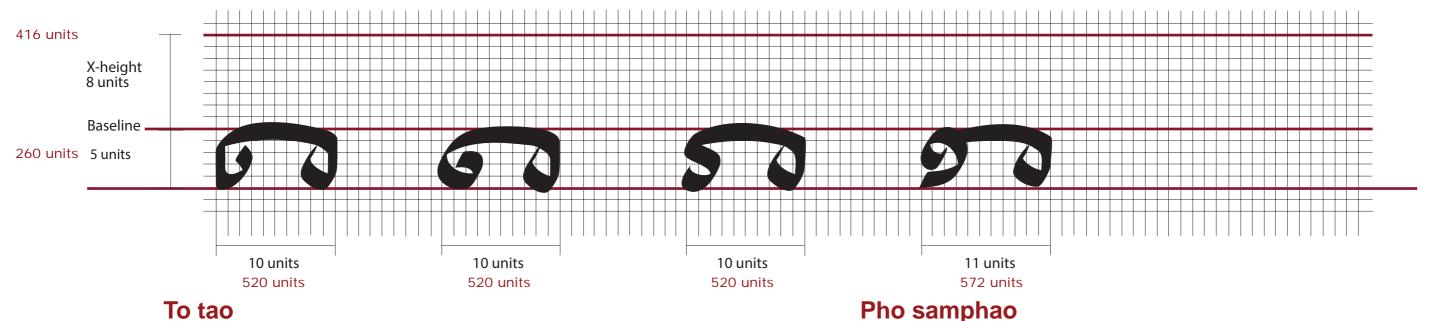
Dimensional proportions of Group 3 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, p.130).

None of the consonantal subscripts have an open side. Therefore, I created rough designs for the characters in this group on the basis of a half-circle.



TLK Brahma

Group 4 consonantal subscripts



The second version

The last version

Pho samphao

The first version

The second version

The last version



The first version











Ko kai

The first version

The second version

The last version



Kho khwai

The first version



The last version











Dimensional proportions of Group 4 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, pp.130-131).

Figure 79. Comparison of Group 3 full-form characters and Group 4 consonantal subscripts

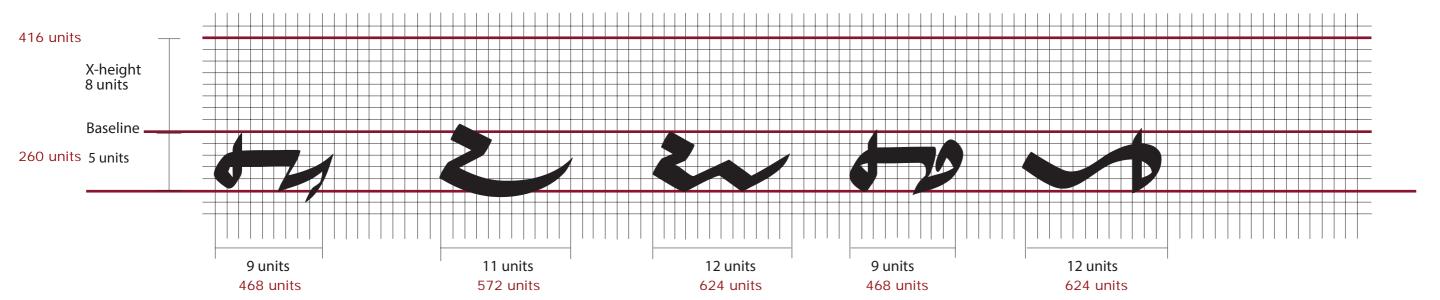
To tao, pho samphao, ko kai, and kho khwai are related letters. They share similar structures, and I therefore used kho khwai as the master design. Their full-form versions are almost identical. The main difference is that the full-form versions feature soks, while the consonantal subscripts do not.



Figure 80. Example pseudowords constructed by Group 4 characters

TLK Brahma

Group 5 consonantal subscripts



Cho ching

The first version

The second version

The last version

No nu

The first version

The second version

The last version













Cho chan

The first version

The second version

The last version



Mo ma

The second version

The last version









The first version





To patak

The first version

The second version

The last version







Dimensional proportions of Group 5 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, p.131).



Figure 81. Example pseudowords constructed by Group 5 characters

As I worked on the first and the second drafts of the characters, their width proportions posed the primary problem. The characters in this group are wider than most of the letters. In the end, I decided to slightly narrow each of them.

Group 6 consonantal subscripts

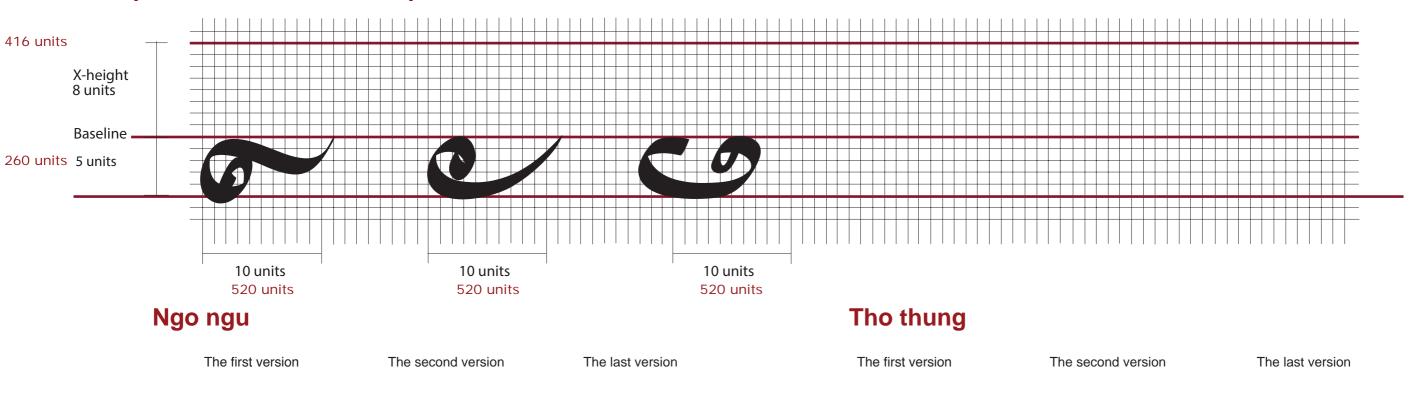




Figure 82. An example pseudoword constructed by Group 6 characters





The second version



Lo ling

The first version



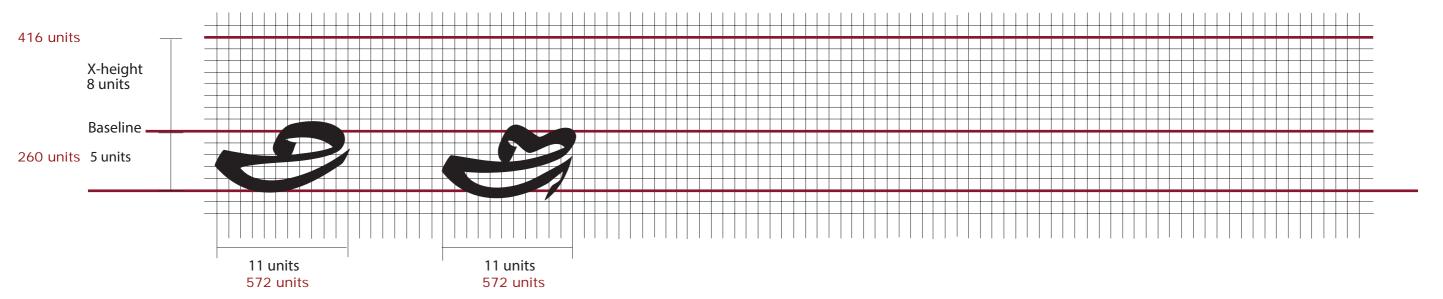
The last version



Dimensional proportions of Group 6 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, p.132).

Again, constructing these characters was simple. Since they only feature a few elements (head and tail), the ending was particularly important for distinguishing between them. Since the letterforms are not identical for each letter. Merely repeating and reflecting shapes from the master design was not enough, and so I had to redraw each character individually to ensure that they were unique.

Group 7 consonantal subscripts



Kho khai

The first version

The second version

The last version









The first version

The second version

The last version







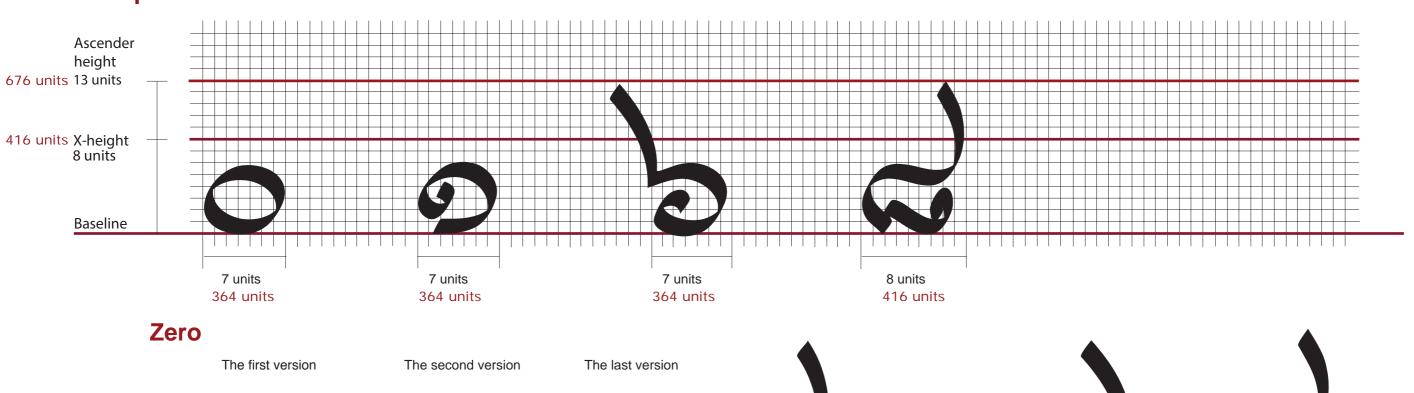


Figure 83. An example pseudoword constructed by Group 7 characters

Dimensional proportions of Group 7 consonantal subscripts and the development of each letter, from the first draft to the final design (see also the thesis, p.132).

Out of all of the characters, lo chula was the most difficult to design. Few references existed that I could use as guidelines. I could not find lo chula represented in the second style of Trai Phum writing. However, Trai Phum's first writing style did depict this letter. Therefore, I used it as a starting point. In my first draft of this letter, the loop is long. However, when forming a pseudoword, lo chula was too complicated. Therefore, I looked to other references, including the National Library's writing model. In that source, the loop was shorter than in Trai Phum. For this reason, I decided to reduce the size of lo chula's loop, making it more practical.

Group 1 numerals









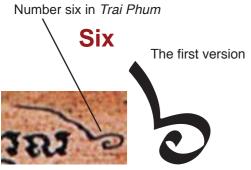


















Figure 84.An example of a group of numbers placed together to determine the overall proportions of the Group 1 letterforms.

Dimensional proportions of Group 1 numerals and the development of each character, from the first draft to the final design (see also the thesis, pp.133-134).

One

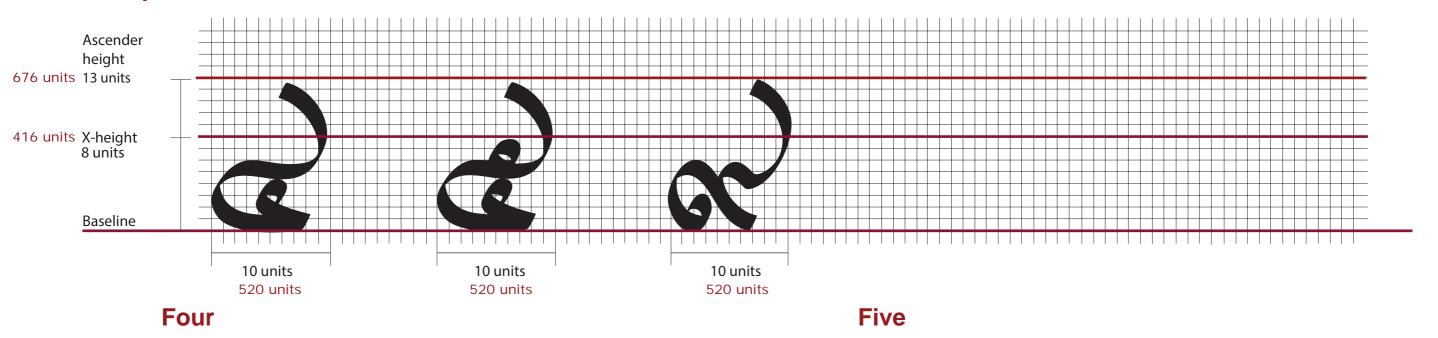
The first version The last version The second version







Group 2 numerals



The first version



The second version



The last version



THOUSE



The first version



The second version

The last version



Nine

The first version



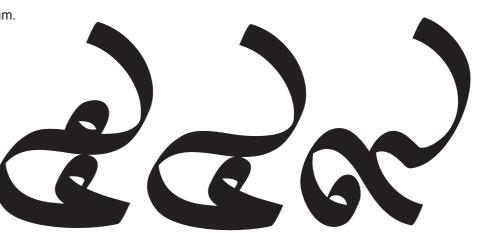
The second version



The last version



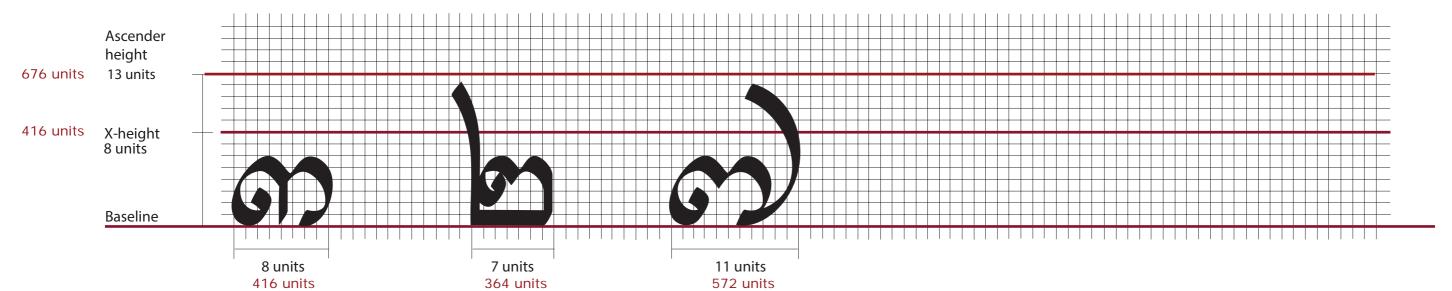
Number five in Trai Phum.



Dimensional proportions of Group 3 numerals and the development of each character, from the first draft to the final design (see also the thesis, pp.134-135).

Figure 85. An example of a group of numbers placed together to determine the overall proportions of the Group 2 letterforms

Group 3 numerals



Three

The first version

The second version

The last version









Number three in Trai Phum

Seven

The first version

The second version

The last version







Dimensional proportions of Group 2 numerals and the development of each character, from the first draft to the final design (see also the thesis, p.135).

The first version

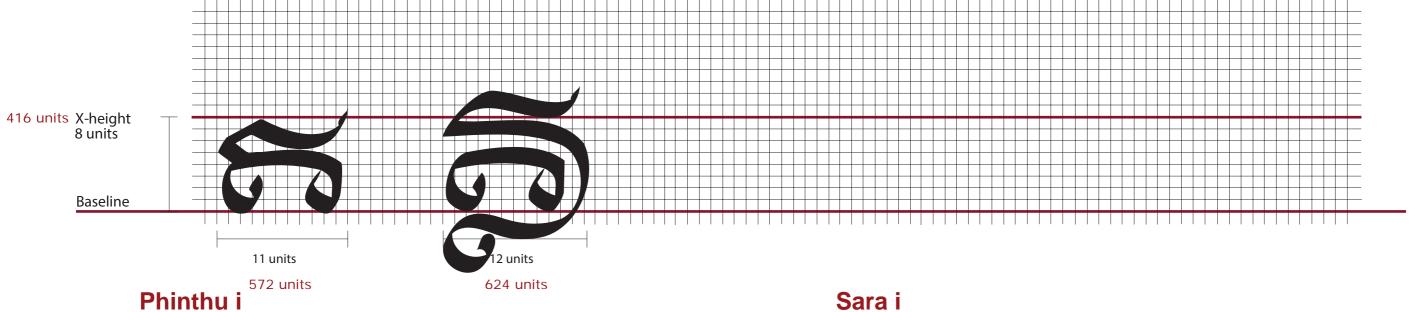
The second version

The last version

The last version

Figure 86.An example of a group of numbers placed together to determine the overall proportions of the Group 3 letterforms

Group 1 independent vowels



The first version The second version The last version



Figure 87. An example pseudoword constructed by Group 1 characters

Sara i

The first version

The second version

The last version



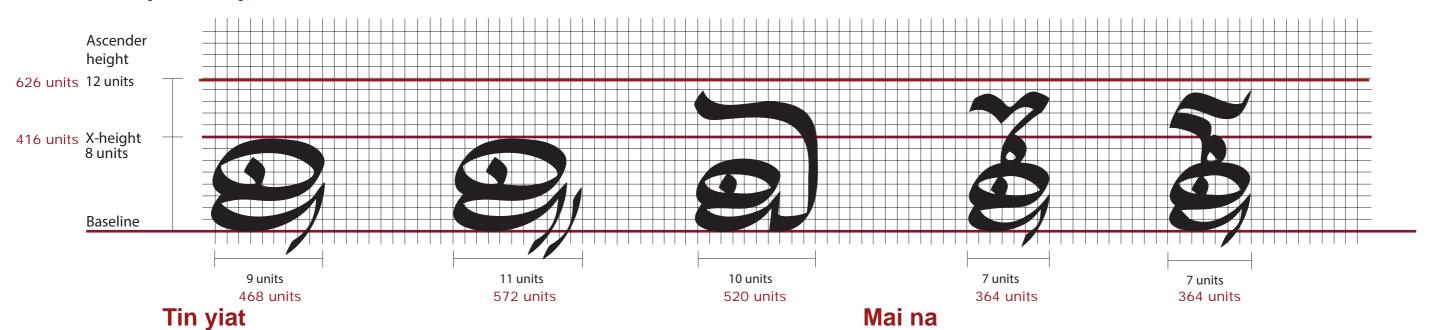




Dimensional proportions of Group 1 independent vowels and the development of each letter, from the first draft to the final design.

I did not have much information regarding sara i. However, it shares some similarities with phinthui, mai o, and kho khwai, and so I developed it using those characters as guidelines.

Group 2 independent vowels



The first version

The second version



The last version

The second version



The last version



The first version

The first version

Mai malai

Tin khu



The second version



The last version







Mai na

The first version



Mai o

The first version



The second version



The last version



The last version



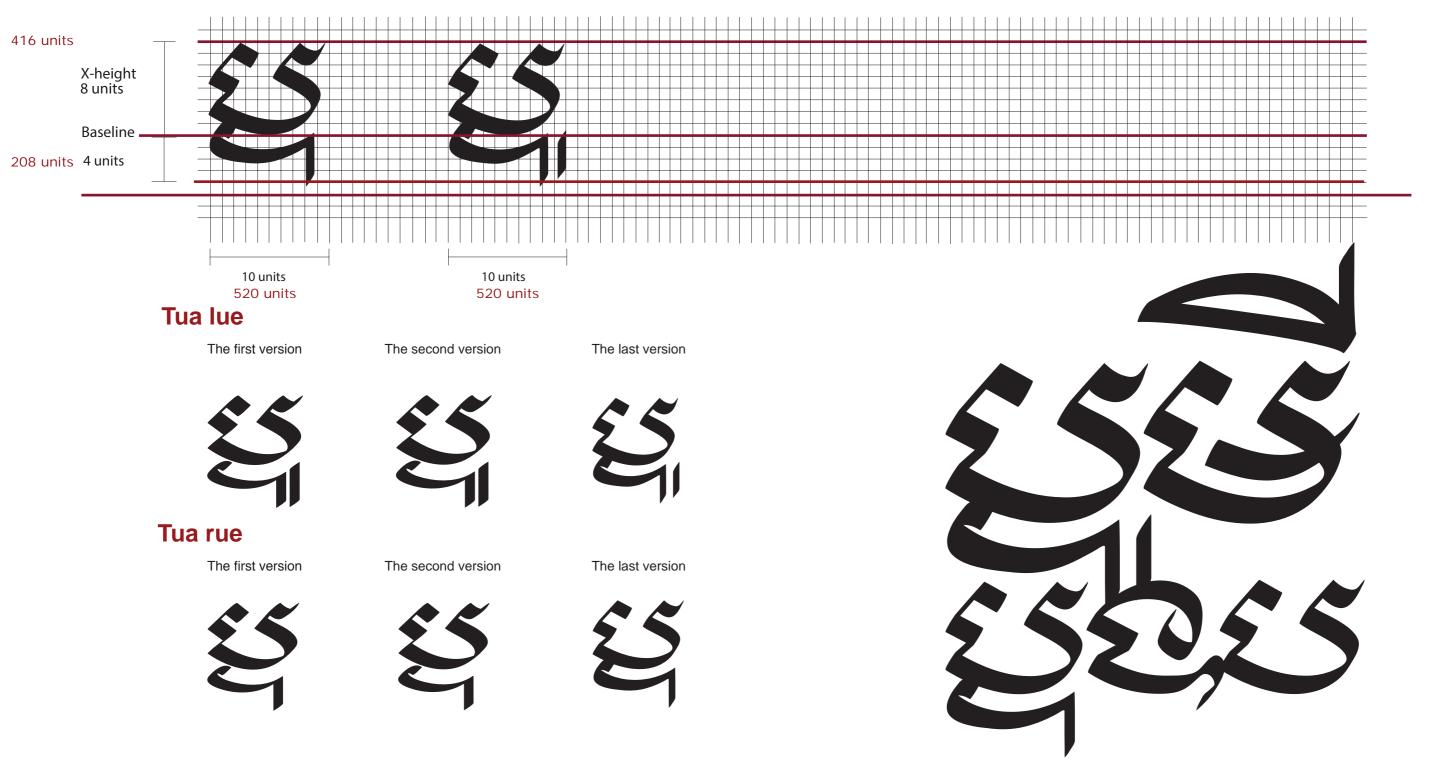
Dimensional proportions of Group 2 independent vowels and the development of each letter, from the first draft to the final design.



Figure 88. Example pseudowords constructed by Group 2 characters

Judging from the overall letterforms, these characters share a common appearance. However, each one is unique, with its own typographic properties.

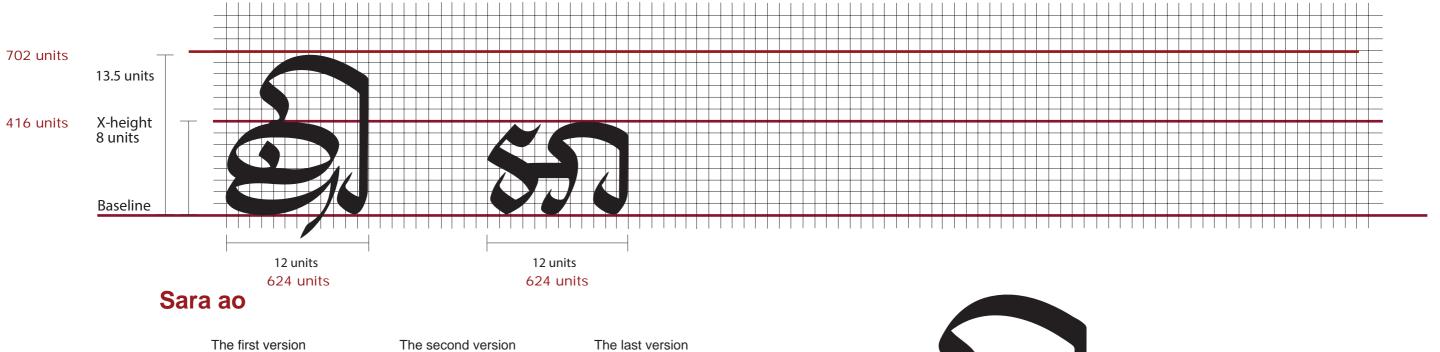
Group 3 independent vowels



Dimensional proportions of Group 3 independent vowels and the development of each letter, from the first draft to the final design.

Figure 89. Example pseudowords constructed by Group 3 characters

Group 4 independent vowels



The first version

The second version

Lak khang



The first version The second version

The last version







Dimensional proportions of Group 4 independent vowels and the development of each letter, from the first draft to the final design. Lak khang and sara ao replicated some elements of o ang, tin khu, and pho samphao.

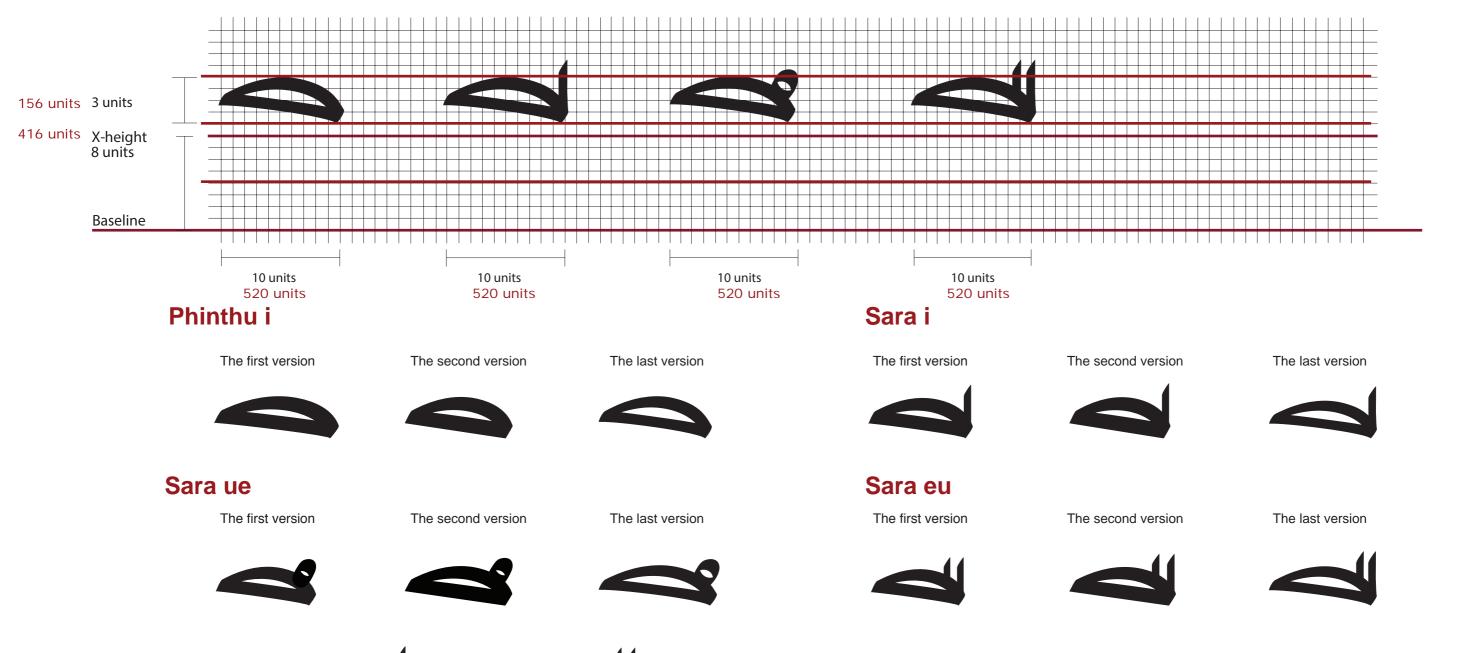


Figure 90. Example pseudowords constructed by Group 4 characters

Dimensional proportions of Group 1 dependent vowels and the development of each letter,

from the first draft to the final design.

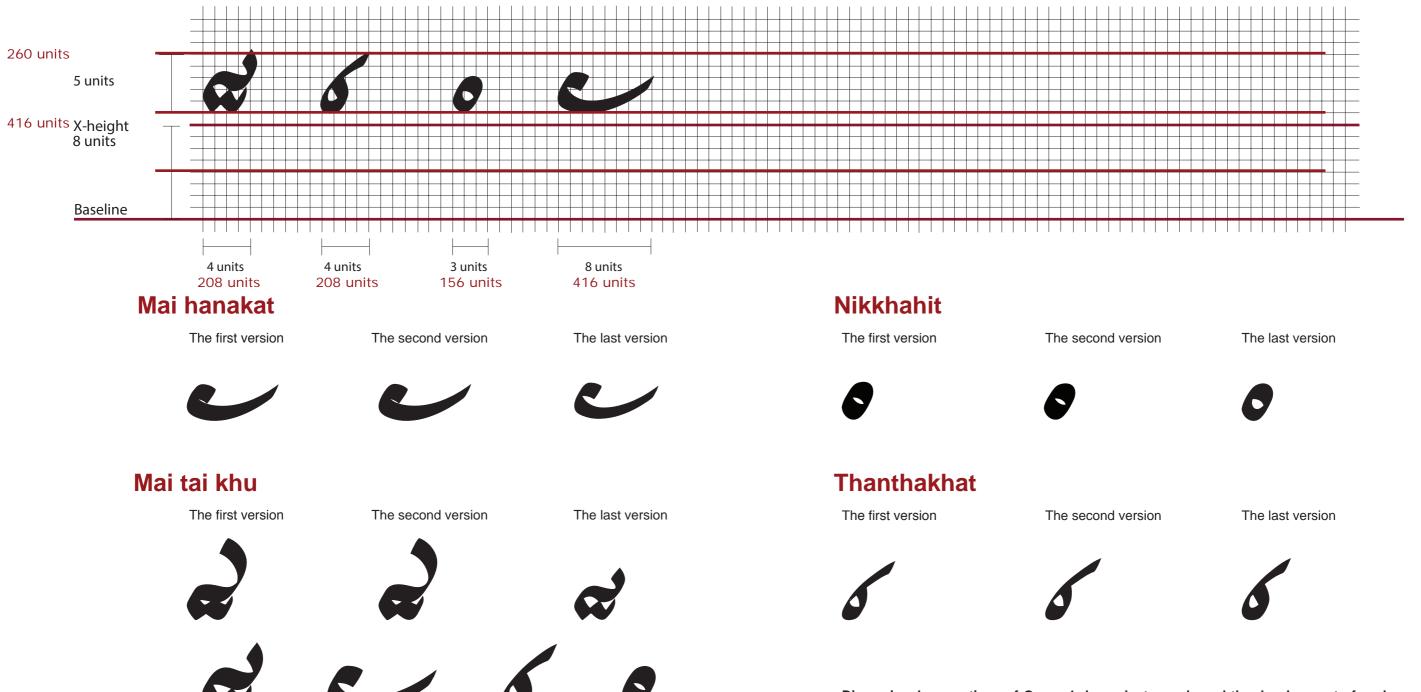
Group 1 dependent vowels



新夕新列

Figure 91. An example pseudoword constructed by Group 1 characters

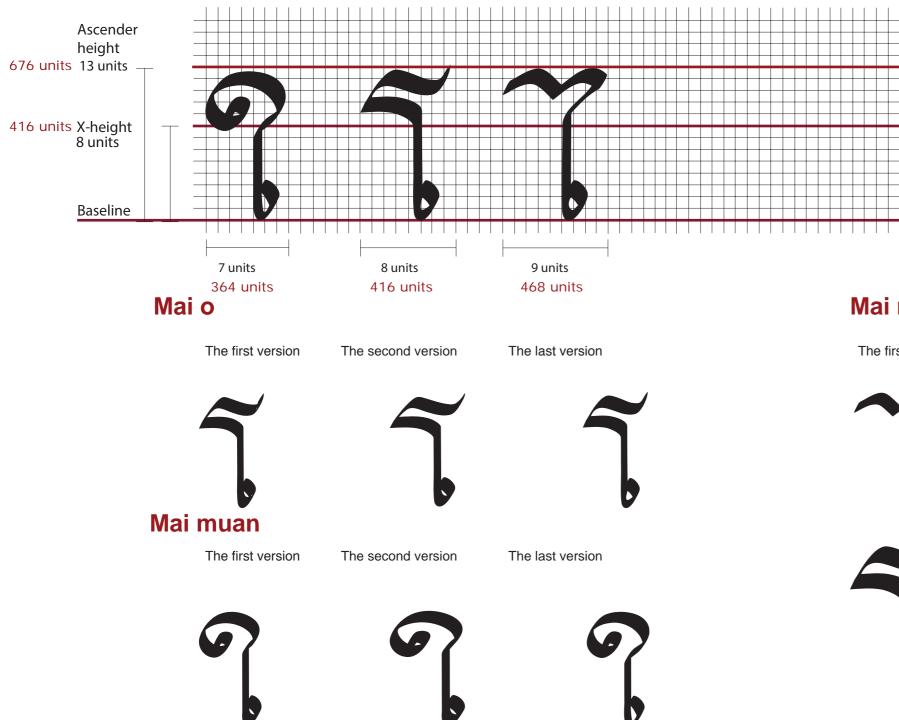
Group 2 dependent vowels



Dimensional proportions of Group 1 dependent vowels and the development of each letter, from the first draft to the final design.

Figure 92. An example pseudoword constructed by Group 2 characters

Group 3 dependent vowels



Dimensional proportions of Group 3 dependent vowels and the development of each letter, from the first draft to the final design.

I designed the basic mai malai letterform by adapting the full-form ro ruea. However, mai malai is taller, and so I increased its height to 13 units. I then used this same height for the other vowels in this group.

Mai malai

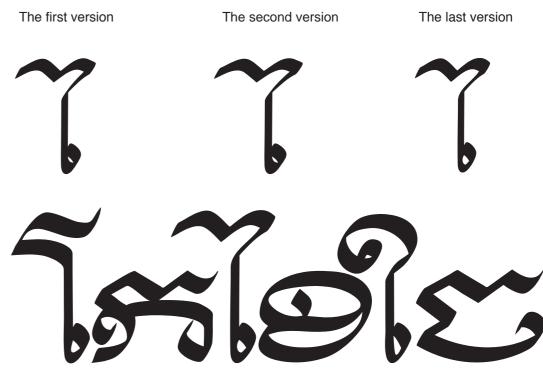
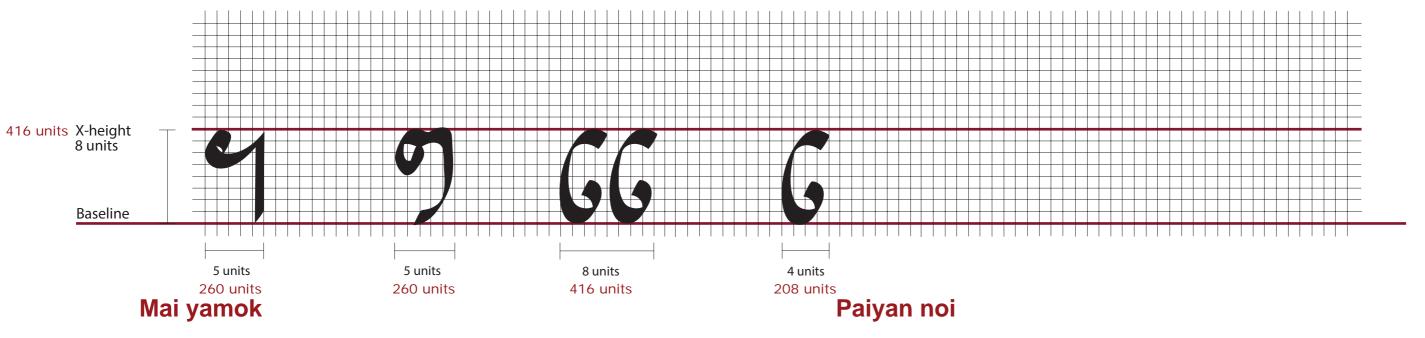


Figure 93. An example pseudoword constructed by Group 3 characters

Group 4 of dependent vowels



The first version

The second version

The last version

The first version

The second version

The last version

Sara ae

The first version

The second version

The last version

Mai na

The first version

The second version

The last version

Dimensional proportions of Group 4 dependent vowels and the development of each letter, from the first draft to the final design.



Figure 94. Example pseudowords constructed by Group 4 characters

Group 5 dependent vowels



The last version

The first version

The second version

The first version

The second version

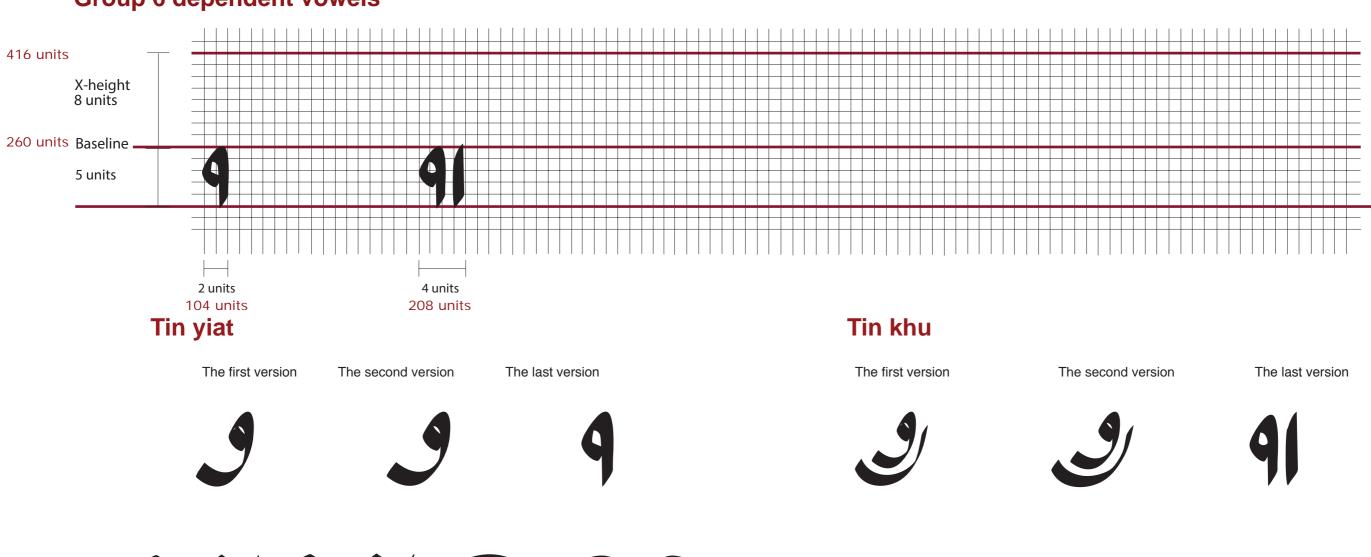
The last version



Figure 95. An example pseudoword constructed by Group 5 characters

Dimensional proportions of Group 5 dependent vowels and the development of each letter, from the first draft to the final design.

Group 6 dependent vowels

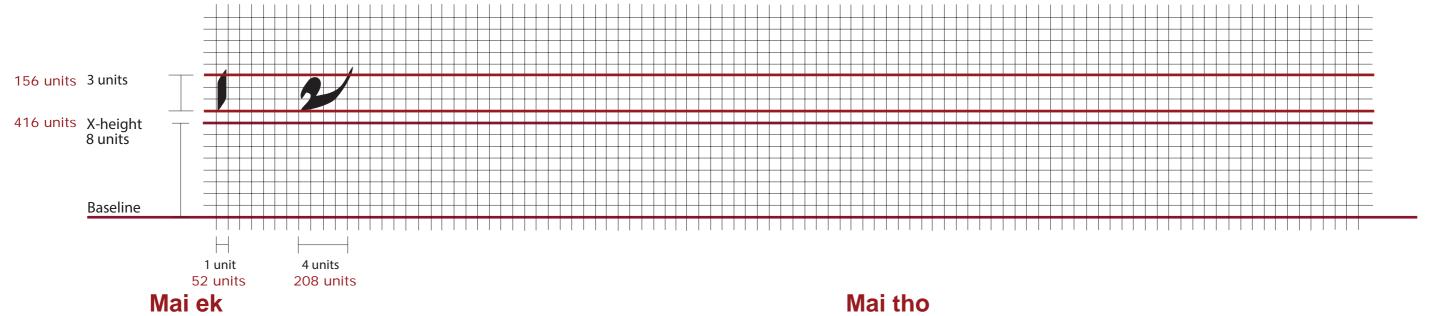


Dimensional proportions of Group 6 dependent vowels and the development of each letter, from the first draft to the final design.

My first designs for these two characters were cursive, because I wanted to imitate brushstrokes. However, the letterforms required more space. According to Trai Phum, these vowels are sometimes straight. In addition, the three main textbooks also depicted straight stems. I decided to straighten the tails so that they would not interrupt the line below.

Figure 96. An example pseudoword constructed by Group 6 characters

Group 1 of tone marks



The first version The second version The last version



Mai tho

The first version The second version The last version

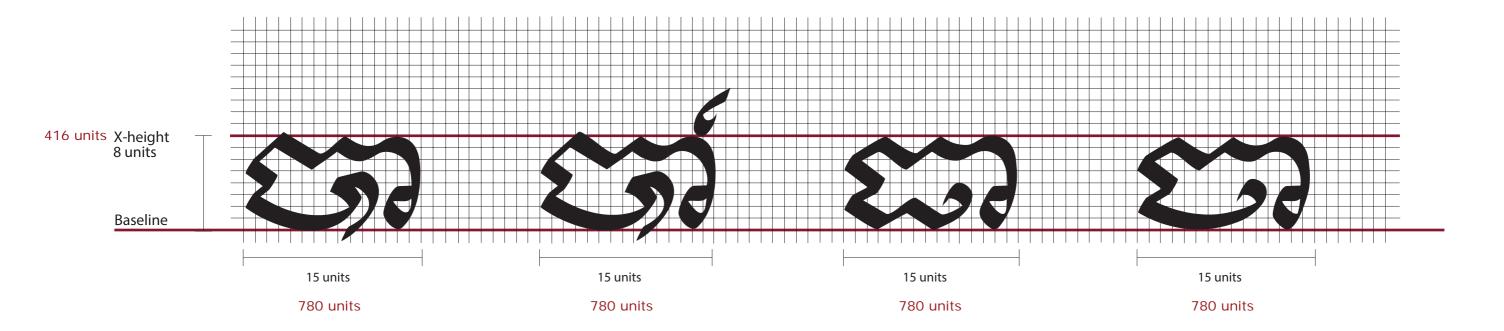


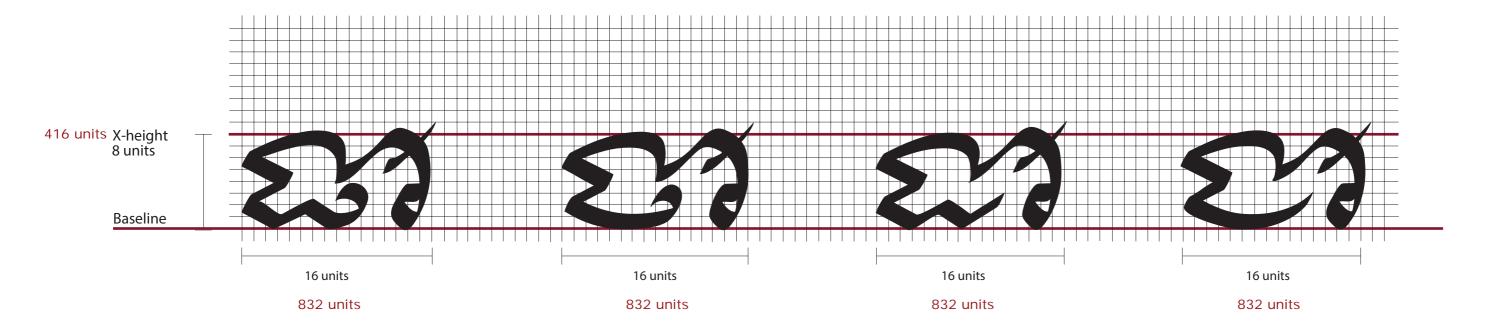
Dimensional proportions of Group 1 tone marks and the development of each letter, from the first draft to the final design.

Figure 97. Example pseudowords constructed by Group 1 tone marks

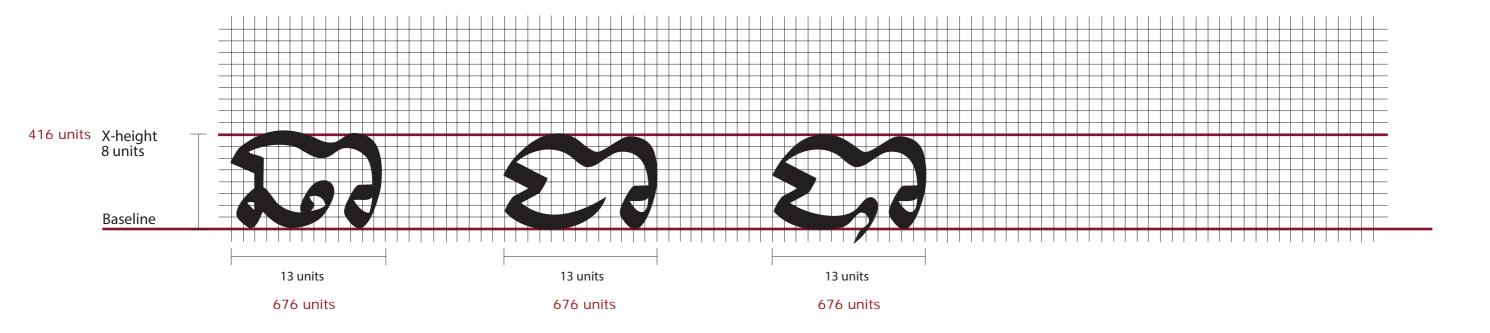
TLK Brahma Ligatures

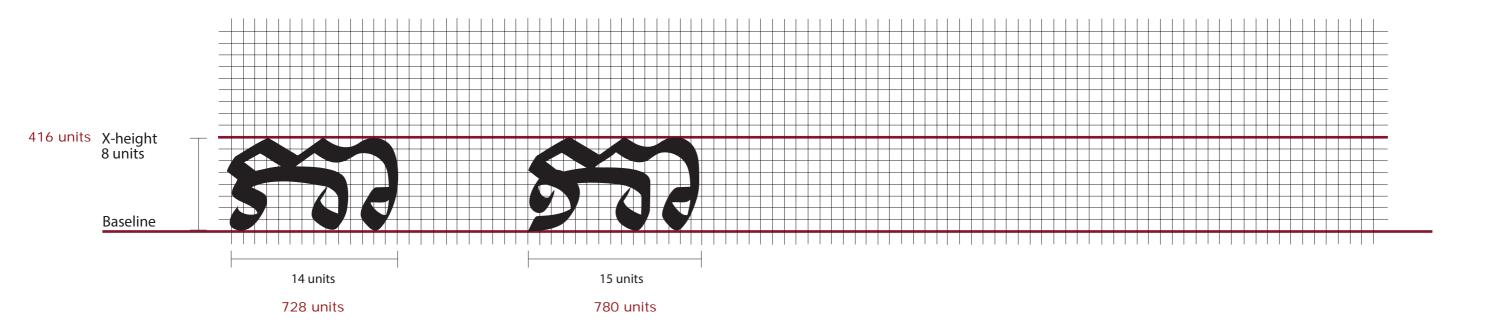
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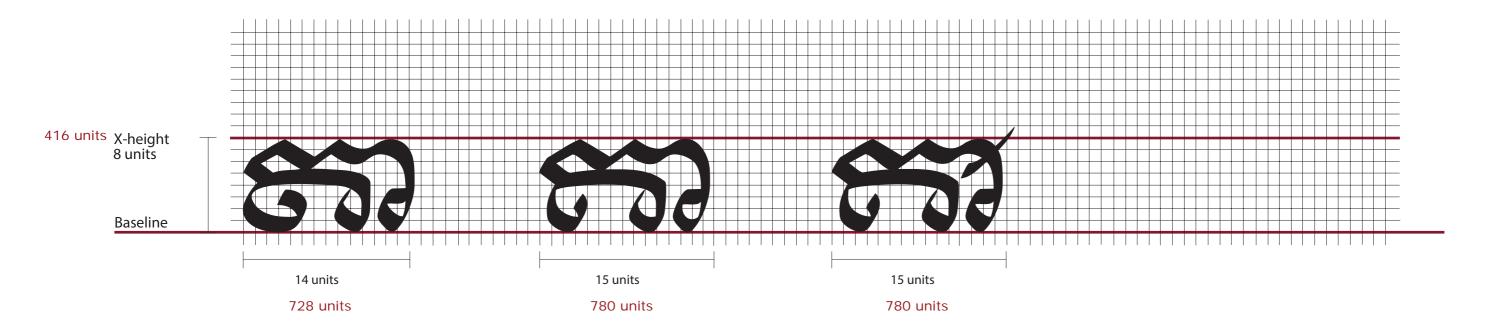


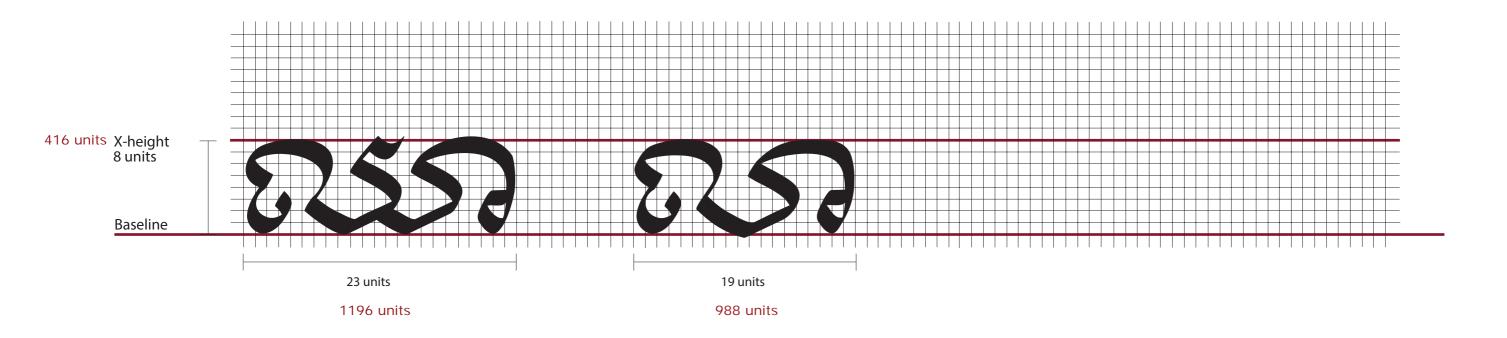


TLK Brahma

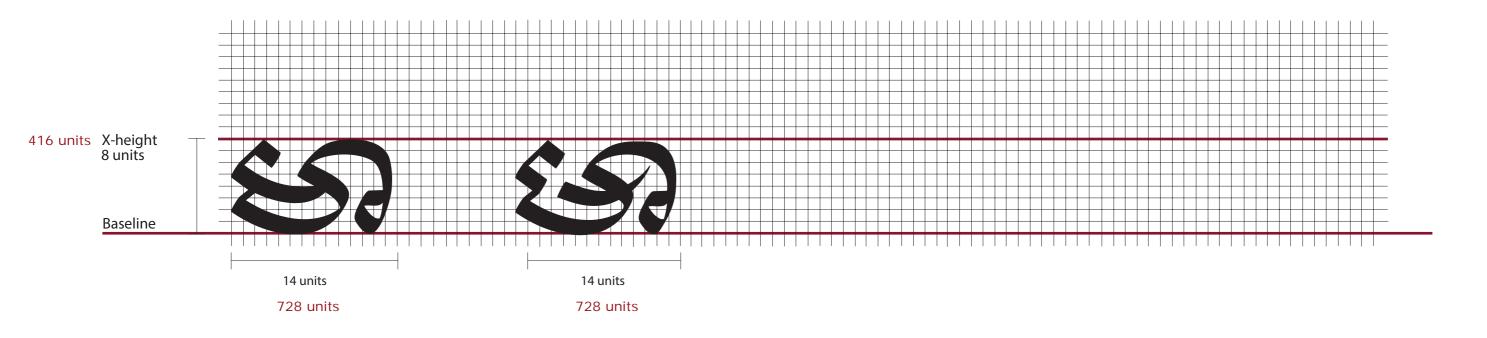


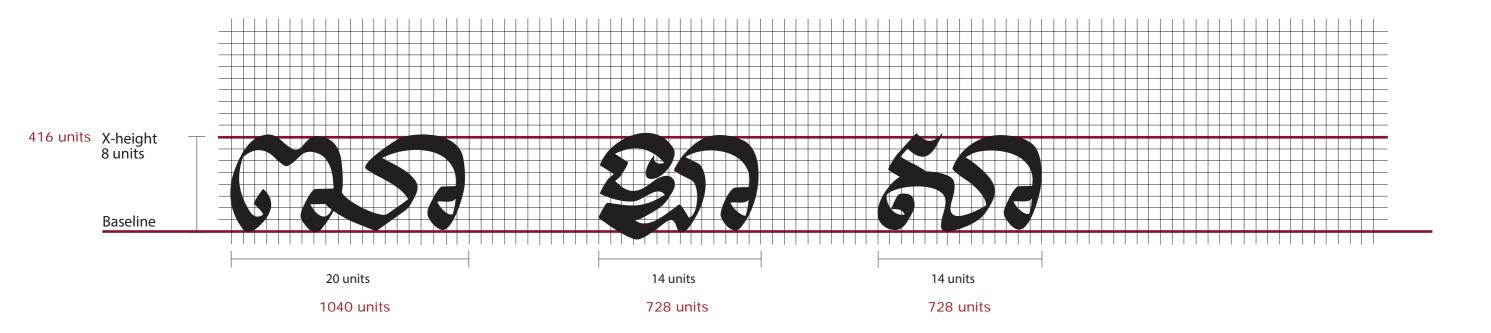




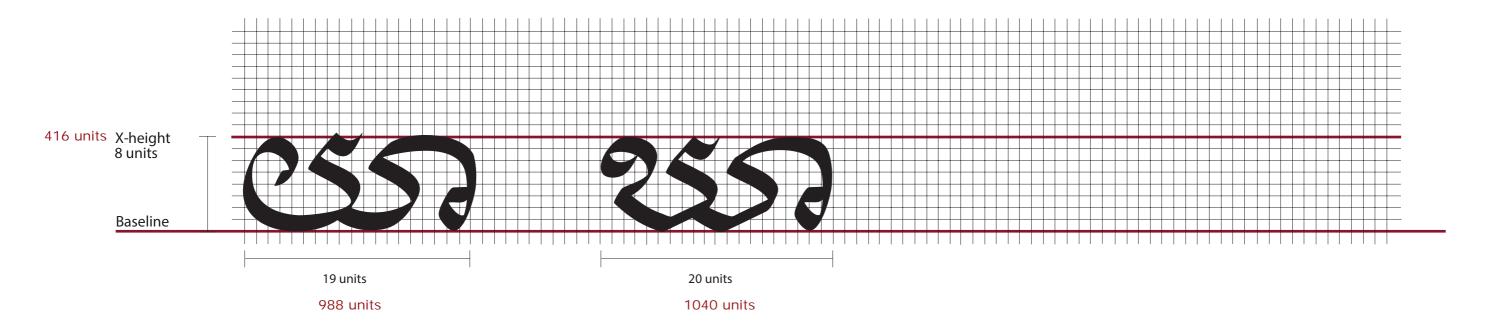


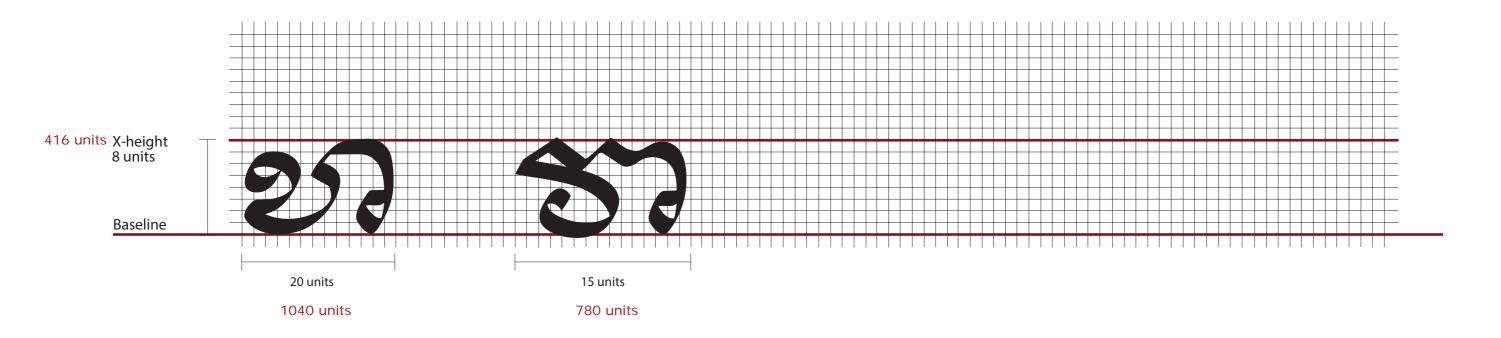
TLK Brahma



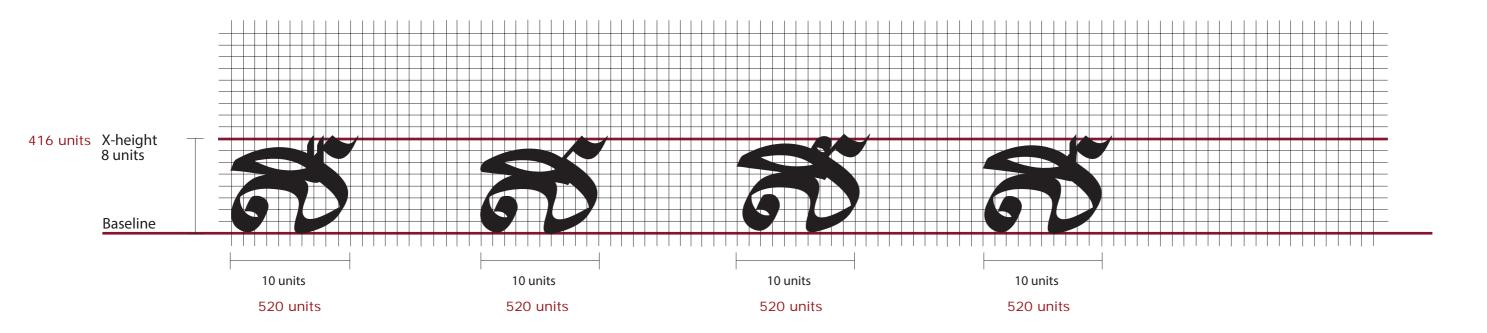


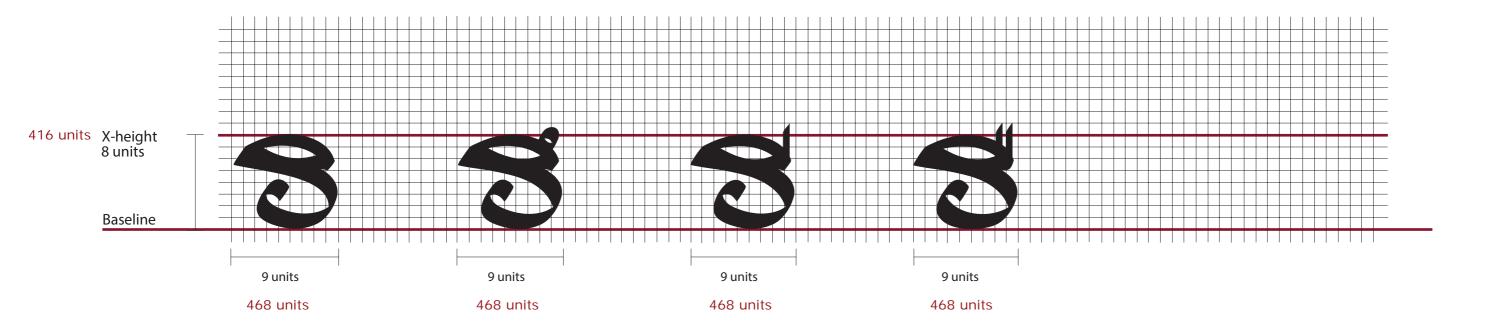
TLK Brahma

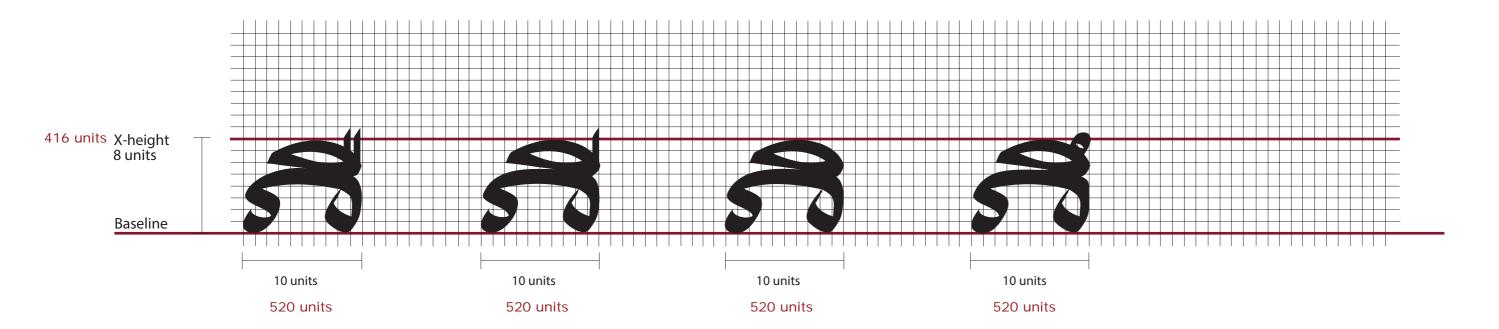


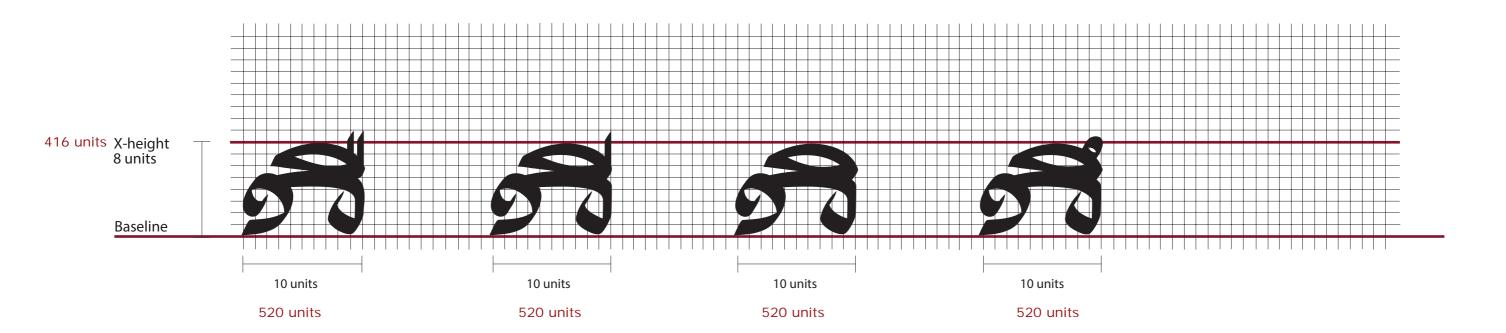


TLK Brahma

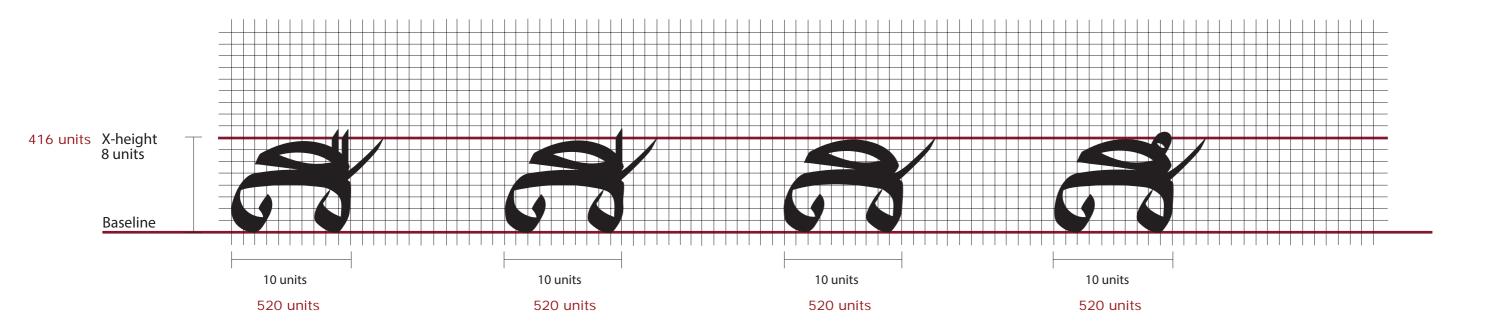


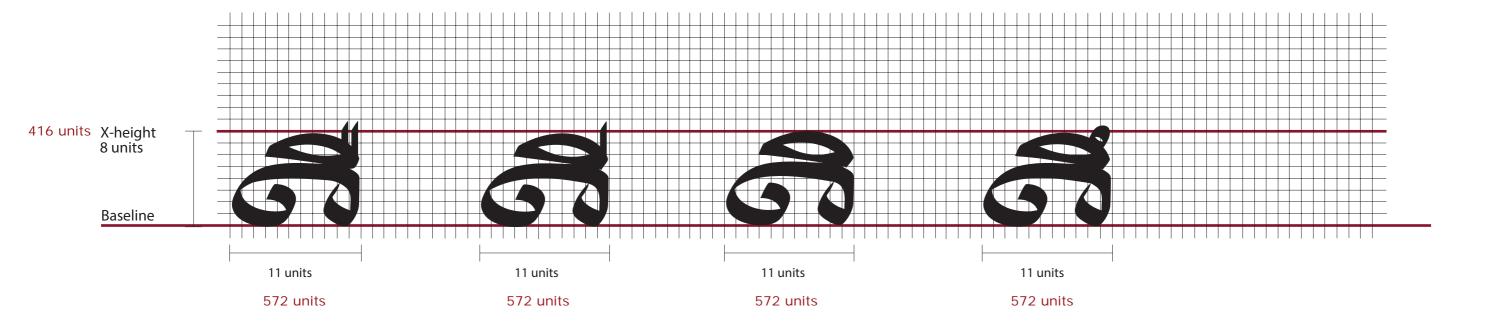


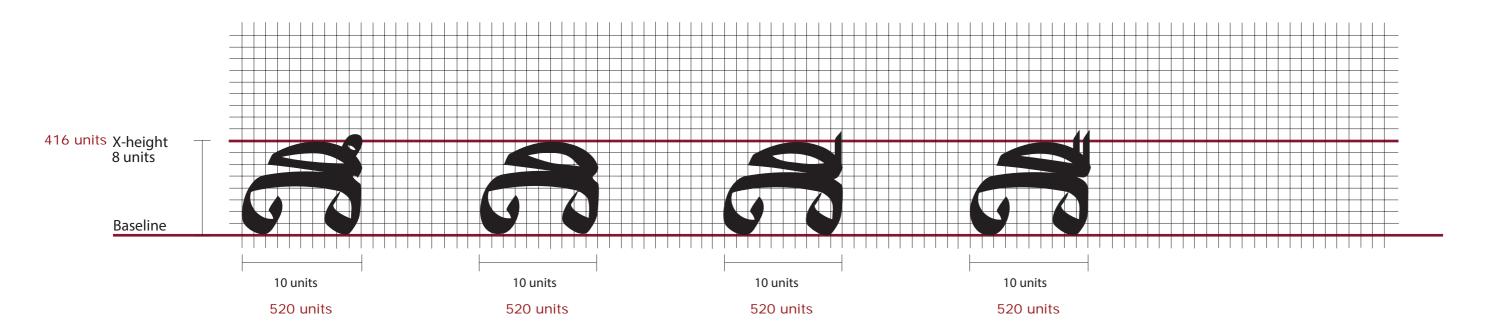


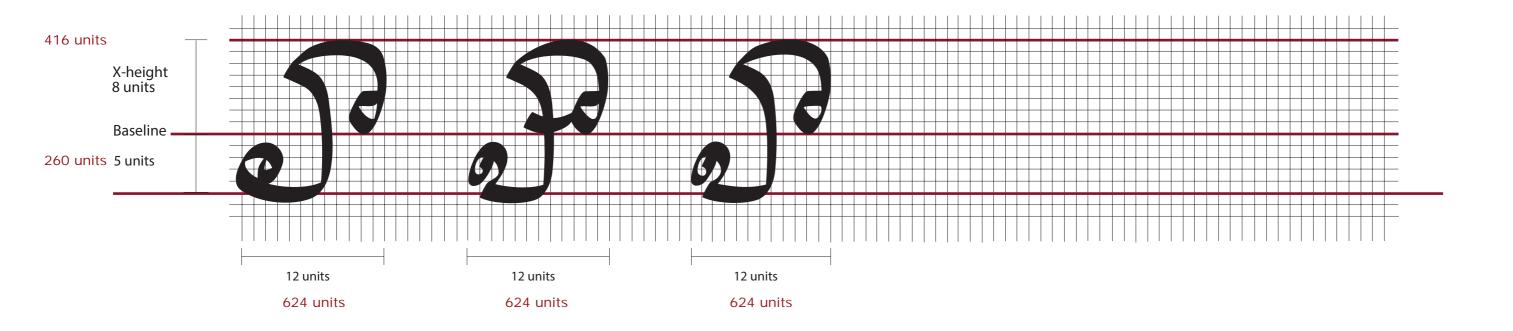


TLK Brahma

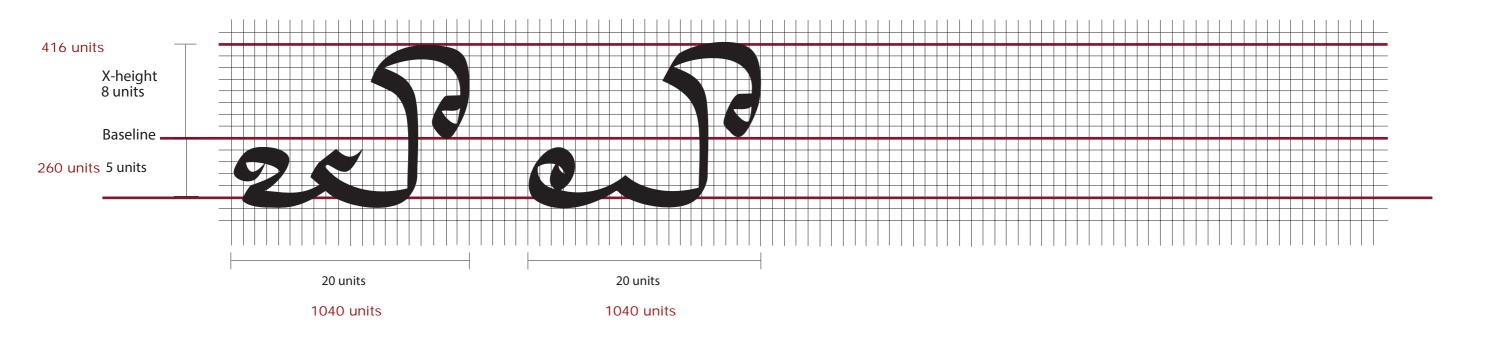


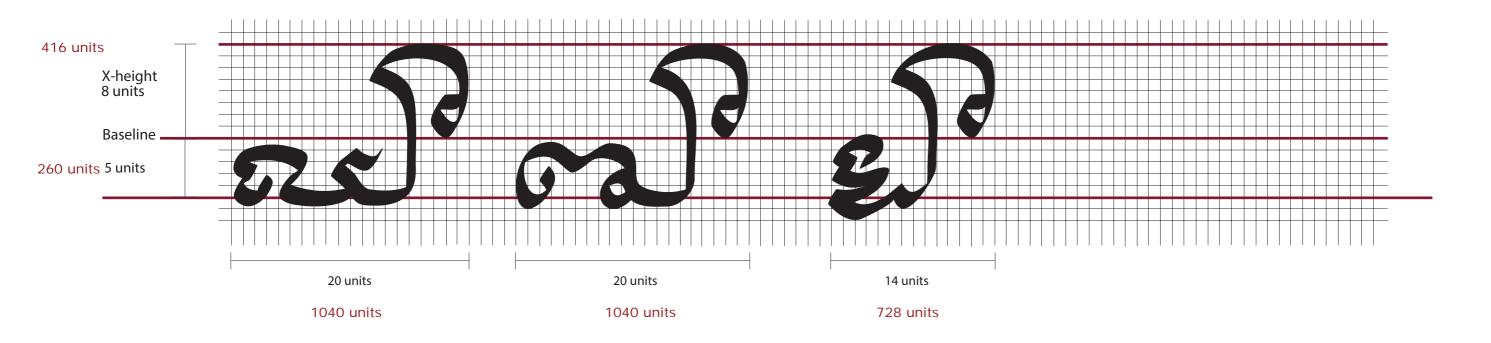






TLK Brahma







TLK Deva as a writing model

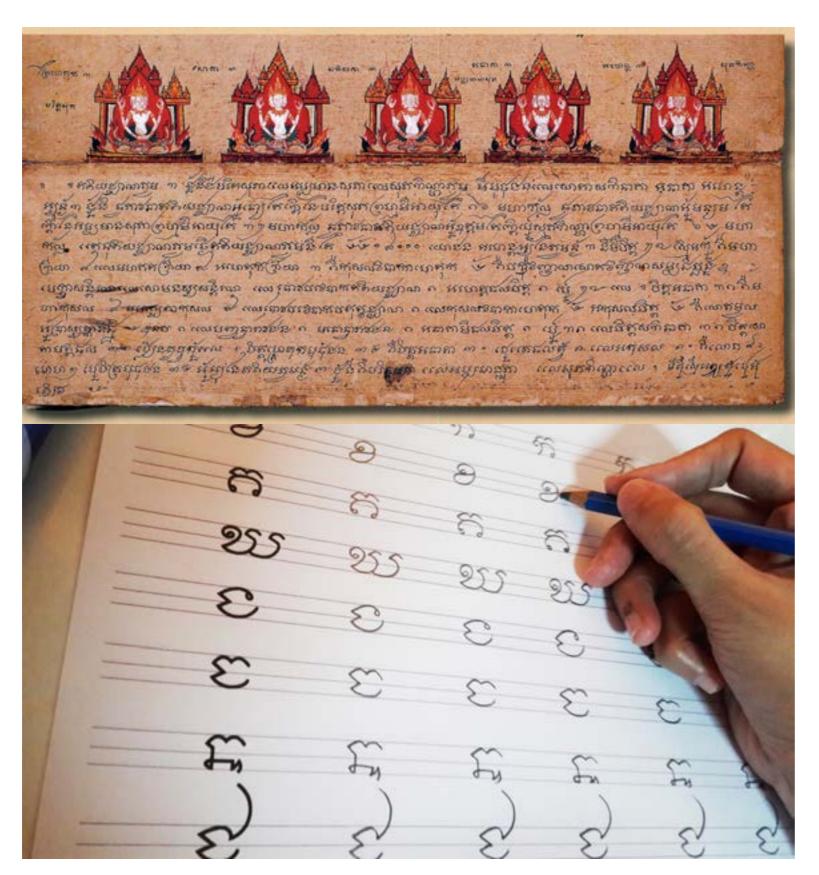


Figure 98. Details of the first writing style in *Trai Phum Ayutthaya no.7* at 25% of the original size. Adapted from *Samutpap Trai Phum chabap akson Khom pasa Thai* ³, by Kana kammakan fai pramuan ekkasan lae chotmaihet, 2007, p. 69, Copyright 2007 by National Library of Thailand.

TLK Deva is a letterform design that is intended as a writing model based on the Sen Chan style. This style has a lighter stroke weight contrast than the Sen Chup style, as demonstrated in Figure 98.

For TLK Deva, the first step of my design method was investigating the letterforms in general. I then captured the basic structures of the key letters before searching for references for each character. As previously mentioned, not all of the characters were contained in Trai Phum. When references were not available, I used structures from the key letters in their place.

Figure 99. Khom Thai characters written in accordance with TLK Deva's model, by Virunhaphol

3 Kana kammakan fai pramuan ekkasan lae chotmaihet. (2007). Samutpap Trai Phum chabap akson Khom pasa Thai [Trai Phum manuscript: Khom Thai version]. Bangkok, Thailand: National Library.

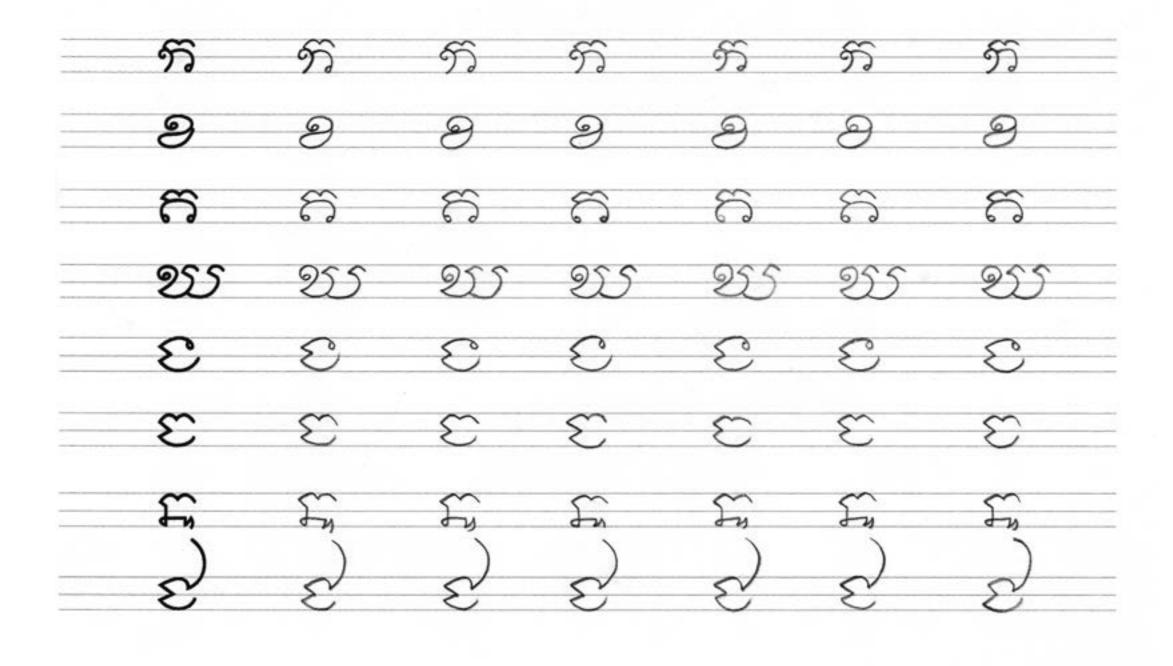


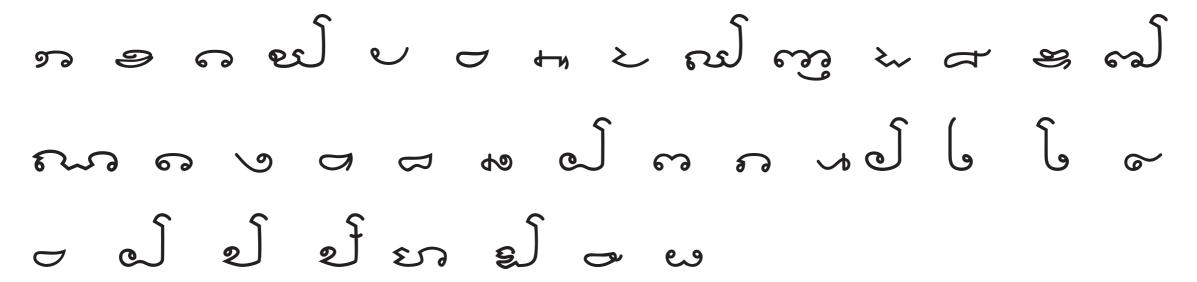
Figure 100. Examples of Khom Thai characters at 100% and written in accordance with TLK Deva's model, by Virunhaphol

TLK Deva Characters

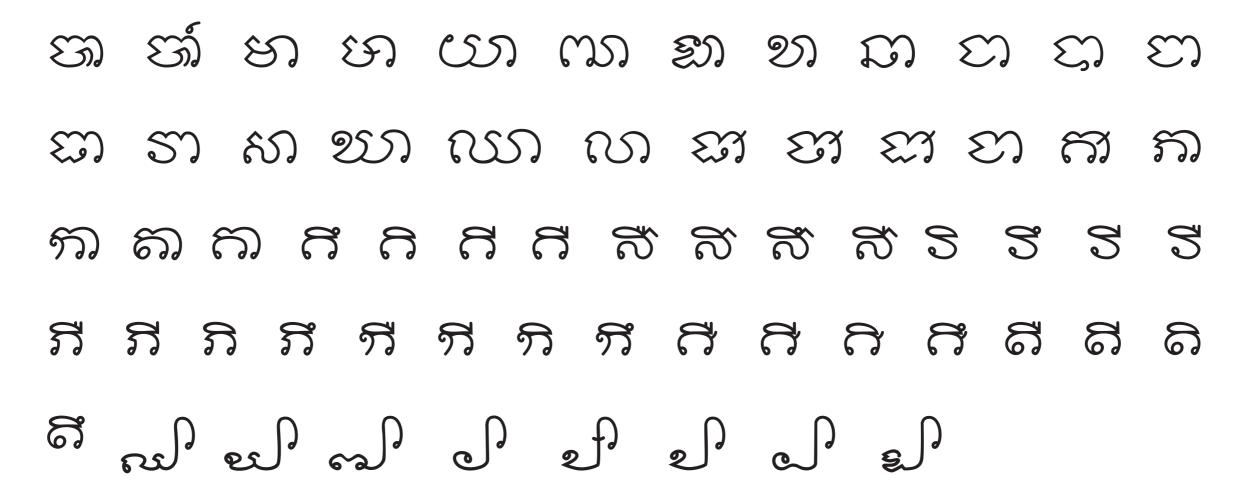
Full-form characters



Consonantal subscripts



TLK Deva Characters



TLK Deva Characters

Independent vowels



Dependent vowels



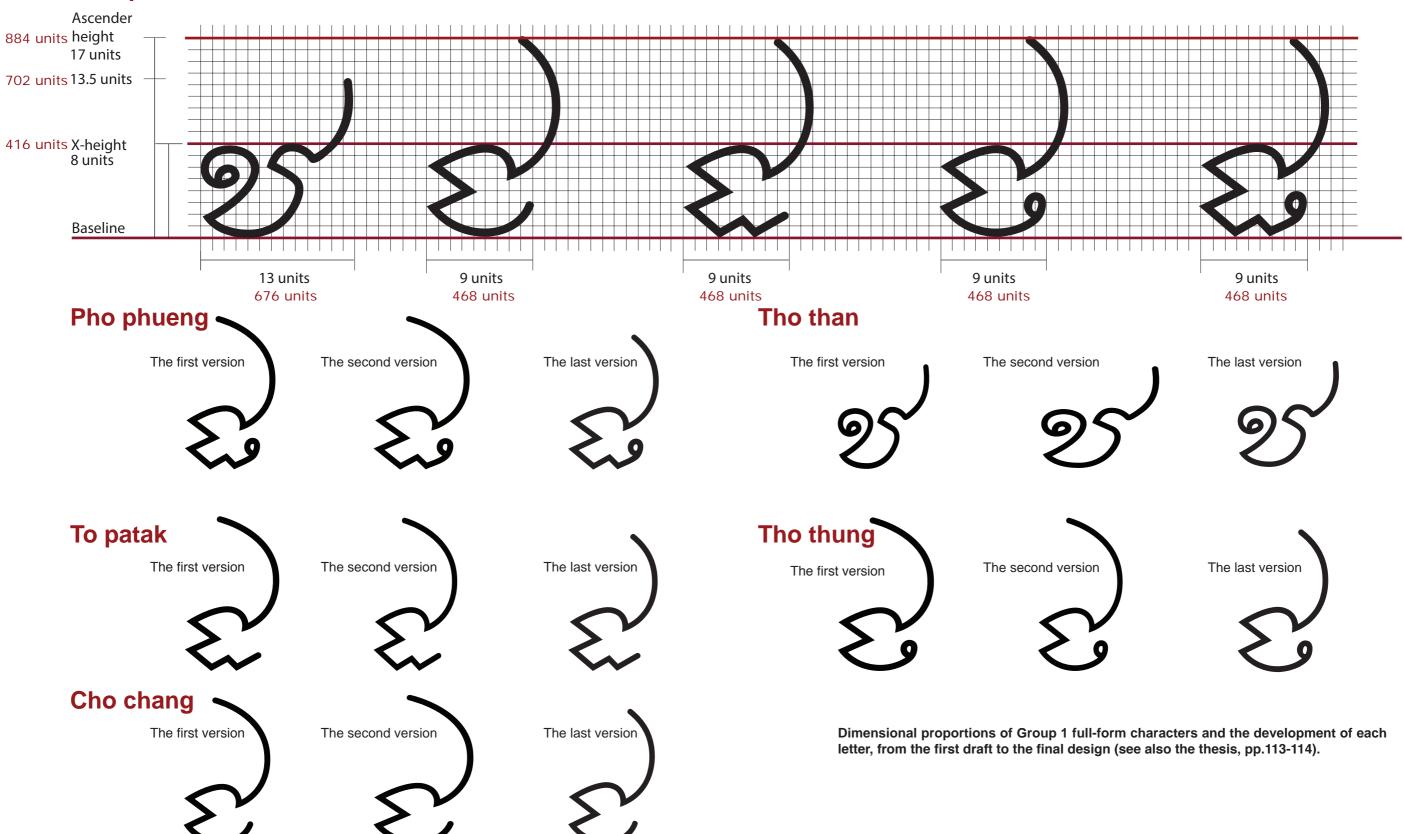
Numbers



Tone marks

1 2

Group 1 full-form characters



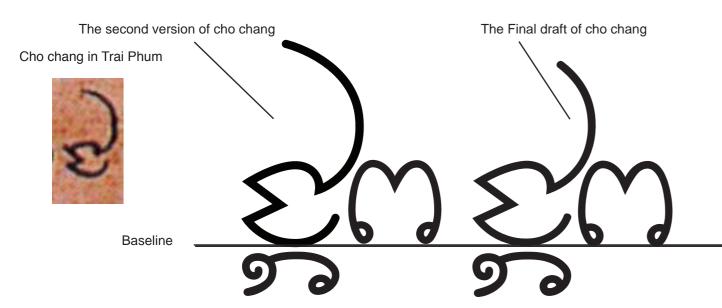


Figure 101. Comparison of cho chang in a pseudoword used for determining the ascender height

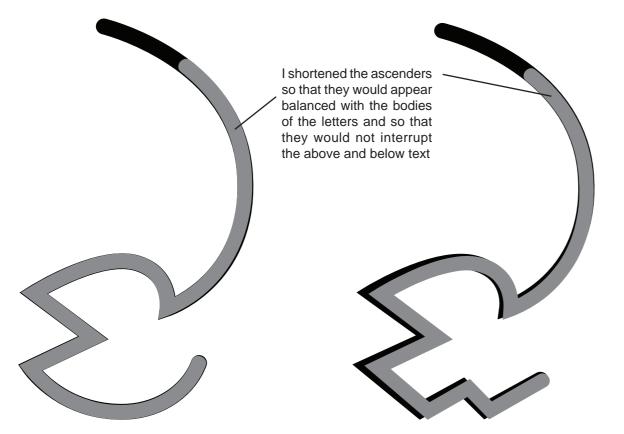


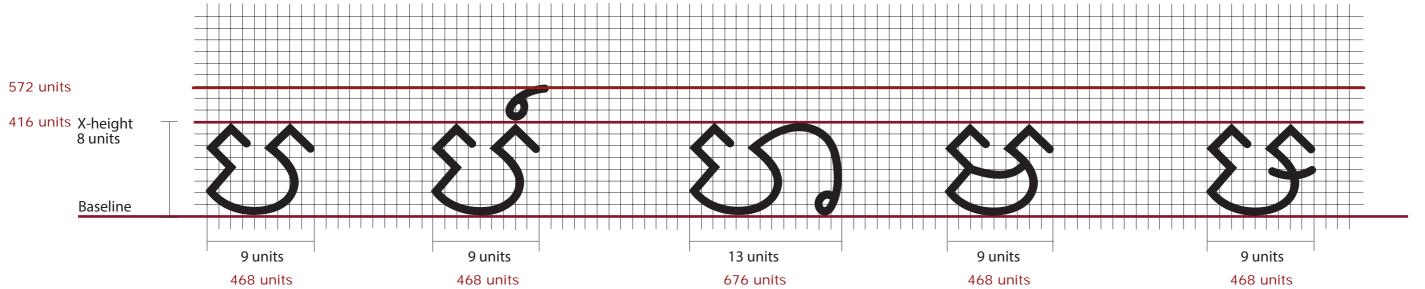
Figure 102. Comparison of cho chan (left) and to patak (right) from the first drafts (black) to the final designs (grey)

For these tall letters, my approach was quite similar to the process for TLK Brahma. First, I needed to determine the ascender height. For the first draft, I was not sure how long it should be, and so I sketched an initial draft and then tested the characters in pseudowords, as illustrated.



Figure 103. Example pseudo words constructed by Group 1 full-form characters

Group 2 full-form characters



Bo baimai

The first version

The second version

The last version



Po pla



The second version



The last version



Mo ma

The first version

The second version

The last version



So ruesi

The first version

The second version

The last version













Ho hip

The first version

The second version

The last version

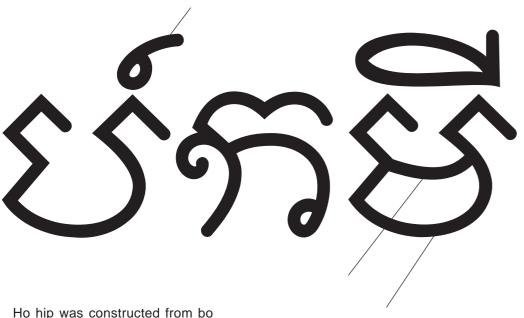




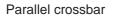


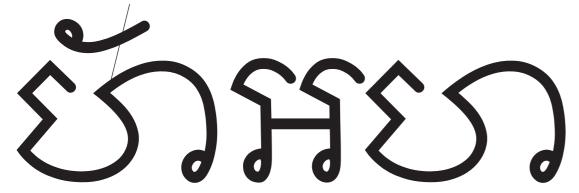
Dimensional proportions of Group 2 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.114-116).

This extra element was moved to the middle of the sok so that the letterform's body appeared more balanced



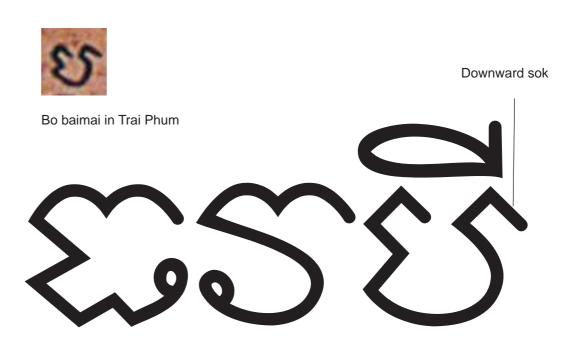
Ho hip was constructed from bo baimai and lak khang











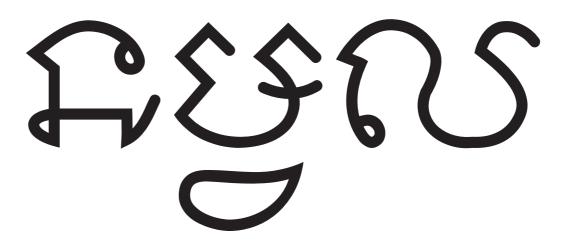
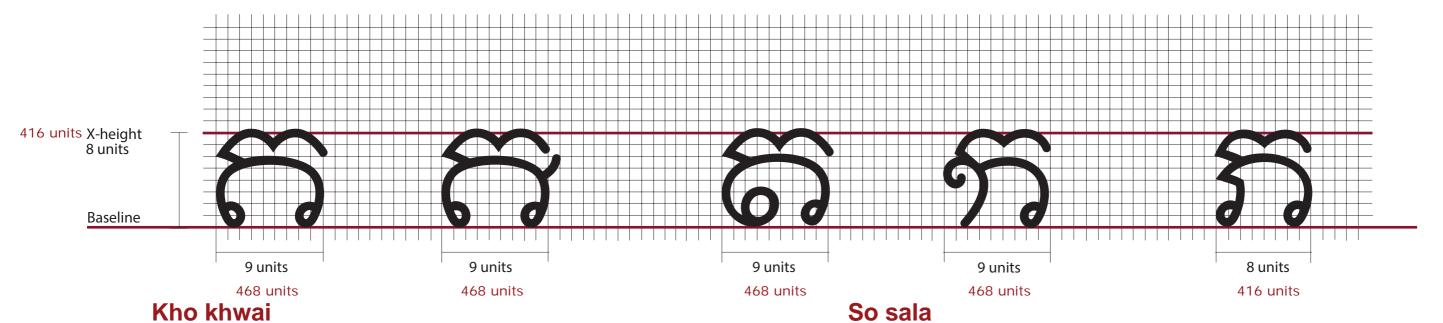


Figure 104. Example pseudowords constructed by the characters in Group 2

I did not significantly modify these characters from the first drafts to the last designs. Mainly, I adjusted the width proportions several times to see what looked the best. Eventually, I found that an 8-unit body (excluding the sok) lent the letterforms a symmetrical appearance.

Group 3 full-form characters



The first version

The second version

The last version











To tao

The first version

The second version

The last version







Ko kai

The first version

The second version

The last version







So sala

The first version

The second version





The last version

Pho samphao

The first version

The second version

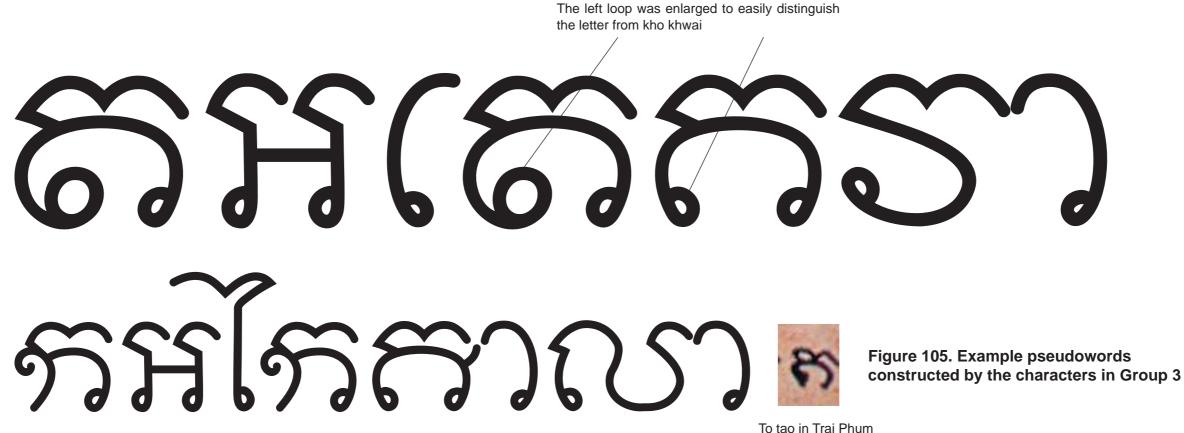
The last version







Dimensional proportions of Group 3 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.116-117).



To tao in Trai Phum

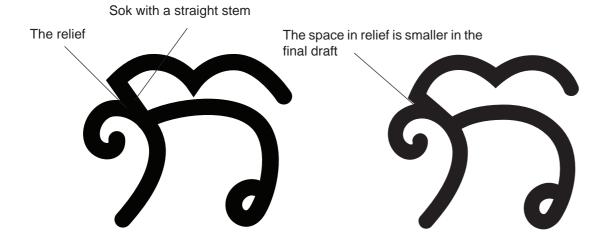
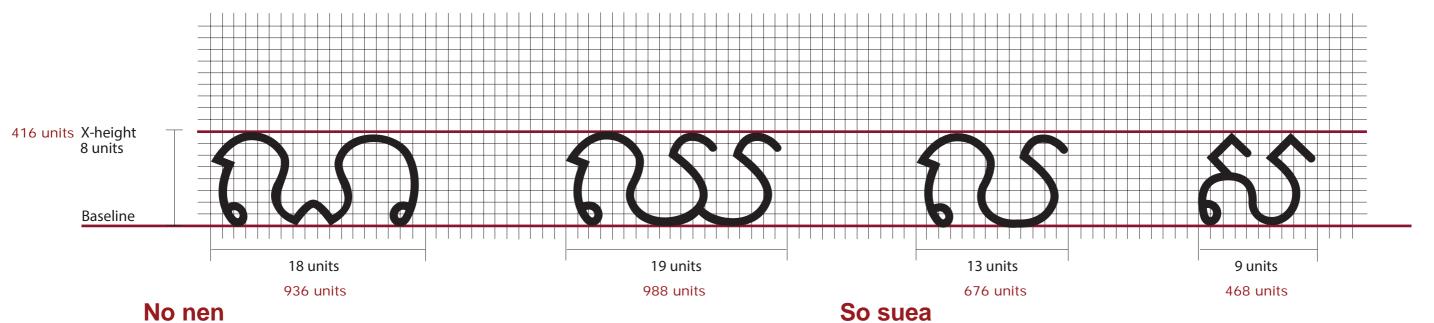


Figure 106. Comparison of ko kai between the first draft (left) and the last design (right)

The characters in this group have medium widths and heights. Unlike the characters in Group 1, designing them was not problematic. Ko kai was the most difficult to design letter in the group, because the spiral on its left did not conform with the shape of the sok. Thus, I adjusted the relief on this character, and I ultimately decided to slightly alter the base of the sok so that it harmonized with the spiral. Another key adjustment affected to tao. The left loop was barely visible in the first draft, and so I increased its size.

Group 4 full-form characters



No nen

The first version

The second version

The last version









The first version



The second version



The last version

The last version

Cho choe

The first version

The second version

The last version



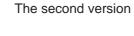




Lo ling

The first version

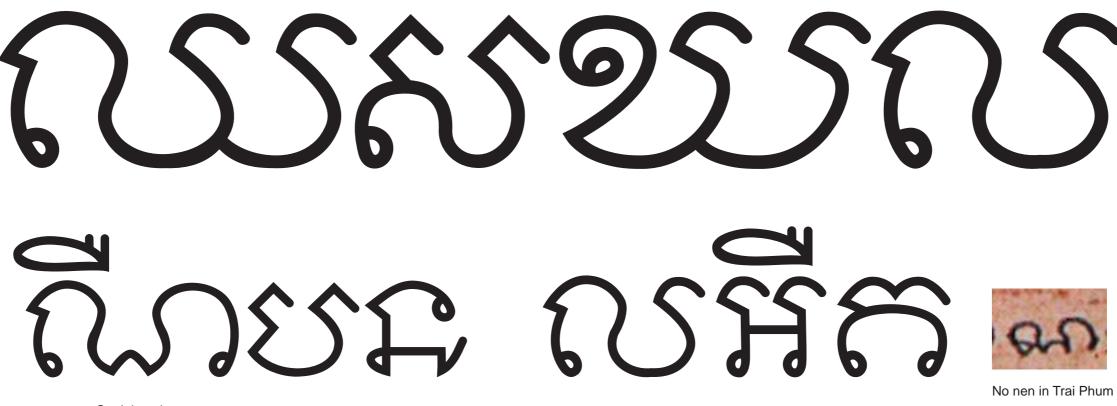






Dimensional proportions of Group 4 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.117-119).

Figure 107. Example pseudowords constructed by the characters in Group 4



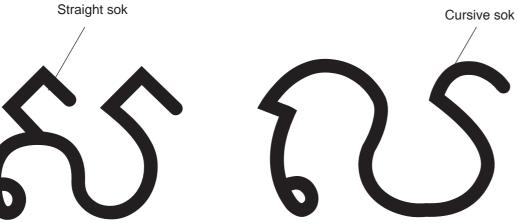
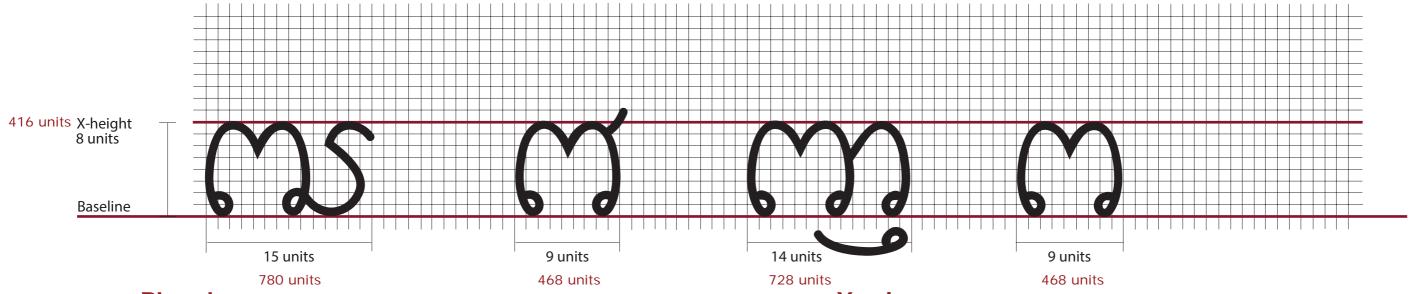


Figure 108. Comparison of so suea (left) and lo ling (right)

This group includes the ultra-wide characters of no nen and cho choe. They were quite difficult to design because their letterforms are more complex than those of typical characters. I doubled the width of both of letters based on lo ling. No nen is slightly wider than cho choe, although both characters had quite similar widths. So suea is the only character that does not share many typographic features with the other group members. However, I thought that its right-hand elements shared commonalities with lo ling. However, the references demonstrated that so suea's sok is ordinarily straight. In contrast, lo ling's sok can be either cursive or straight.

Group 5 full-form characters



Pho phan

The first version

The second version

The last version









The first version

The second version

The last version







Yo ying

The first version



The second version



The last version

Tho phuthao

The first version

The second version



The last version



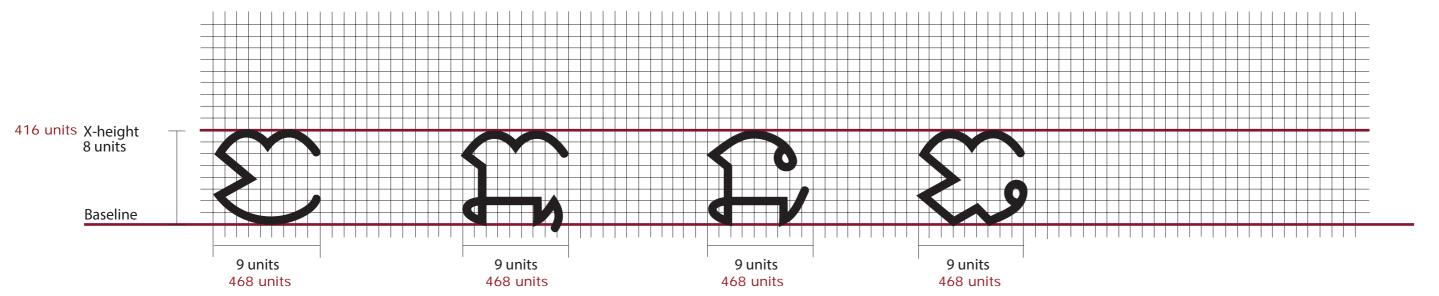
Dimensional proportions of Group 5 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.119-120).

The key character, pho phan, was easy to design due to its symmetry. I could reflect its left-hand elements to create the right side of the character. After designing pho phan, I replicated its main elements to form the other letters in the group.



Figure 109. Example pseudowords constructed by the characters in Group 5

Group 6 full-form characters



Cho chan

The first version

The second version

The last version









The first version

The second version

The last version







Cho ching

The first version

The second version

 \sim





The last version

No nu

The first version

The second version

The last version







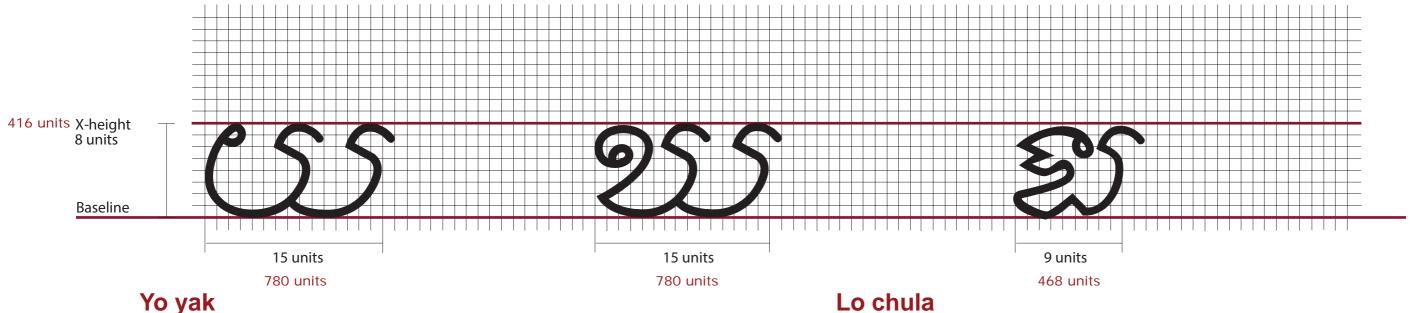
Dimensional proportions of Group 6 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.121-122).

Like the sok of its counterpart, the upper elements of most characters in this group were constructed on the basis of the Group 3 characters, thus uniting the letters as a whole. However, the lower part of each character is different. Therefore, I designed no nu and cho ching together to define the basic proportions of the characters in this group. I then adjusted the letterforms to create cho chan and tho thong.

Figure 110. Example pseudowords constructed by the characters in Group 6



Group 7 full-form characters



Yo yak

The first version

The second version

The last version



The first version



The second version

The last version



Kho rakhang

The first version

The second version

The last version



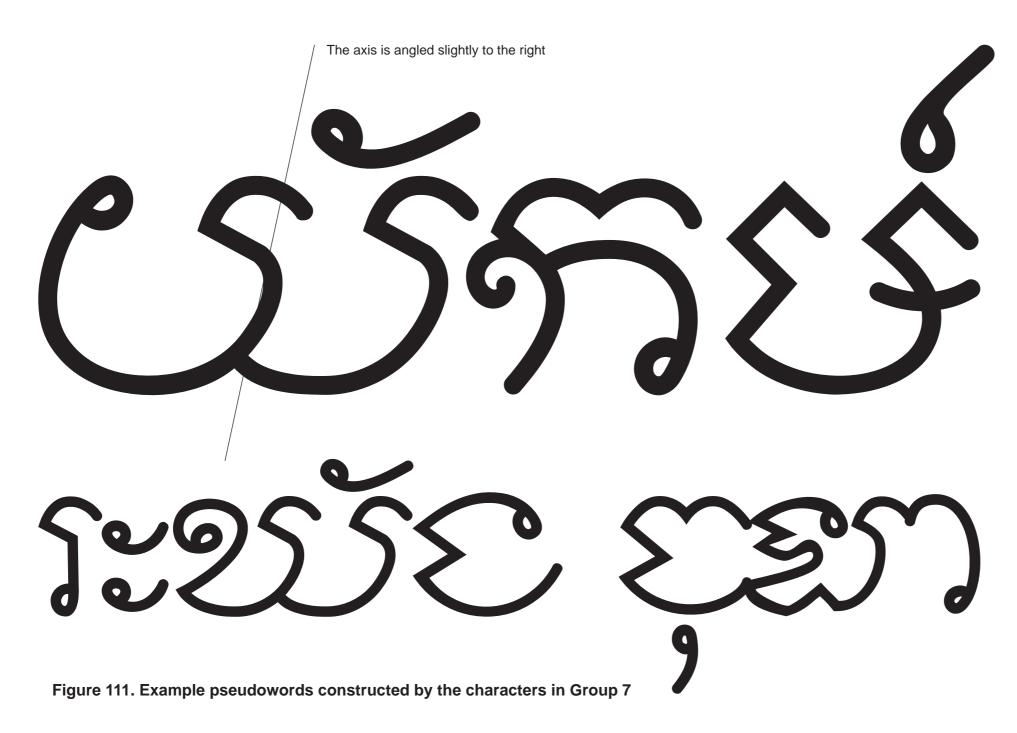






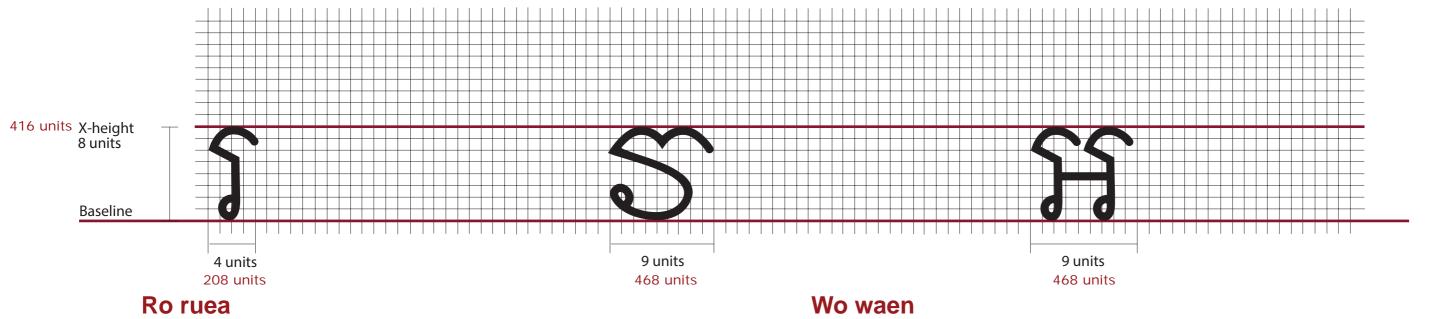
Lo chula in Trai Phum

Dimensional proportions of Group 7 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.122-123).



In TLK Deva, lo chula again posed the most significant design problem. However, unlike in the case of TLK Brahma, I found an example of this character in the first Trai Phum writing style. At first, I utilized a long loop for the character. However, when I placed lo chula in pseudowords, it stood out too much from the other characters. Moreover, it required an excessive amount of interline space. Therefore, I adjusted the loop in the final version.

Group 8 full-form characters



The first version

The second version

The last version













The first version

The second version

The last version









the sok area





The first version

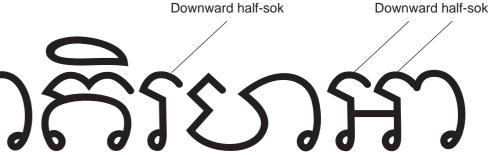


The second version



The last version

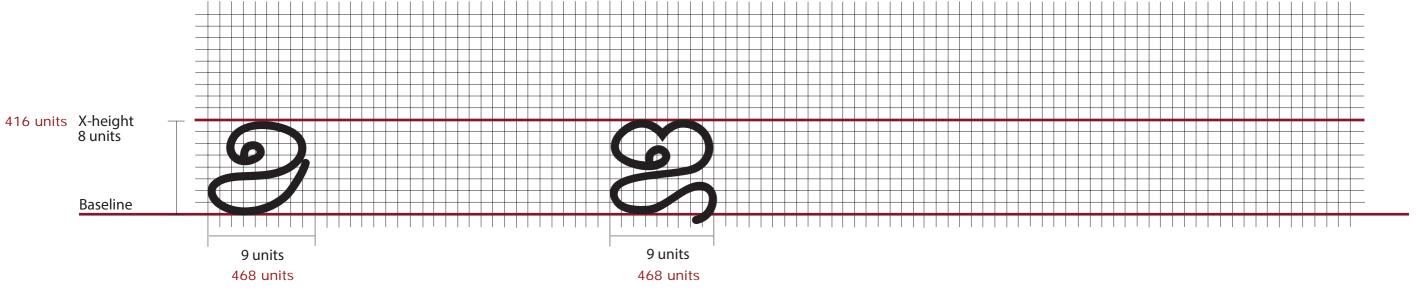
The spine remains inside Downward half-sok



Dimensional proportions of Group 8 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.123-124).

Constructing the Group 8 characters was simple, since they only feature a few typographic elements. Among the three characters, ro ruea is the narrowest. The stem is simply a straight line attached to a loop and a sok. I had already formed these elements for other groups, and so I just needed to replicate them to create ro ruea and o ang. When designing wo waen, I gradually bent ro ruea's steam to create the spine, and I later placed a full sok above the body.

Group 9 full-form characters



Kho khai

The second version

The last version

Tho montho

The first version

The second version

The last version









The first version





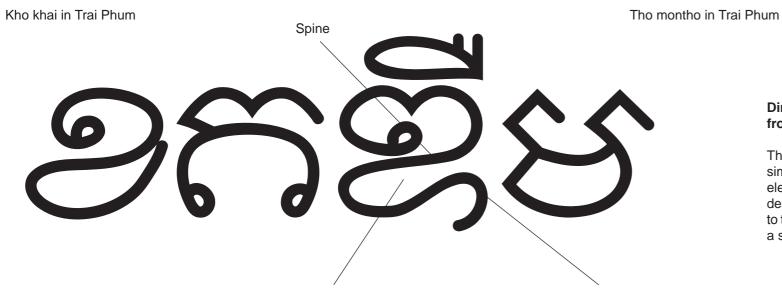












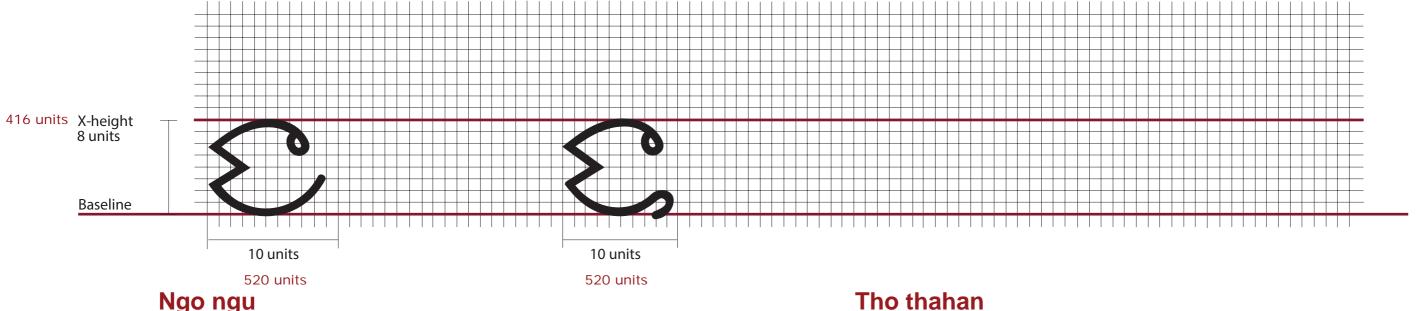
Less negative space inside.

The descender was moved so that it originated closer to the spine (above)

Dimensional proportions of Group 9 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.124-125).

These two characters do not have soks. However, the upper part of tho montho shares some similarities with a sok. When designing this letter, I adjusted the form of the sok to create the upper elements of tho montho. The negative space of its body looked too large, and I thus moved the descender so that it originated closer to the spine. For kho khai, I did not need to make many changes to the first draft. The only major modification was that I adjusted the stroke weight and width to create a sense of unity among all of the characters.

Group 10 full-form characters



Ngo ngu

The first version

The second version

The last version











The first version

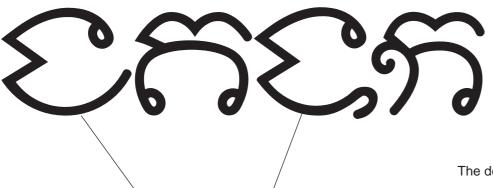


The second version



The last version

Tho thahan in Trai Phum



The lower curves were adjusted

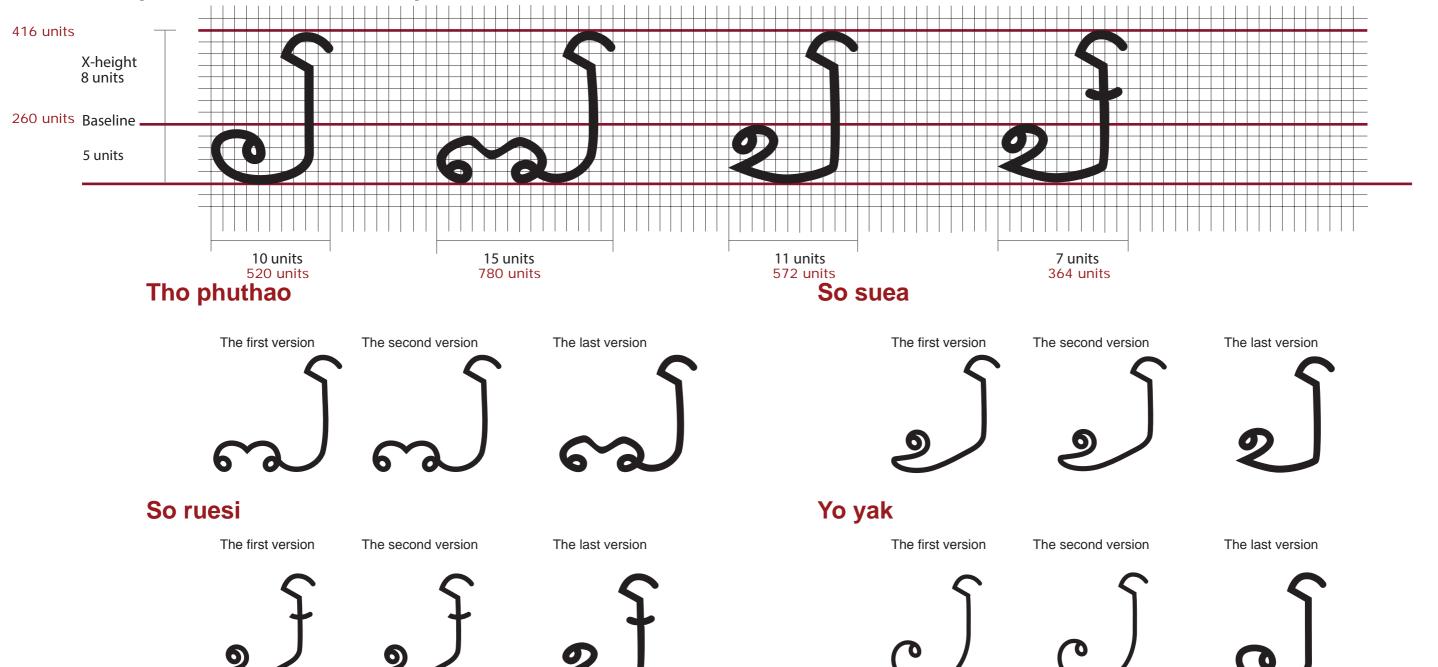


The descender rests slightly under the baseline

Dimensional proportions of Group 10 full-form characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.125-126).

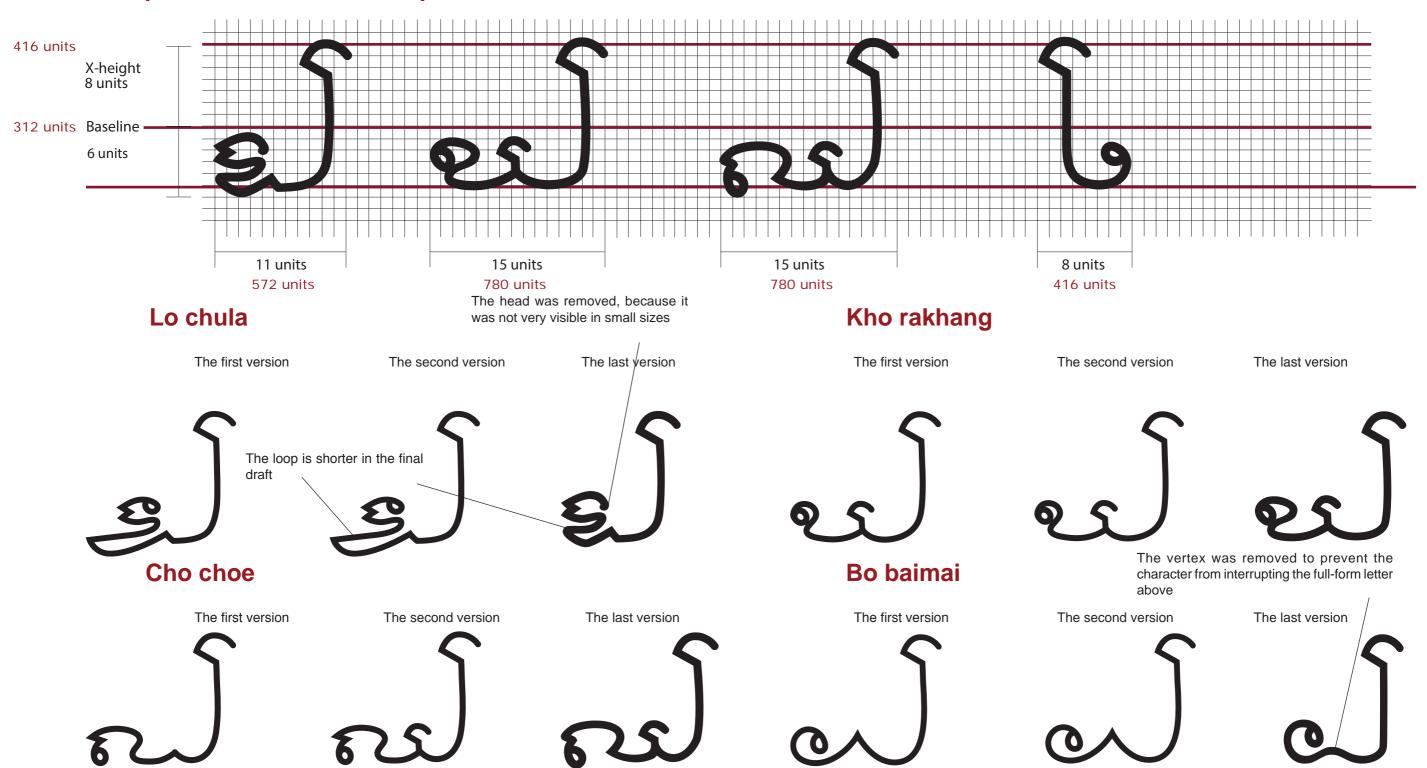
To construct these two letters, I started by creating an ellipse, and I then added the loop and the descender. At first, the lower curves of ngo ngu and tho thahan were not smooth, and so I improved them in the final draft.

Group 1 consonantal subscripts



Dimensional proportions of Group 1 characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.127-128).

Group 1 consonantal subscripts



Dimensional proportions of Group 1 characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.127-128).

As with TLK Brahma, the first factor that I considered when designing these consonantal subscripts was the extenders. This element needed to conform with the full-form characters resting above the consonantal subscripts. When I designed the first and the second drafts, I did not really consider how I wanted each character to look when it formed part of a word. However, my experiments with pseudowords made it obvious that the overall proportions needed to be adjusted.

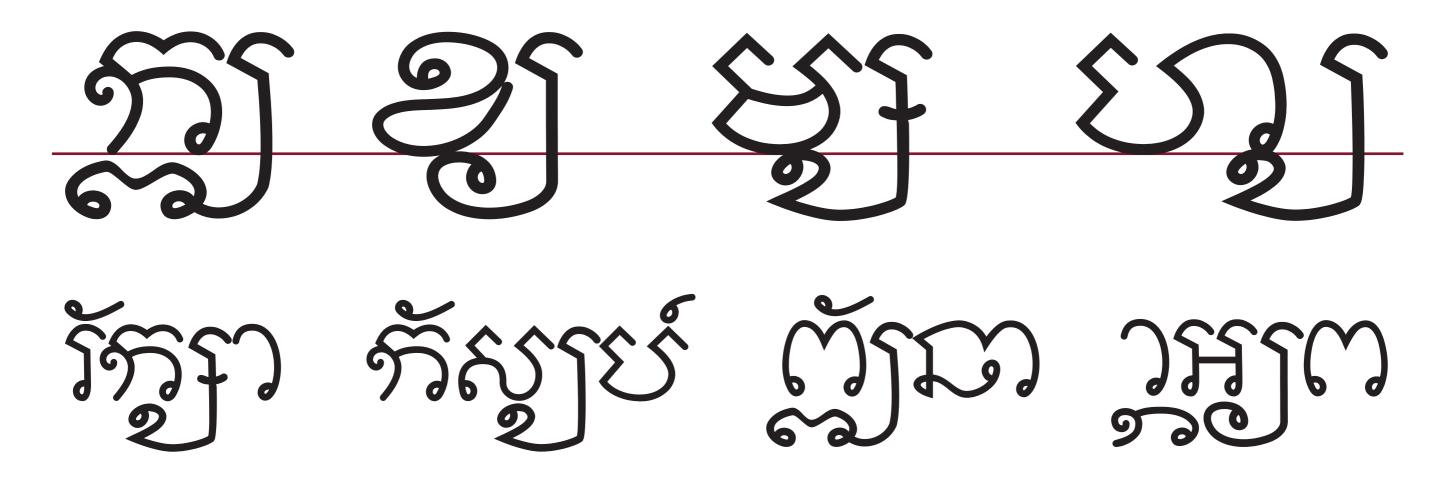
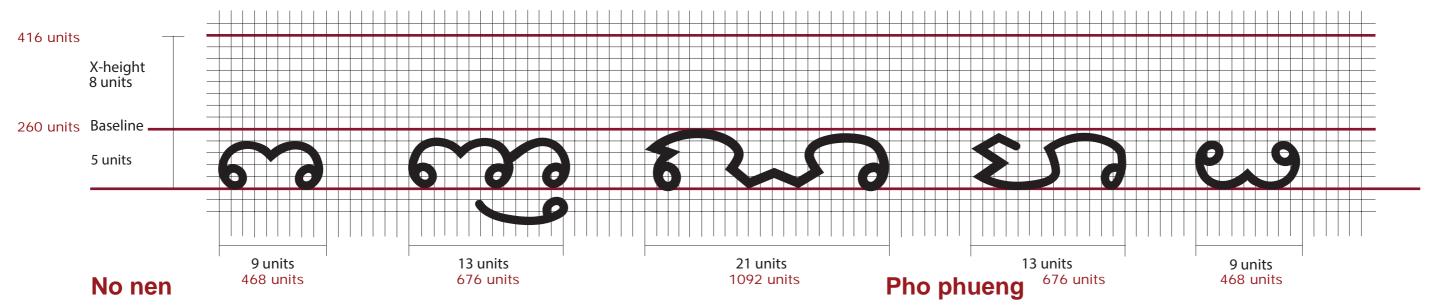


Figure 112. Example pseudowords constructed by the characters in Group 1

Group 2 consonantal subscripts



The first version

The second version

The last version

The first version

The second version

The last version













Yo ying

The first version

The second version

The last version

Pho phan

The first version

The second version

The last version













Ho hip

The first version

The second version

The last version

Dimensional proportions of Group 2 characters and the development of each letter, from the first draft to the final design (see also the thesis, p.129).







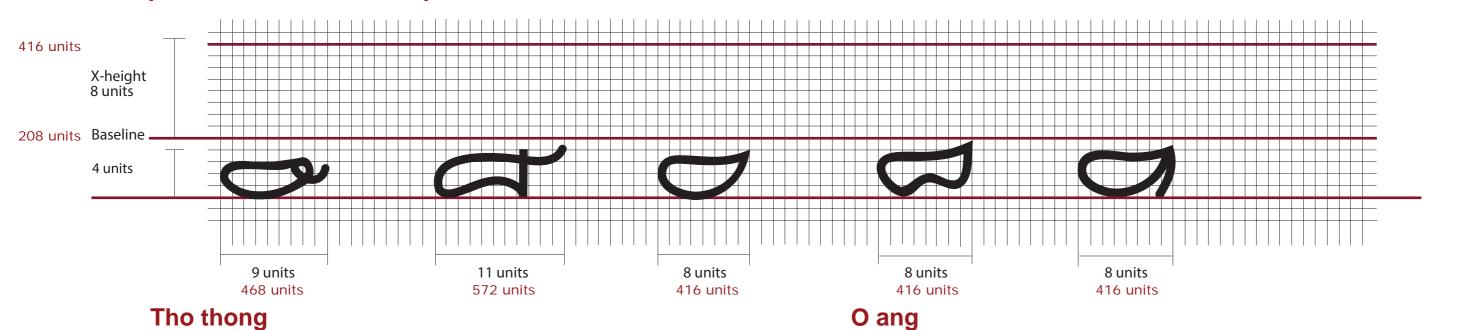
Figure 113. Comparison of the full-form version (above the baseline) and the consonantal subscript characters (under the baseline)



Figure 114. Example pseudowords constructed by the characters in Group 2

These consonantal subscripts are shorter versions of their full-form counterparts. In general, I adjusted the overall structures based on the full-form characters. Pho phueng is the only consonantal subscript character that does not share similarities with its full-form equivalent. However, its letterforms resemble the pho phan consonantal subscript. Therefore, I utilized a mirror image of pho phan to create pho phueng.

Group 3 consonantal subscripts



The first version

The second version

The last version

The first version

The second version

The last version













Wo waen

The first version

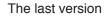
The second version

The last version





The second version











Tho than

The first version





Tho thahan

The first version

The second version

The last version







Dimensional proportions of Group 3 characters and the development of each letter, from the first draft to the final design (see also the thesis, p.130).

As for TLK Brahma, these characters could be formed from a half-circle or ellipse. After I crafted the basic forms, I then fine-tuned each character in accordance with the references.

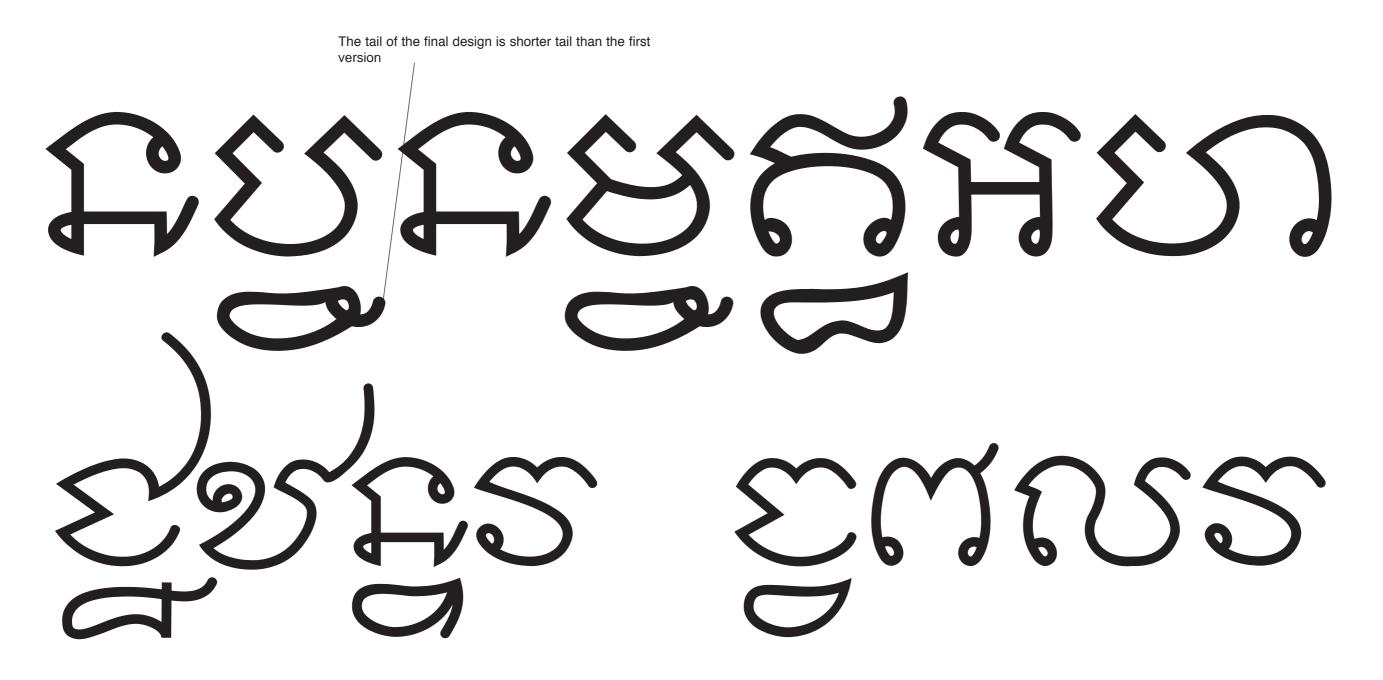
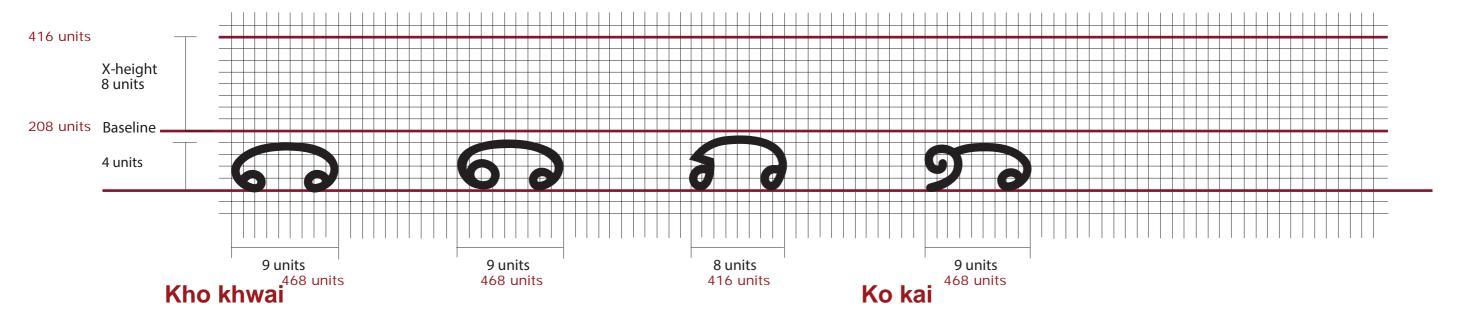


Figure 115. Example pseudowords constructed by the characters in Group 3

Group 4 consonantal subscripts



The first version

The second version

The last version

The first version

The second version

The last version









Pho samphao

The first version





To tao

The first version

The second version

The last version





The last version

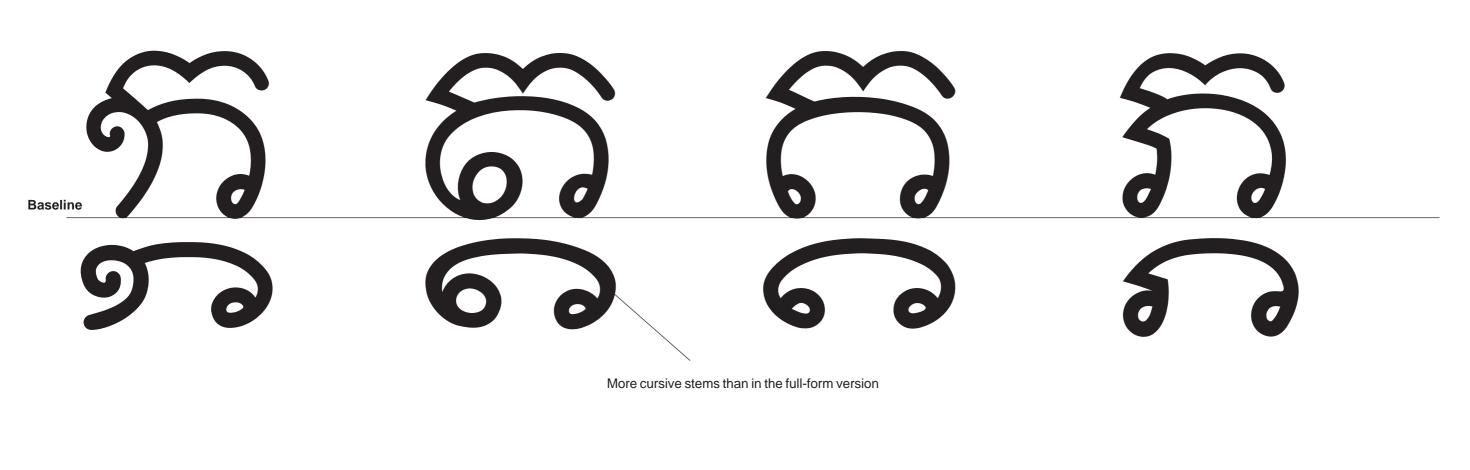


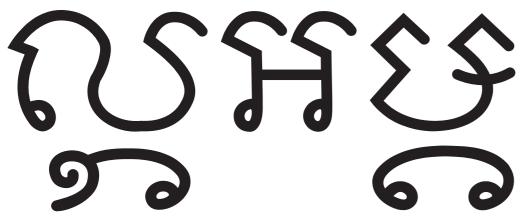


Dimensional proportions of Group 4 characters and the development of each letter, from the first draft to the final design (see also the thesis, pp.130-131).

In most cases, the bodies of these characters have the same construction as their full-form equivalents. However, since they are shorter, their stems are therefore more cursive.

Figure 116. Comparison of the full-form version (above the baseline) and the consonantal subscript characters (under the baseline)





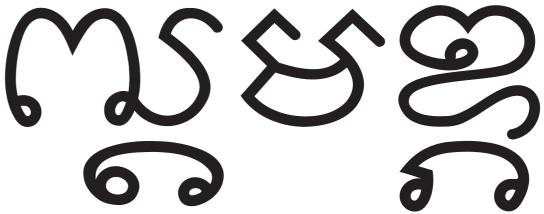
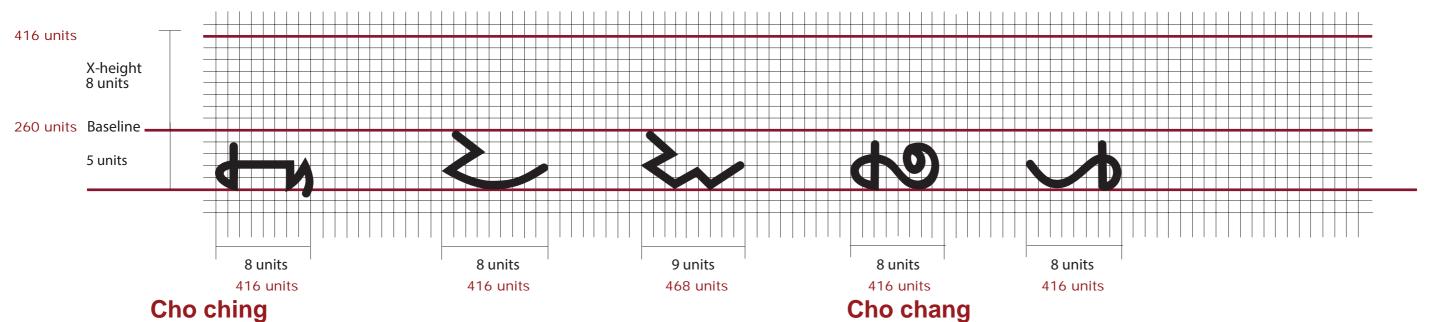


Figure 117. Example pseudowords constructed by the characters in Group 4

Group 5 consonantal subscripts



The first version

The second version

The last version

one onang

The first version

The second version

The last version













To patak

The first version

The second version

The last version

No nu

The first version

The second version

The last version













Mo ma

The first version

The second version

The last version







Dimensional proportions of Group 4 characters and the development of each letter, from the first draft to the final design (see also the thesis, p.131).

Cho chang, cho ching, and to patak were easy to design since they are composed of the lower components of the respective full-form characters. No nu and mo ma do not share any features with their full-form counterparts, and so I needed to draw them from scratch.

Figure 118. Comparison of the full-form version (above the baseline) and the consonantal subscript characters (under the baseline)

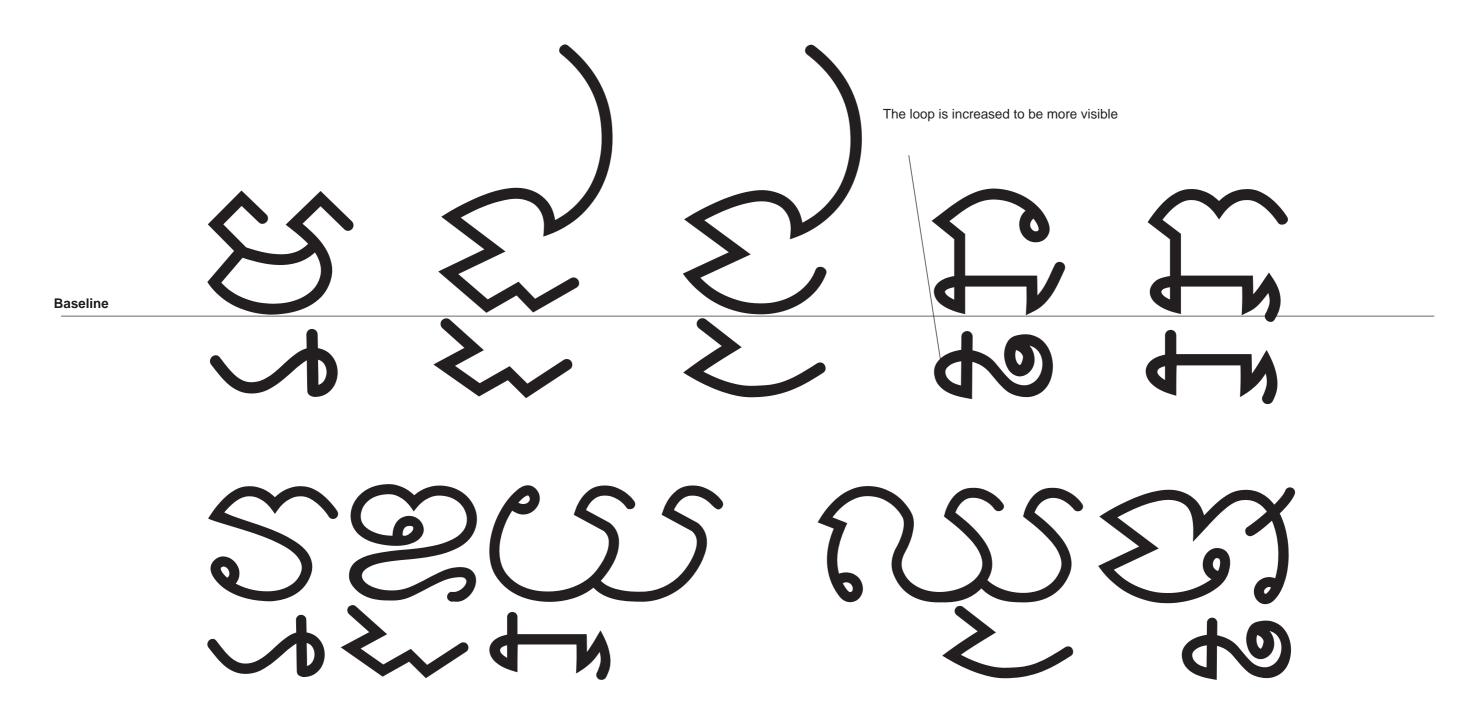
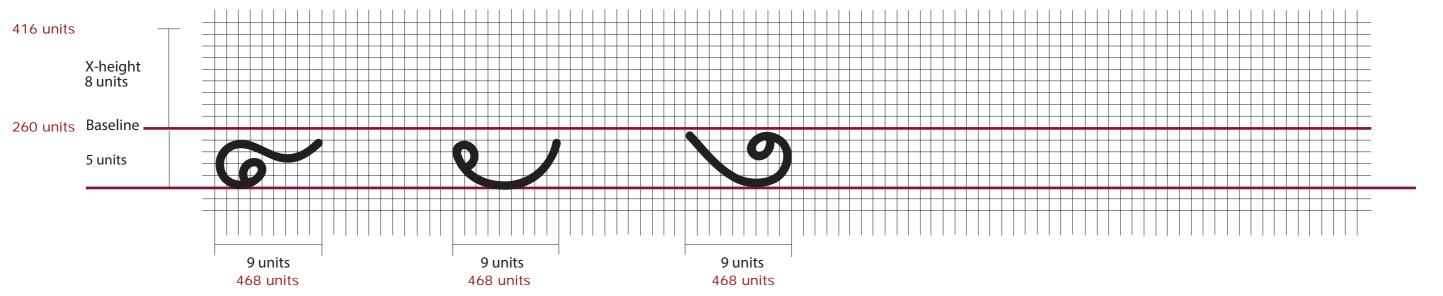


Figure 119. Example pseudowords constructed by the characters in Group 5

Group 6 consonantal subscripts



Ngo ngu

The first version

The second version

The last version







Tho thung

The first version

The second version

The last version







Lo ling

The first version

The second version

The last version



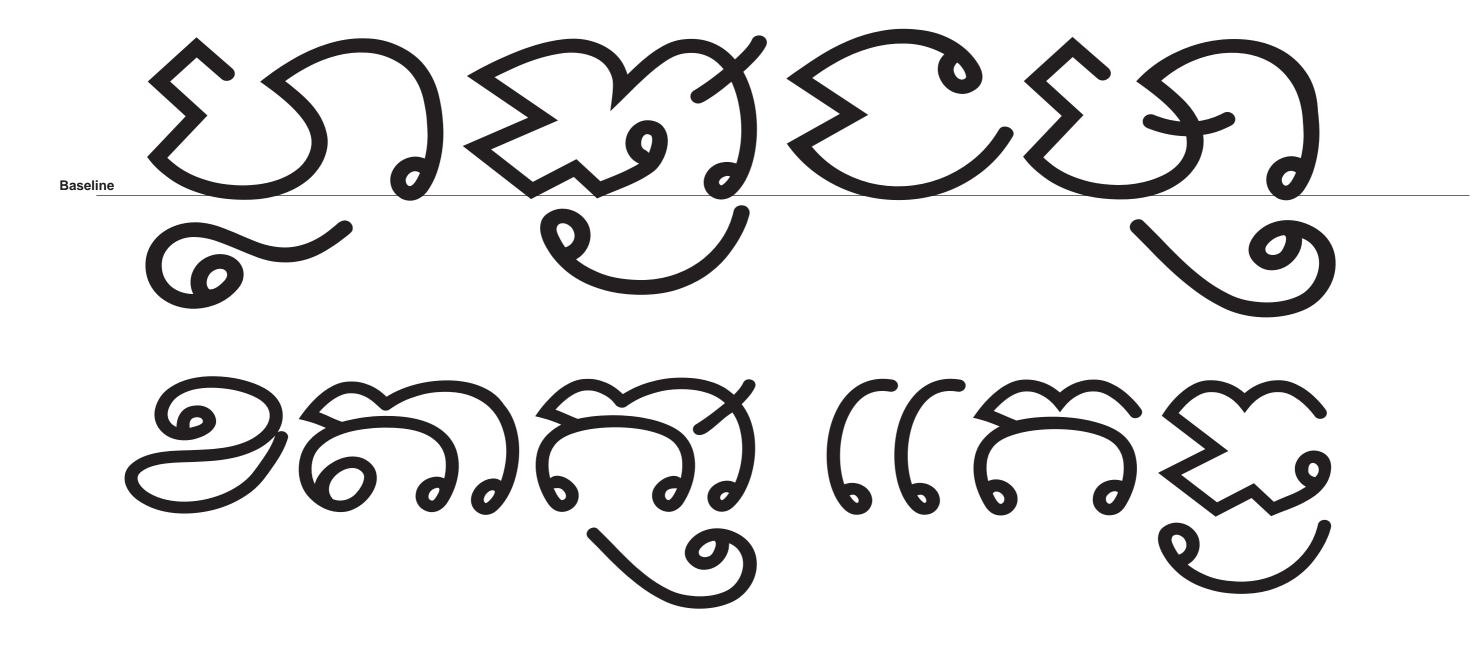




Dimensional proportions of Group 6 characters and the development of each letter, from the first draft to the final design (see also the thesis, p.132).

I did not face many obstacles in designing these characters, since their structures are very simple. Lo ling was probably the greatest challenge in this group, due to its asymmetry.

Figure 120. Example pseudowords constructed by the characters in Group 6



Group 7 of consonantal subscripts

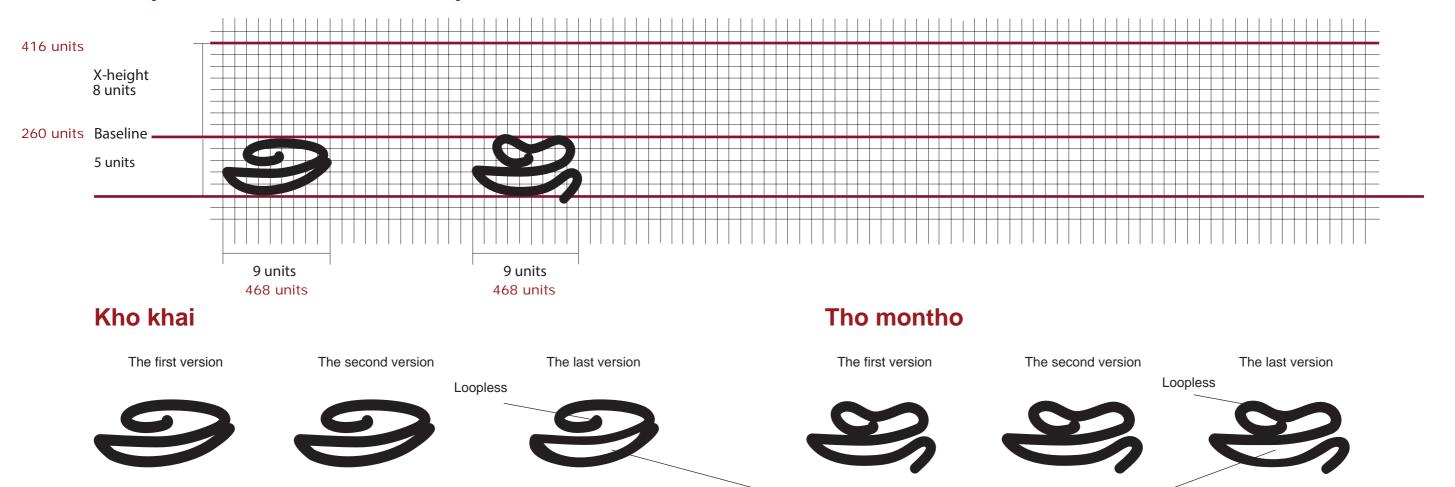




Figure 121. An example pseudoword constructed by the Group 7 characters

Dimensional proportions of Group 7 characters and the development of each letter, from the first draft to the final design (see also the thesis, p.132).

The negative spaces were increased

Although the skeletons of both characters are quite similar to their full-form versions, the proportional dimensions needed to be adjusted, since the consonantal subscripts were shorter. For this reason, I needed to remove the loops from the head to preserve the overall structures. In addition, I increased the amount of negative space inside both of them, since they looked too thick in small sizes.

Group 1 numerals

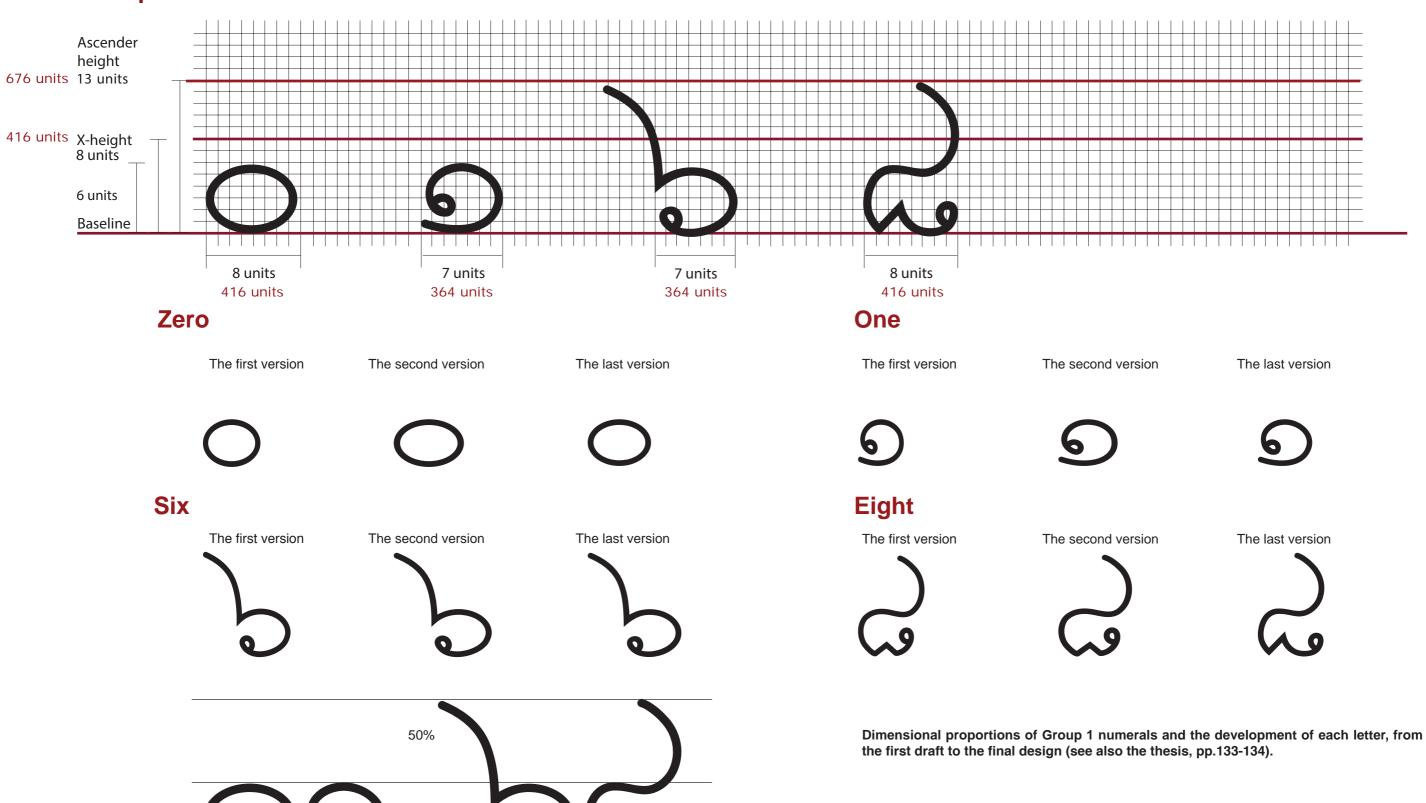
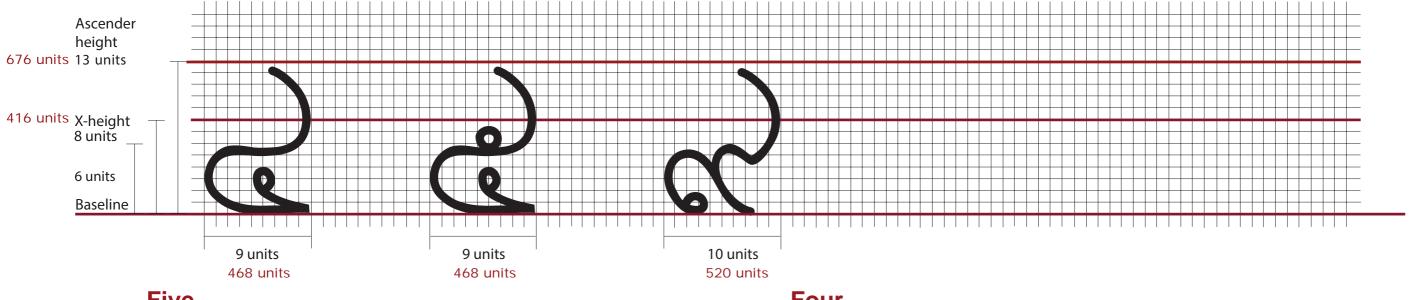


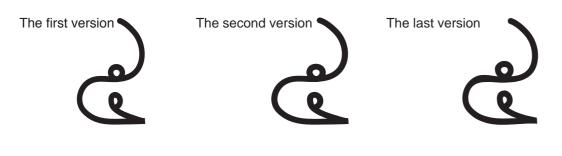
Figure 122. A proportional comparison of each number

50%

Group 2 numerals



Five



Nine



Dimensional proportions of Group 2 numerals and the development of each letter, from the first draft to the final design (see also the thesis, p.134).

These numbers were quite difficult to design, since they are asymmetrical. Therefore, I could not flip elements so that their mirror images created the second side of the of the character, as I did with Group 2. I started by freely drawing the characters, and I then gradually adjusted them. Like some full-form characters, the numbers in Trai Phum sometimes had very long ascenders to the point of being impractical. The ascenders of TLK Deva's numbers are approximately 12–13 units. The numbers' bodies were about half as tall as their ascenders.

Four

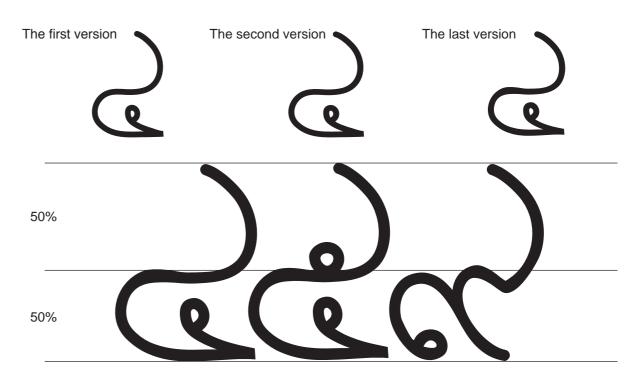


Figure 123. A proportional comparison of each number

Group 3 numerals Ascender height 676 units 13 units 416 units X-height 8 units 6 units Baseline 7 units 7 units 9 units 468 units 364 units 364 units Two Seven The first version The second version The last version The first version The second version The last version The ascender of number two is a little longer than number seven. **Three** 50% The first version The second version The last version 50%

Figure 124. A proportional comparison of each number

Dimensional proportions of Group 3 numerals and the development of each letter, from the first draft to the final design (see also the thesis, p.135).

Group 1 independent vowels

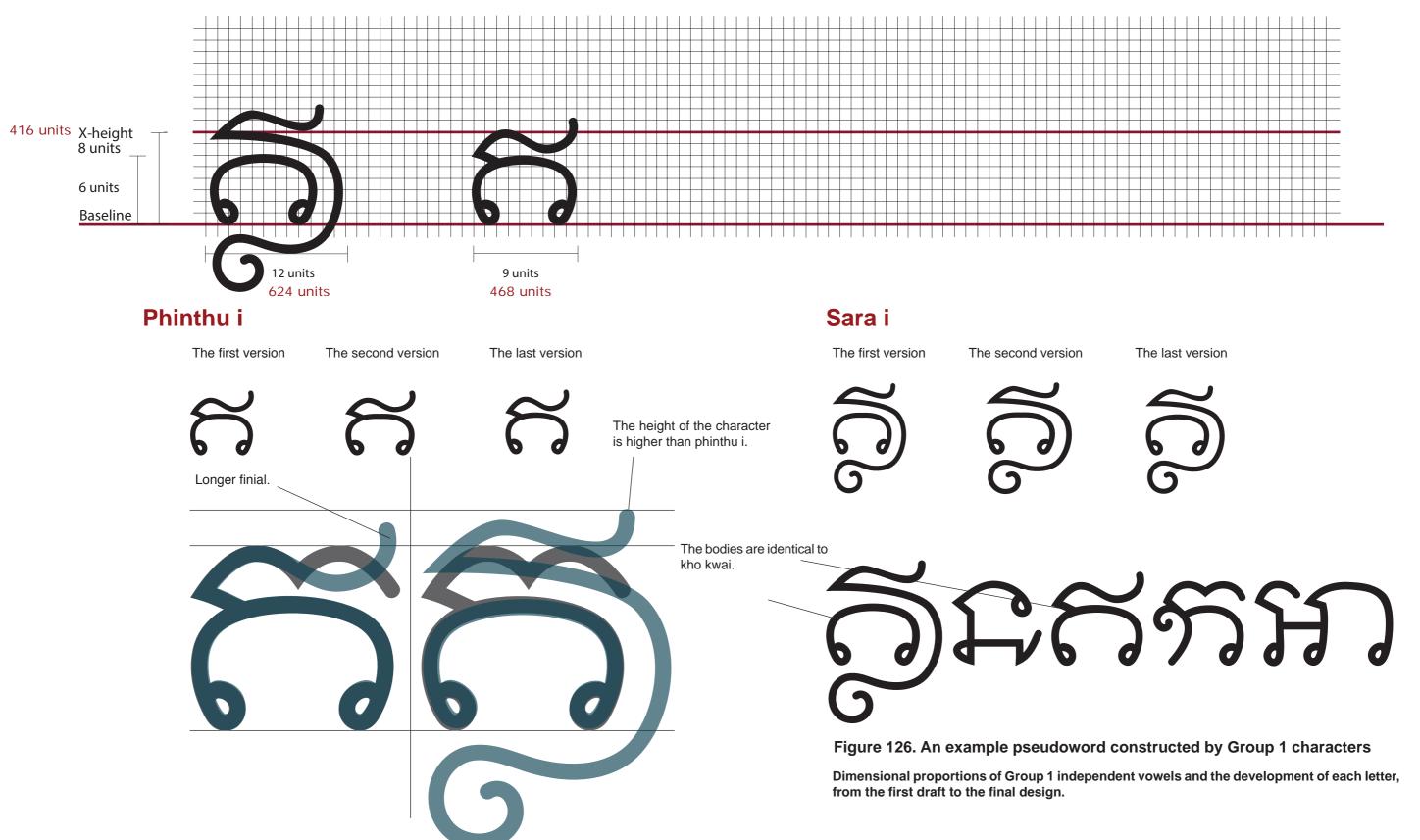
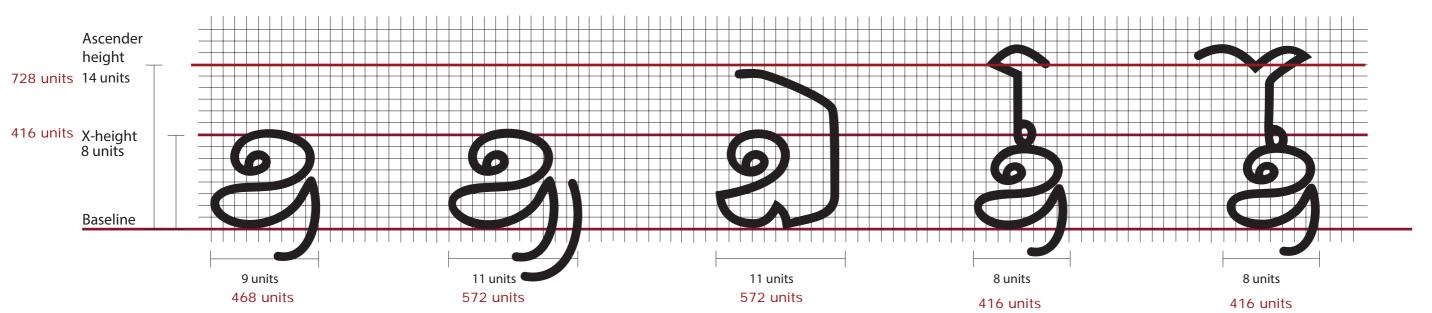


Figure 125. A proportional comparison between kho khwai (grey), phinthu i and sara i (green)

Group 2 independent vowels



Mai o

The first version



The first version



Tin khu

The first version



The second version



The second version



The second version



The last version



The last version



The last version



Mai na

The first version



The second version



The last version

Mai malai

The first version



The second version



The last version



Dimensional proportions of Group 2 independent vowels and the development of each letter, from the first draft to the final design.

I altered the height of mai o and mai malai several times. In the first draft, the upper part of both of characters seemed too long. The result was a lack of unity with the other characters. For this reason, I decided to reduce the body height by 1 unit, and I set the total height at 16.5 units.

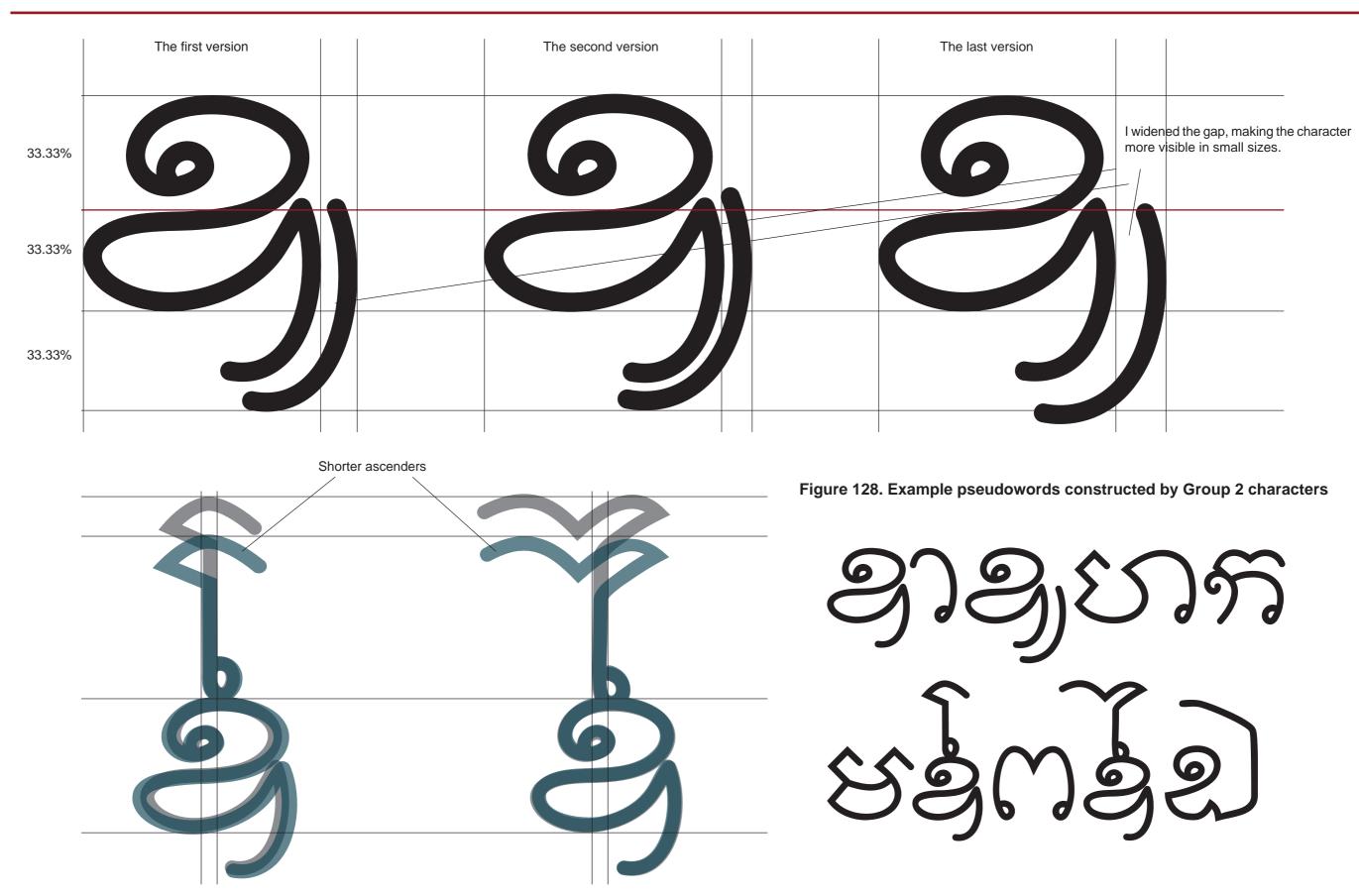
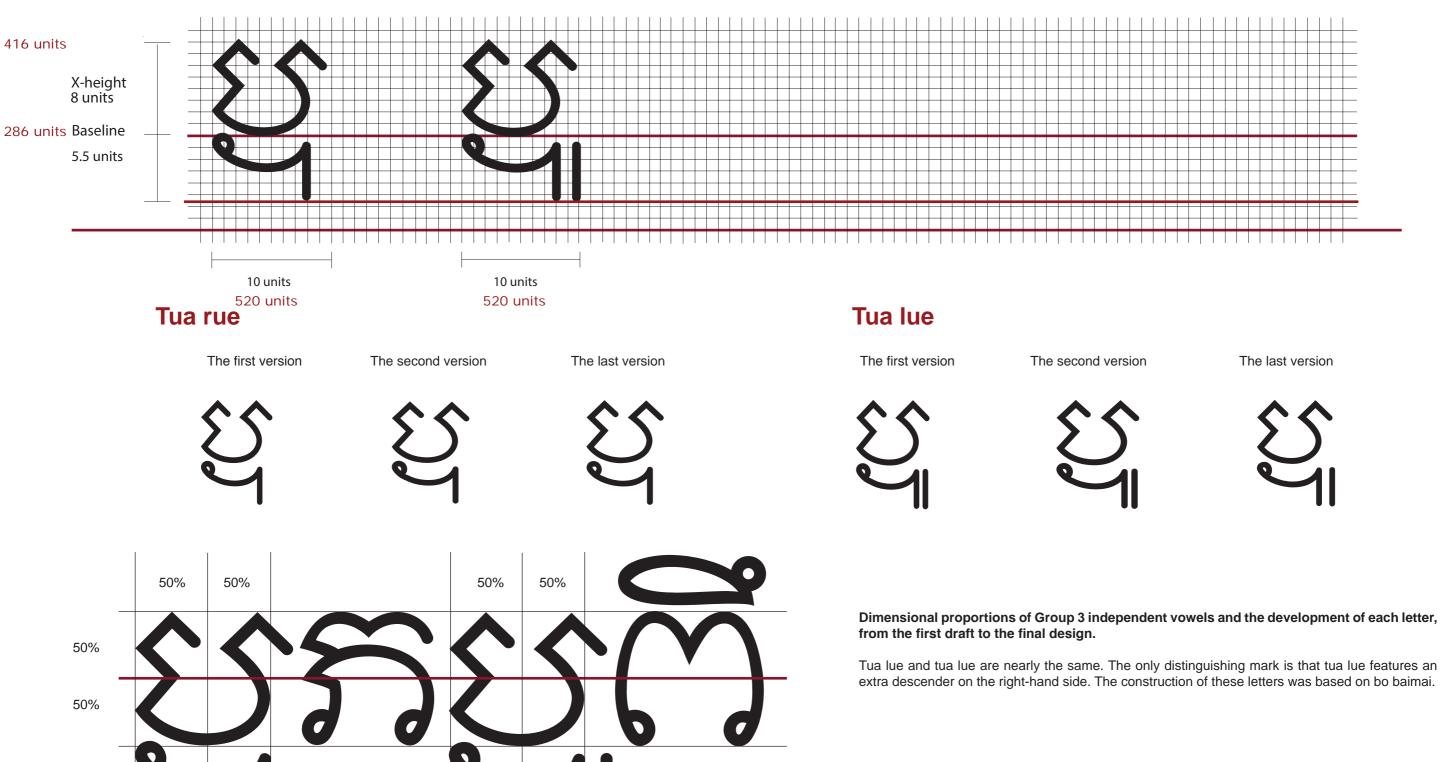


Figure 127. A proportional comparison between the first drafts (grey) and the final designs of mai o (left) and mai malai

Group 3 independent vowels



I increased the size of the gap to make the character more visible in small sizes

Figure 129. An example pseudoword constructed by Group 3 characters

Group 4 independent vowels

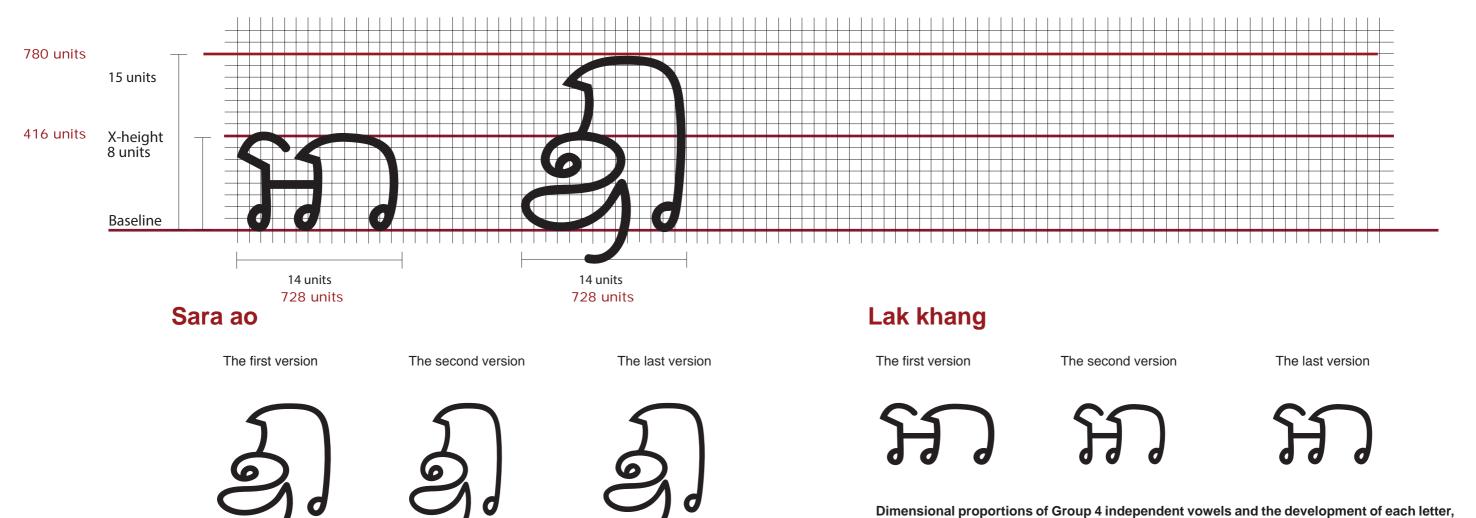
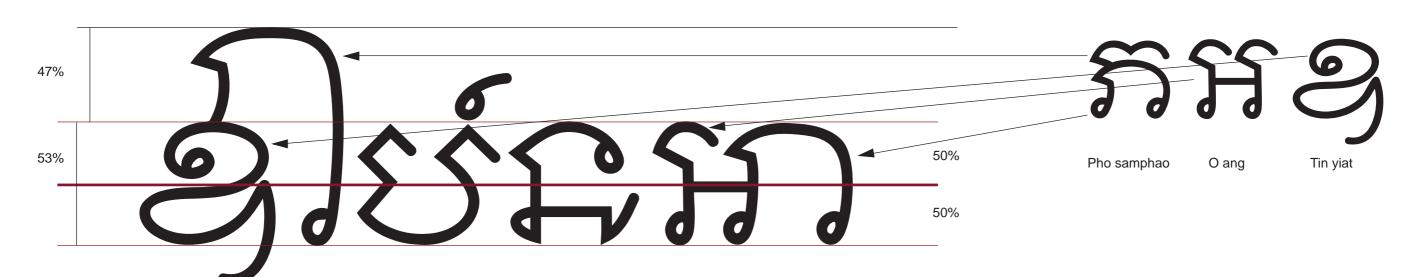


Figure 130. An example pseudoword constructed by Group 4 characters

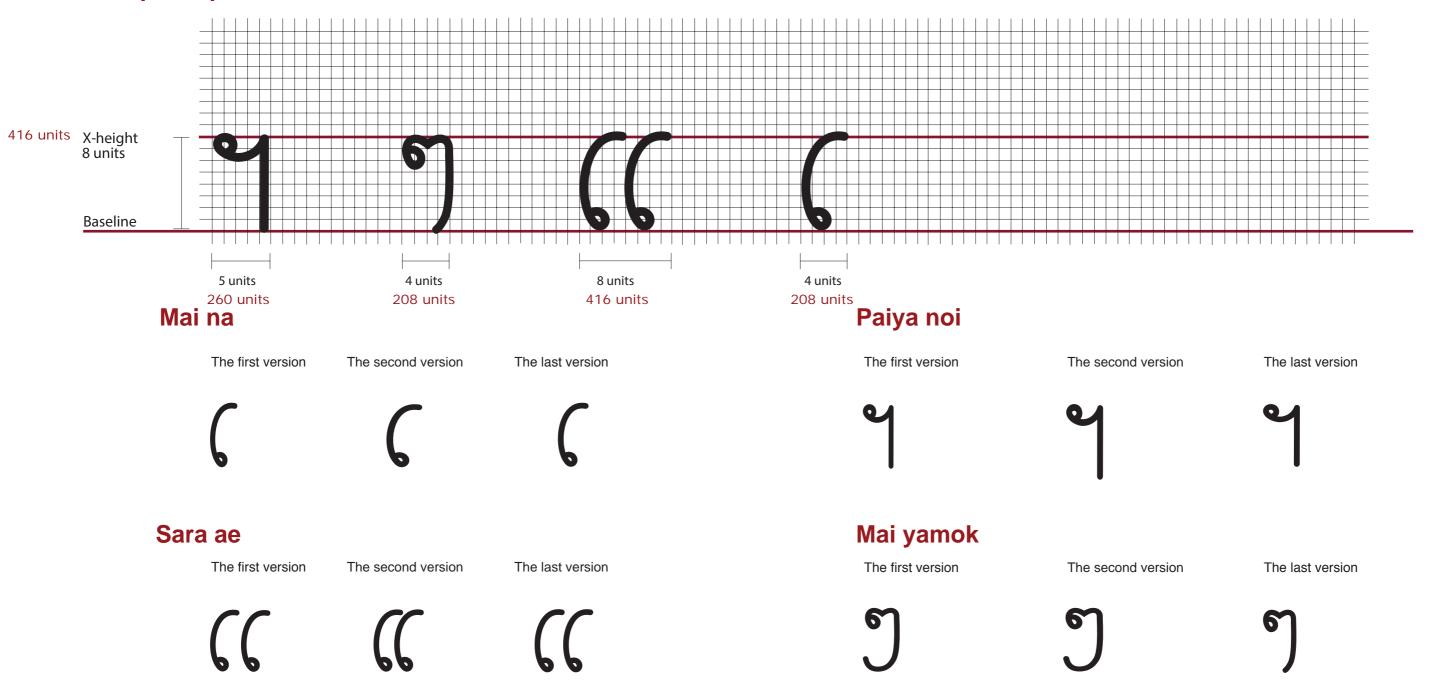
from the first draft to the final design.

As illustrated in Chapter 2 of the thesis, these characters were constructed from o ang, tin yiat and



pho samphao.

Group 1 dependent vowels



Dimensional proportions of Group 1 dependent vowels and the development of each letter, from the first draft to the final design.

TLK Deva

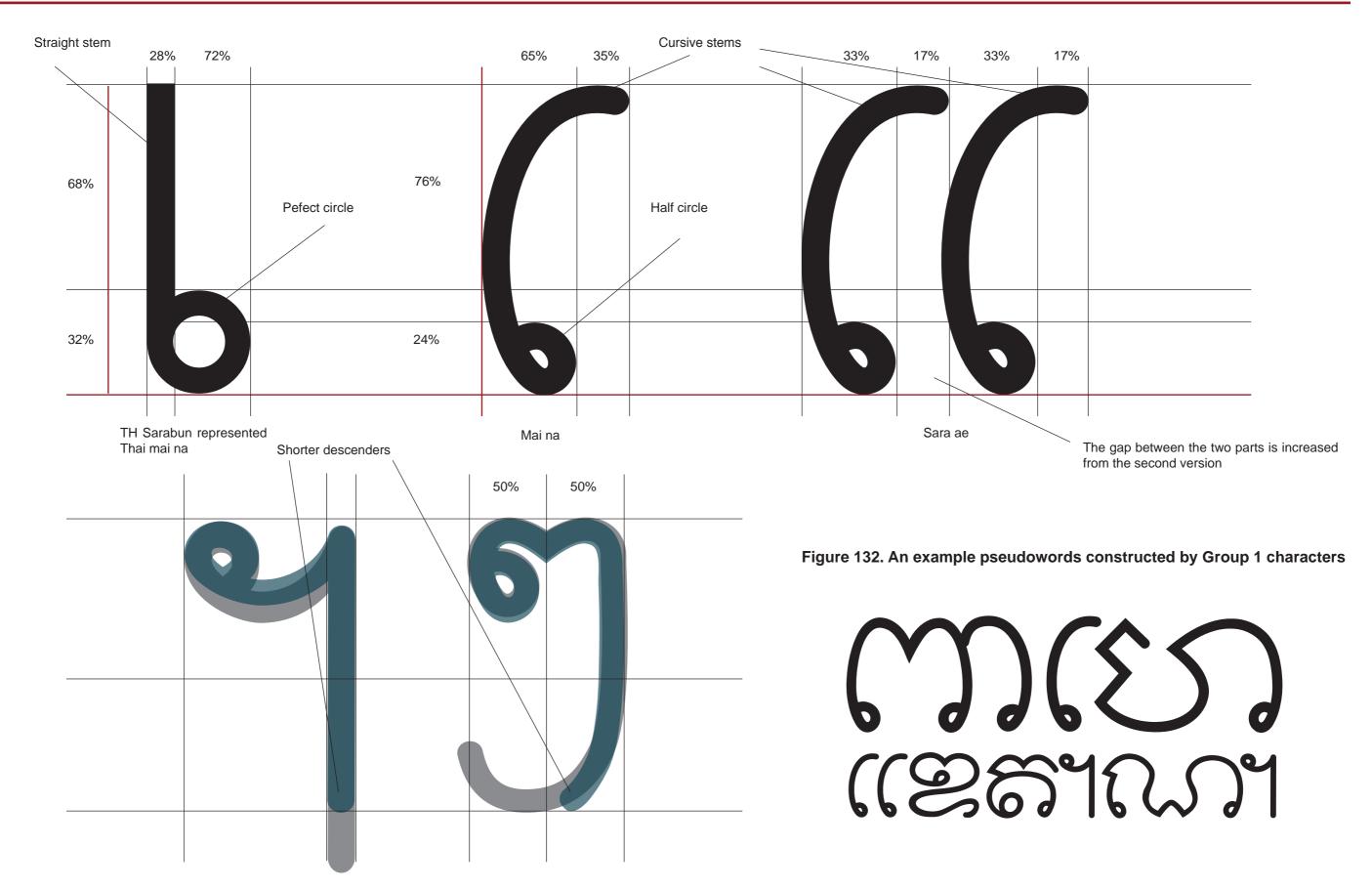


Figure 131. A proportional comparison between the first drafts (grey) and the final designs of paiyan noi (left) and mai yamok

Group 2 dependent vowels

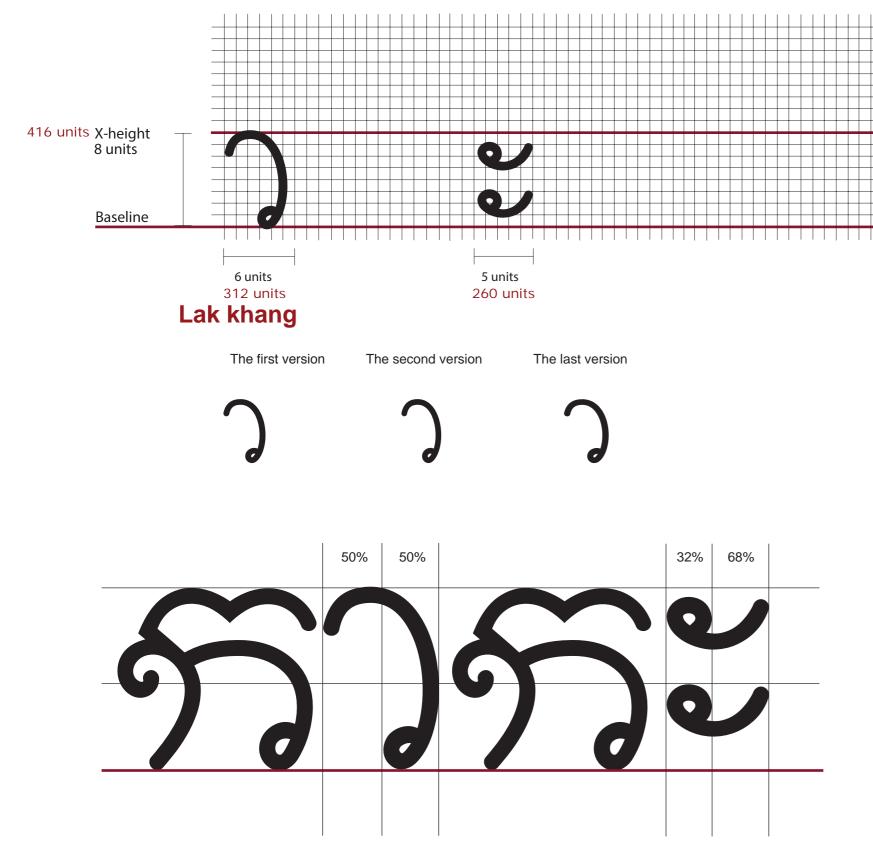


Figure 134. An example pseudowordsconstructed by Group 2 characters

Wisanchani

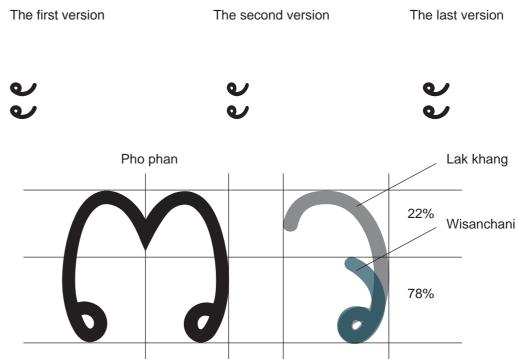
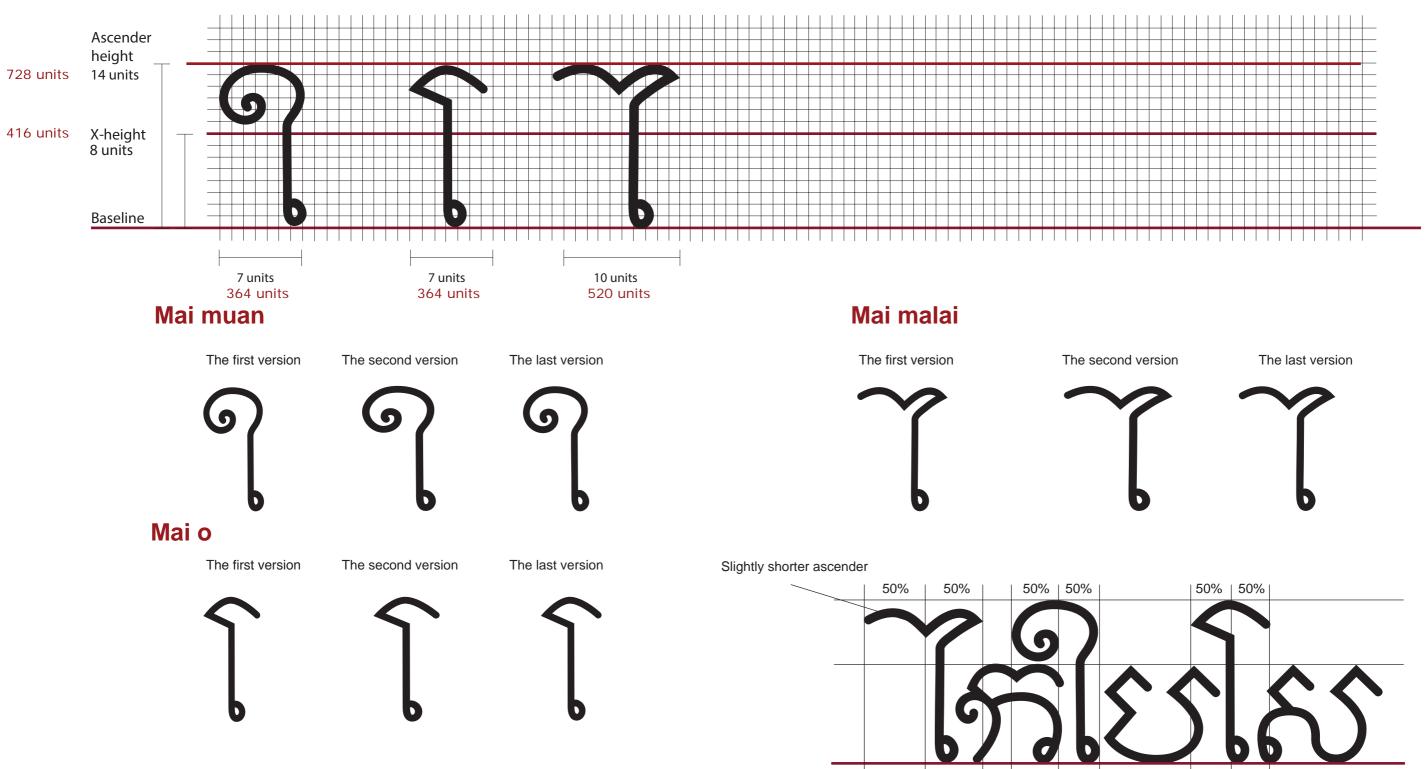


Figure 133. A proportional comparison between lak khang (grey) and wisanchani (green)

Dimensional proportions of Group 2 dependent vowels and the development of each letter, from the first draft to the final design.

Judging from the overall letterforms, wisanchani does not share most common features with lak khang. However, when rotating wisanchani we can see that part of the letterform shares partial element with lak khang. I created lak khang based on the curve of pho phan. I then made it wider.

Group 3 dependent vowels

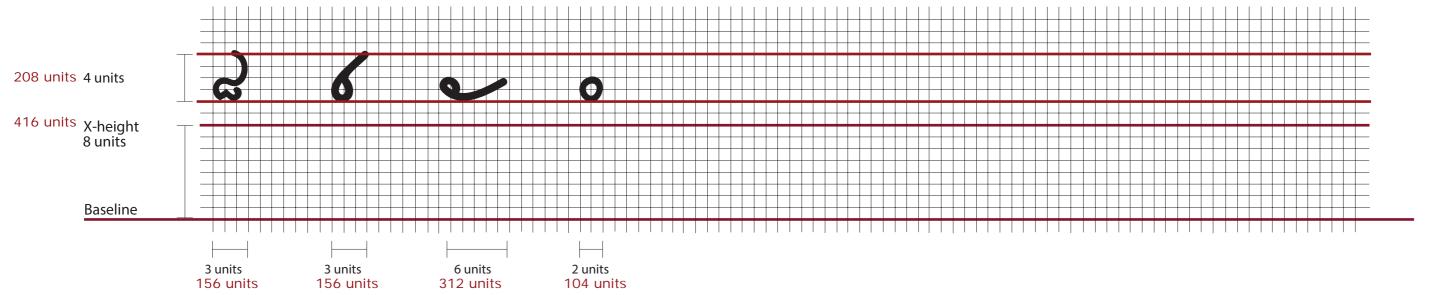


Dimensional proportions of Group 3 dependent vowels and the development of each letter, from the first draft to the final design.

The ascenders of the characters in this group are shorter than typical ascenders by 4 points. Thus, they harmonized with the other characters.

Figure 135. An example pseudoword constructed by Group 3 characters

Group 4 dependent vowels



Thanthakhat

The first version The second version

The last version







Mai taikhu

The first version The second version

The last version







Mai hanakat

The first version

The second version

The last version







Nikkhahit

The first version

The second version

The last version







Dimensional proportions of Group 4 dependent vowels and the development of each letter, from the first draft to the final design.

These characters are smaller than those in other categories. Hence, I had to remove a loop from mai taikhu, since leaving it in place would have only left a small negative space inside the character, making it too dense. The other characters were simple to create. This was especially true of nikkhahit, since it is just a circle. Thanthakhat and mai hanakat were based on wisanchani.

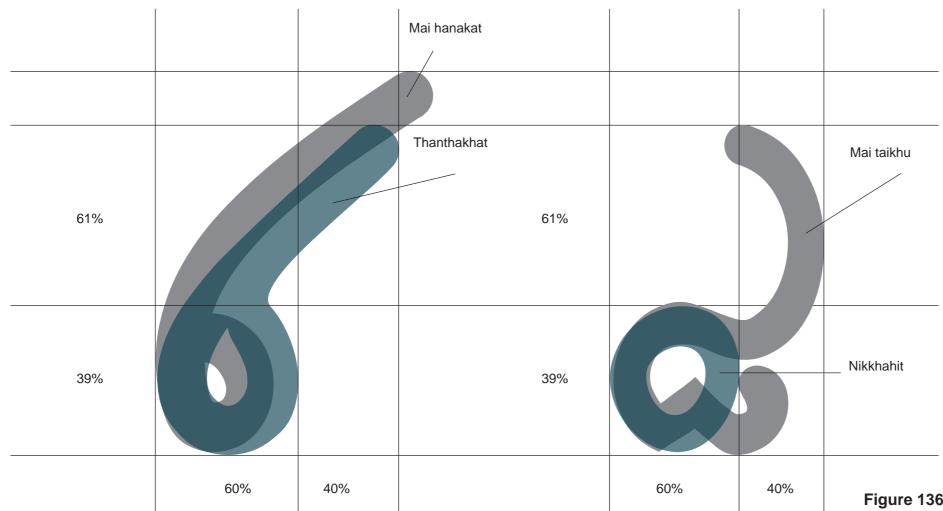


Figure 136. A proportional comparison of Group 1 characters

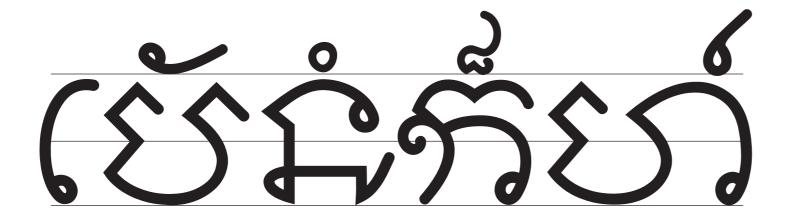


Figure 137. An example pseudo word constructed by Group 1 characters

Group 5 dependent vowels

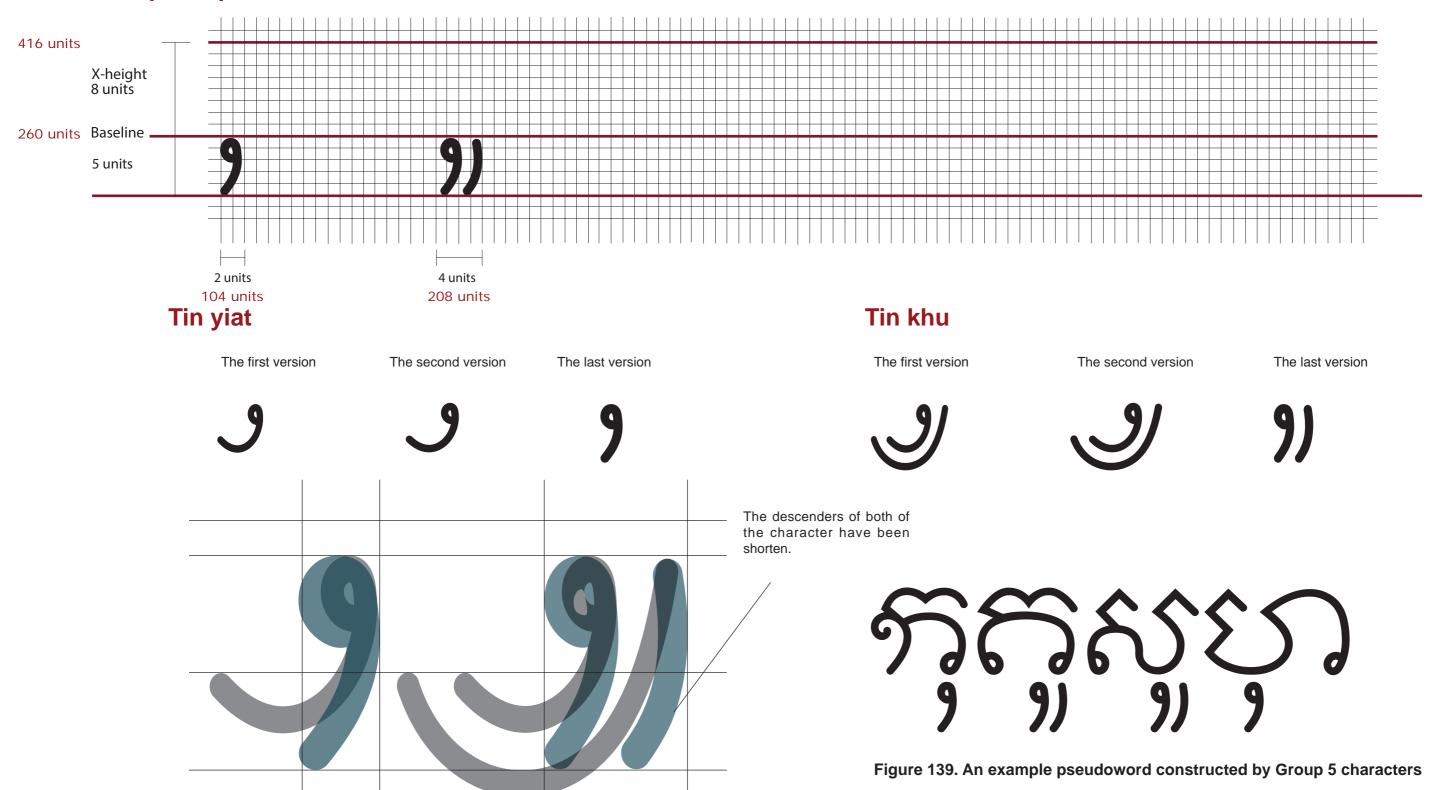


Figure 138. A proportional comparison between the first version (grey) and the last version(green) of tin yiat (left) and tin khu (right)

40%

60%

Dimensional proportions of Group 5 dependent vowels and the development of each letter, from the first draft to the final design.

Group 6 dependent vowels

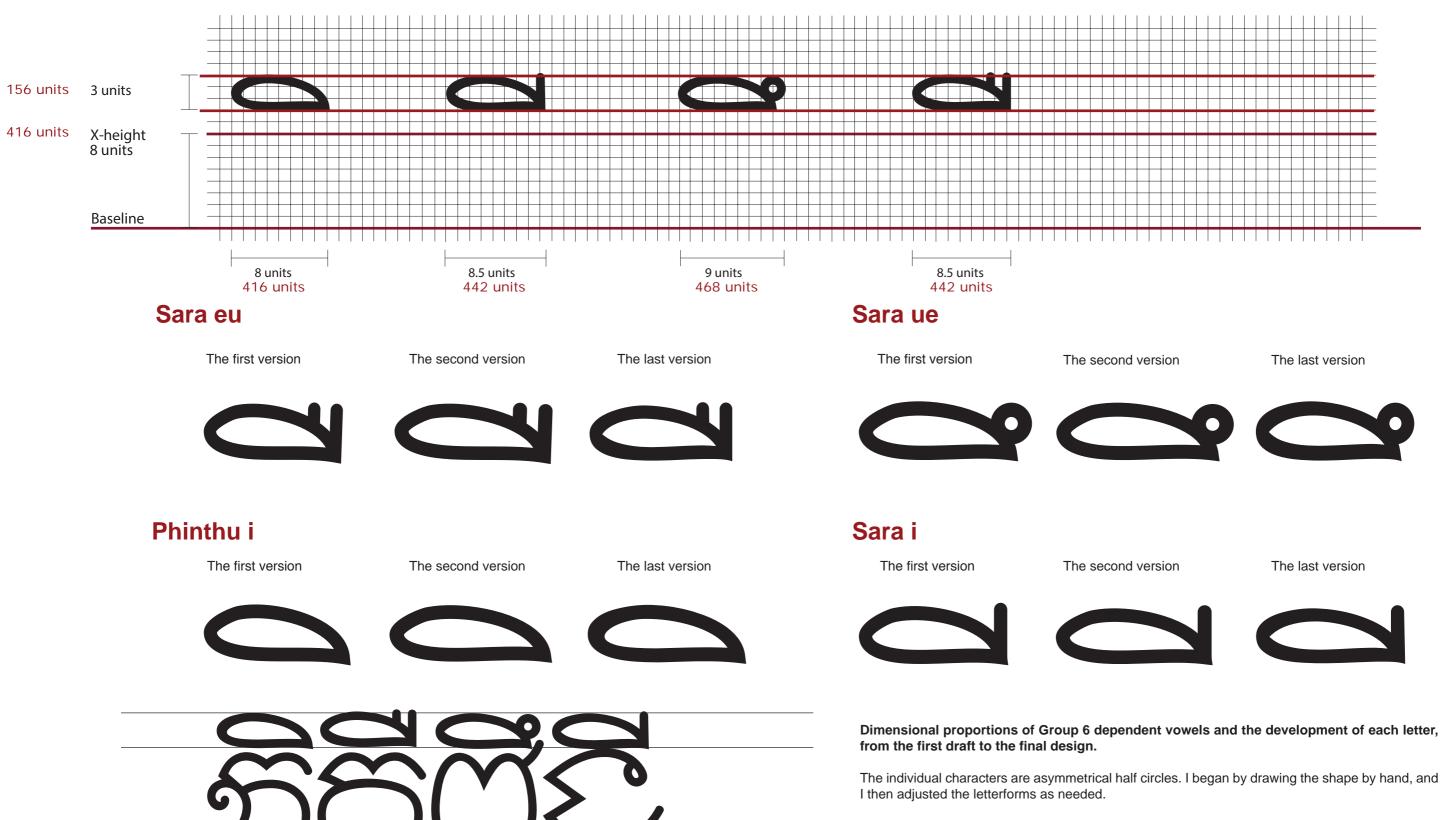


Figure 140. An example pseudoword constructed by Group 6 characters

Group 1 tone marks

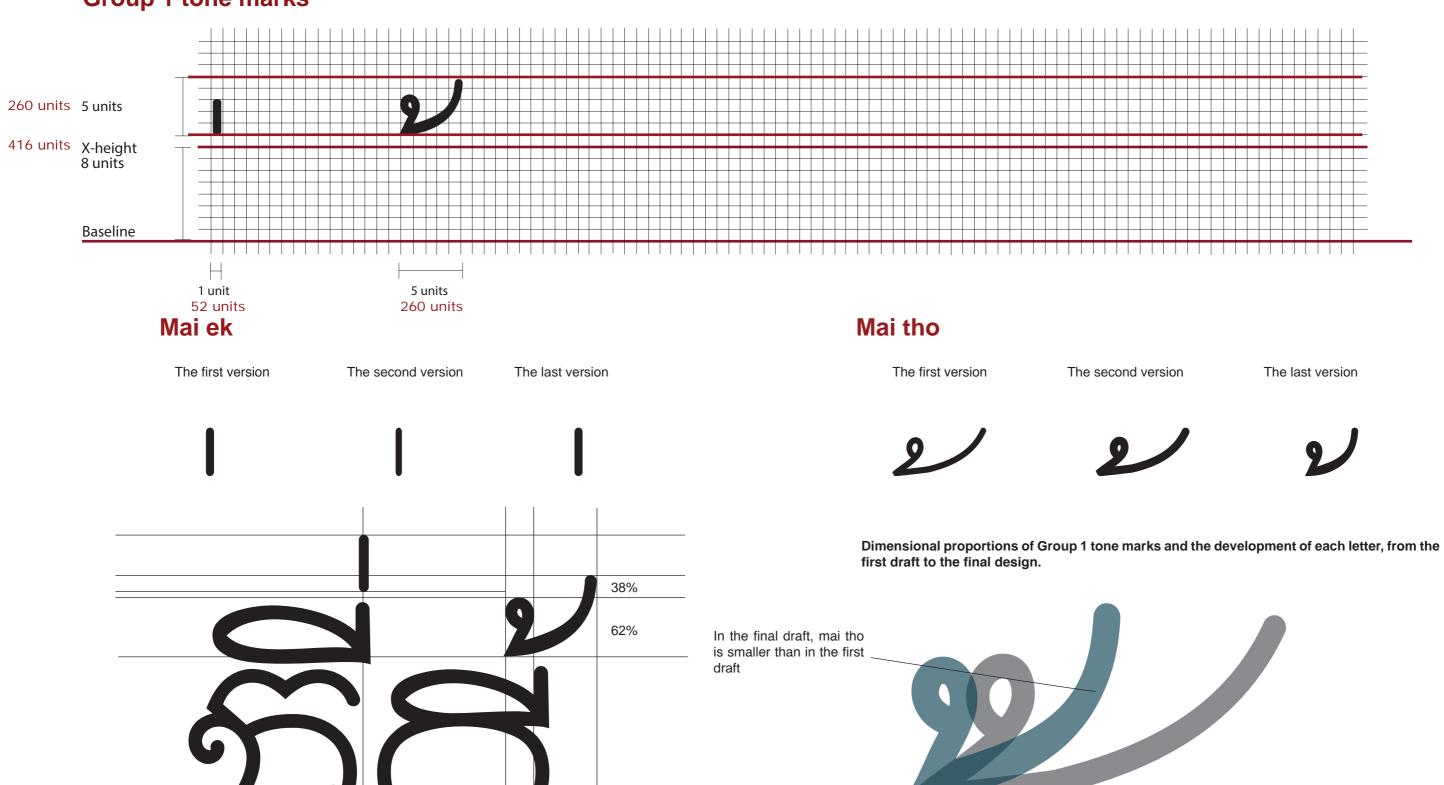
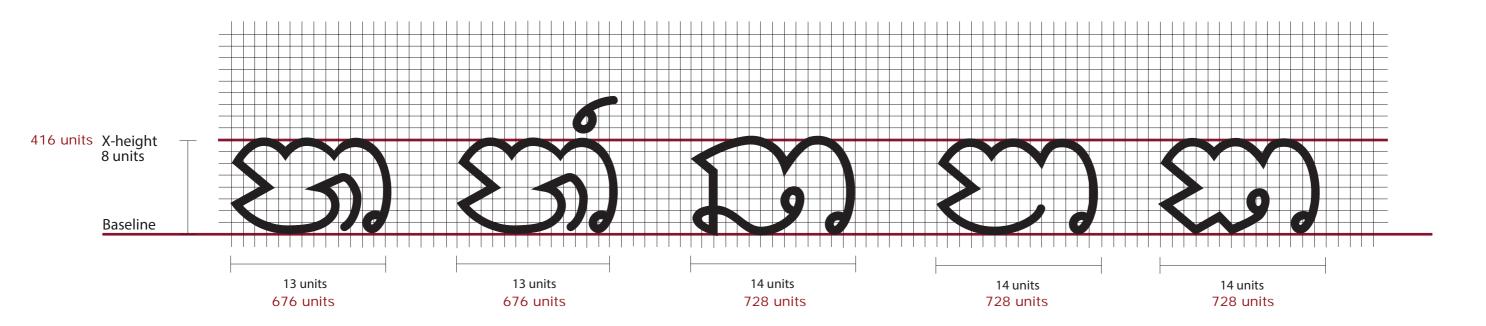


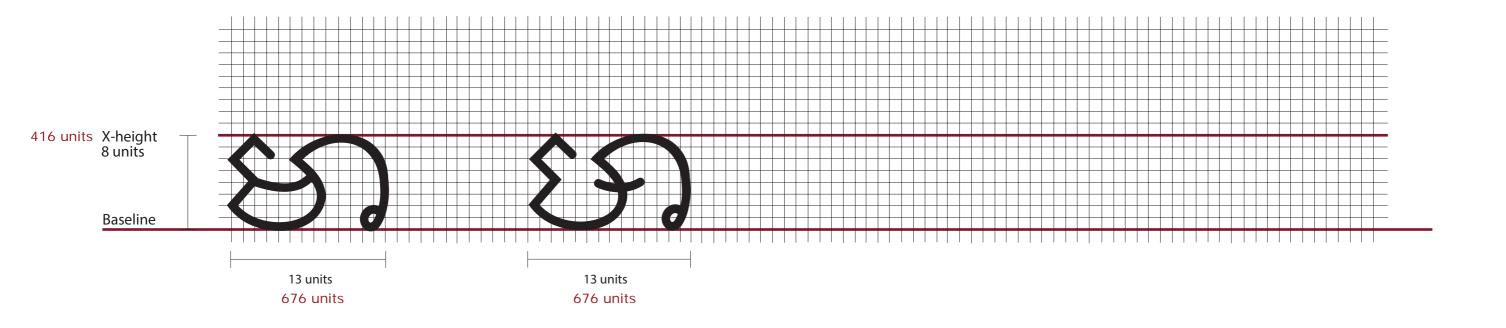
Figure 142. An example of pseudo words constructed by the characters in Group 1

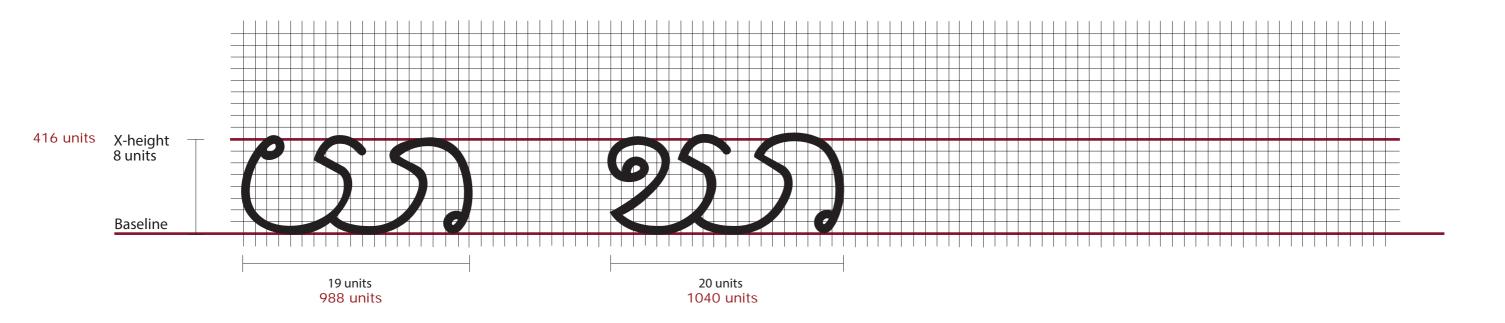
Figure 141. A proportional comparison between the first version (grey) and the last version (green) of mai tho

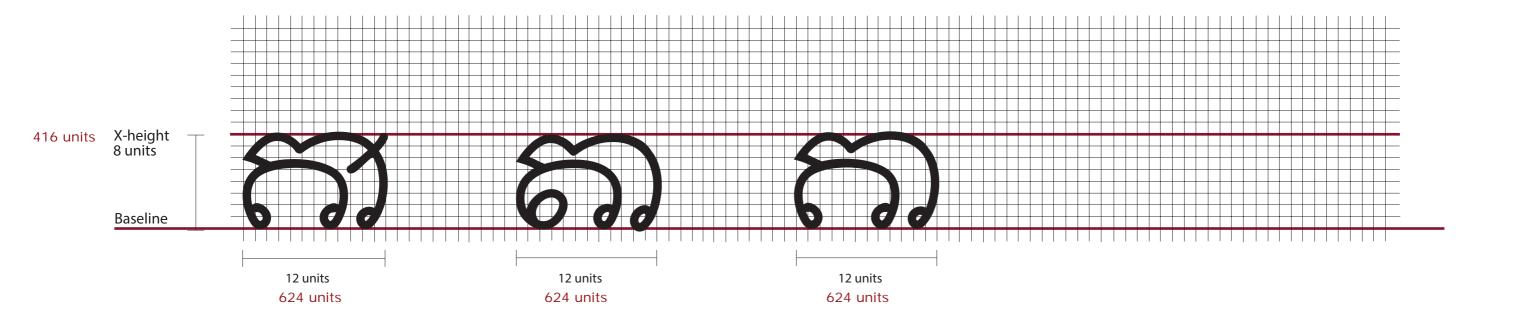
TLK Deva Ligatures

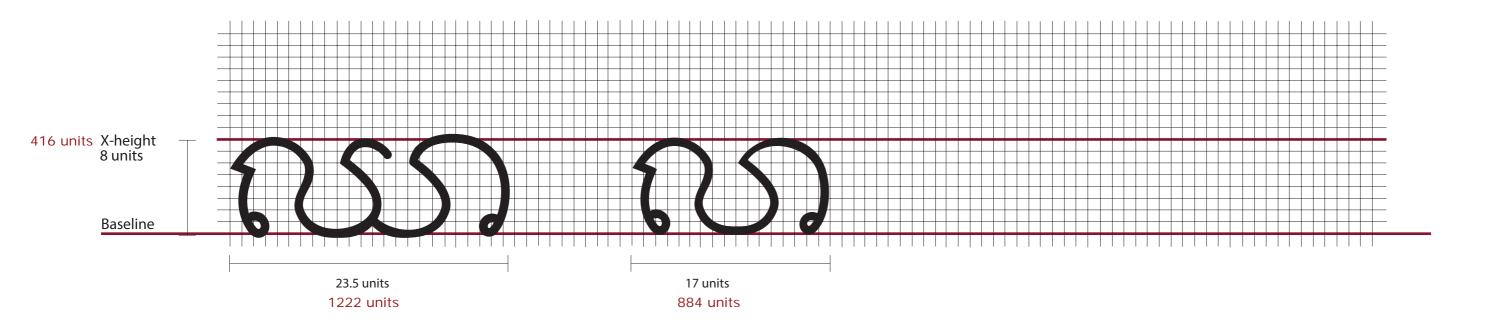
FIGH CUSS TIENTSE CARRIAGE SCREEN RCRCRCS B G (A) SENSE STREET

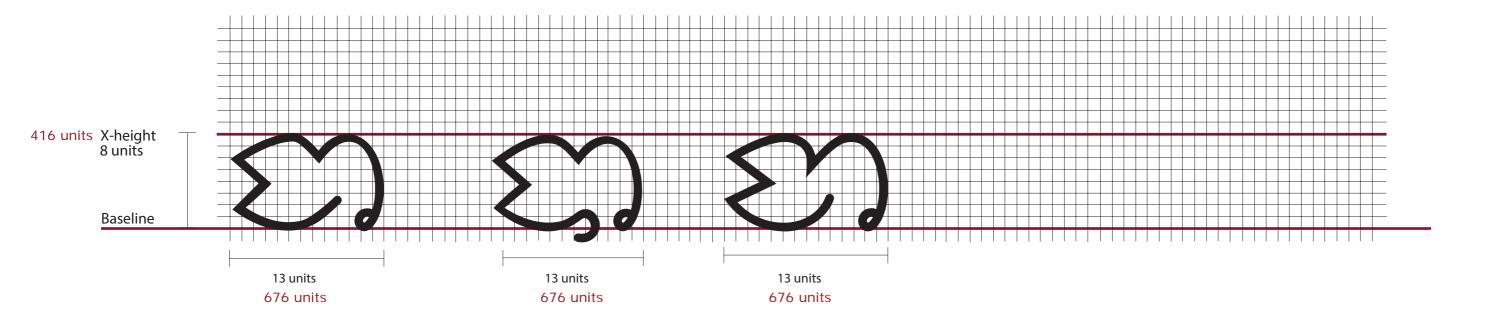


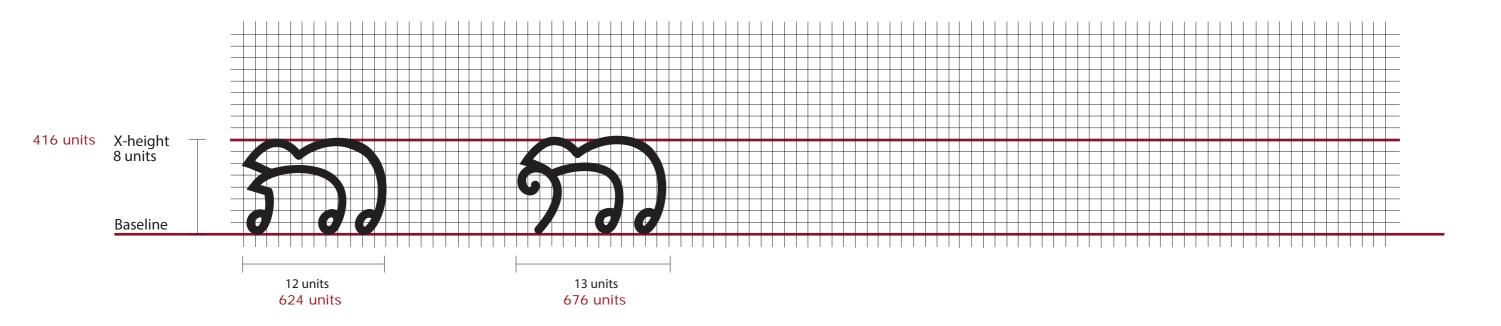


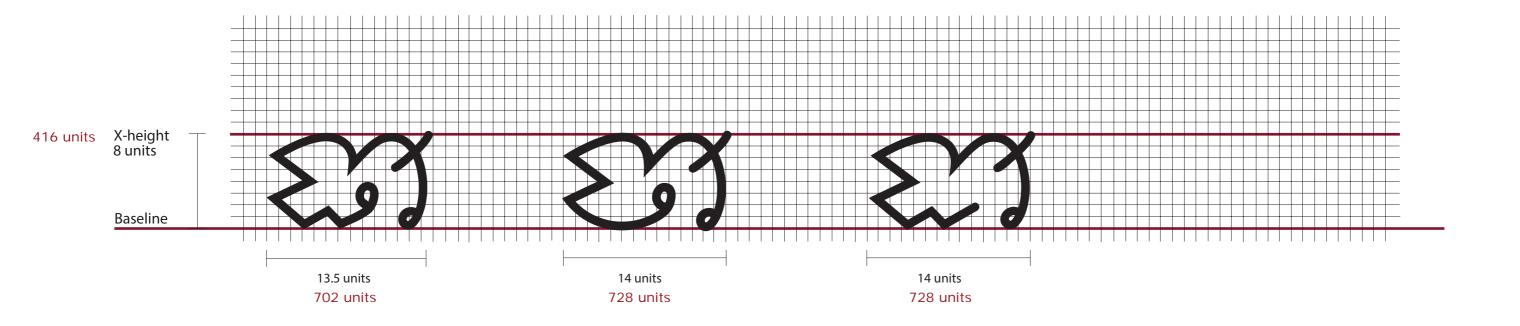


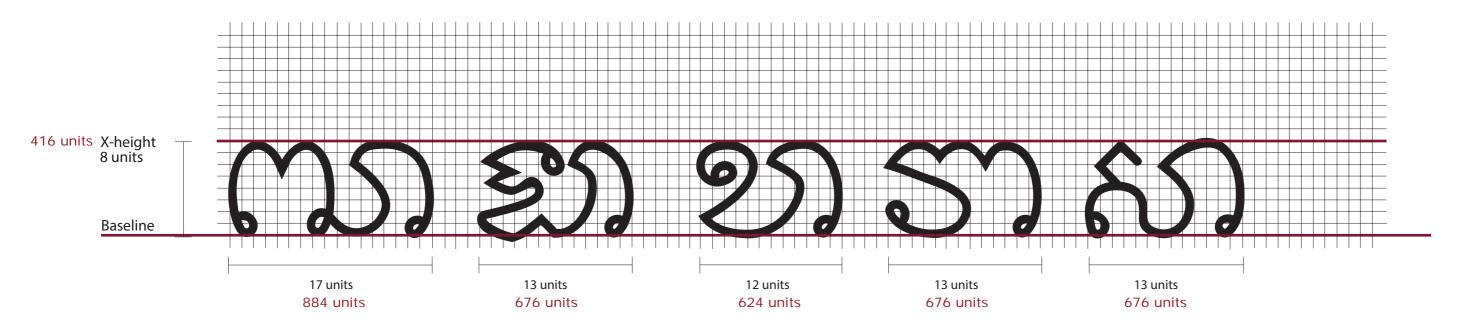


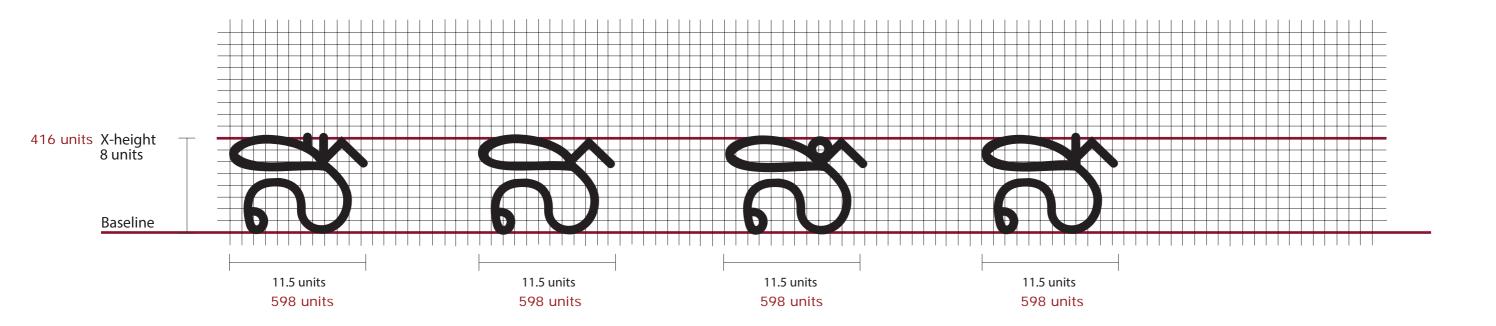


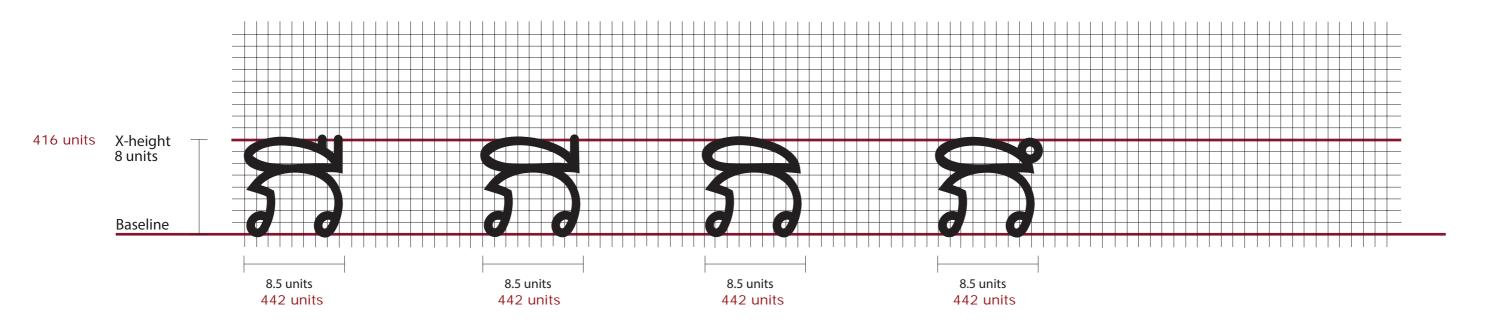


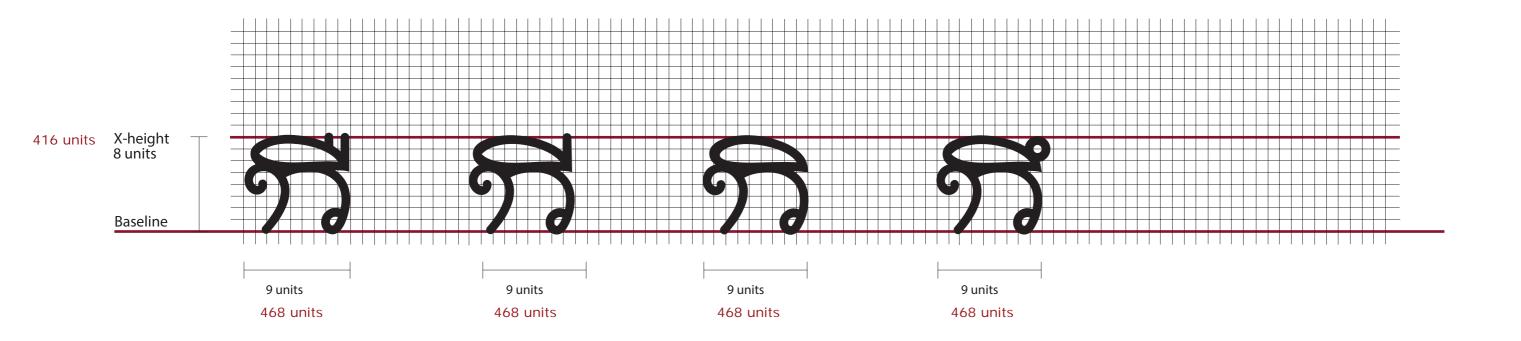


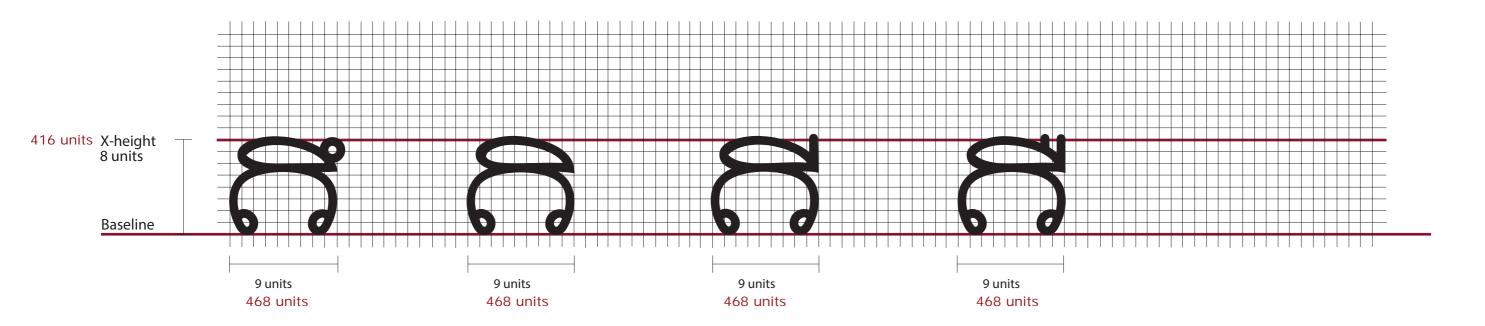


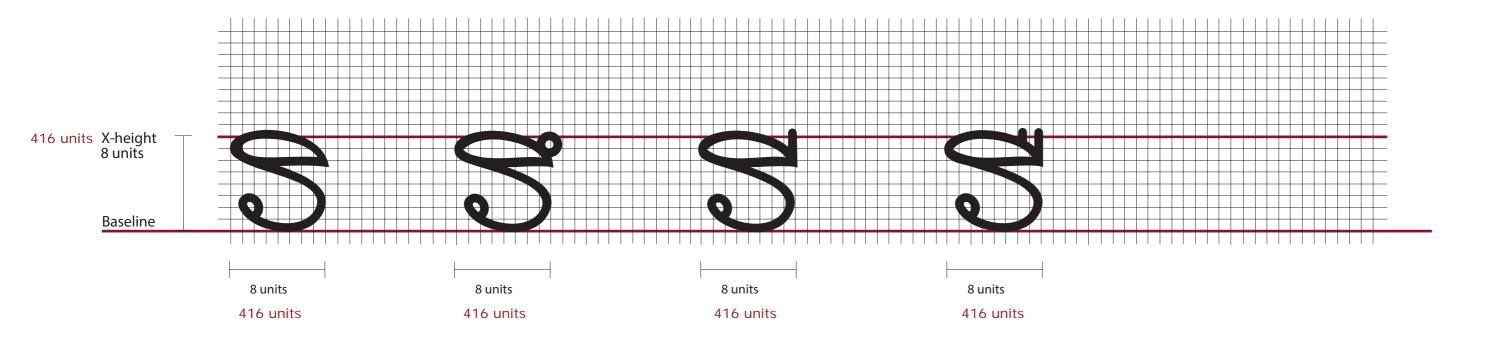


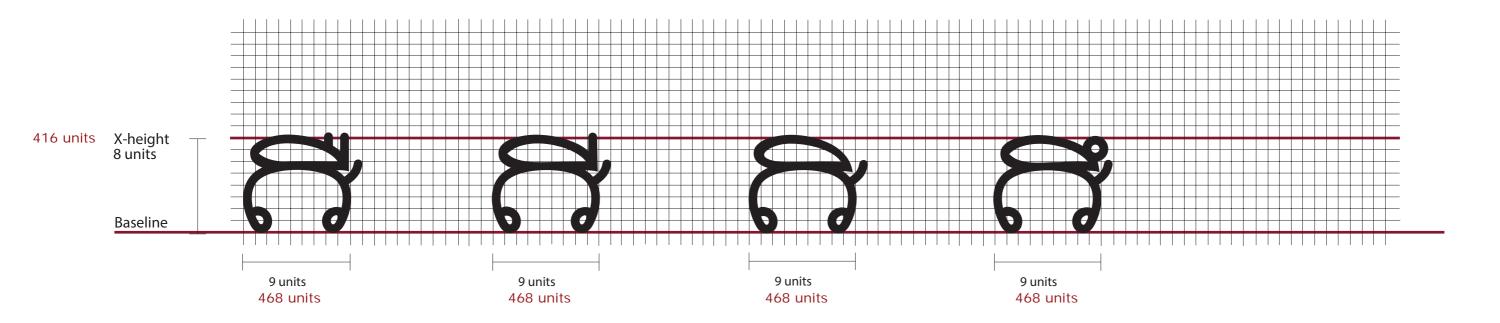


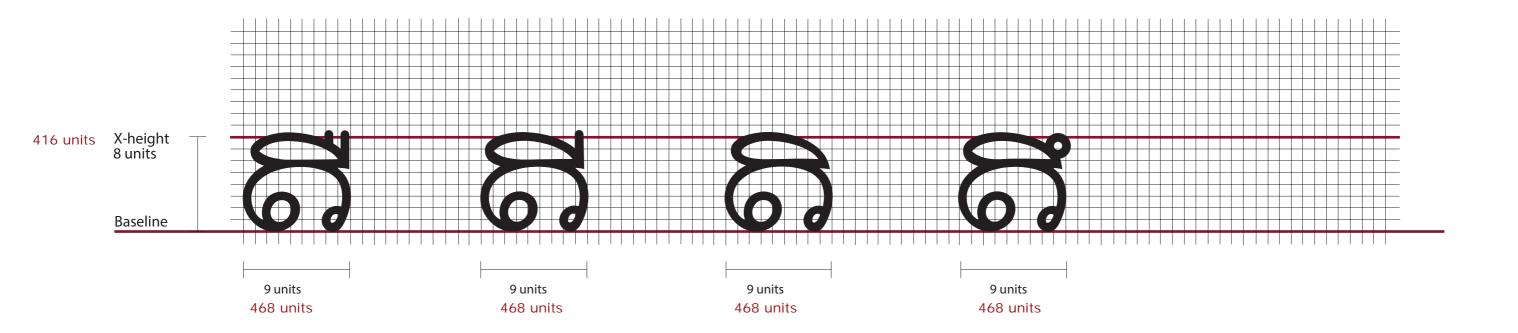


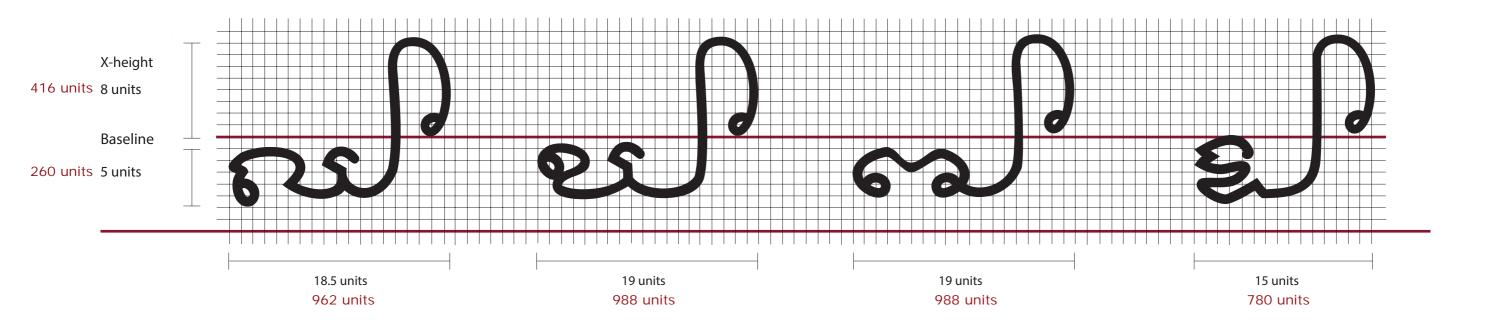


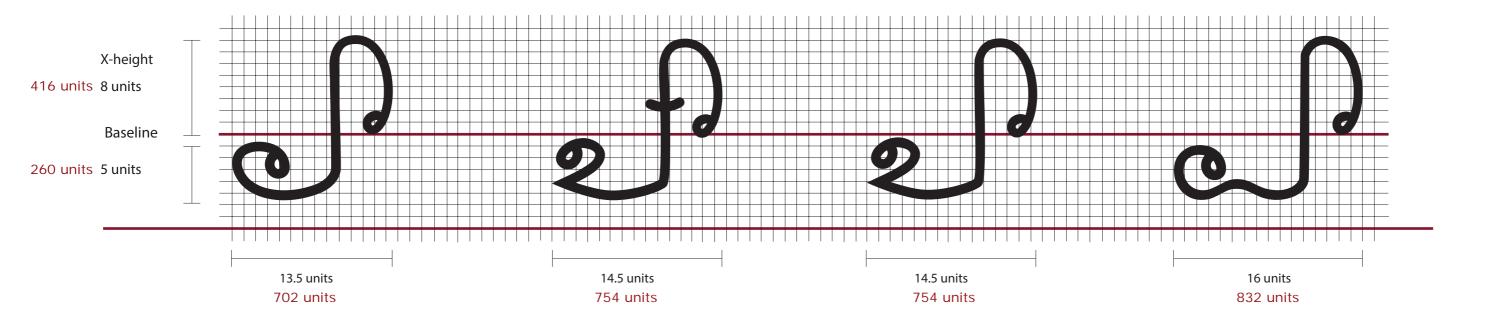












TLK Manussa ជីររកល់ពេយាជួសសា

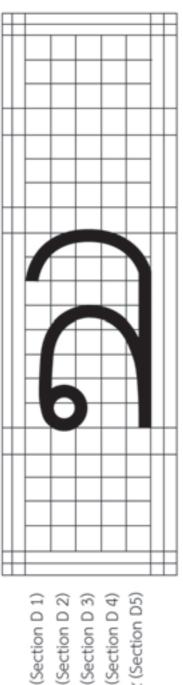
TLK Manussa

TLK Manussa as character mnemonics

3 3 3 0 0 0 (Line (Line 3 Q € € 포포포포

ช่วง ร ๑๖ (Section R 16) ช่วง ร ๑๕ (Section R 15) ช่วง ร ๑๔ (Section R 14) ช่องว่าง (Space) ช่วง ร ๑๒ (Section R 12) ช่วง ร ๑๑ (Section R 11) ช่วง ร ๑๐ (Section R 10) ช่องว่าง (Space) ช่วง ร ๘ (Section R 8) ช่วง ร ๗ (Section R 7) ช่วง ร ๖ (Section R 6) ช่วง ร ๕ (Section R 5) ช่วง ร ๙ (Section R 4) ช่วง ร ๓ (Section R 3) ช่วง ร ๒ (Section R 2) ช่วง ร ๑ (Section R 1) ช่องว่าง (Space) ช่วง ร -๒ (Section R -2) ช่วง ร -m (Section R -3) ช่วง ร -๙ (Section R-4)

ข่วง ร -๕ (Section R -5)



m (Section [⊌ (Section

€ €

6

เส้น ร ๑๖ (Line R 16) เส้น ร ๑๕ (Line R 15) เส้น ร ๑๔ (Line R 14) เส้น ร ๑๓ (Line R 13) เส้น ร ๑๒ (Line R 12) เส้น ร ๑๑ (Line R 11) เส้น ร ๑๐ (Line R 10) เส้น ร ๙ (Line R 9) เส้น ร ๘ (X-height) เส้น ร ๗ (Line R 7) เส้น ร ๖ (Line R 6) เส้น ร ๕ (Line R 5) เส้น ร ๔ (Line R 4) เส้น ร ๓ (Line R 3) เส้น ร ๒ (Line R 2) เส้น ร ๑ (Line R 1) เส้นรo (Baseline) เส้น ร -๑ (Line R -1) เส้น ร -๒ (Line R -2) เส้น ร -๓ (Line R -3) เส้น ร -๔ (Line R -4) เส้น ร -๕ (Line R -5)

In certain non-Latin scripts, such as Japanese, the character structures tend to be complex, although that is not the case in the Latin script. Therefore, character mnemonics are sometimes used as a learning tool to remember each letter. Character mnemonics can be pictorial illustrations, charts, or diagrams that connect meanings or familiar letterforms to the target letter.

In appearance, TLK Manussa is a hybrid of Khom Thai and present-day Thai, and it is the most familiar letterform design of the three. Since it incorporates characteristics of modern Thai, this letterform design is the most angular in the series inspired by the Royal Society of Thailand's manual.

The intention behind the design of TLK Manussa was to use it as a learning material. One possibility for using this letterform design would be to develop it into character mnemonics, as illustrated in Figure 146. TLK Manussa could be presented in accordance with both Thai and Khom Thai (TLK Deva or TLK Brahma) so that students can associate the familiar characteristics of letterforms. Using them as a reference would facilitate the learning process.

Figure 143. Dimensional proportion of lo ling, as specified in the Royal Society of Thailand's manual, Redrawn by Virunhaphol. Adapted from Mattrathan krongsang tua akson Thai chabap Ratchabandittayasathan, by Royal Society of Thailand⁴, 1997, p.71. Copyright 1997 by Royal Society of Thailand.

Royal Society of Thailand. (1997). Mattrathan krongsang tua akson Thai chabap Ratchabandittayasathan [Standard dimensional proportions of the Thai script by the Royal Institute]. Bangkok, Thailand: Royal Society.

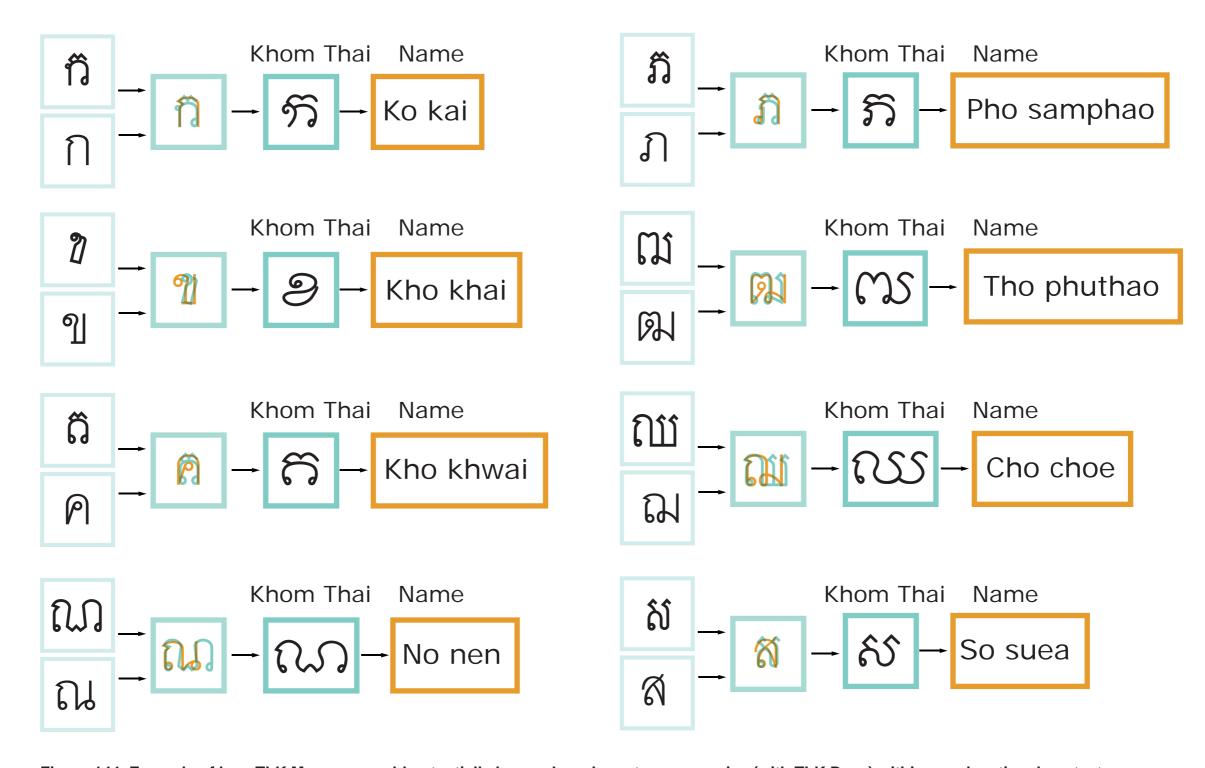


Figure 144. Example of how TLK Manussa could potentially be used as character mnemonics (with TLK Deva) within an educational context

Full form letters



Consonantal subscripts



Ligatures

Independent vowels



Dependent vowels



Numbers

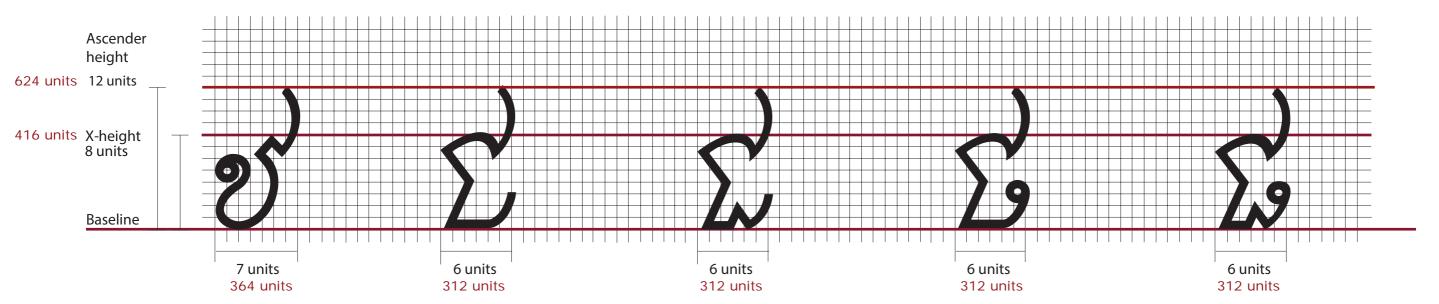


Tone marks



TLK Manussa

Group 1 full-form characters



Tho than

The first version

ล

The second version



ersion



Pho phueng

The first version



The second version



The last version



To patak

The first version

 \sum_{i}

The second version



Tho thung

The first version



The second version



The last version



Cho chang

The first version



The second version



The last version



Dimensional proportions of Group 1 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.113-114).

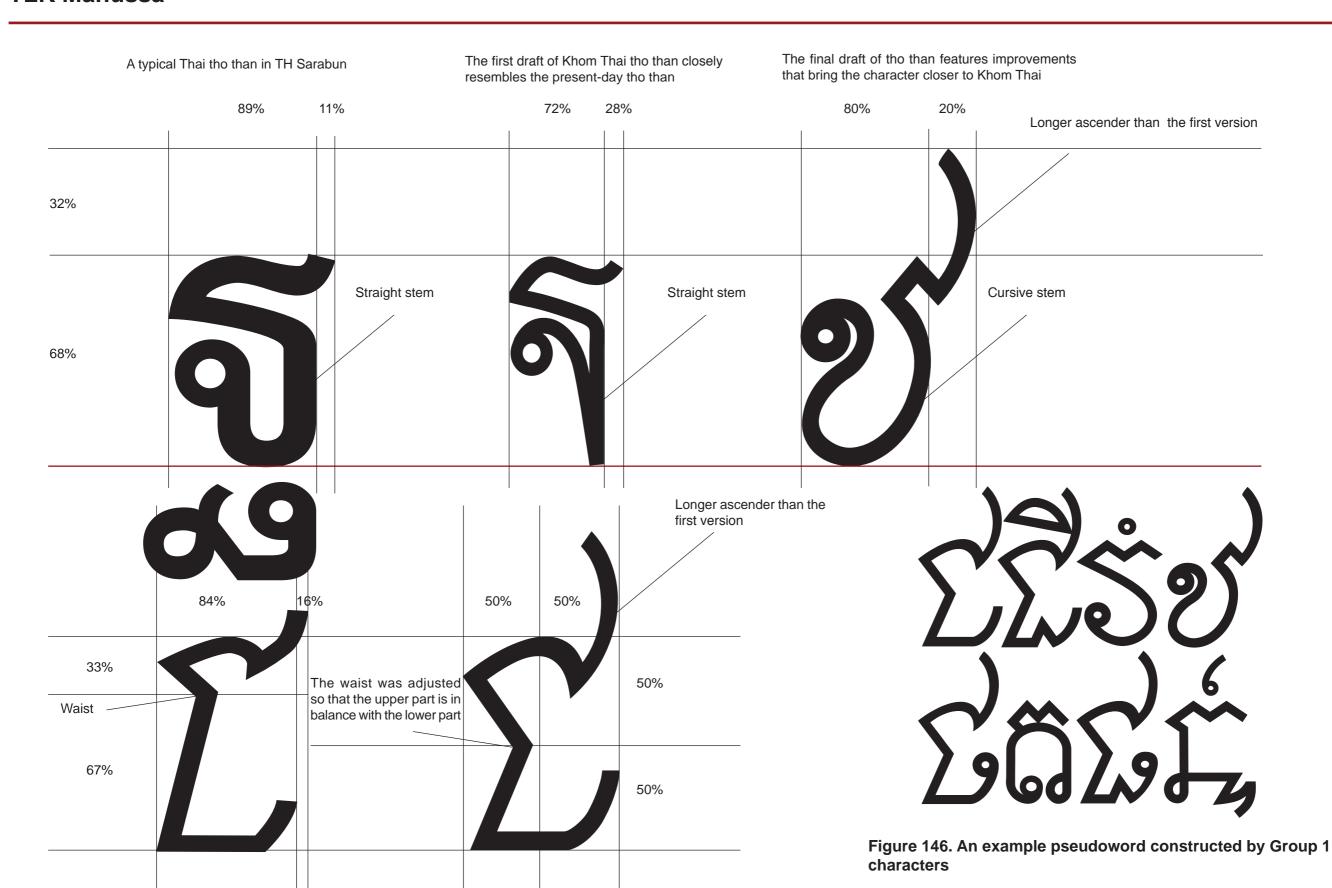
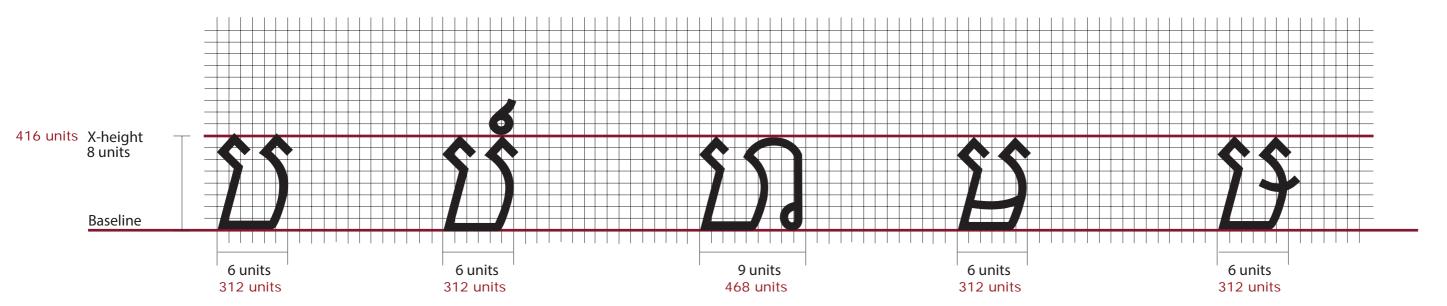


Figure 145. A proportional comparison between the first draft (left) and the last design (right) of cho chang

The extenders of modern-day Thai characters are commonly quite short. The ascender height is approximately 1 unit more than the x-height. With these proportions, the upper part did appear to be in balance with the lower part. Therefore, I needed to increase the length of the ascender.

Group 2 full-form characters



So ruesi

The first version

The second version

The last version

99

Bo baimai

The first version

The second version

The last version





Mo ma

The first version

The second version

The last version

The first version

Po pla

The second version

25

The last version

Ho hip

The first version

The second version

The last version

பி

Dimensional proportions of Group 2 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.114-116).







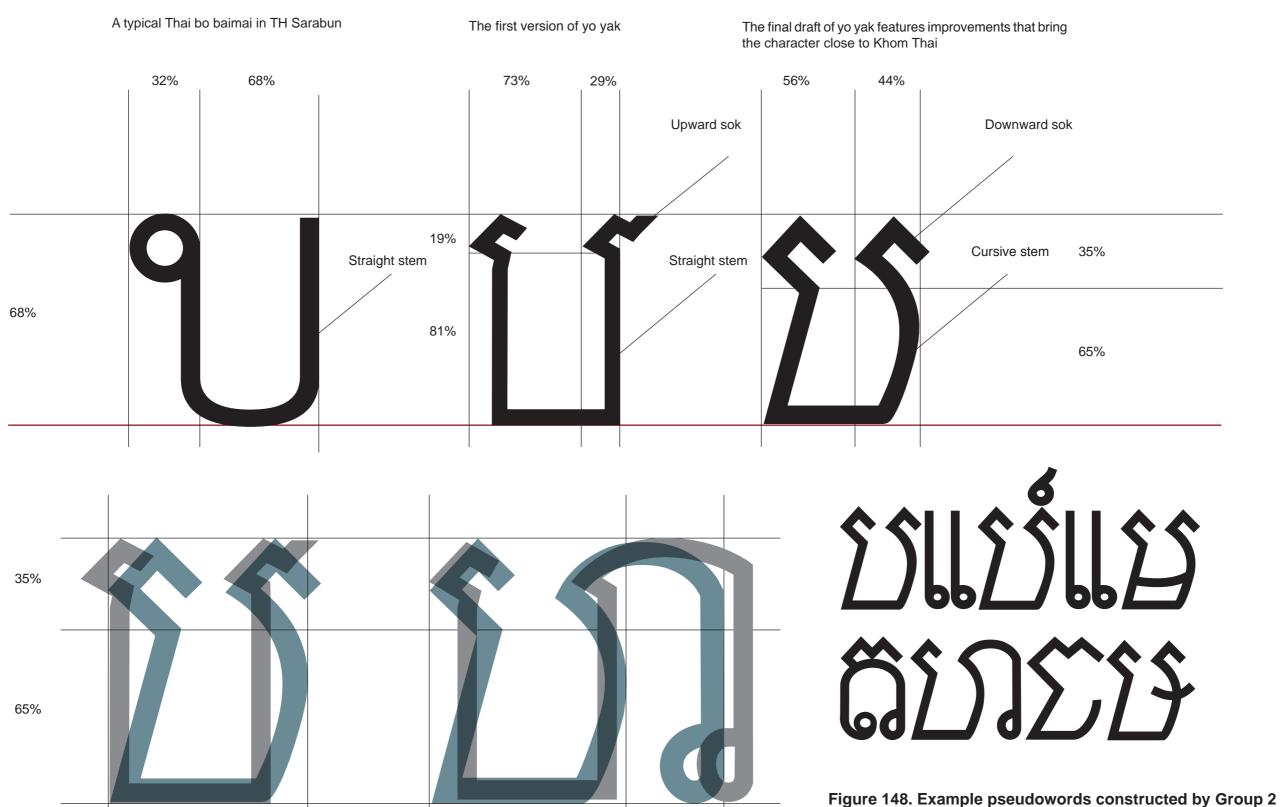


Figure 147. A proportional comparison between the first drafts (grey) and the last designs (green) of bo baimai and ho hip

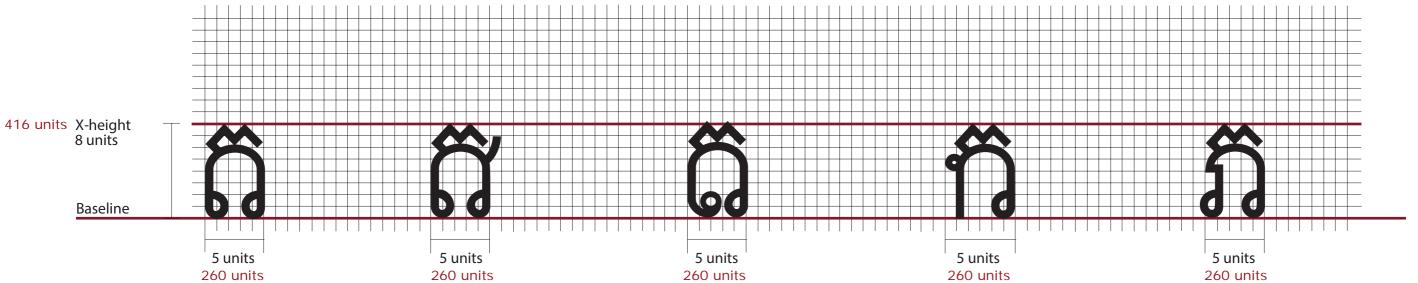
72%

28%

Figure 148. Example pseudowords constructed by Group 2 characters

As mentioned in Chapter 3, I initially based the Khom Thai bo baimai's design on the Thai bo baimai. However, the first draft did not resemble Khom Thai at all. In contrast, the final version is more cursive, as is Khom Thai.

Group 3 full-form characters



To tao

The first version

The second version

The last version





Pho samphao

The first version

The second version

The last version







Kho khwai

The first version

The second version

The last version







So sala

The first version

The second version

The last version







Ko kai

The first version

The second version

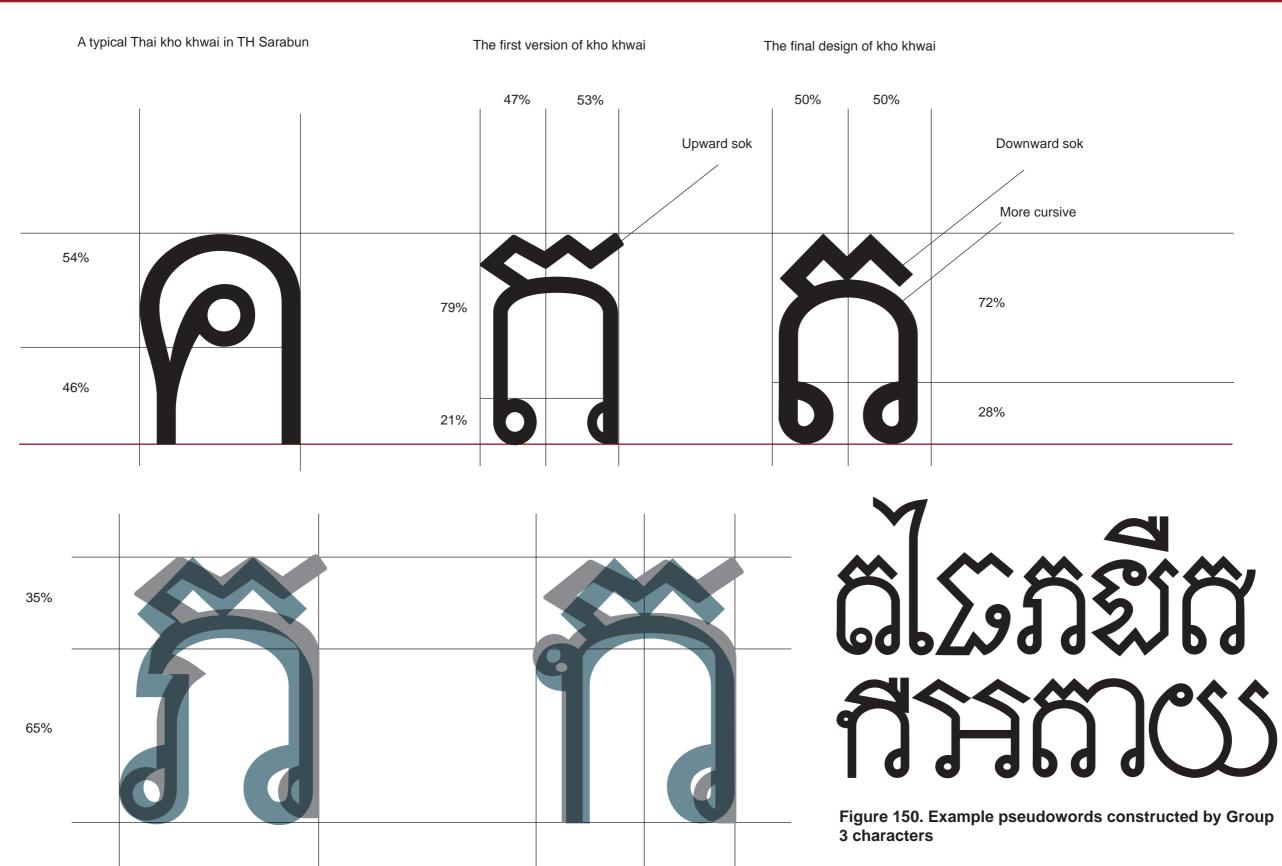
The last version







Dimensional proportions of Group 3 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.116-117).



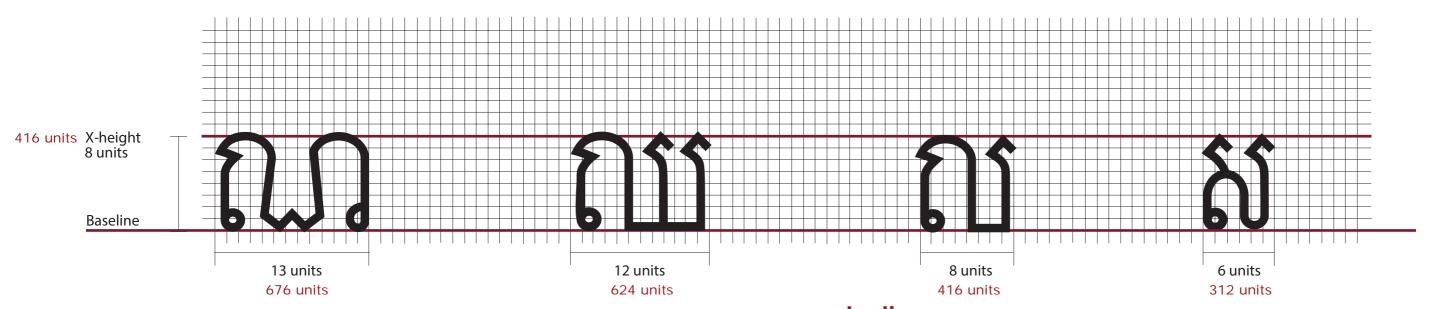
72%

28%

Figure 149. A proportional comparison between the first drafts (grey) and the last designs (green) of pho samphao (left) and ko kai (right)

In general, the second and final drafts were almost the same. The exception was that the width and stroke thickness of the characters slightly increased. Also, I redesigned the sok to angle downwards, and I also enhanced the curve of the shoulders.

Group 4 full-form characters



No nen

The first version

The second version

The last version

M



Lo ling

The first version

The second version

The last version







So suea

The first version

The second version

The last version

ည်

Cho choe

The first version

The second version

The last version







Dimensional proportions of Group 4 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.117-119).

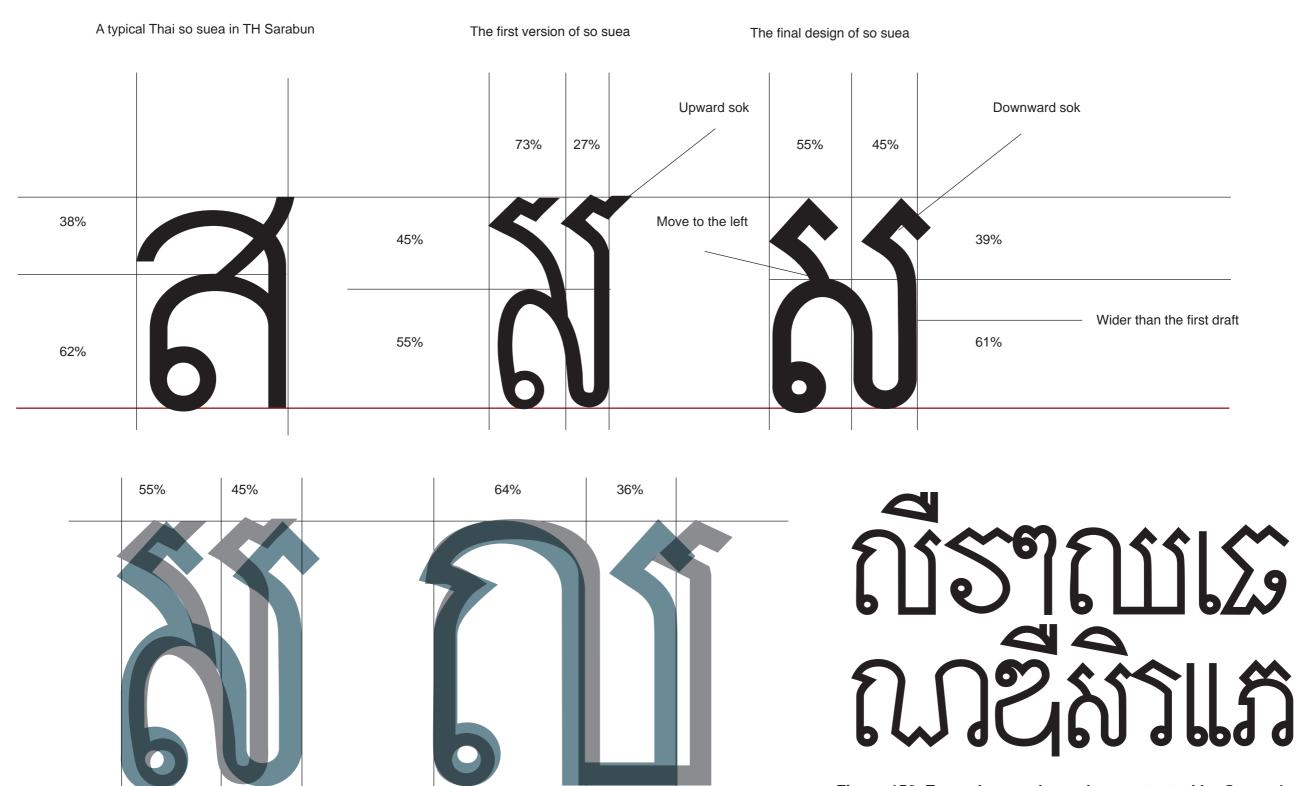
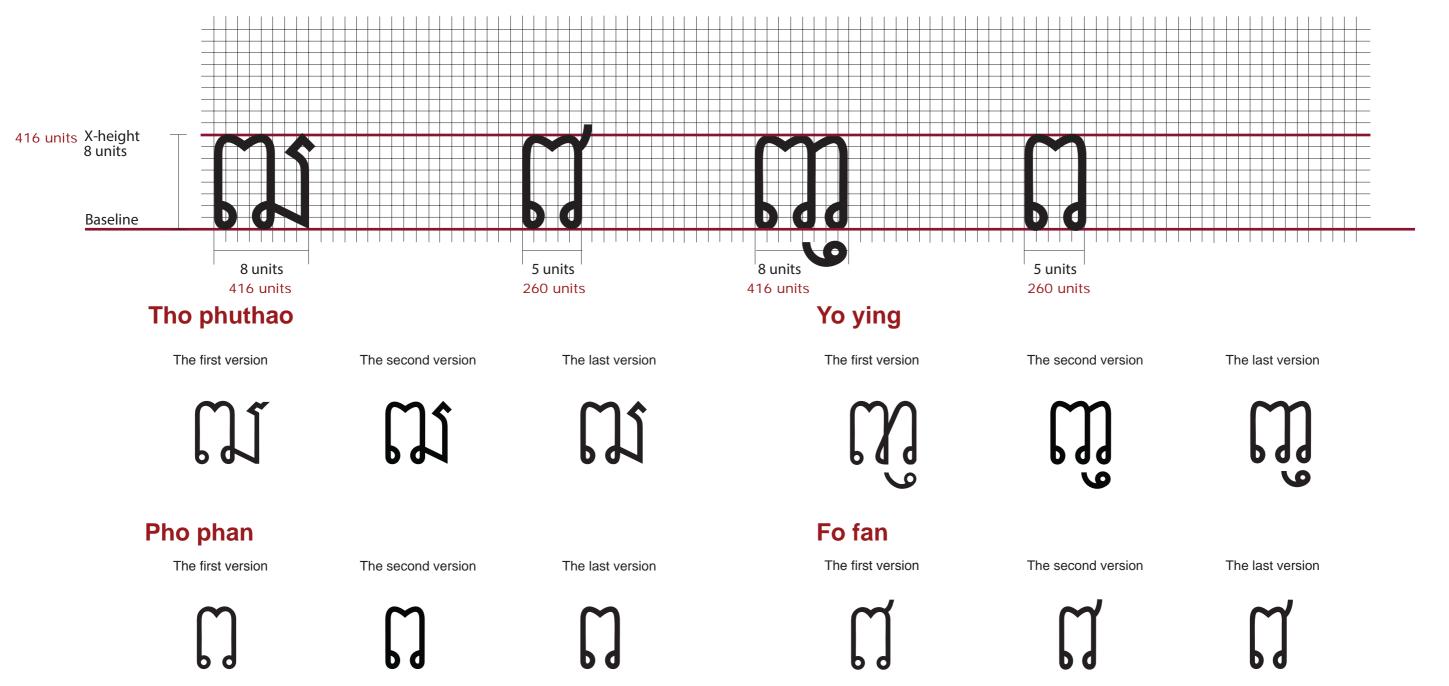


Figure 151. A proportional comparison between the first drafts (grey) and the last designs (green) of so suea (left) and lo ling (right)

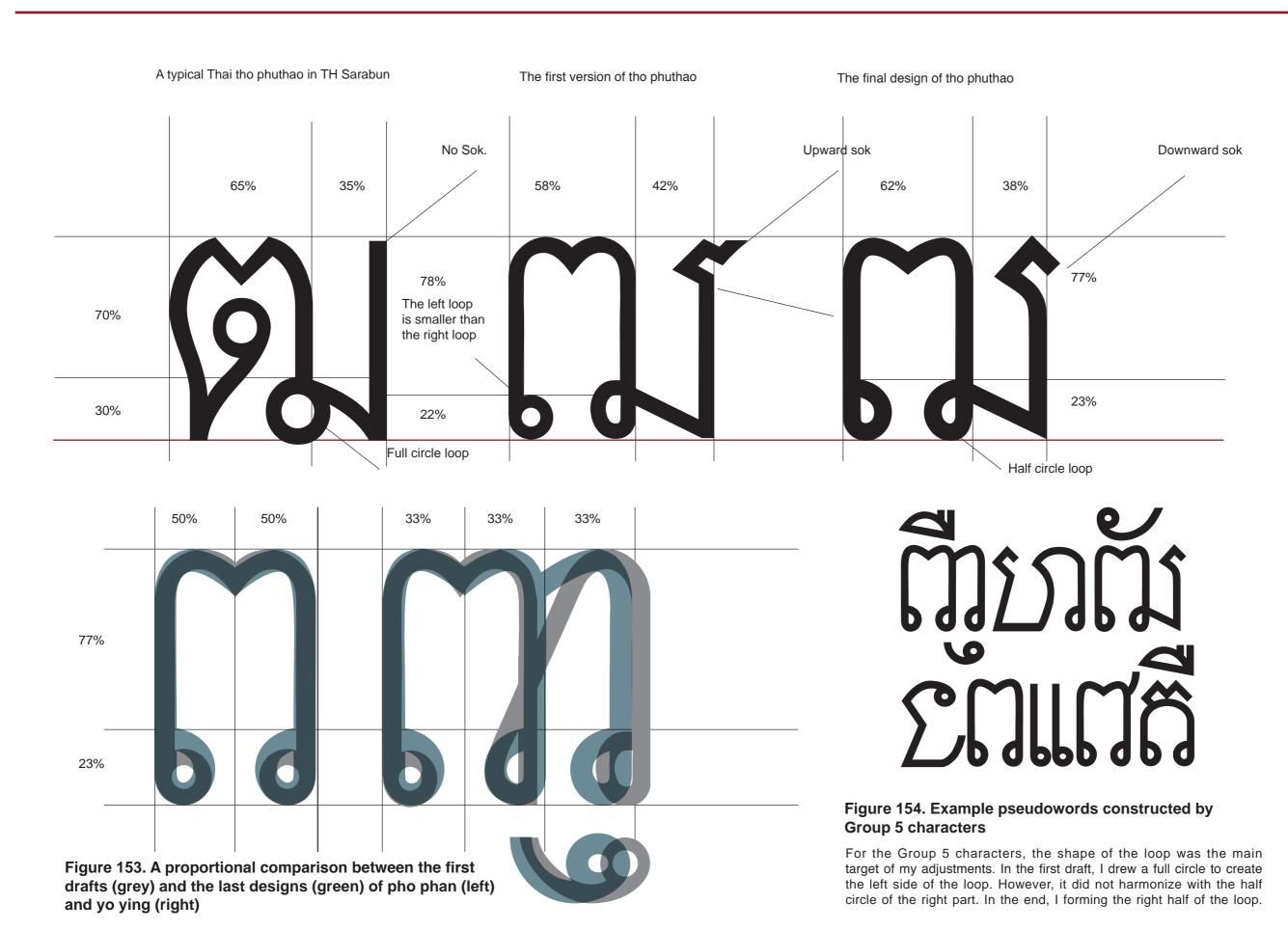
Figure 152. Example pseudowords constructed by Group 4 characters

Apart from so suea, the characters did not undergo major changes. I was primarily concerned with the position of both soks, since the first draft seemed so foreign to me. I eventually designed more a more symmetrical sok.

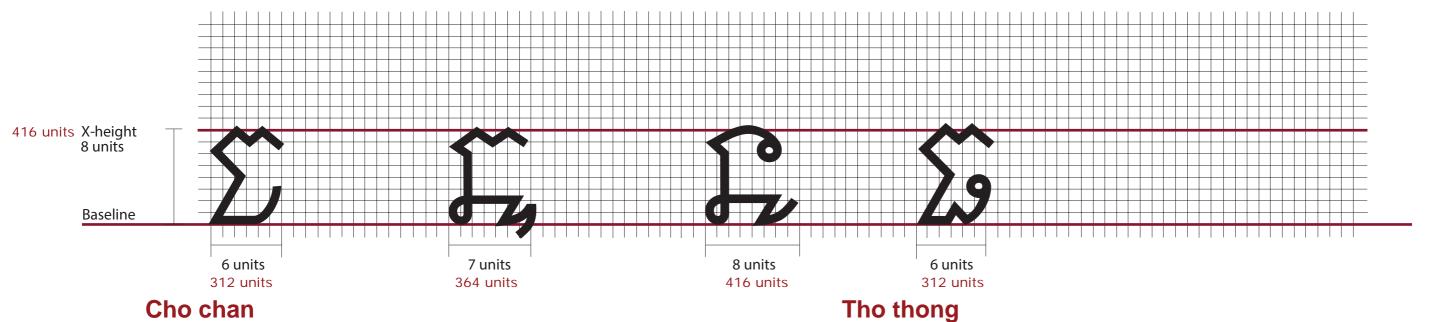
Group 5 full-form characters



Dimensional proportions of Group 5 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.119-120).



Group 6 full-form characters



Cho chan

The first version

The second version

The last version



The first version



The last version



Cho ching

The first version

The second version

The last version



No nu

The first version

The second version

The second version

The last version







Dimensional proportions of Group 6 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.121-122).

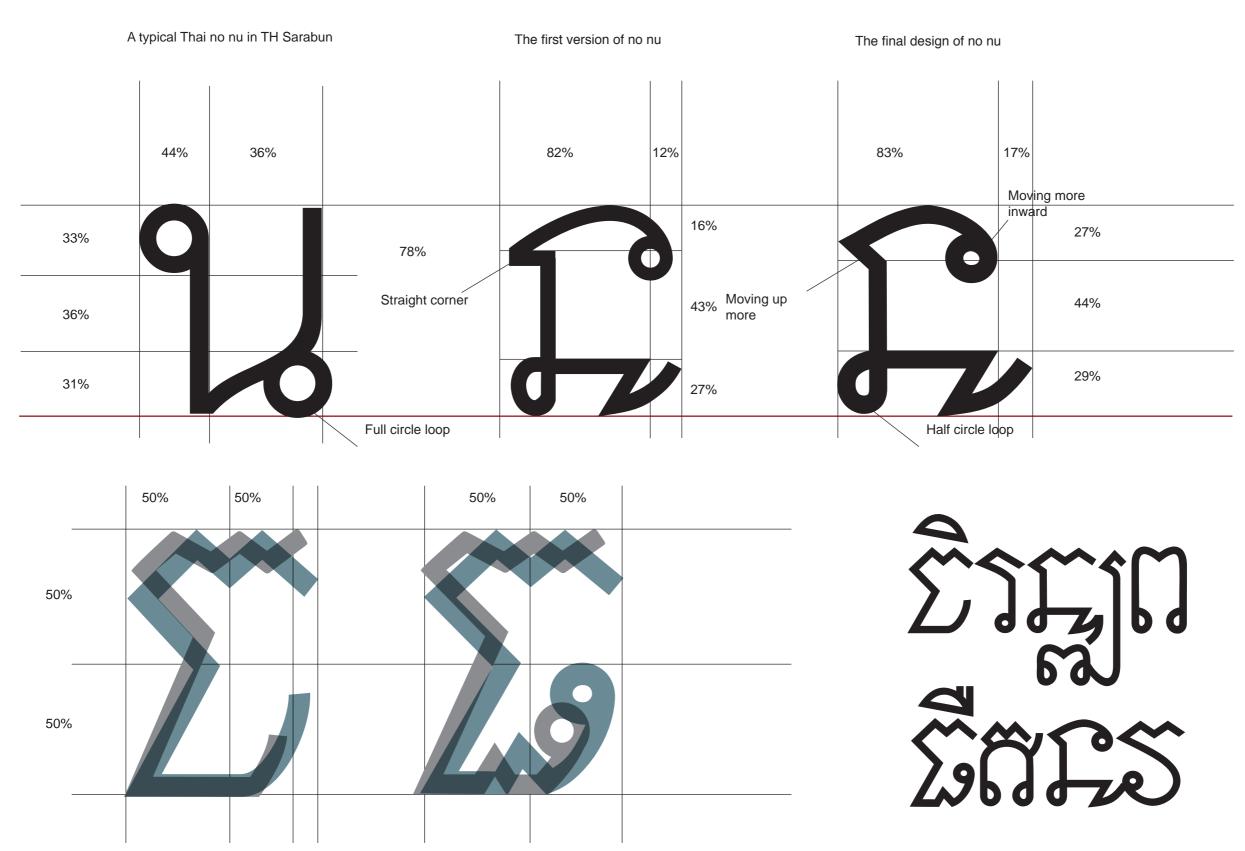
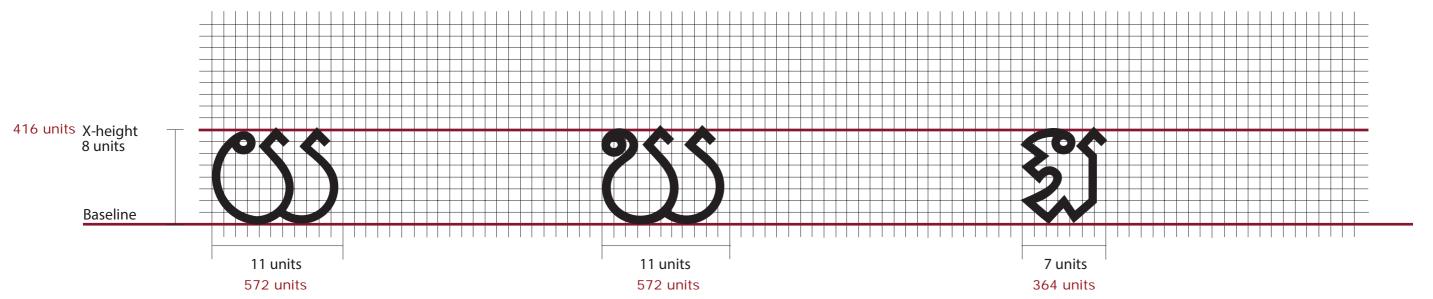


Figure 155. A proportional comparison between the first drafts (grey) and the last designs (green) of cho chan (left) and tho thong (right)

Figure 156. Example pseudowords constructed by Group 6 characters

Group 7 full-form characters



Yo yak

The first version

The second version

The last version

(3)

P??

Lo chula

The first version

The second version

The last version







Kho rakhang

The first version

The second version

255

The last version



Dimensional proportions of Group 7 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.122-123).

TLK Manussa

A typical Thai lo chula in TH Sarabun

In my opinion, I think lo chula looks highly incorrect in TH Sarabun. Specifically, the right stem should be longer, and so the TH Sarabun design is disproportional. However, I think the designer of TH Sarabun might have been motivated by the desire to save space.

The draft of lo chula posed the greatest design challenge. No commonalities exist between the Thai and Khom Thai versions of that character. Thus, I could not use the Thai lo chula as a reference. Therefore, I adjusted the Khom Thai letterform to be more angular, in accordance with TLK Manussa's style.

The final draft of lo chula is more symmetrical than the first draft.

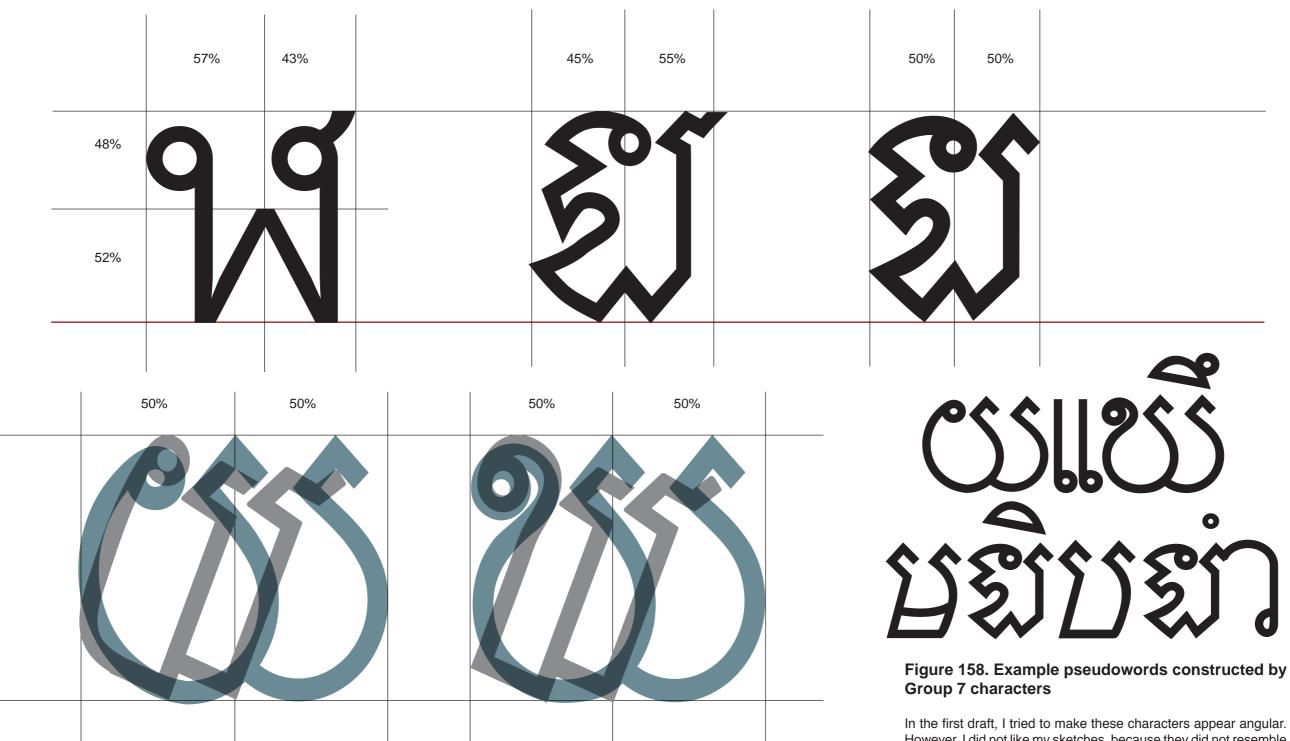
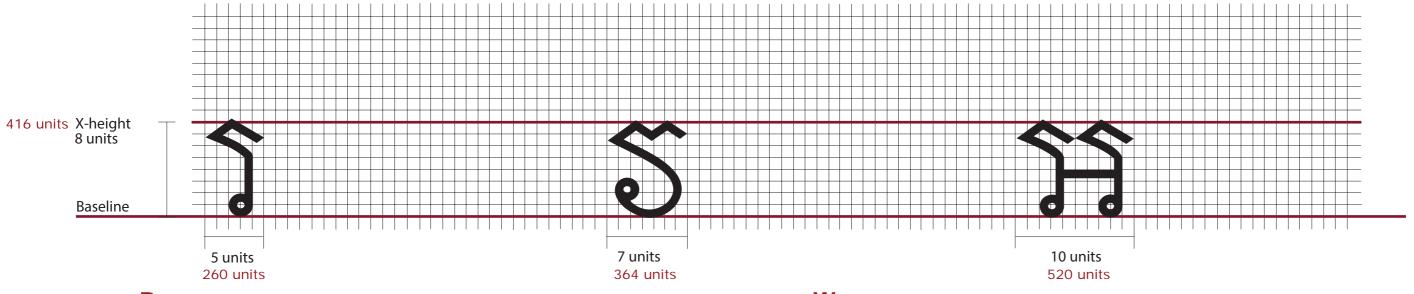


Figure 157. A proportional comparison between the first drafts (grey) and the last designs (green) of yo yak (left) and kho rakhang (right)

In the first draft, I tried to make these characters appear angular. However, I did not like my sketches, because they did not resemble Khom Thai characters. Traditionally, these characters are cursive. However, the Thai letters are more angular and rigid. I eventually increased the letters' width and adapted the stems, making them more cursive.

Group 8 full-form characters



Ro ruea

The first version

The second version

The last version

Wo waen

The first version

The second version

The last version



O ang

The first version

The second version

The last version







Dimensional proportions of Group 8 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.123-124).

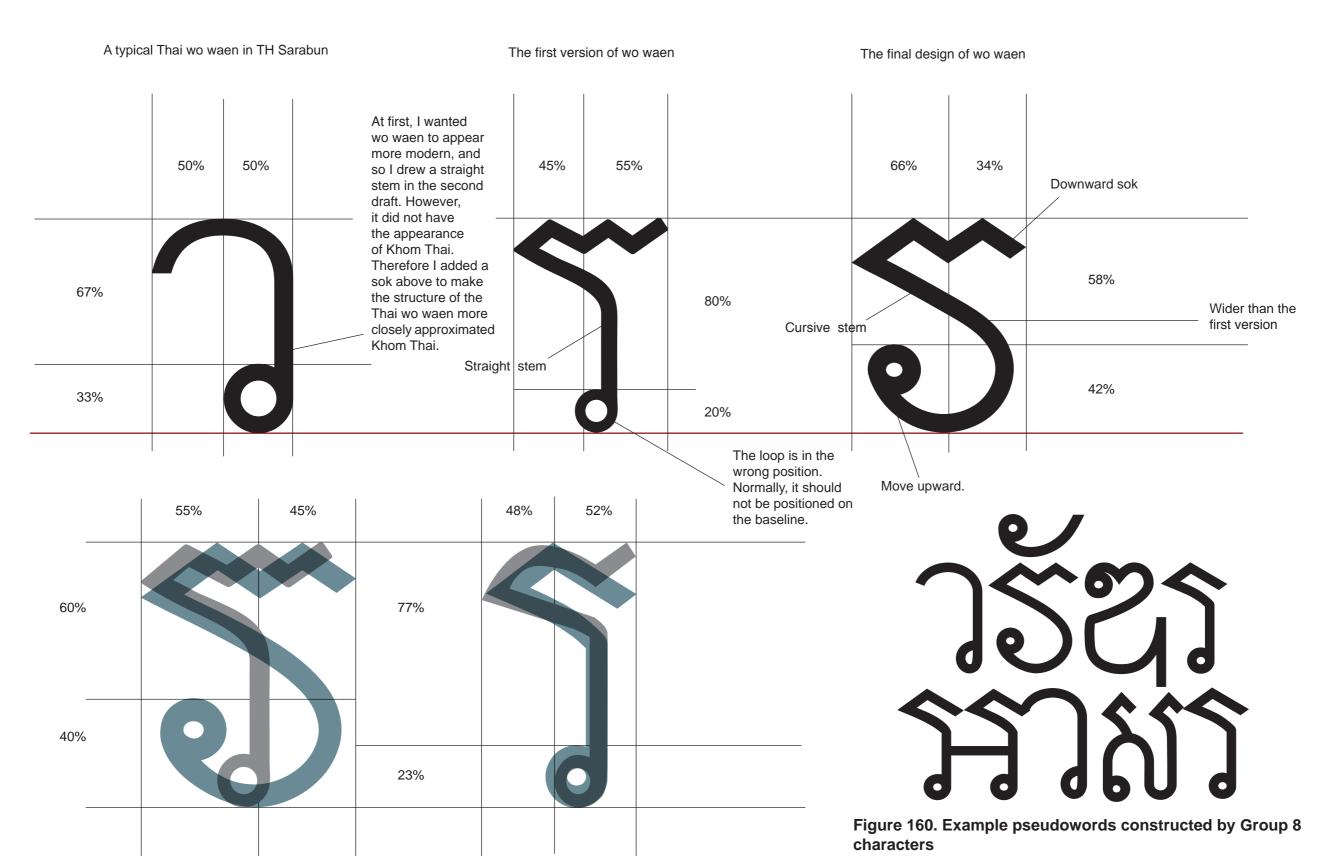


Figure 159. A proportional comparison between the first drafts (grey) and the last designs (green) of wo waen (left) and ro ruea (right)

The main change from the first version to the last is Sok. Wo waen has a major change since I feel that the first version look like ro ruea too much. The stem has been adjusted to be more cursive.

Group 9 full-form characters

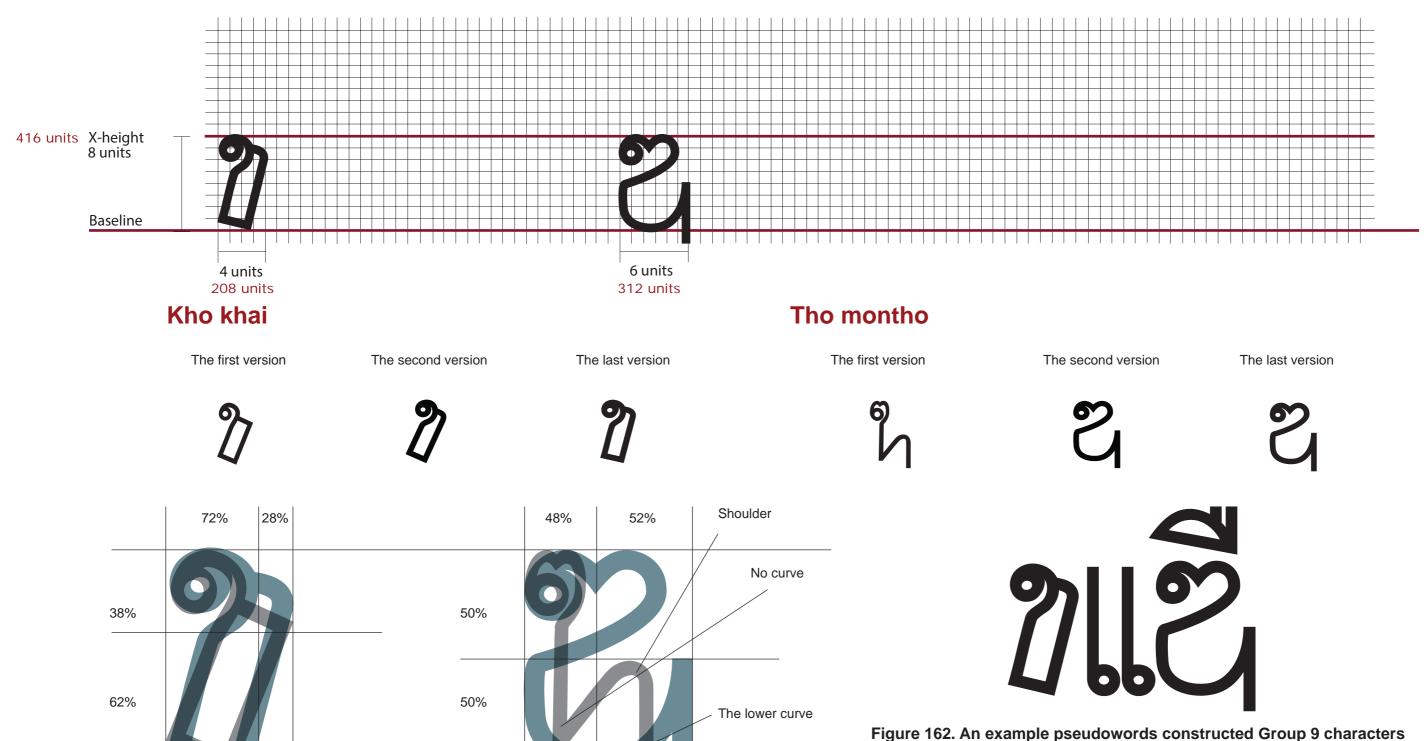
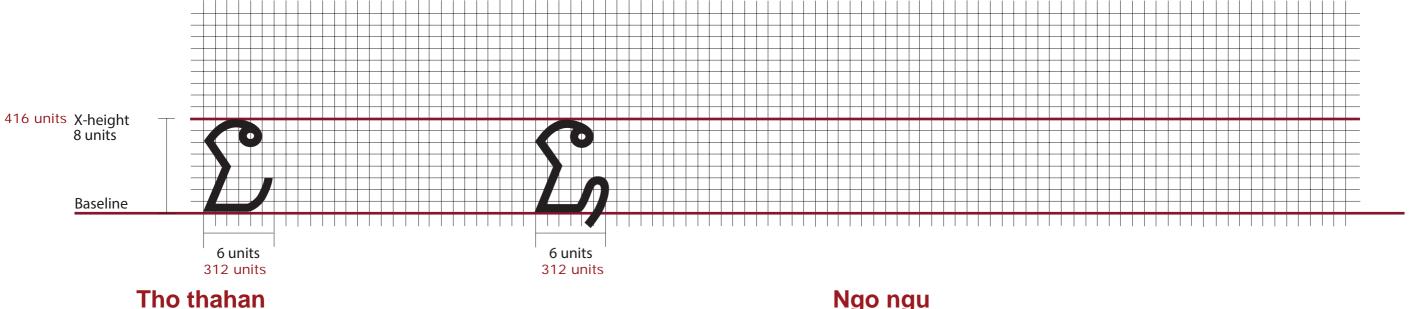


Figure 161. A proportional comparison between the first draft (grey) and the final designs (green) of kho khai (left) and tho montho (right)

Dimensional proportions of Group 10 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.124-125).

Tho montho is much wider in Khom Thai than in Thai. Therefore, I added a lower curve to this character. I also eliminated the shoulder from the first draft.

Group 10 full-form characters



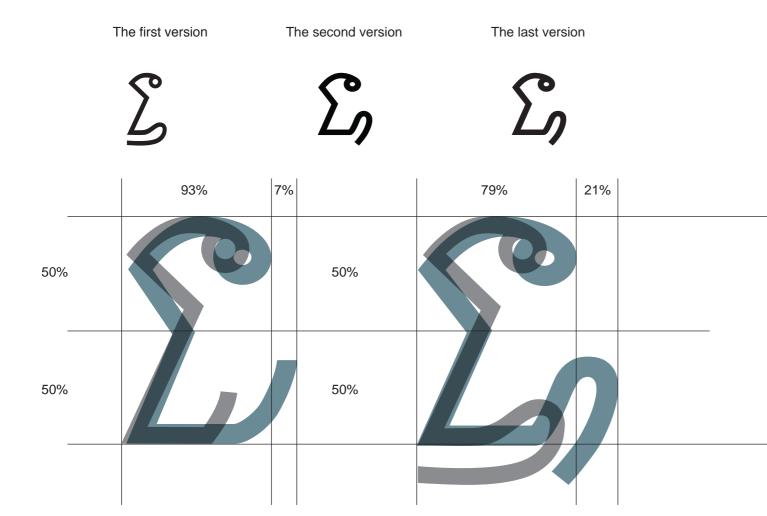


Figure 163. A proportional comparison between the first drafts (grey) and the final designs (green) of ngo ngu (left) and tho thahan (right)

Ngo ngu

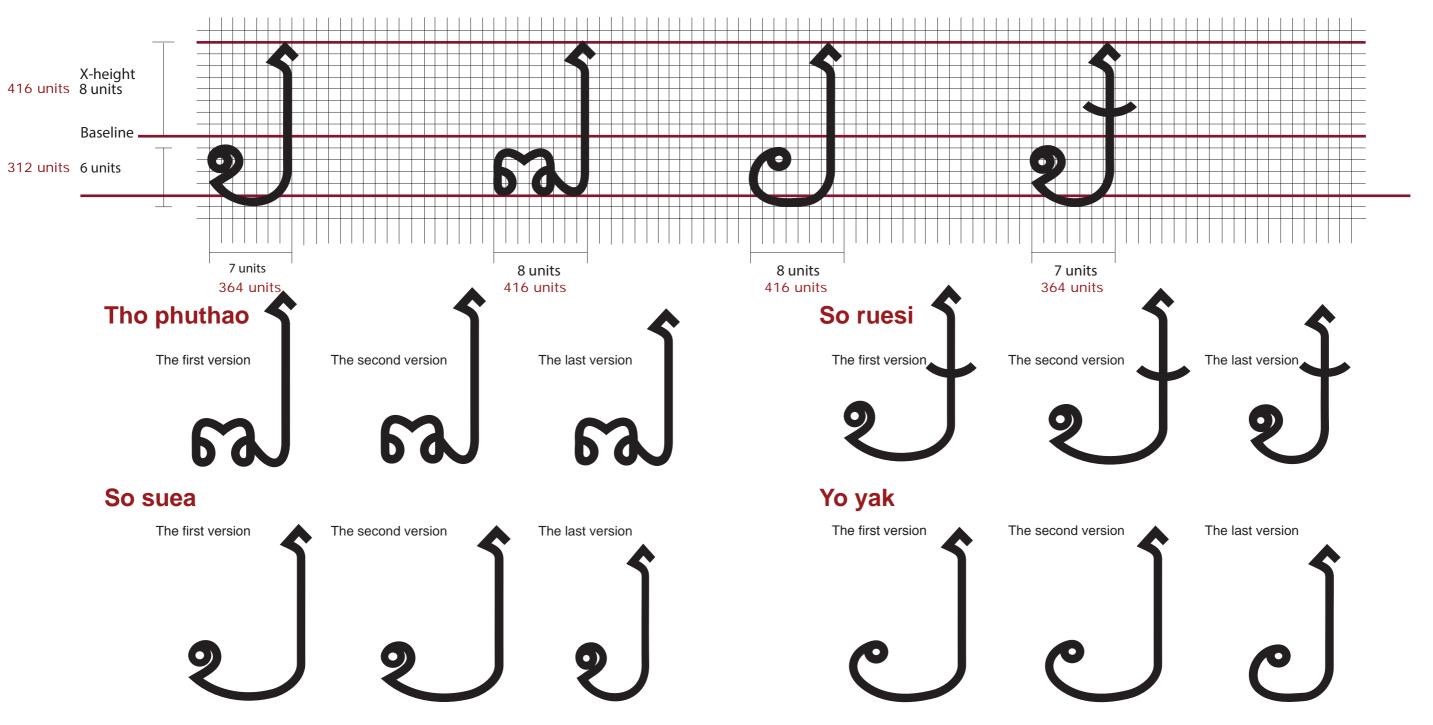
The first version The second version The last version

Figure 164. An example pseudoword constructed by Group 9 characters

Dimensional proportions of Group 10 full-form characters and the development of each character, from the first draft to the final design (see also the thesis, pp.125-126).

The first draft's characters were too narrow, so I widened them in final version, since in Khom Thai these two characters are medium-wide letters.

Group 1 consonantal subscripts



Dimensional proportions of Group 1 consonantal subscript characters and the development of each character, from the first draft to the final design (see also the thesis, pp.127-128).

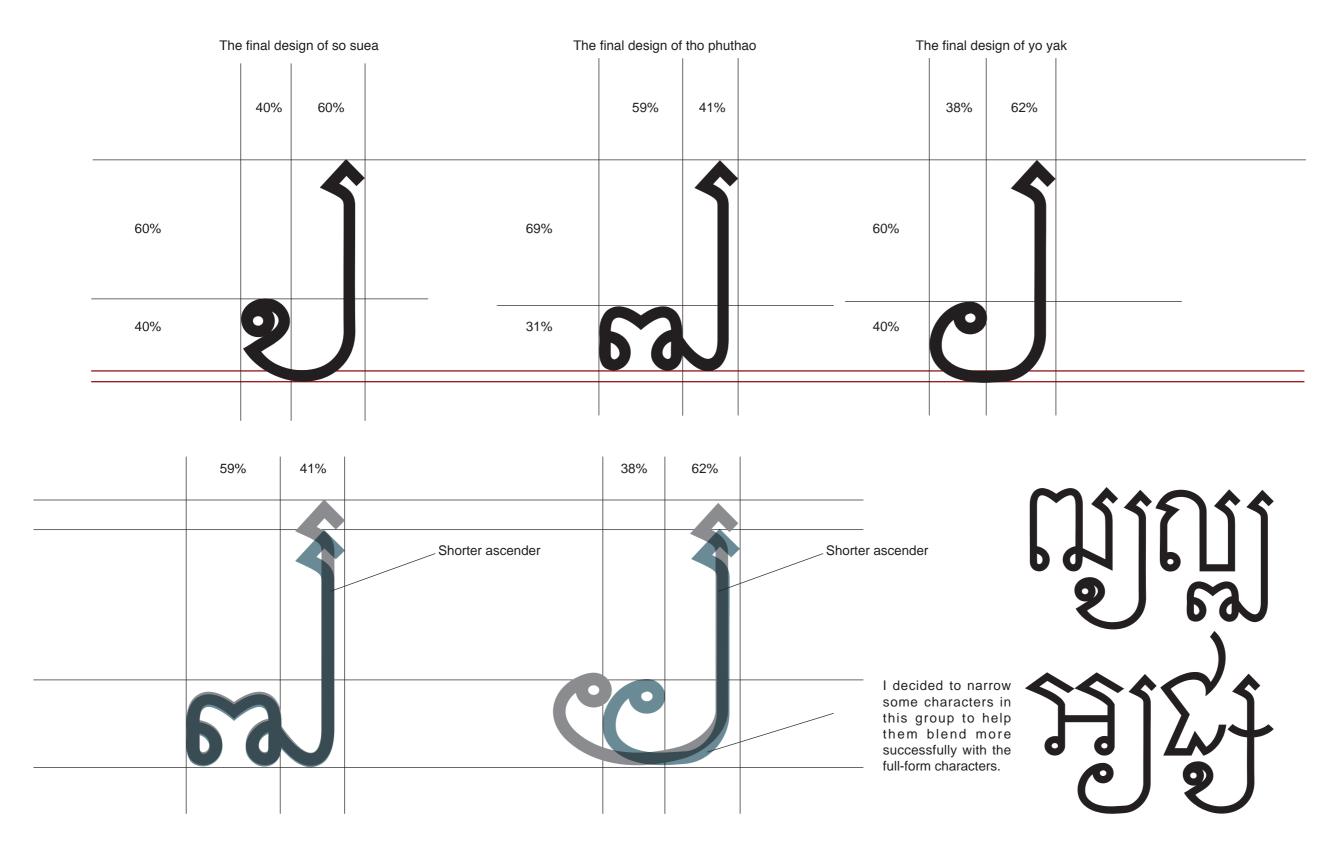
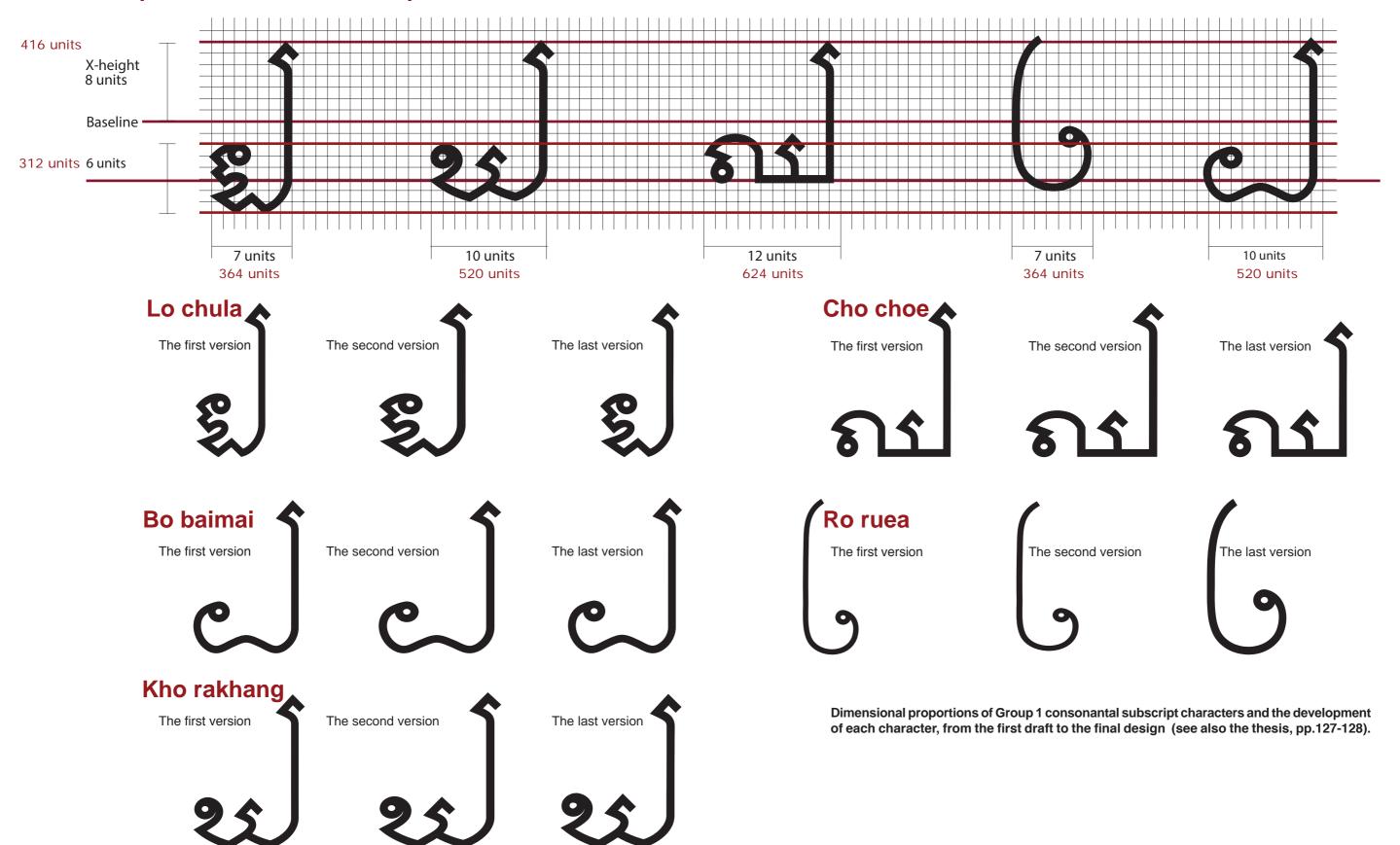


Figure 165. A proportional comparison between the first draft (grey) and the final designs (green) of tho phuthao (left) and yo yak (right)

Figure 166. Example pseudowords constructed by Group 1 characters

Group 1 consonantal subscripts



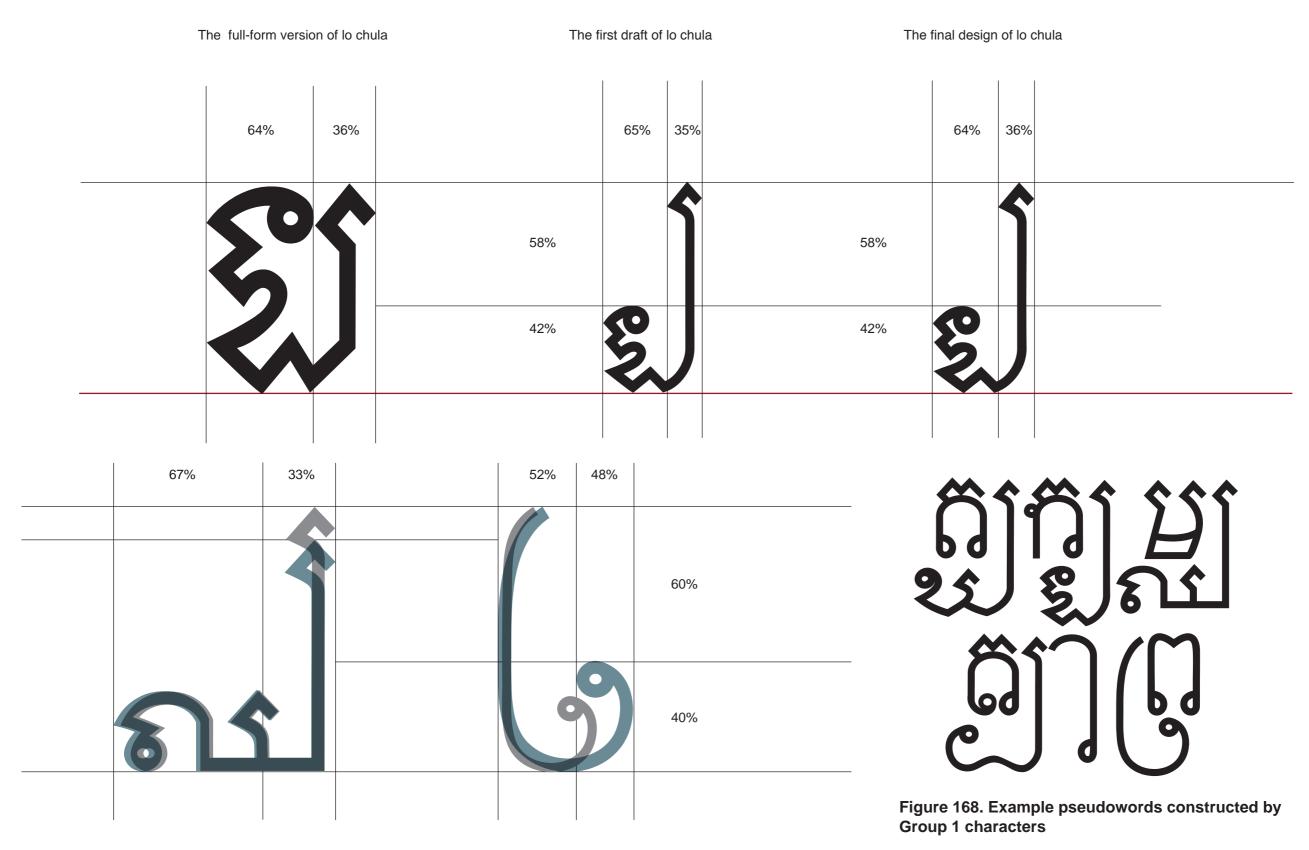
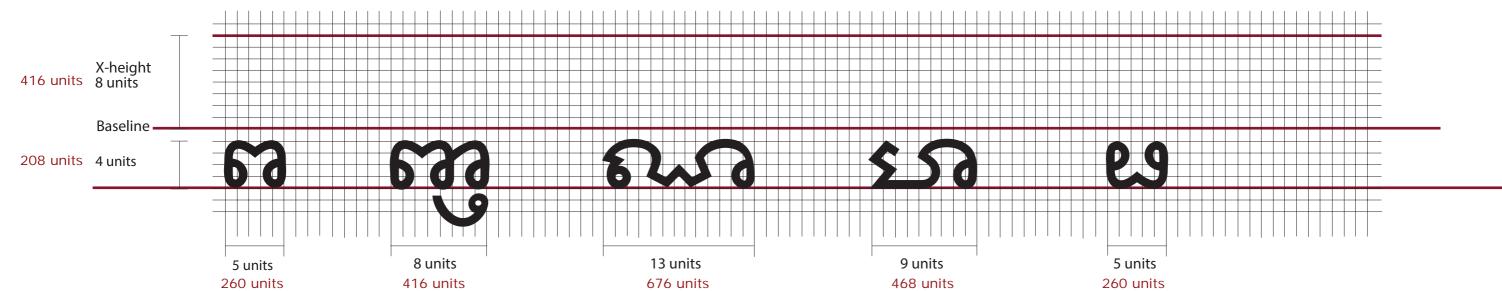


Figure 167. A proportional comparison between the first draft (grey) and the final designs (green) of cho choe (left) and ro ruea (right)

TLK Manussa

Group 2 consonantal subscripts



Pho phan

The first version

The second version

The last version

Ho hip

The first version

The second version

The last version

63





20



The second version



Pho phueng

The first version

The second version

The last version

ಲ



ಲ್ರ

633

The first version

Yo ying





The last version

No nen

The first version

The second version

The last version







Dimensional proportions of Group 2 consonantal subscript characters and the development of each character, from the first draft to the final design (see also the thesis, p.129).

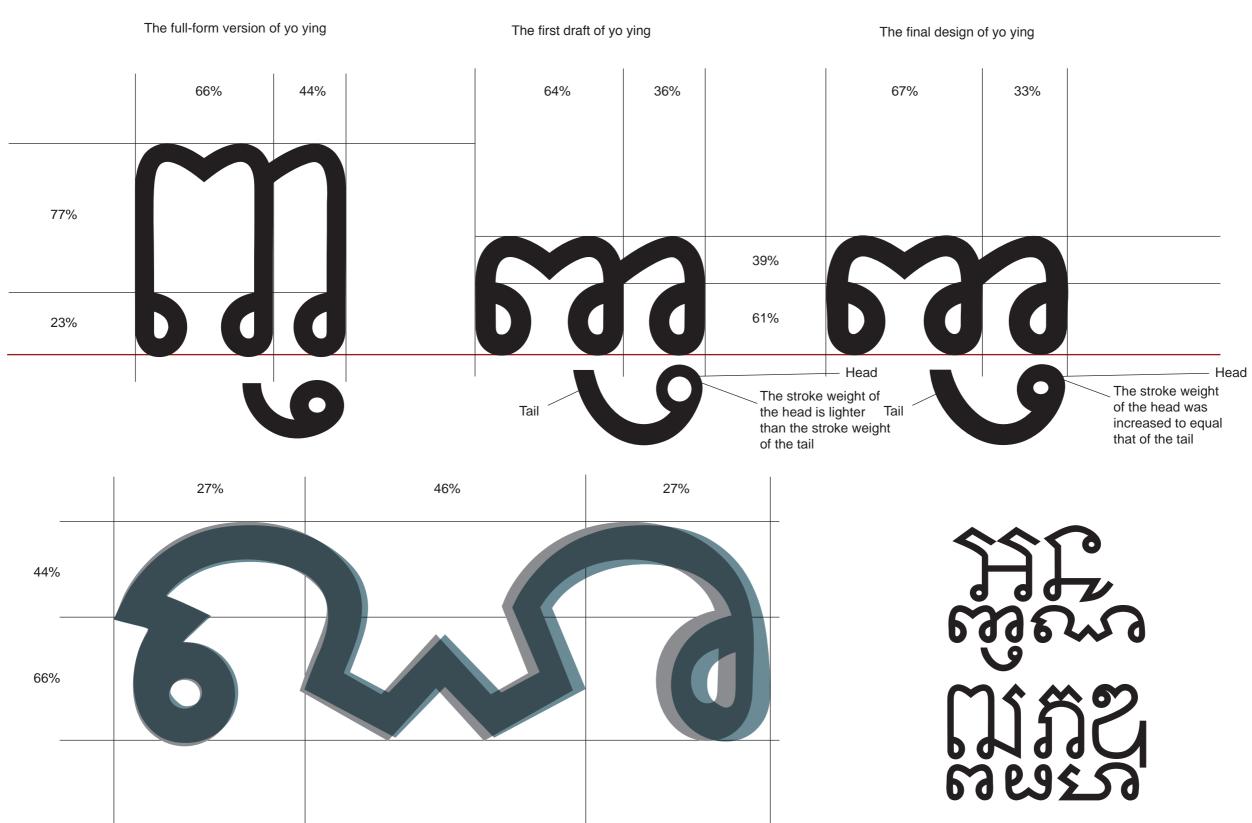
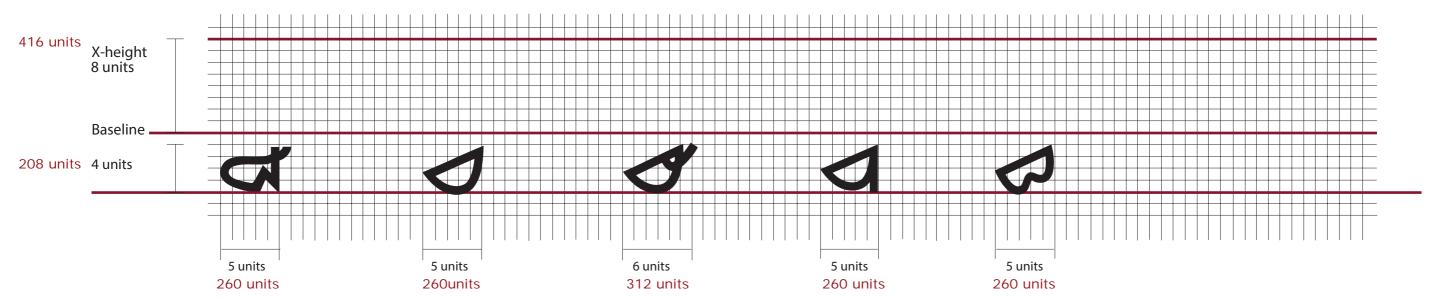


Figure 170. A proportional comparison between the first draft (grey) and the final designs (green) of no nen

Figure 169. Example pseudowords constructed by Group 2 characters

Group 3 consonantal subscripts



O ang

The first version

The second version

The last version

4

The last version



Wo waen

The first version

The second version

The last version

Tho than

The first version

The second version

The last version







Tho thahan

The first version

The second version

4

The last version

Tho thong

The first version

The second version

The last version







Dimensional proportions of Group 3 consonantal subscript characters and the development of each character, from the first draft to the final design (see also the thesis, p.130).

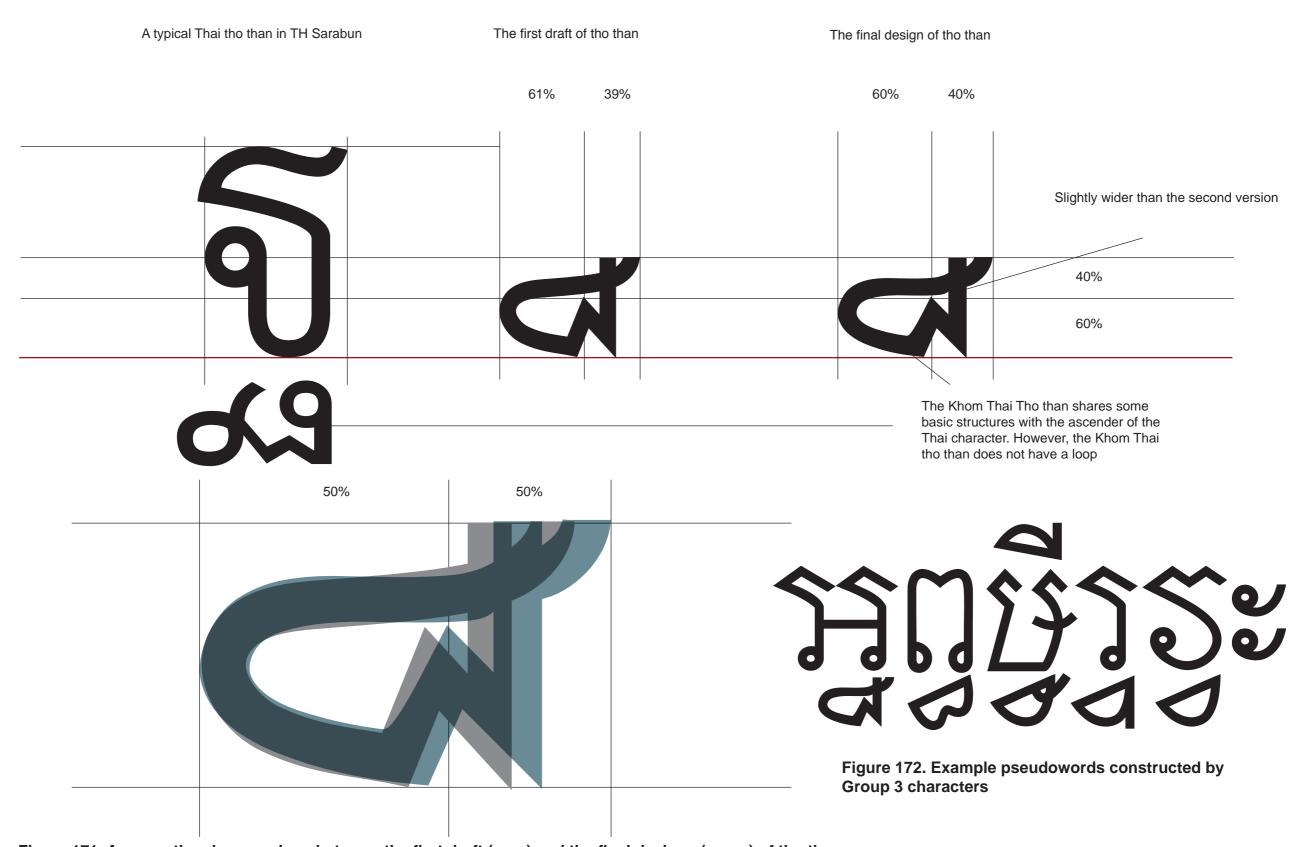
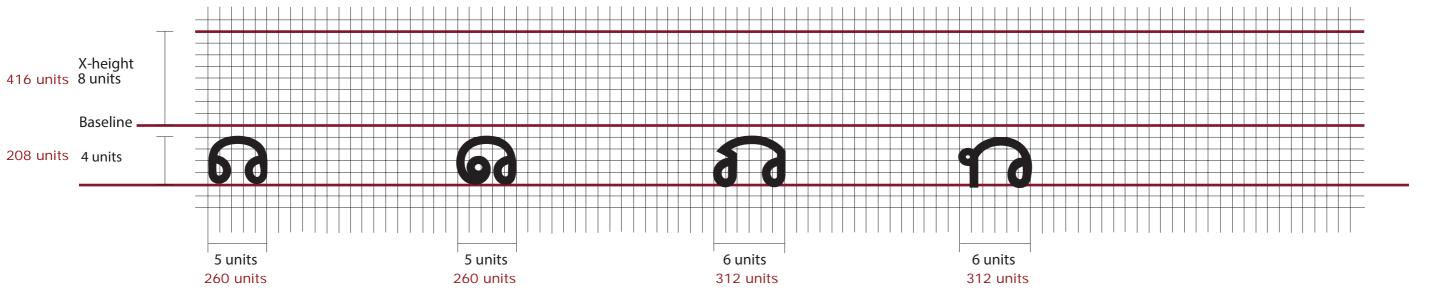


Figure 171. A proportional comparison between the first draft (grey) and the final designs (green) of tho than

Group 4 consonantal subscripts



To tao

The first version

The second version

The last version

Ko kai

The first version

The second version

The last version













Kho khwai

The first version

The second version

The last version



The first version

Pho samphao

The second version

The last version







Dimensional proportions of Group 4 consonantal subscript characters and the development of each character, from the first draft to the final design (see also the thesis, pp.130-131).

В	Basic form of kho kwai		The first draft of kho khwai		he final design of kho khwai		
						38%	
			DO		DO	62%	

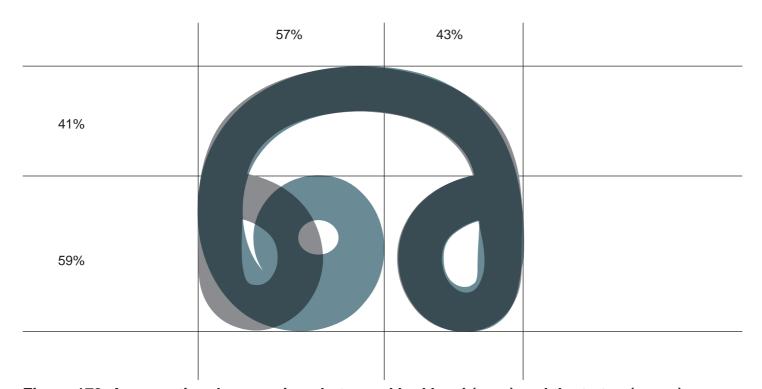
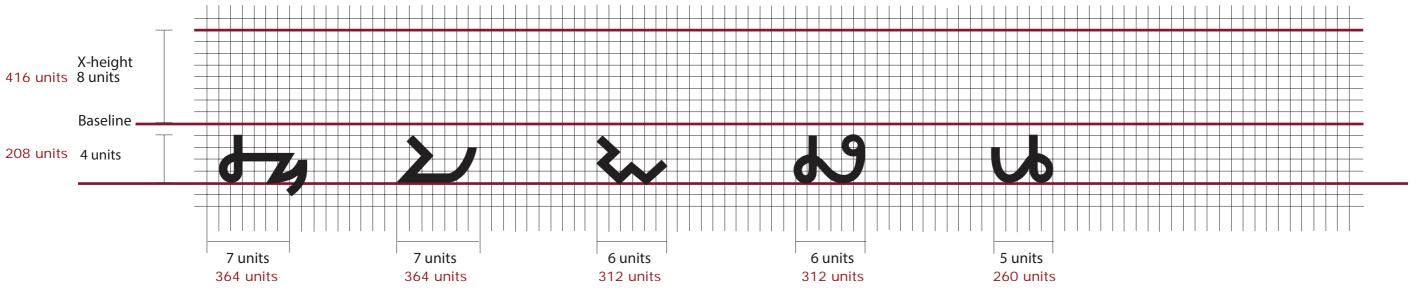




Figure 174. Example pseudowords constructed by Group 4 characters

Figure 173. A proportional comparison between kho khwai (grey) and the to tao (green)

Group 5 consonantal subscripts



Cho ching

The first version

The second version

The last version

Mo ma

The first version

The second version

The last version

4











Cho chang

The first version

The second version

The last version

No nu

The first version

The second version

The last version

2





り





To patak

The first version

The second version

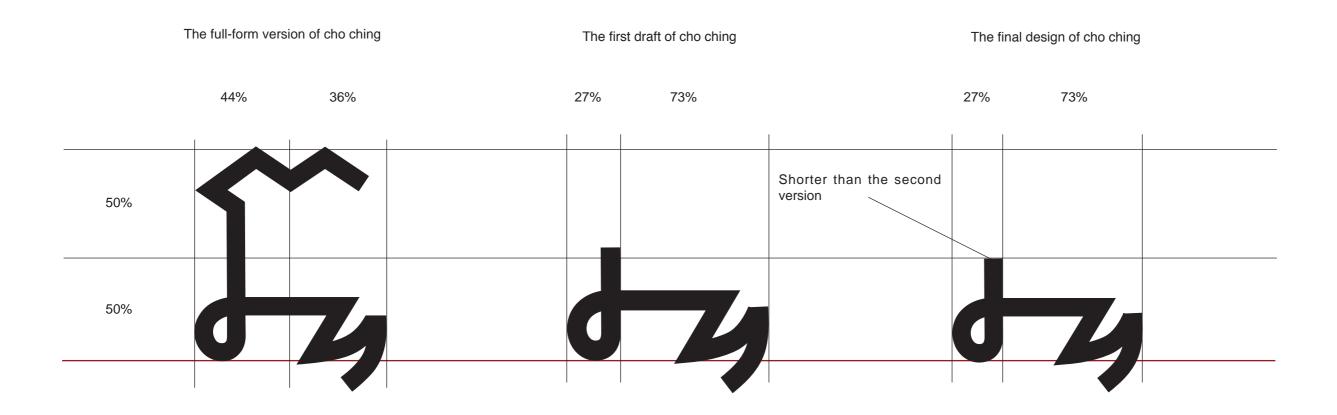
The last version

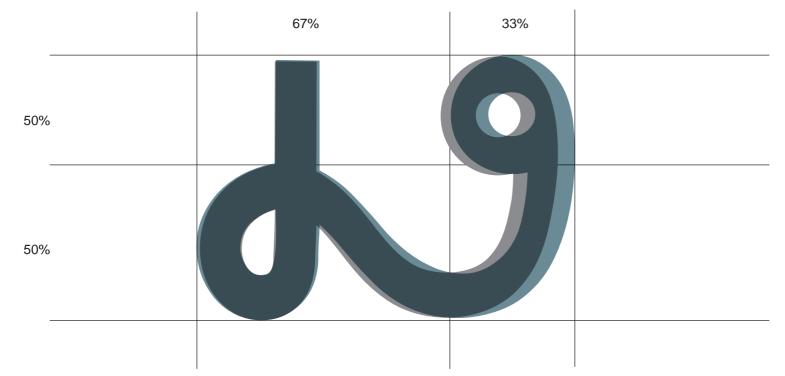






Dimensional proportions of Group 5 consonantal subscript characters and the development of each character, from the first draft to the final design (see also the thesis, p.131).





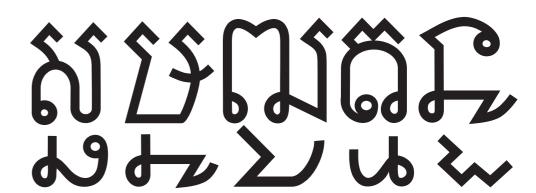


Figure 176. Example pseudowords constructed by Group 5 characters

Figure 175. A proportional comparison betweenthe first draft (grey) and the final design (green) of no nu

Group 6 consonantal subscripts

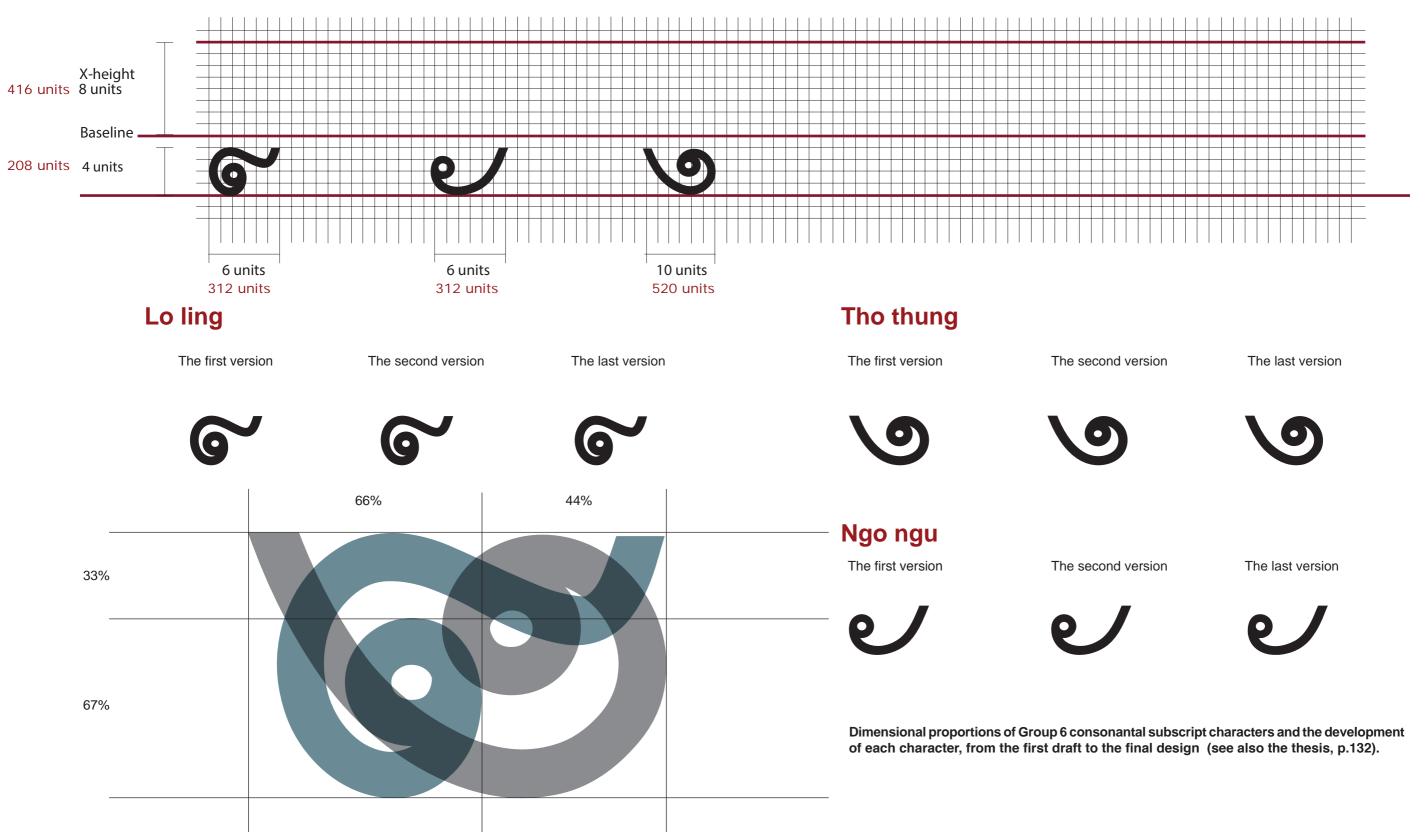


Figure 177. A proportional comparison between tho thung (grey) and lo ling (green) of wo waen and ro ruea

46%

Group 7 consonantal subscripts

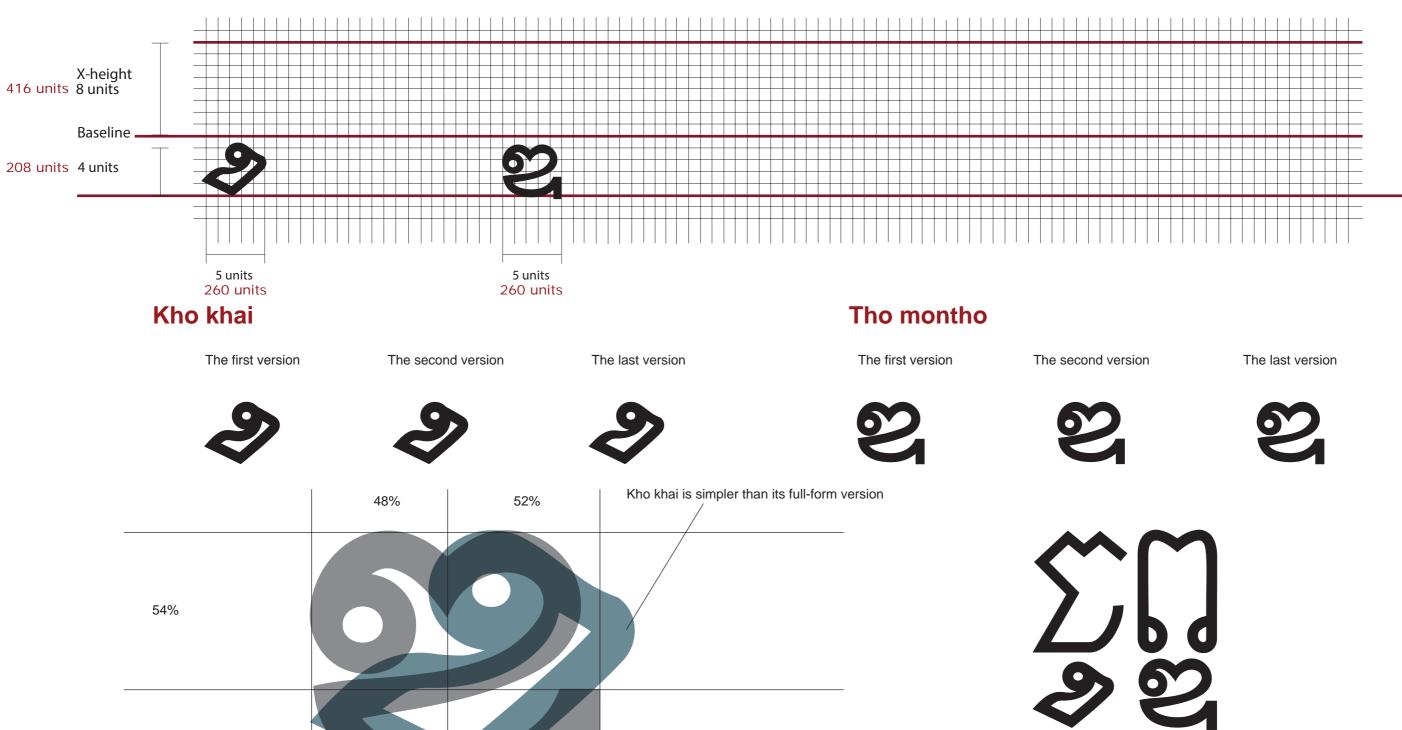


Figure 178. A proportional comparison between tho montho (grey) and kho khai (green)

Figure 179. An example pseudowordsconstructed by Group 7 characters.

Dimensional proportions of Group 7 consonantal subscript characters and the development of each character, from the first draft to the final design (see also the thesis, p.132).

Group 1 numerals

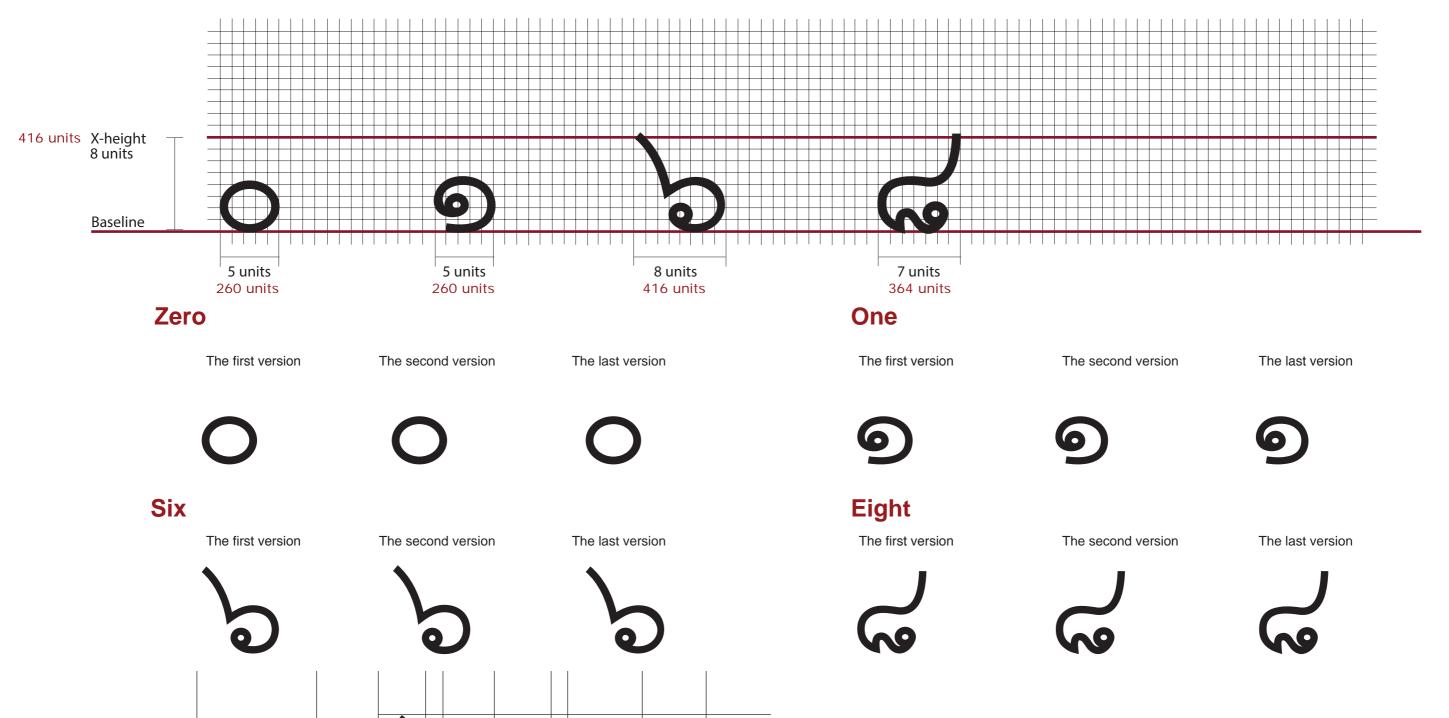
55%

55%

45%

65%

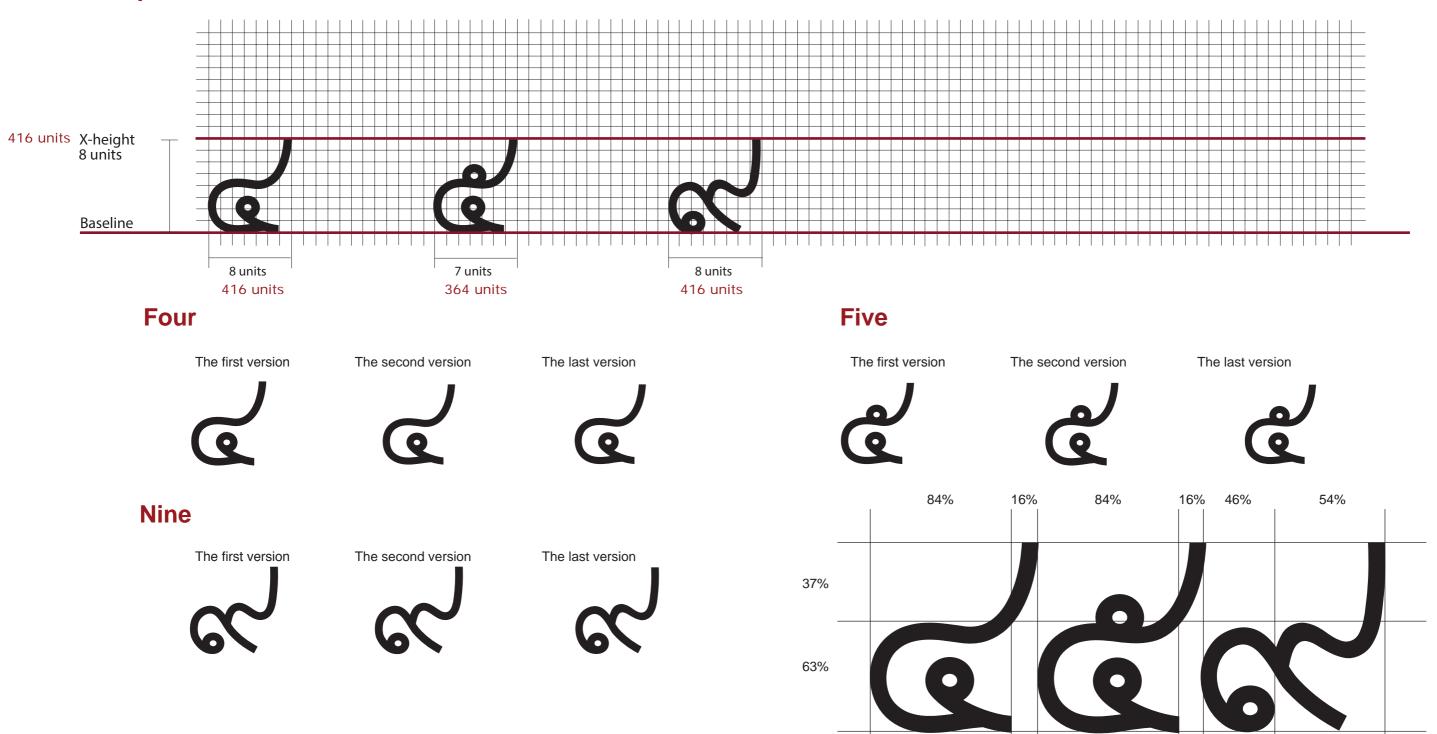
35%



Dimensional proportions of Group 1 numerals and the development of each character, from the first draft to the final design (see also the thesis, pp.133-134).

Figure 180. Dimensional proportions of the numbers in Group 1

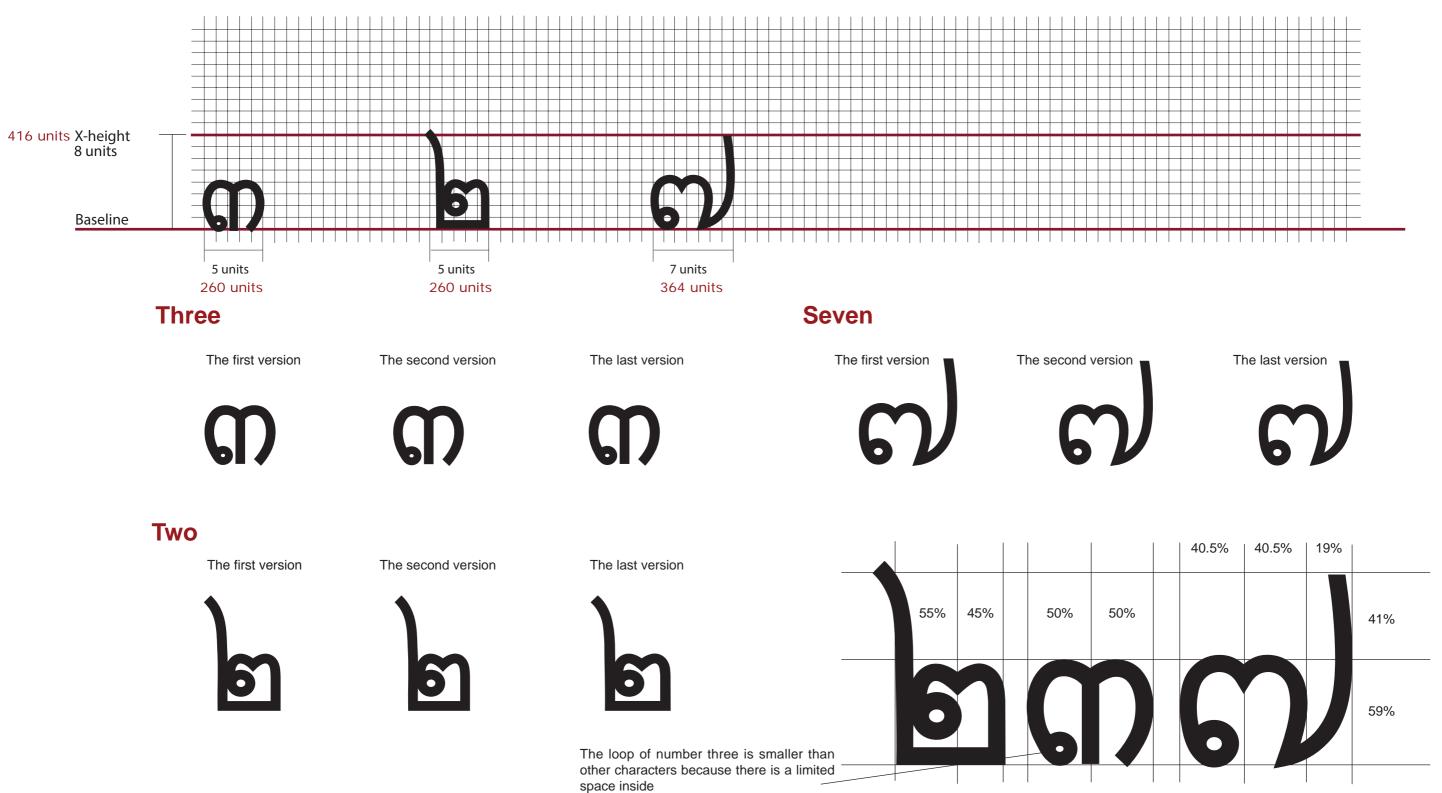
Group 2 numerals



Dimensional proportions of Group 2 numerals and the development of each character, from the first draft to the final design (see also the thesis, pp.134-135).

Figure 181. Dimensional proportions of the numbers in Group 2

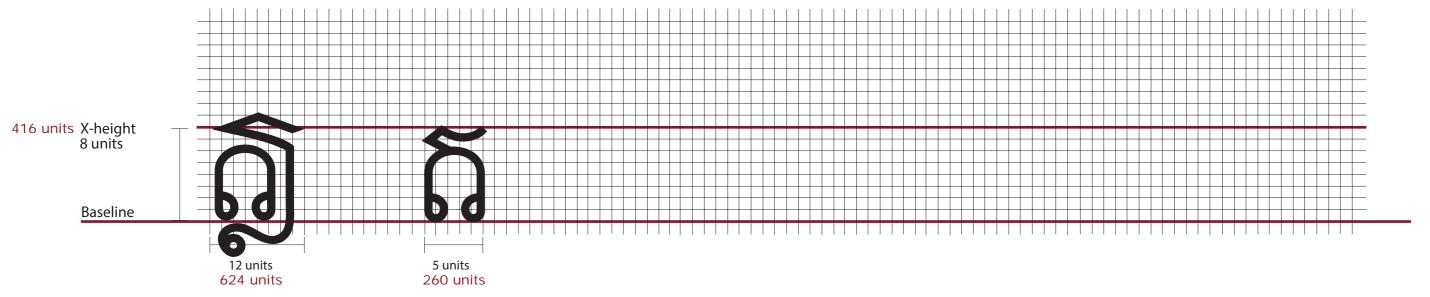
Group 3 numerals



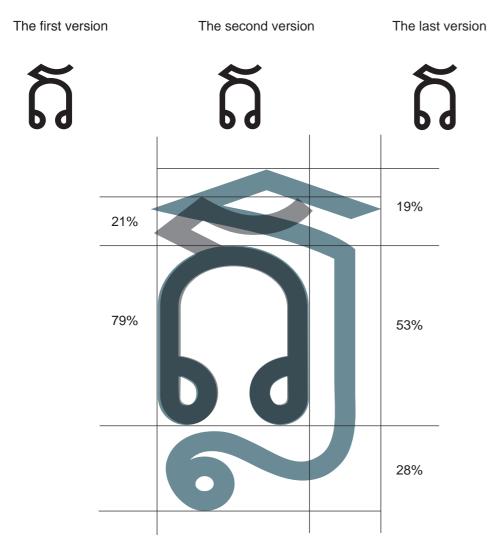
Dimensional proportions of Group 3 numerals and the development of each character, from the first draft to the final design (see also the thesis, p.135).

Figure 182. Dimensional proportions of the numbers in Group 3

Group 1 independent vowels



Phinthu i



Sara i

The first version

The second version

The last version





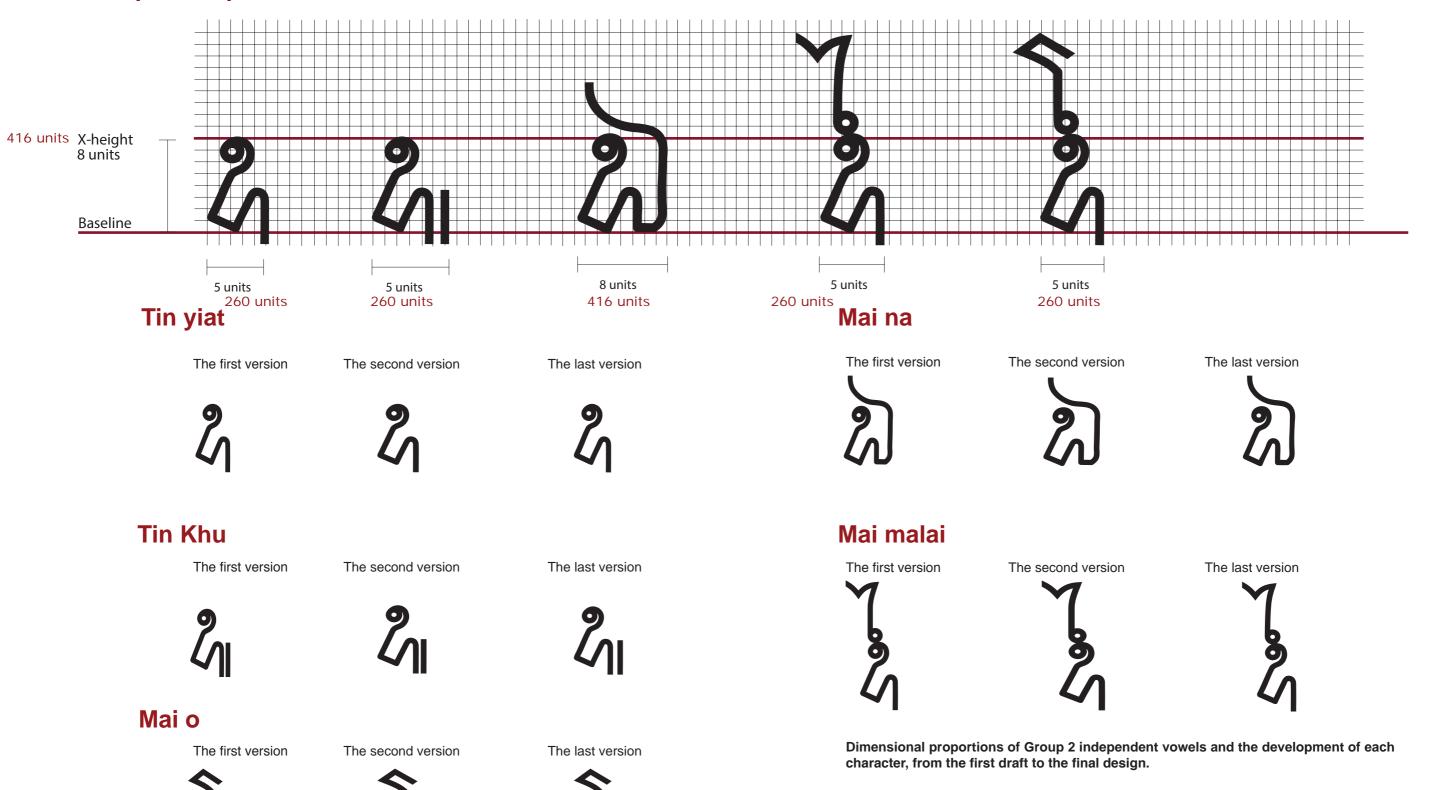


Dimensional proportions of Group 1 independent vowels and the development of each character, from the first draft to the final design.



Figure 183. An example pseudoword constructed by Group 1 characters

Group 2 independent vowels



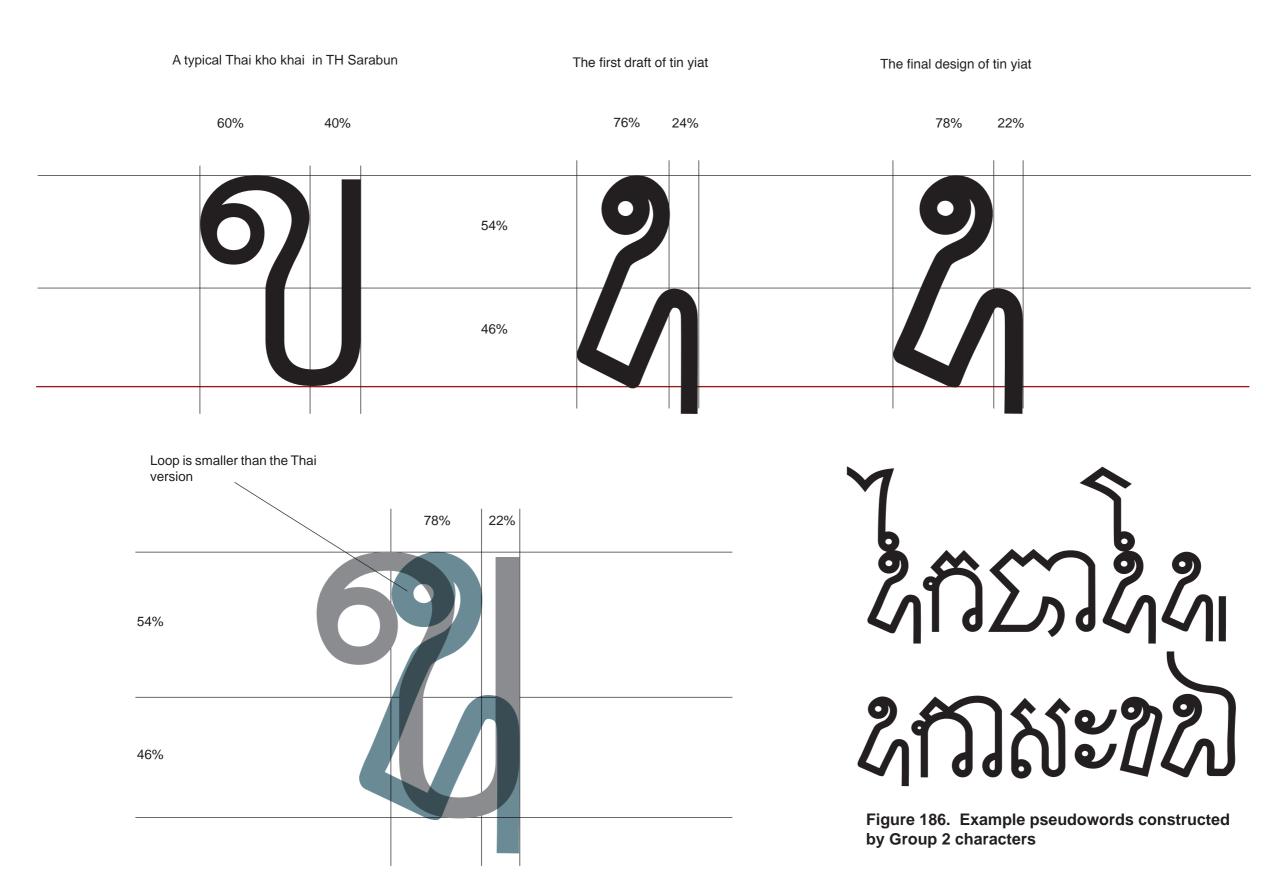
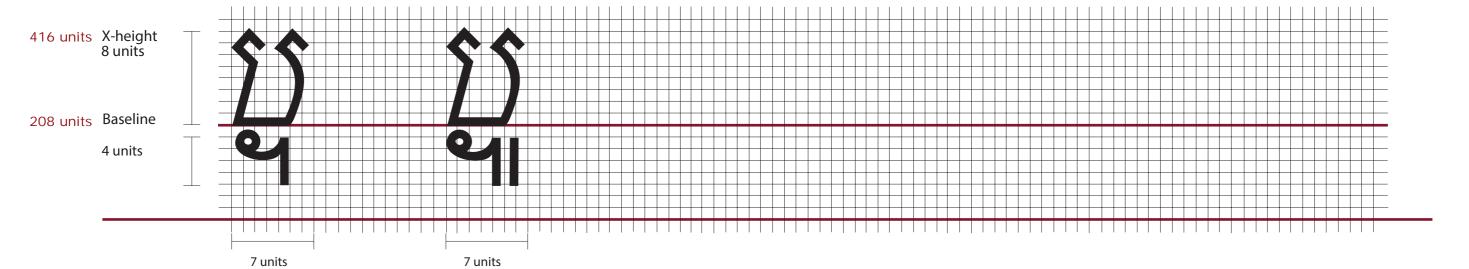


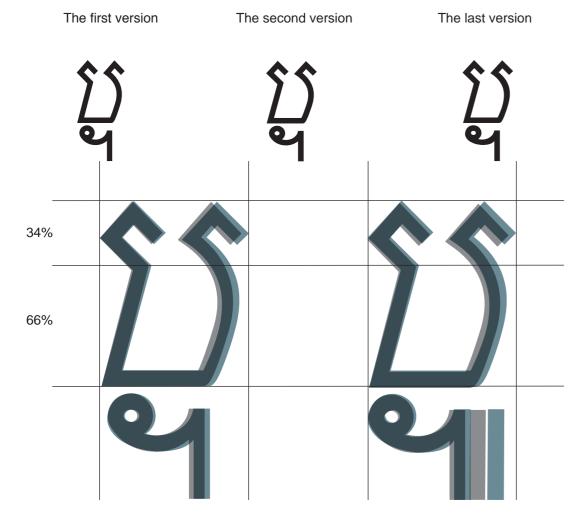
Figure 185. A proportional comparison between Thai kho khai (grey) and tin yiat (green)

Group 3 independent vowels

364 units



Tua rue



364 units

Figure 187. Proportional comparisons between the first version (grey) and the last version (green) of tua rue (left) and tua lue (right)

Tua lue

The first version

The second version

The last version

The last version

Dimensional proportions of Group 2 independent vowels and the development of each character, from the first draft to the final design.

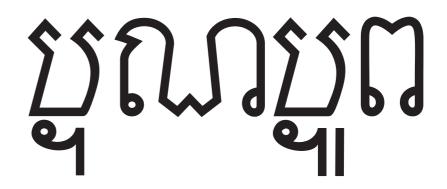


Figure 188. An example pseudoword constructed by Group 3 characters

Figure 190. An example pseudoword constructed by Group 4

characters

Group 4 independent vowels

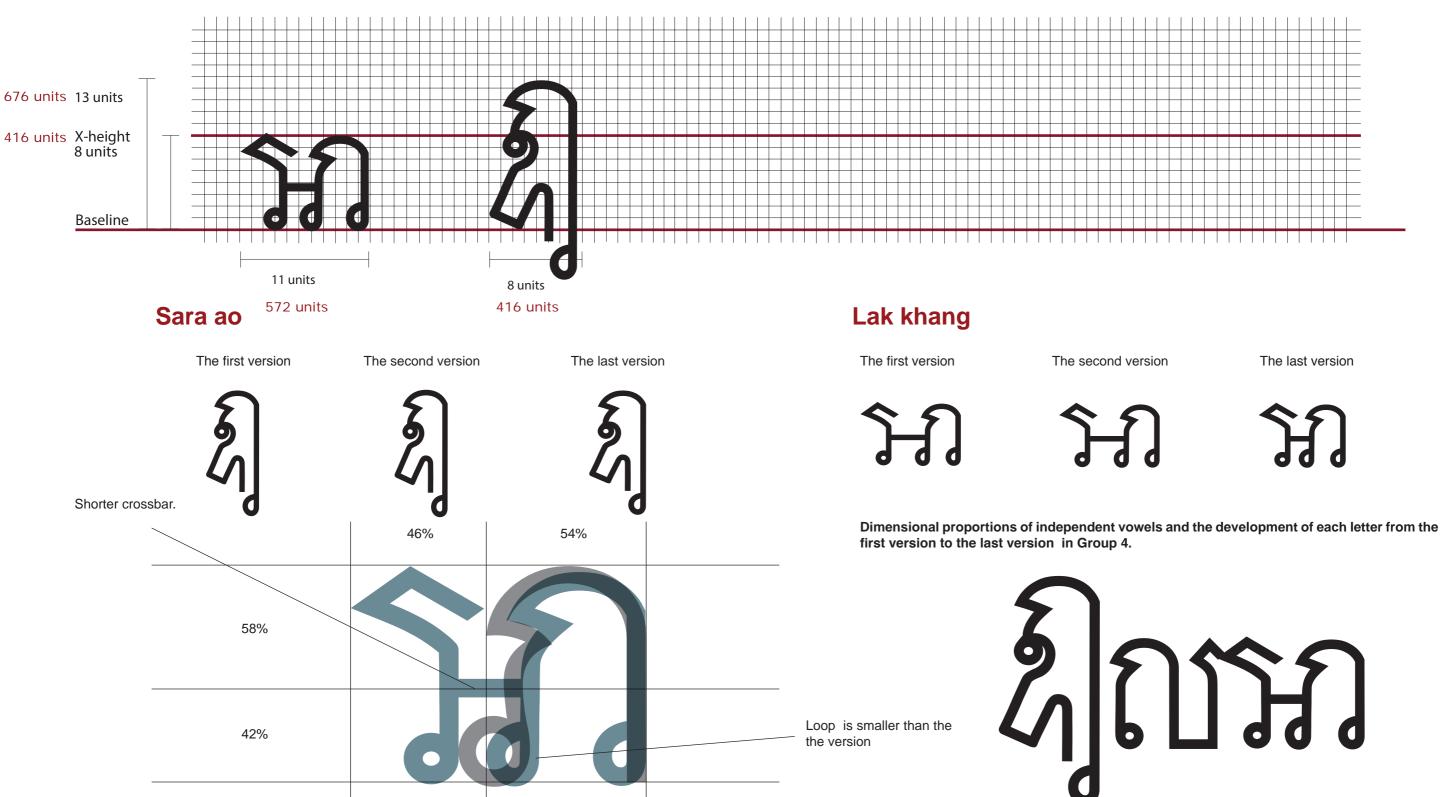
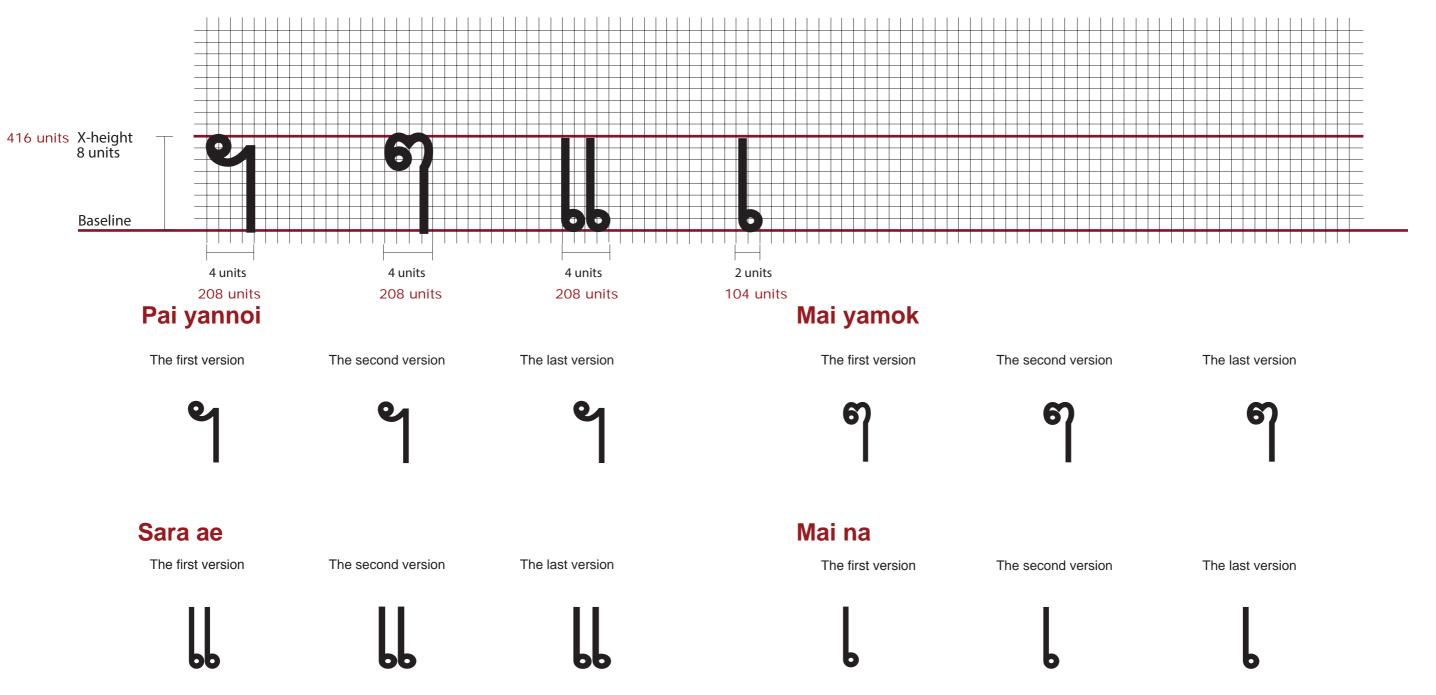


Figure 189. A proportional comparison between Thai pho samphao (grey) and Khom Thai lak khang (green)

Group 1 dependent vowels



Dimensional proportions of Group 1 dependent vowels and the development of each character, from the first draft to the final design.

TLK Manussa

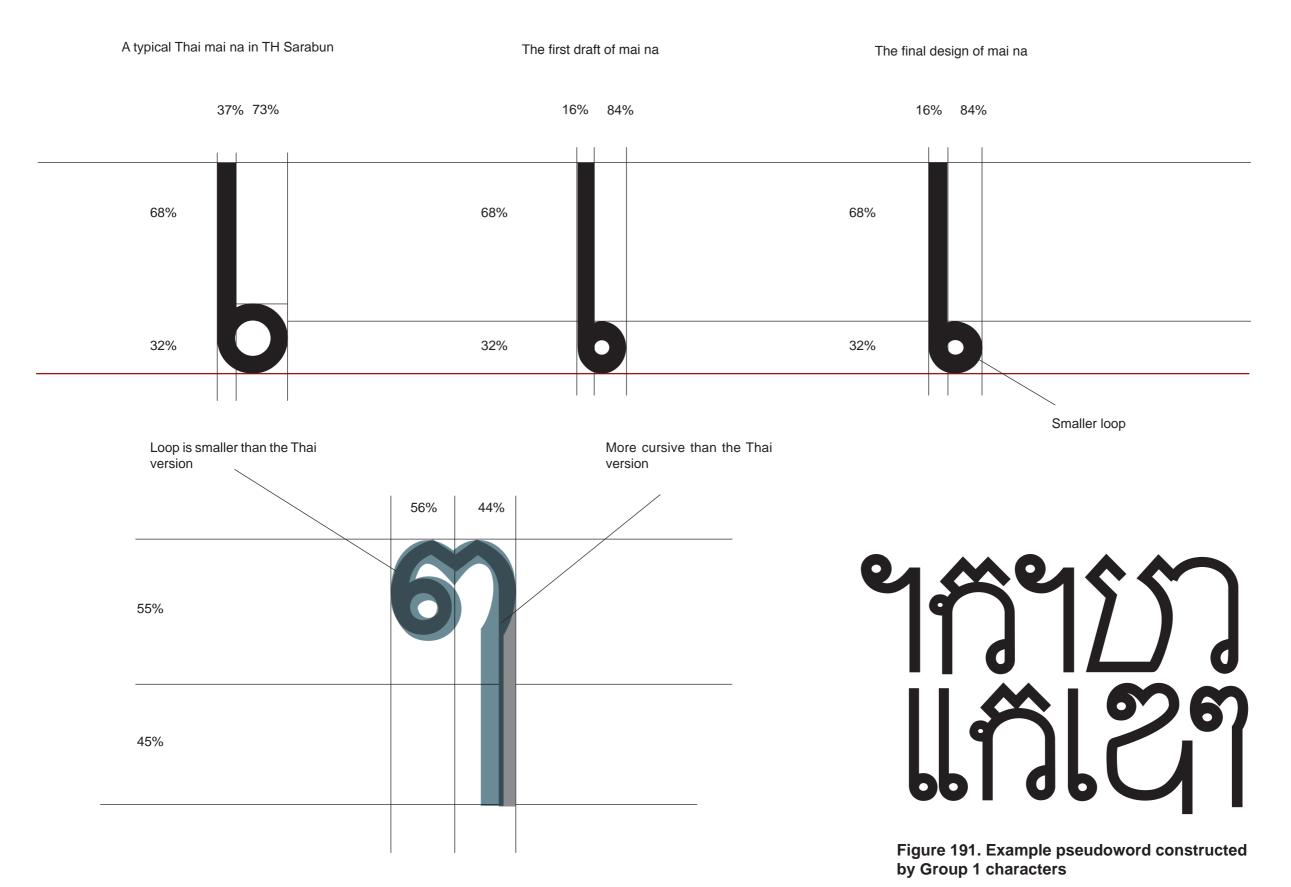


Figure 192. A proportional comparison between Thai (grey) and Khom Thai mai yamok (green)

Group 2 dependent vowels

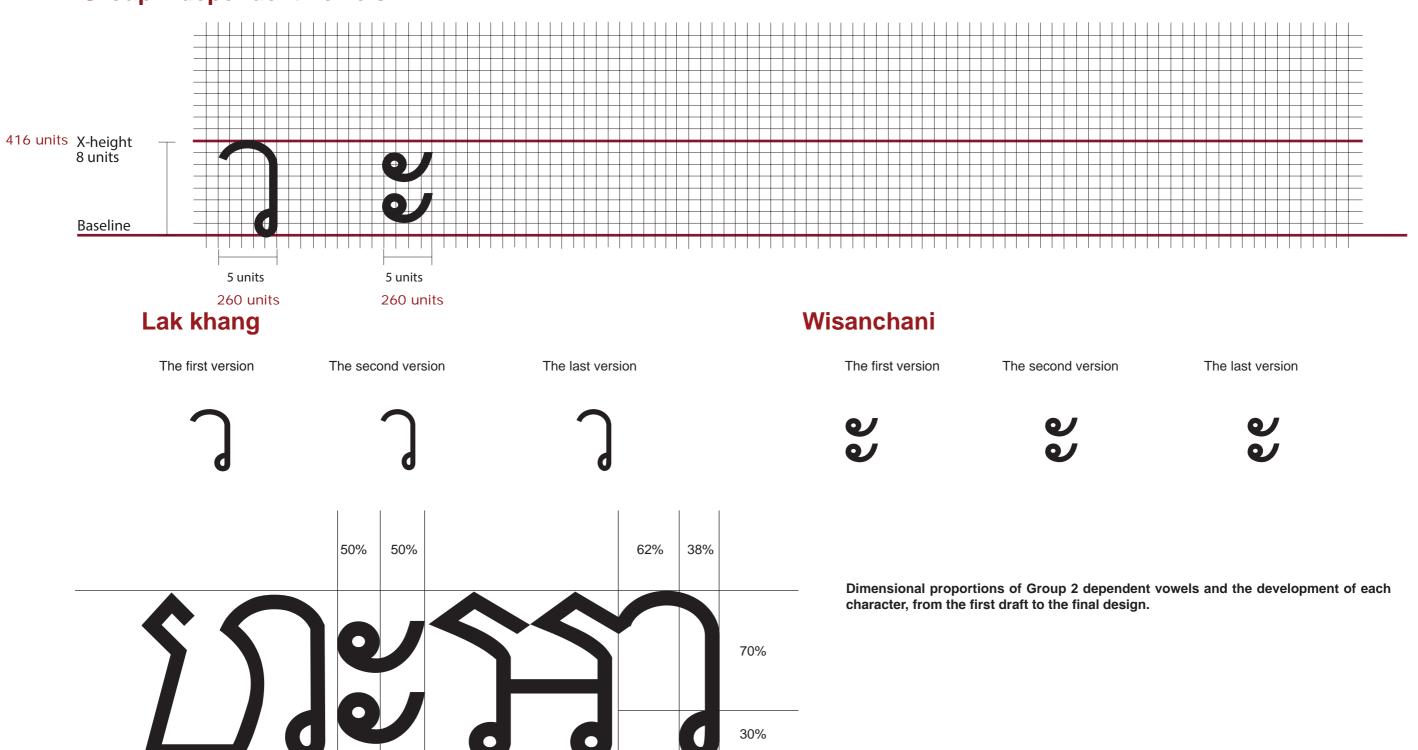


Figure 193. An example pseudoword constructed by Group 2 characters

Group 3 dependent vowels

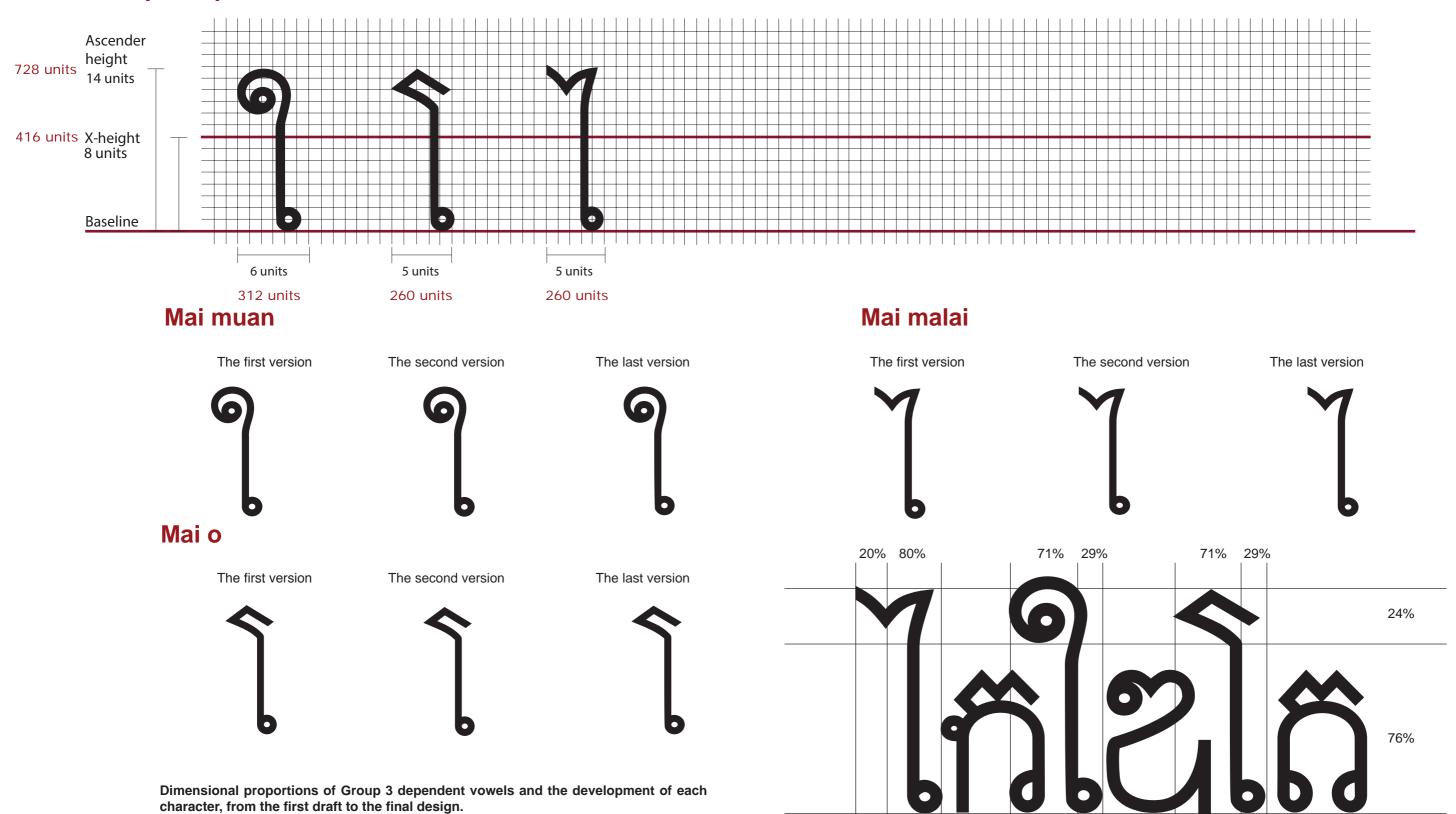


Figure 194. An example pseudoword constructed by the characters in Group 3

Group 4 dependent vowels

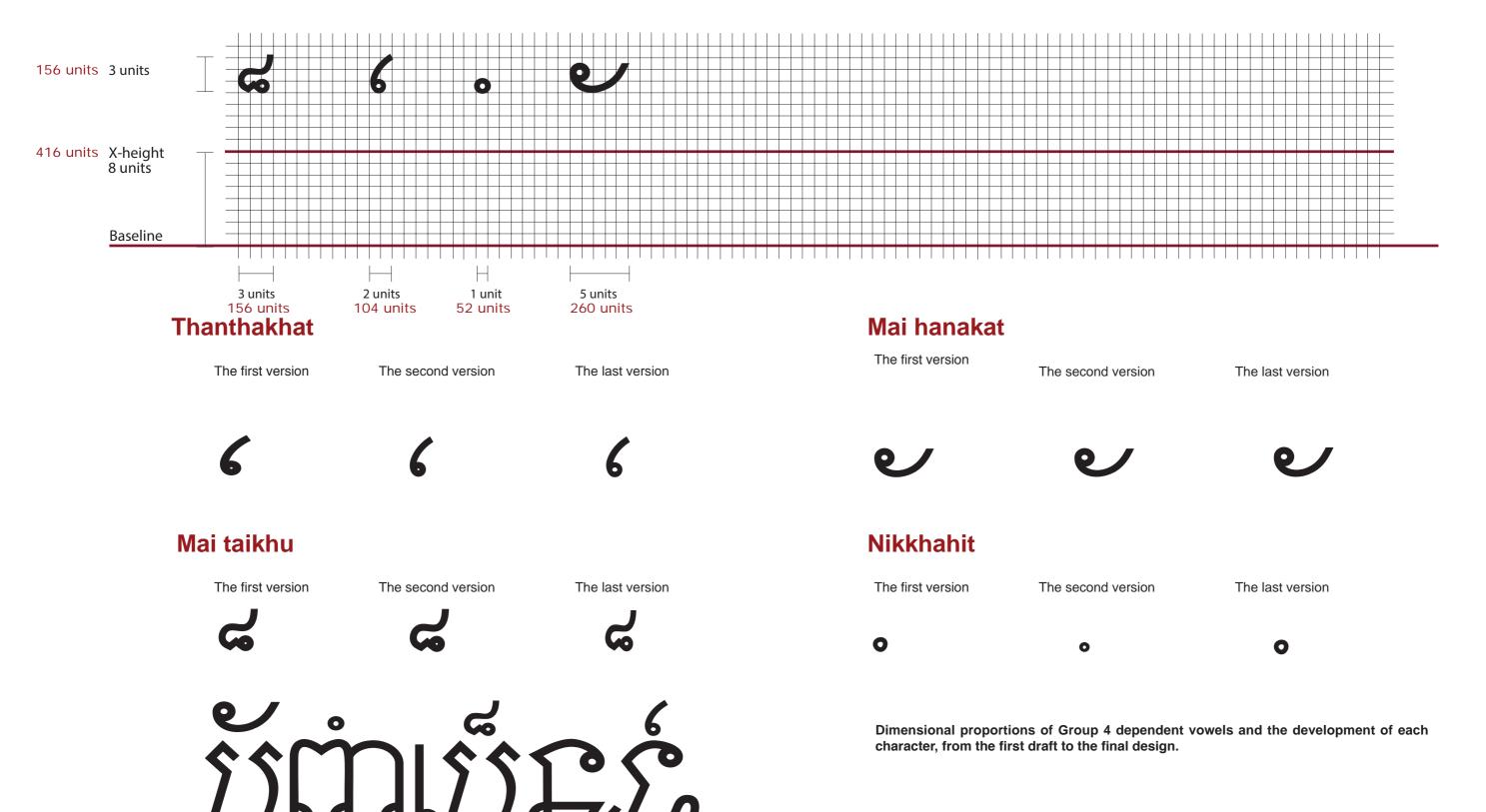


Figure 195. An example pseudoword constructed by Group 4 characters

Group 5 dependent vowels

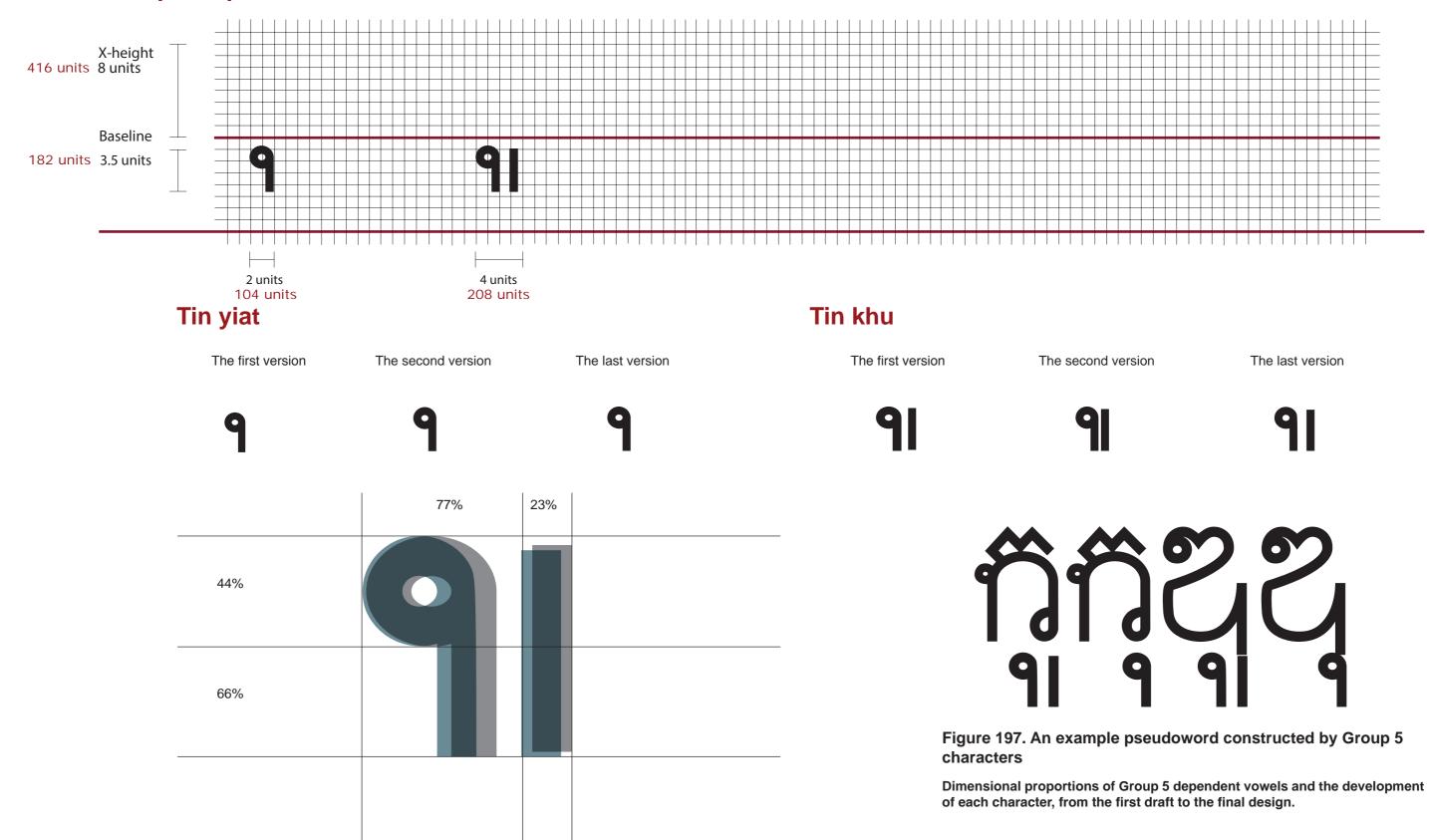


Figure 196. A proportional comparison between The first draft (grey) and the final design of tin khu (green)

Group 6 dependent vowels

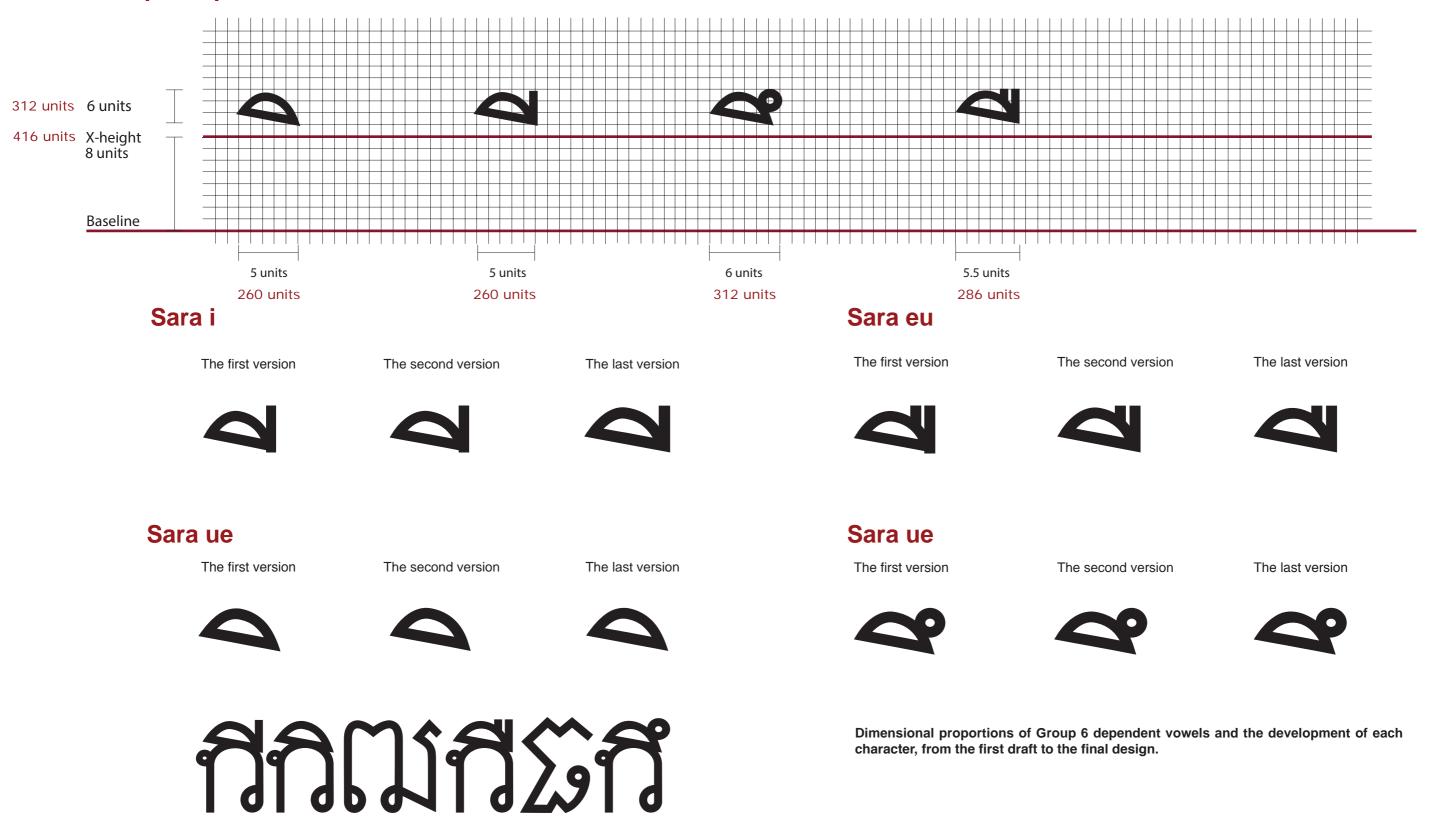


Figure 198. An example of pseudoword constructed by Group 6 characters

Group 1 of tone marks.

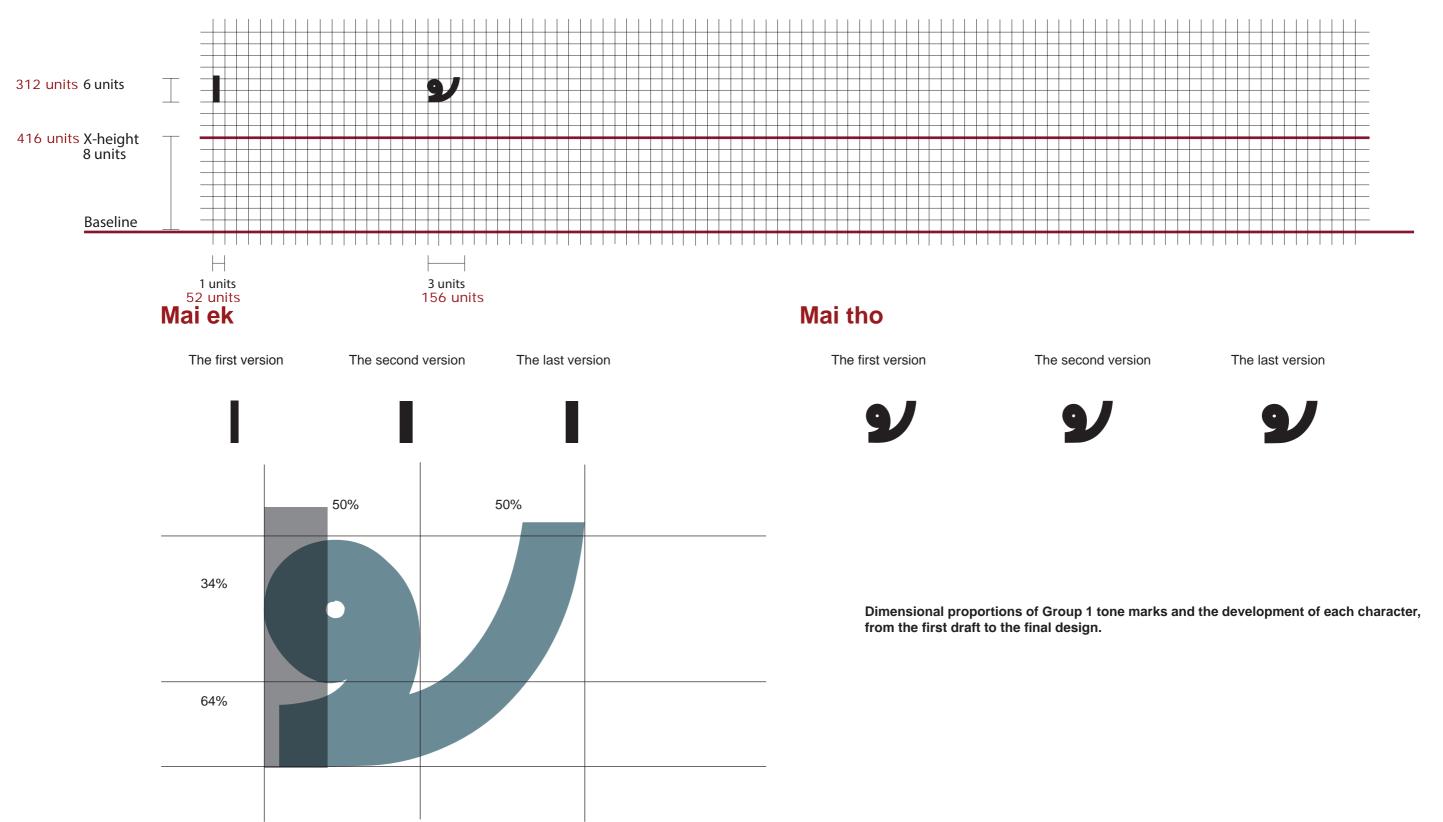


Figure 199. A proportional comparison between mai ek (grey) and the last version of mai tho (green)

TLK Manussa Ligatures

