

千葉工業大学
博士学位論文

The study on the cognitive process of Thai
language for developing user interface

ユーザインタフェース開発のための
タイ語の認知プロセスに関する研究

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Abstract

The user interface is an important factor in the development of up-to-date technology, representing a medium whereby connections between devices and users occur focusing on the user's experience and interaction by reducing high personal skills and allowing proficiency after a short period of training that makes the user's interaction as simple and efficient as possible, in terms of accomplishing user goals.

In addition, the research and development of creating User interface results in adding High value added in product. This help avoiding the cost competition with other competitors and taking new opportunities in expanding the markets. For the current situation in Thailand, user interface design in Thai electronic industry relies on foreign investor's know-how, whether it be Japan or USA. There is no own interface design on electronic products, whether it be command buttons, software and so on. Thai users need to rely on translated data which is not designed for Thai users and cannot make the most of them. This reflects the lack of development interface design in electronic industry of Thailand. Therefore, researchers realize the problem of Interface designs which are not made for Thai users and intend to create Interface designs which specially work for Thai users

Keywords—Thai language, Final Consonants, Information Processing, Cognitive Processing, Thai electronic industrial.

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Chapter 1

Introduction

Chapter 1 Introduction

1.1 Research background

Within only 2 decades, Thai's electronics industry has increased its quality and finally become one of the leaders in Southeast Asia. In 2016, Thailand ranked in 14th largest E&E exporter in global market and the export revenue was worth USD 55 billion. Moreover, it became the second global production, expertise in the field of air-conditioning units and refrigeration, and tend to be continually developing. International outsourcing and foreign direct investment (FDI) trends taking place in Thai E&E industry since the 1980s which is help for promoting technology knowledge and supporting the finance and marketing of E&E products comparison with the fact that FDI provides no help for Thai industrial structural adjustments and technological upgrading. Regarding this reason, OEM (Original Equipment Manufacturer) is the main business for Thai electronic industry. There, if Thailand would like to maintain its competitiveness, the transition to knowledge-intensive activities is a must. Therefore, Thailand are still one of the leaders in electronic industry in ASEAN and being competitive globally. This research provide possibility to add Value Added to products by developing and solving problem of user interface design in Thai's electronics industry. From the study of the current situation, it was found that user interface design in Thai electronic industry relies on foreign investor's know-how and design, whether it be Japan, Korea, US., and China. Thai is no own interface design on electronic products, whether it be control panel menu on electronics, software, manual and along with others. Moreover, regarding the survey of all buttons on control panel menu on Thai electronic products, it is found that those buttons always display in English or Thai including the image menu, there is no standard for one, design agreement depends on each company judgment. As a result, some menu explanations use the different terms even the devices are produced in the same company which confuses users. In addition, the manual written in foreign language may be the problem for users who have limited knowledge in language and may lead to the misuse of the devices. Furthermore, the standardization of user interface design in Thailand are developed under the auspices of the international Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Most of Thai electronic companies normally pass the ISO standard but there just operates following the standard from the headquarters such as Japan, Korea and United States. Most designs are created to support country of origin design, not for local users. Therefore, it can be summarized that the problem of user interface design in Thailand results from the lack of realization how important it is. That is the reason why user interface design is not developed and has no standard. Thai users mostly use any devices incorrectly all along and it is considered a disadvantage when competing with other countries. Therefore, to increase awareness and make change to create own user interface design in Thailand, cross-cultural elements during internalization and localization is become important factor. For that reason, this study will examine the current position of user interface design preferences and present the way to create own user interface design in Thailand. The findings from many studies ensures that to create a proper interface design, it is necessary to start from studying the cognitive information process. For instance, Monique and et.al (2004) was study design a user

interface for a pediatric oncologists' computerized patient record by used think aloud method which is one of the measurements of the human cognitive process. The results indicated that the development on user interface minimized pediatric oncologists' workload and was highly efficient in supporting the pediatric oncologists in preparing their patient visits. In addition, they also claimed that the think aloud method, if applied under prescribed conditions, is a valuable information source of human task-behavior and as such a useful technique for requirements analysis in designing clinical computer. Thus, cognitive study method has affected to create the better user interface design. To create Thai user interface design, the study of relation between human language through cognitive process in human computer interaction (HCI) were done in this study. The previous research showed the relation between human language and cognitive process for create user interface design. For instance, Kaufmann, et.al (2007) pointed out usability and Natural languages interfaces (NLIs) are useful from an end-user point view by present usability benchmark for 4 different query language to the semantic web. The result indicated that NLIs are useful for querying semantic web data. Ben (2005) suggested that user interfaces are created to strengthen the relationship between users and systems via natural language. The result turned out to be a lot of advantages in developing the cognition. For that reason, cognitive process studies will provide researcher more understanding about the different cognition of each language and can apply the unique feature of each language to improve user interface design. This research focused only on the cognitive information process in Thai language. Thai language is one of the tonal language group with respect to speech recognition. According to Thai pronunciation standard has a syllable which is represented in the form of CiV(Cf)(T) when Ci denotes an initial consonant, V denotes a vowel, Cf denotes a final consonant, and the last T denotes a tonal marker. There are 44 consonants and all of them can be an initial consonant; however, not all Thai consonants can be a final consonant. Moreover, Thai language reading is considered hard to understand because there are no spaces between the words as in English, and Thai is not represented as pictographic characters like kanji in Japanese. Moreover, some of the compound words have differences in meaning such as “น้ำ” (water) and “ตา” (eyes). These two words can be combined into one compound word as “น้ำตา” (tear). Therefore, readers who are not proficient in Thai are unable to separate the words correctly, causing the possibility of misunderstanding in the meaning of the sentence. Thus, word identification is the key that improve Thai language cognition. Previous studies also paid attention to the same problem that mention above. For instance, Winkle Et.al (2009) study the effect of space between word for reading English and Thai, the result show that space in English language would increase reading speed and improve fixation landing position between word and word. Moreover, Ikeda (2012) pointed out that during the test of Eye tracking camera which recorded the eyes movement when participants were reading Thai language, the result showed that readers' eyes focus on final consonants in order to identify words. Tomomizu (2013) point out that each word in Thai language has its own meaning which makes it quite similar to some other languages and final consonants have a high influence on the word cognitive acceleration. Phenpimon (2014) has studied the cognitive process of Thai language and verification influence of final consonants (Tuasakot) by using image identification tasks. The test result indicated that final consonants have a huge influence on the cognition of Thai language because final consonants (Tuasakot) make

accelerated cognitive process which stimulates the cognition. The aforementioned clarify and have us understand the special characteristics of cognitive process in Thai language. Final consonant becomes the key that affect on the cognitive acceleration in Thai language. Regarding the research of Phenpimon (2014), it is necessary to study the effect of final consonants in the cognitive process of Thai Language. The experiment that proved the importance of final consonants is done by using word identification tasks and recording time spent answering between word with and without final consonants. Then the data was analyzed to prove the importance of final consonants in the cognitive process of Thai Language. The results were later used to develop and create own user interface design for Thai users.

Previous research show that time spent on answering and correctness in answering questions played an important role to indicate the ability of Thai language cognition. Time spent to answering could measure the cognitive process when the words appear on the screen until participants finish choosing. And Processing procedures begin once participants press the “Start” button in each test and end as they finish choosing the last answer. The experiment was performed on the website via www.touchthailanguage.com, that required 100 of Thai-Nichi institute of technology students to participate experiment. To sum up, final consonants work as the space in English is used for separating words and sentences and can make the Thai language easier for detect words in Thai language and also reduce the confusion when separating words in the long run on sentences. It works as the accelerator of competency in cognition of Thai language and helps learners to receive more precise and faster information. Moreover, this study has done the types of questions comparison that help learners to better approach the data. Questions with isolated words spent less time in answering than questions with sentences; however, questions with sentences have the higher correctness ration than questions with isolated words. The result of time and correctness varies to the difficulty of words following the rule in the test. The last on is that similarities and homographs cause more errors in cognition and spent more time in answering question.

In conclusion, it can be claimed that to design the practical Interface data in Thai language, it is suggested that special feature of final consonants should be applied to support the cognition as it gains the correctness. To identify words, it is necessary to pay attention to the difficulty of words and avoid using homographs and similarities in order to prevent the confusing. The finding will offer guidelines for develop the next step to create own user interface design and standard in Thai electronic product that is the main objective of this study.

1.2 Research objective

- 1) To study the current situation of user interface in Thai electronic industry.
- 2) To study the effect of final consonants in Thai language
- 3) To Understand the cognitive information process of Thai user.
- 4) To create user satisfaction and reduce user error occurring from usability design problem of electronic products in Thai
- 5) To Suggest the way to create own user interface design in Thailand

1.3 Article structure and outline

In order to understand the structure of this research, this chapter will describe in detail about the relation in each chapter.

Chapter 1 Research introduction

The overview of this research was addressed in this chapter. The main content is to summarize all problems and explain the research process to make readers understand main purpose of this study.

Chapter 2 The study on the current situation of Thai electronic industry

This chapter indicates causes and problem of User interface in Thai electronic industry and focuses on the importance role of user interface towards electronic industry in Thailand by using observational analytic study for case control of retrospective study. The research was done by SWOT analyzing of previous research so that over current problem can be seen clearly. Therefore, researcher can see strengths, weaknesses, and obstacles of user interface design development. After finishing SWOT analysis, TOWS matrix and Logical model Analysis is used for problem solving guideline. Logical model Analysis allows us to identify resourcing which can help to solve short-term, mid-term, and long-term problem. Moreover, this analysis allows us to see operation process towards goal achievement of the research. Finally, the result will be presented to experts in various field such as Government sectors, Private sectors and Education sectors. The problems will be evaluated, and researcher collect all comments and advices to improve and develop again.

Chapter 3 Thai usability interface design in Electronic Industry Problem Analysis

Survey electronic devices which present in leading shops in Thailand by collecting Thai users' comment via online questionnaire. The questions are divided in to 5 parts;

- 1) Demographic is to collect general information of participants such as Name, Gender and so on.
- 2) Top 5 most visited shops by customers.
- 3) Patterns of manual, frequency, and usage behavior.
- 4) Top 5 most important electronic devices for everyday life.
- 5) Top 5 most complicating electronic devices in using.

After finishing the survey, it is found that consumers mostly buy products from Power Buy (electronic device shop which has a lot of branches in all regions of Thailand with great aftersales services and highly appreciated by consumers). Moreover, it is clearly that Thai users hardly read using manual. 88.39% of participants admitted that they read manual when the devices start working abnormally. If they find out that it is too difficult to understand, they simply call to Service Center. 92.16% informed that studying manual is wasting their time. Therefore, it is necessary for producer to design easier control functions so that user can access and understand the functions. Also, consumers sometimes cannot understand warning messages or symbols. Hence, this chapter decided to choose the most complicate used device to be sample in this test, a washing machine. A washing machine has a lot of functions with dozens of buttons. Some words shown on

the devices are incorrect and inappropriate because it has no standard. This chapter will prove the hypothesis that user interface design shown on washing machine buttons are just translated from country of origin language to Thai language and there is no standard word. To prove this issue, researcher survey usage manual of 3 washing machine brands from 3 countries, Japan, Korean and Western. Then select top 3 popular brands. Next, select top 5 most selling models for each brand to participate in this experiment which are totally 45 models. The data is collected and analyzed by ANOVA and T-Test. The result show that there are various type of words using for explaining the usage. Some words mix between Thai and English which is incorrect for user interface design which the purpose in to provide convenience to users as much as possible.

Chapter 4 User interface Design

To understand truly about the objective of this study, this chapter presents the definition, significance, principles and process of creating user interface design. This research proceeds upon the means that review previous studies and select the relative studies in order to determine the guideline of making user interface design suited with Thai people. User interface is an important factor in the development of up-to-date technology, representing a medium whereby connections between devices and users occur focusing on the user's experience and interaction by reducing high personal skills and allowing proficiency after a short period of training that makes the user's interaction as simple and efficient as possible, in terms of accomplishing user goals. This study pointed out cultural factor in user acceptance of human computer interface. It is grounded in beliefs that culture is a discernible variable in interface acceptance, and that interface designed for globally marketed software should accommodate users' cultural difference.

Evers, V. and Day, D. (1997) indicated the significant differences exist within two Asian country (Indonesian and Chinese), Indonesian like soft colors, black and white displays and pop-up menus more than do Chinese. Also, Indonesians seem to like new technology and alternative input and output (e.g., sounds, touch screens, data gloves and multimedia) more than do Chinese. On the other hand, the use of many different colors seems more active for Chinese. Although all ASEANs people have similar culture, their satisfaction on user interface design are different. Moreover, Jakob Nielsen's (1994) acceptance and approval sign such as cross or check are the common symbols that can simply see on graphical interfaces in western cultures. However, cross sign means differently in Japanese. It means unacceptance and disapproval sign. Interpretation of color also has different meaning across culture difference. For instance, the color of combustible waste trash in Japan is painted in Red; while in Thailand, it means dangerous waste. As a result, it can be seen that colors, symbols and other interfaces may not have universal meaning. Thus, in order to create good user interface, designer needs to know the between the regions culture diversity. Therefor, in order to connect with the world, user interface designers must be alerted in cross culture difference and develop traditional software by cooperating closely with natives from the target cultures. During the stages of the product's development, all designs must be reviewed and feedback by target cultures user. In addition, the research and development of creating User interface results in adding High value added in product. This help avoiding the cost competition with other competitors and taking new opportunities in expanding the markets.

Chapter 5 Cognition Process

Cognitive processing is a method to explore how human beings perceive the visual sensation and cognition which occurs in sequence. Each language in the world has its own unique characteristics and ways of study which cause differences in cognition. For example, English has spaces, Japanese has Kanji which have their own meaning, while Thai has no spaces between words. Due to the special characteristics of these 3 languages, the speed of visual cognition is likewise different. The differences in the capacity to receive information in the English, Japanese, and German languages (Fukuda, 1992). The result indicated that the capacity to receive data amounted to 50 bits per fixation. (Ikeda, 2012) On the contrary, Thai language reading in the same way and the result turned out to be that the Thai language can receive data amounting to 88 bits per fixation, which is higher than the English, Japanese, and German languages. The Thai language is one of the tonal language group with respect to speech recognition. (Kasuriya and est.la, 2003)

Chapter 6 Thai language system

Thai Language is used by about 65 million people in Thailand and who are interesting to study in Thai language. Thai Language is closely with Lao, and northern slangs are more or less mutually intelligible with Lao. Thai vocabulary includes many words from Pail, Sanskrit and some words are transcribed with foreign languages. Using foreign languages transcribing is widespread but still keeps the origin of Thai reading and writing form such as Computer, Fax and etc. Thai language is included in the group of Isolating Language which has a unique pattern called Single Word or sometimes known as Monosyllabic Language.

The pattern is compound many syllables to form a complete word and sentence but still keeps the original form of each word. However, there is a change in meaning if the words switch their positions in a sentence. For instance, "Ants eat a fish" and "A fish eats ants". The meaning of these 2 sentences is totally different because of the position switch. Moreover, the nature of Thai language does not have spaces in a sentence and words will be written continuously until the end of the sentence that sometimes lead to ambiguity. For instance, the same character in one string was analyzed words in different meaning. Occasionally, Thai reader read all along the sentence until they find out what those words really mean or use the influence of final consonant to separate words. Word separation is the basic procedure of natural language processing for analyzes voices, for example, when a human communicates with others people, the word will be analyzed by cognitive processing that help listeners to understand the correct meaning and purpose of the speaker. In the same way, it also benefits for reading processing because it will help reader to understand easier and to develop the cognitive processing to identify words and meaning for reading passages in papers or screens. For that reason, word separation also important to identify words and meanings in Thai language in order to develop the skill to separate words as faster.

Chapter 7 literature review

To understand core concept of development on Thai user interface design, Previous research indicated that cognitive information process can be a key to solve user interface design problem in Thailand, which can prove by research of Fukuda (1998), Eiling and Julie (2006), Winskle Et.al (2009), Ikeda (2012), Tomomizu (2013) and others. Therefore, to understand truly about the objective of this study, this chapter proceeds upon the means that review previous studies and select the relative studies in order to determine the guideline to create own user interface in Thai electronic industry.

Chapter 8 Studying on the Cognitive Process of Non-kanji Isolating Language by Image Identification Task

The cognitive information processing and Interface design supporting system were operated based on human information processing. This study were used the function of cognitive information process to verify influence of final consonant. Based on the eye-tracking experiments, it was found that the final consonants works not only for identifying the words from sentences but also for promoting the cognitive information processing in Thai reading process. Therefore, This study were created the experiment on image identification task in order to verify the difference in cognitive processing between final consonants and non-final consonant by require participants to choose images that match with the word. The difference of time spent on choosing image was very important as it could measure the cognitive processing. In experiment, words were divided into 5 groups (Unrelated meaning, related meaning, Homonym, and Homophone). In each group, final consonant (Tuasakot) and non-final consonant (Non-Tuasakot) were mixed with others word. 57 of Thai people were employed as participants. The result of average time spent on answering between final consonant and non-final consonant were analysis by t-test. To summarized that consonant plays an important role for the reading process because it was used for differentiating between normal consonants and final consonants. However, final consonant has its own pattern. Thus, cognitive investigation guideline is very important and helpful in reading comprehension. In Transcription of final-consonant, Thai language will be written as a long sentence without space to guide that it is the end of the words like English. With regard to the above mention, final consonant is very significant for the cognitive information processing in Thai language because it works as same as TRIGGER which can indicate words. The result of the experiment was found that the average time spent on answering the test between final consonant and non-final consonant was ($p=0.002<0.01$). It emphasizes that final consonant has a high influence on cognitive processing in Thai language. As a result, it was clearly saw that the average result between words with final consonant and non-final consonant are considerably different ($p=0.54>0.01$). Words in Related meaning group with final consonant tended to gain language cognitive processing faster than words non final consonant, which also spent even longer time. It shows that final consonant has a high influence on cognitive processing in Thai.

Chapter 9 The effect of final consonants in the cognitive process of Thai Language

Each language in the world must consist of a language system, meaning, and structure in order to create the cognition of that language. This research focuses on the cognitive process in Thai language because the written nature of Thai language does not have spaces in a sentence like English and does not have Kanji characters as in Japanese. Words will be written continuously until the end of the sentence, which sometimes leads to ambiguity. This chapter created the study on cognitive processing and influence of final consonants and non-final consonants by using word identification tasks to verify the differences in time spent to answer and correct data consisting of 4 main variables: Types of question divided by single words and sentences; Types of option word or word choices divided by words with consonants and without consonants. The level of difficulty was divided into 3 levels: easy, middle, and hard, while the Type of word was divided into 4 types: Uncontrolled, Homophone, Homograph, and Semantic. The differences of average duration for identifying target words were analyzed by ANOVA and t-test that is statistical analysis. The results showed that final consonants work as the space in English is used for separating words and sentences. It works as the accelerator of competency in cognition of Thai language and helps learners to receive more precise and faster information. Moreover, this study also compared the types of questions which can help learners to better approach the data. And avoid what kind of word should be used to create Thai user interface.

Chapter 10 Conclusion

In this chapter, the content of the study will be summarized and will describe the future plan of this research.

1.4 Research Framework

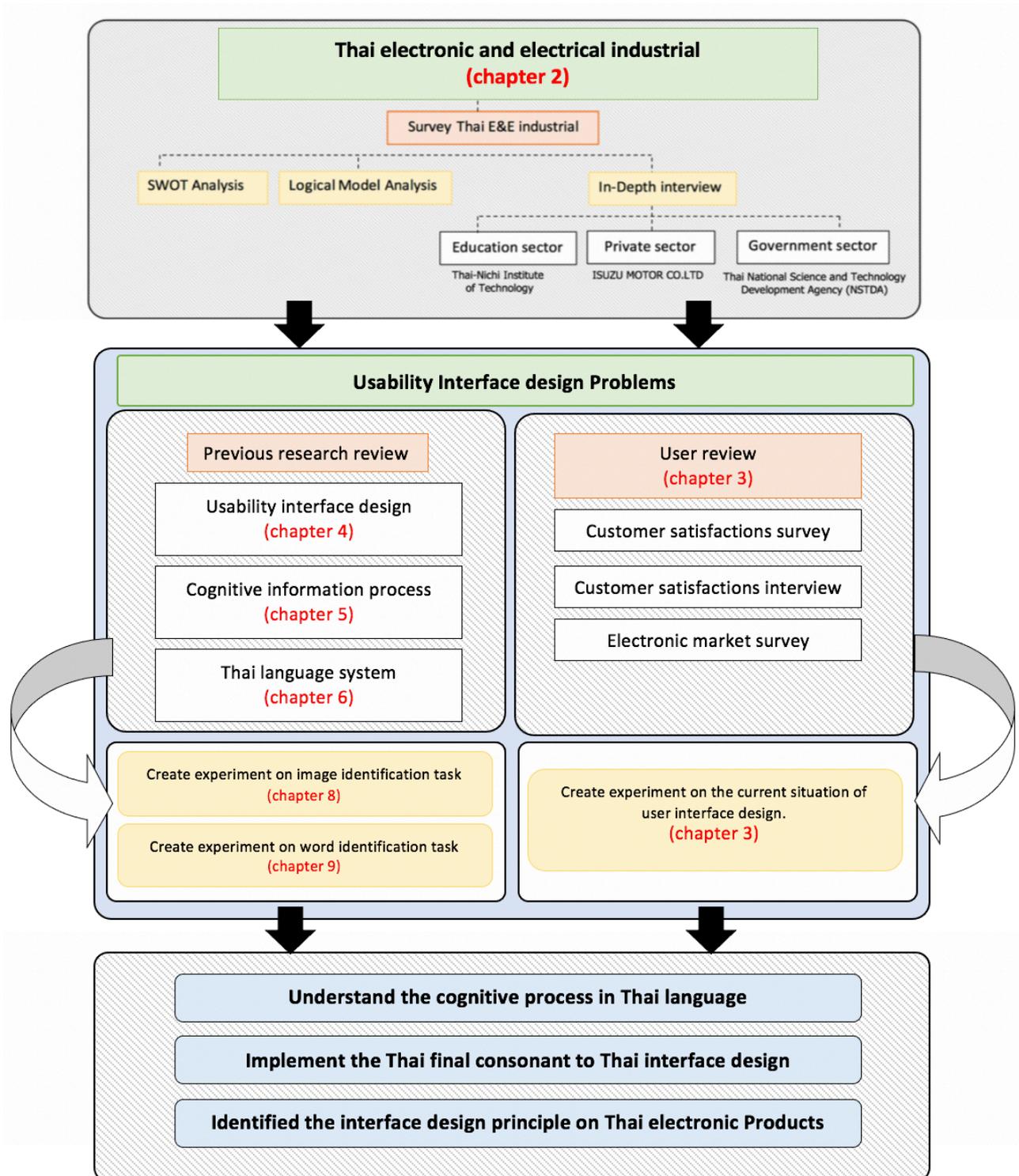


Figure 1 Research conceptual Framework

Chapter 2

The study on the current situation of Thai electronic industry

Chapter 2 The study on the current situation of Thai electronic industry

2.1 Thai electronic industry background

Technology plays a significant role in the daily activities of modern humans, both at work and for leisure purposes. However, its principal application has been to enhance the industry supply chain, starting from the point where suppliers provide companies with the raw materials they need, and ending only when the final customer receives the finished product. Technology controls the handling of resources and people throughout that supply chain, allowing goods and services to be moved from the very beginning until the final step of distribution to the end-user. As technology has developed, and global trade has increased as a consequence of nations removing barriers to trade and welcoming increased levels of foreign investment, the electronics and electrical products (E&E) sector has become a major industry, boasting one of the world's most extensive and wide-reaching supply chains. The global leader in the E&E sector is China; the country's production for 2015 amounted to US\$2.4 trillion, or the equivalent of 42% of the total value of E&E production worldwide. As the world's leading E&E exporter, China has now consolidated its position as the global hub for this particular industrial sector. (1) In recent years, however, other nations throughout East and Southeast Asia have been able to take advantage of their competitively priced workforce to take an increasing share of the global E&E market. Their role has been to contribute to the supply chain through specialization in the manufacturing and assembly stages, which can be performed more efficiently and cost-effectively than ever before. In some cases, these nations have also begun to contribute to the production stages which are knowledge based and require a more skilled and advanced workforce. Thailand is also one of Southeast Asian nations which has developed an electronics industry which is able to export competitively worldwide. The Thai government has played its part in creating an industrial environment in which the electronics sector can thrive. In particular, the encouragement of FDI (foreign direct investment) has helped Thailand to acquire the technological knowledge required to build success. It can be argued that Thailand was quickly able to adjust its policies in response to shifting trends in the global supply chain, thereby allowing the country to benefit from the increased demand for E&E products. The government understood that the Thai domestic market would be insufficient to support the growing E&E production sector, so sought to promote exports rather than merely aiming to replace imports with its own production. However, to achieve this goal it was first necessary to liberalize the economy to encourage the necessary levels of investment and then trade. Investment in the E&E sector in Thailand was valued at around \$4.5 billion during the period from 1986-2001, and this provided the foundation for Thailand's successful development. Today, FDI remains essential in promoting technology transfer and supporting the financing and marketing of E&E products, while steady growth in foreign trade has also boosted the industry. At present, 15% of Thailand's GDP is created by the E&E sector, and this increases further to 25% of Thailand's exports. The country employs around three-quarters of a million people and is highly regarded worldwide for its manufacturing capacity. Nowadays, Thailand ranks second in the global production of air-conditioning units and has particular expertise in

refrigeration. The total value of Thai exports of electrical appliances in 2014 stood at US\$23.5 billion while imports were just US\$17.6 billion. According to the Office of Industrial Economics, one of Thailand's particular strengths in E&E is that the country serves as a manufacturing base for Singapore, the United States, and most importantly Japan. These countries have made considerable investments in Thai manufacturing in recent years, providing employment for Thai workers and equipping Thailand with the necessary skills to offer more advanced manufacturing. It has been claimed that Thai workers show great attention to detail and are able to work well in the intricate processes of electronics production. Furthermore, Thailand has made advances in the quality of its research and testing systems with regard to electrical goods and can now meet all required international standards, ensuring that products made in Thailand gain international trust and acceptance. Although Thailand has demonstrated considerable success in drawing in foreign investment and developing its workforce to boost export growth in the E&E sector, the contribution made by Thailand is still limited primarily to the assembly of products. Design and product development have not yet become areas where Thailand can compete internationally or excel, as skill levels in these areas remain limited. One report from the Japan Oceanographic Data Center (JODC) revealed that one of the key challenges facing the E&E sector is that of finding skilled labor in sufficient quantities. One of the reasons for this is that the number of students pursuing further education in the fields of science or engineering remain comparatively low. The academic records of Thai students have also fallen short of international norms, as indicated by the PISA (Program for International Student Assessment) scores covering science, reading, and mathematics. The latest round of testing in 2015 showed that Thai students were not readily able to use their knowledge in these subject areas to solve practical problems, lagging behind neighboring countries such as Vietnam. This has given Vietnam a clear advantage in developing IT professionals and may allow the country to become a hub for software outsourcing as a result. By 2017, Vietnam had already become the leader among ASEAN nations for mobile applications, and it is apparent that Vietnam places considerable emphasis upon developing a highly skilled IT sector. This will give Vietnam the necessary skills required to make advances in electronics design and development, and must be considered a potential threat to Thailand's own strong position in E&E. In response to this situation, the government of Thailand has begun to focus attention on encouraging research in to design and product development, while simultaneously trying to upgrade its foreign technology. This strategy aims to allow Thailand to move higher up the value chain, ensuring that it does not remain merely a contract manufacturer falling behind rivals.

2.2 State of problem in Thai electronic and electrical Industry

Thai industries are OEM (Original Equipment Manufacturer). Therefore, product design or software design used in Thai electronic were followed the foreign investor know-how, whether from Japan or the USA. At the present time, Thai producers need to rely on translated data, which is not domestic interface design and standard for Thai users and cannot be utilized fully. For instance, command menu of Thai products always displays in English or Thai including the image menu, there is no standard as it depends on design agreement of each company. Moreover, it can be found that, some menu explanations use the different terms

even the devices are produced in the same company which confuses users. Moreover, the manual written in foreign language may be the problem for users who have limited knowledge in language and may lead to the misuse of the devices. To solve this problem, it is necessary for Thai electronic and electrical industry have to pay more attention to the user interface design and designing standard. Regarding to the standardization of user interface design in Thailand. Standards for HCI and usability are developed under the auspices of the International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC). Thai electronic companies normally pass the ISO standard. However, Thai industry just operates standard following the standard from the headquarters such as Japan. Moreover, Data from the Ministry of Education indicated that no education institute system in Thailand sees the importance of beginning curriculum in Interface design and HCI field. There are only a few elective subjects which are not enough to use or adapt in create own interface design. Comparing to developed country like USA that have more than 2,000 of specialized university for interface design. And Japan also put user interface as a core subject in IT or computer engineering faculty. It shows that developed countries and leading manufacturing countries see the importance of studying user interface design and human computer interaction. Not only education institute system, but USA, Japanese and Chinese are also interested to promote research on user interface design filed, there are more than 10,000 study about interface design on the electronic and electrical product. In the meanwhile, Thai has a few researches about Interface design and HCI. Most of such research is for the support and improvement of efficiency in internet banking. Research about the design and development of user interface design is hardly found in Thailand. Therefore, knowledge about user interface design in Thailand is not enough to improve and develop E&E industry, which affects Value Added (VA). When the current VA is not developed, there is no High Value Added (HVA) of Product/Services in the electronics industry. For that reason, Thai electronic and electrical Industry is still frozen as OEM (Original Equipment Manufacturer). However, Thailand needs to transition to knowledge-intensive activities if it is to retain its competitiveness regionally and globally.

2.3 Problems solution

To work out the solution of user interface design in Thai electronic and electrical Industry, it is necessary to study the current situation of Thai electronic and electrical Industry at macro level follow with the previous research, which will be carried out in order to collect all important data and SWOT analysis, TOWS matrix and Logical model will have done to evaluate internal and external factors related.

2.3.1 SWOT analysis

The analysis of SWOT allows researchers to identify the strengths and weak points, opportunities and obstacles for the electronics industry in Thailand. These factors can then be adapted to plan the strategy and objectives to develop interface design in electronics and electrical industry, as well as find the benefits of the environment, set strategies to overcome the obstacles and reduce the weak points as much as possible. The result can be divided into 4 main topics

A Opportunities

I. Government launch Thailand 4.0 strategy policy

The Thailand 4.0 strategy for industry aims to see the country adding value to its manufacturing and innovating to develop new products. Thai manufacturers are thus encouraged to invest in research and development in order to accelerate the progress of Thailand 4.0 strategy calls the “Smart Electronics Industry”.

II. The gradual recovery the real estate market which drives demand for household electrical appliances

The changing of people these days behavior which prefers convenient lifestyle and living in a small family results in the expansion of condominium selling. In 2017, new condominiums have been built the most over the past 4 years, 63,626 units and increased up to 9.0% due to government first-house policy during 2015-2016. Moreover, there is the regulation that allow foreigners to own the condominium property, but not over 49% of overall units. Thus, condominium industry has expanded the market up to 49.8% over the past 10 years. Thus, the increasing of condominium has been affected to demand of electronic appliances number.

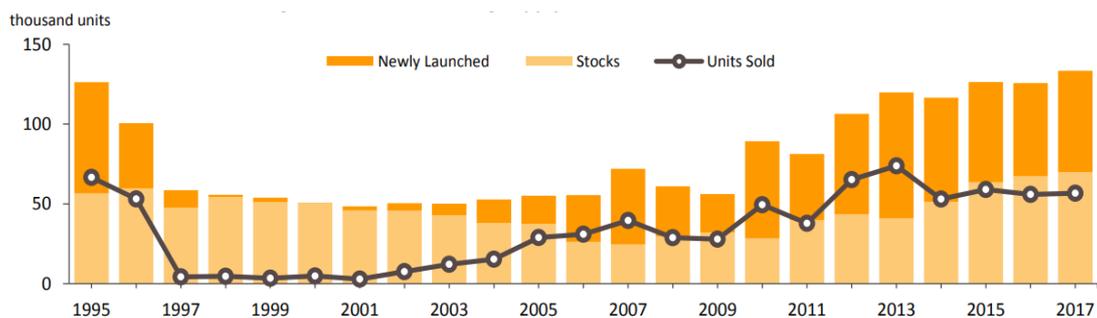
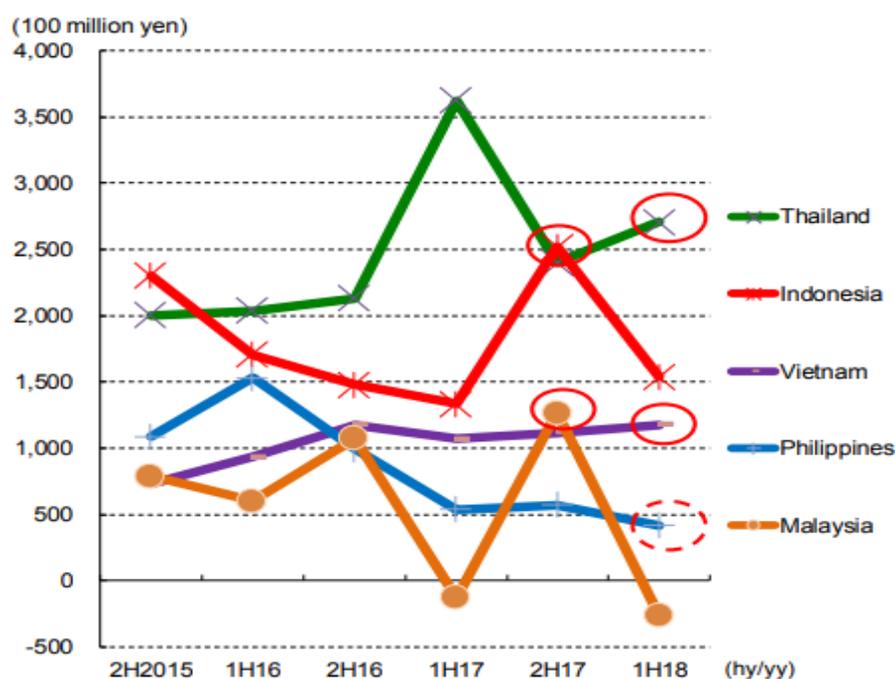


Figure 2 Annual Housing Supply and Units Sold – Condominiums

B Strengths

I. Thailand is high foreign investment country

International outsourcing and foreign direct investment (FDI) trends taking place in Thai E&E industry since the 1980s can be explained largely by the following technology and trade (Sturgeon and Kawakami, 2011) Especially, Japan has the highest investment value in Thailand among ASEAN which most of the investment are manufacturing



Source: Bank of Japan, Balance of Payment

Figure 3 Japan's FDI in ASEAN

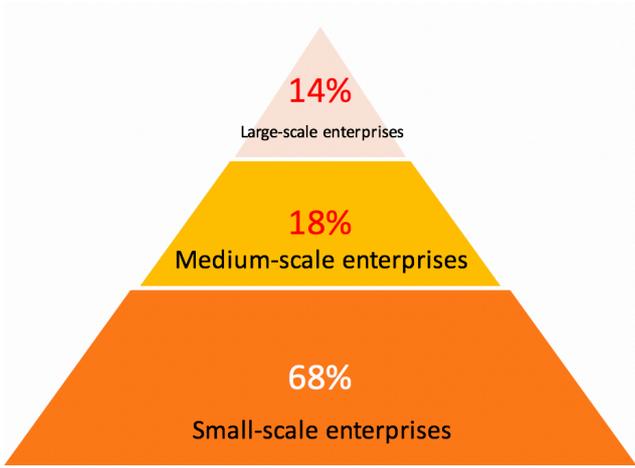
Table 1 Japan's FDI in Thailand by industry

(Unit: 100 million yen)

Industry/Year	2H2015	1H16	2H16	1H17	2H17	1H18
Manufacturing	1,335	1,354	1,336	3,246	1,881	1,129
Food	-39	-26	60	28	57	-48
Textile	28	96	12	38	16	14
Lumber and pulp	-27	82	46	71	49	41
Chemicals and pharmaceuticals	60	212	76	553	112	204
Petroleum	12	0	1	0	0	0
Rubber and leather	110	67	107	150	27	-23
Glass and ceramics	10	17	72	43	27	83
Iron, non-ferrous, and metals	145	191	81	297	291	146
General machinery	332	169	163	113	267	-75
Electric machinery	373	269	534	513	512	295
Transportation equipment	279	213	62	1,274	404	398
Precision machinery	34	29	46	72	41	40
Non-manufacturing	569	468	794	379	521	1,579
Farming and forestry	3	0	0	0	0	0
Fishery and marine products	2	6	0	0	0	0
Mining	0	0	0	0	0	0
Construction	8	35	8	9	8	98
Transportation	55	53	9	23	-11	24
Communications	0	0	0	3	-16	31
Wholesale and retail	222	178	266	239	322	170
Finance and insurance	232	157	457	62	142	1,397
Real estate	-1	5	12	30	85	38
Services	26	2	23	-14	-20	-213
Total	1,904	1,823	2,130	3,625	2,402	2,707

Source: Bank of Japan, Balance of Payment

The vast majority of Electronics and electrical (E&E) part producers are SMEs that manufacture component parts for large producer, which can be split into two groups: (1.) major international brands such as Mitsubishi, Sony, Hitachi, Samsung, and Toshiba; and (2.) Thai manufacturers, a group which includes both those producing to supply other brands and which are therefore original equipment manufacturers, or OEM such as Tasaki, Saijo-Denki, Uni-aire, and Central Air, all Thai brands such as Hatari, Accord, and MasterKool.



Source: E&E Intelligence Unit, as of Jul 2016

Figure 4 Electrical Appliance Producers

I. Thai workers are equipped with manufacturing skill

They are elaborate and work well for tiny skill. E&E sector is estimated to represent 12 percent of total employment in manufacturing in 2015 (Rynhart et al., 2016). In 2016, There are over 2,300 manufacturers employing nearly 750,000 workers operating in the industry, (Hotrakool, 2016).

II. R&D activity conduct at university and public research institute

Thai government recognizing the importance of the electronics and electrical industry to Thailand’s economy has established various programs to ensure the competitiveness of Thailand. To ensure a stable pool of qualified workers for the industry, Thailand has developed an intricate network of research centers and institutes that offer resources for technical training including

The National Science and Technology Development Agency in 4 areas:

- Hard Disk Drive Industry Research Program
- Air-Conditioning and Refrigerator Industry Program
- Automotive and Automotive Parts Industry Program
- Thailand Electronics Design Industry Human Resource Development Project

Asia Institute of Technology in 2 areas:

- Microelectronics and Embedded System Program
- Mechatronics Program

NECTEC's Industry/University Cooperative Research and Development Units in 4 areas:

- Advanced Automation and Electronics Research Unit – Embedded System Technology Laboratory and Industrial Control and Automation Laboratory

- Engineering and Innovation Development Unit – Industrial Prototype and Product Development **Laboratory**

- RFID Institute
- The Thai Microelectronics Center (TMEC)

King Mongkut's University of Technology in 7 areas:

- Electronic and integrated circuit design research
- Robotics and automation research
- Precision engineering research
- Foundry engineering research
- Molds and dies design research
- Research Center of Air Conditioning and Refrigeration
- Electronics and Microprocessor Laboratory

King Mongkut's Institute of Technology in 3 areas:

- Electrical and Electronic Products Testing Center (In Cooperation with NSTDA)
- Data Storage and Technology and Applications Research Center
- College of Data Storage Innovation

C Weakness

I. Skill labour shortage

When considering employment figures across occupations, we observe that in 2015, 80 percent of the total workforce in the E&E industry was employed in low-skilled occupations, mostly as assembly workers, plant and machinery operators, with the remaining 20 percent being employed in more skilled positions at a managerial, professional and technician level. Moreover, Thailand still has insufficient product designer and experts in interface design.

II. Research centers in user interface design filed are not sufficient

Thai industries are few a research centers and institutes in user interface design filed. Even though the government pays attention to electronic and electrical industry by establishing research centers and institutes, it is found that there is no research centers and institutes that relates to user interface design specially.

III. Lack of official curriculum for interface design and HCI subject in Thailand

There is no official curriculum for interface design and HCI subject in Thailand. Those subjects have been included in one of the subjects in the field of computer science, Information technology engineering or Business administration depend on university judgment.

IV. Lack of knowledge transfer

Electronic and electrical industry in Thailand is still lacking of Knowledge transfer between International investor who are technology owner and local supplier who are the producer for mass production.

V. Lack of industrial linkage between industry and university

Lack of industrial linkage between industry and university for improve and develop interface design and HCI in electronic and electrical industry. This causes insufficiency in research, development, and problem solving. Interface design knowledge Thailand cannot provide high value add in product.

VI. Thai user lacking realization about important of design and product developing for more convenience usage

Table 2 E&E manufacturing employment across subsector and occupation in 2015

Occupation	Subsector			Total E&E n.e.c
	Computer, electronics and optical products	Electrical equipment	Machinery and equipment n.e.c	
Managers	22 023	14 262	6 128	42 413
Professionals	22 558	15 978	10 167	48 702
Technicians and associate professionals	34 022	17 662	15 377	67 061
<i>More skilled workers</i>	78 602	47 902	31 671	158 176
<i>As % of total</i>	16.7%	25.6%	24.1%	20.0%
Clerical support workers	31 135	5 262	5 983	42 380
Service and sales workers	1 011	538	159	1 708
Skilled agricultural, forestry and fisheries workers	352	-	-	352
Craft and related trades workers	49 231	23 565	31 226	104 022
Plant and machine operators, and assembly workers	286 233	95 685	58 532	440 450
Elementary occupations	24 989	13 878	4 020	42 887
<i>Less skilled workers</i>	392 951	138 928	99 920	631 798
<i>As % of total</i>	83.3%	74.4%	75.9%	80.0%
TOTAL	471 553	186 830	131 591	789 974

Source: Authors' and ILO RESA calculations from Thailand's Labor Force Survey (LFS 2015)

D Threat

- I. Government policy rather emphasize on supporting the manufacturing than doing the research, designing products, developing software and building IT professionals. There is no continuous support from government about researching and developing the products.
- II. Political insecurity is the obstacle that affects the decisions of foreign investors.
- III. It is the industry that has a rapid change as it concerns about technology and human behavior factors.

IV. Investors and headquarters have a Second Production Base policy which shares the risk about investment, disaster, worker, and technology. Therefore, they relocated their manufacturer base from Thailand to other countries in ASEAN.

2.3.2 TOWS Matrix

This experiment applied TOWS Matrix analysis to form strategies in order to solve current problem of user interface design in Thai electronic industry. The analysis was done by analyzing the relation of strength points and opportunities, weak points and limited issues. According to the analyzed results, the strategies can be divided into 4 categories.

I. SO Strategy

This is to consider environment and find strength points and opportunities to form a proactive strategy.

II. ST Strategy

This is to consider environment and find strength points and limited issued to form a preventive strategy. Even though Electronic and Electrical industry has a lot of strength points, there are some external limited issues which are out of control. However, the strength points can prevent those limited issues.

III. WO Strategy

This is to consider environment and find weak points and opportunities to form a solution strategy. Electronic and Electrical industry can adapt new idea or new innovation to solve current weak points.

IV. WT Strategy

This is to consider environment and find weak points and limited issued to form a reactive strategy because there are some external limited issues which are out of control.

it can be summarized in table 3

Table 3 TOWS Matrix

		Internal environmental analysis	
		S (Strength)	W (Weakness)
		<ol style="list-style-type: none"> 1. Thailand is the manufacturing base for exporting E&E industrial components of USA/JAPAN / Singapore. 2. Thailand is the 2nd largest Electrical Appliances producer in Asia After China 3. Thai workers are equipped with manufacturing skills. They are elaborate and work well for tiny details which suits for E&E industry. 4. There are a lot of Supporting Industries which relative activity with the electronic industry such as Automotive industry, Service industry and so on. 5. Most R&D activity are conducted at university and public research institution. 6. Electronic products from Thailand receive universal standard for industrial product and manufacturing quality. That is the reason why the quality of electronic components from Thailand is widely accepted globally. 7. Internet transaction is very popular in Thailand. Therefore, banking is the main business that needs to rely on UI and HCI so that users are able to receive the service in the most effective way. 	<ol style="list-style-type: none"> 1. The lacking of knowledge about Interface design and HCI of Thai workers results in lacking of realization about the important of designing and product developing for more convenience usage. 2. There is no official curriculum for Interface design and HCI subjects in Thailand. Those subjects have been included in one of the subjects in the field of Science and Technology Engineering and Business Administration in some universities. 3. Most of Thai industries are a few researching development and research center about Interface design and HCI. 4. Lacking professional with stronger IT and programming skill. 5. Insufficient university-industry linkages 6. Thai workforce is lacking skills need in E&E industry 7. Thai industry is still lack of cluster development and technology transfers between local supplier and International contractor. 8. High value added (HVA) in Interface design and HCI of E&E industrial has been poorly managed.
External environmental analysis	O (Opportunity)	<ol style="list-style-type: none"> 1. Global market for electronic part is expected to reach up USD 390 billion by 2020 especially, In Asia pacific. 2. Proliferation of consumer electronic especially, Mobile device 3. Increasing use of electronic components in Automotive electronic 4. Government has launched the policy to support foreign investment such as import duties exemption for automotive components. 5. Thailand industry 4.0 policy is the policy that develops innovative technology, aiming for adding value to product design and investing in invention and innovation. 6. Foreign organizations invest more in researching and developing in ASEAN market 7. Domestic electronic market business has expanded. 8. Thailand has the most suitable geography for being a manufacturing base. 	<p>1. Maximum Use of opportunity</p> <ol style="list-style-type: none"> 1. (S6+O1) The strategy is to expand the market to the countries in ASEAN and Thailand is the manufacturing base for E&E industrial components. 2. (S5+O3+O5) Establish the research center about E&E industrial components supported by the Government, Thailand 4.0 policy, driving E&E industry to adapt with electronic automotive industry, technology growth, and transportation in ASEAN supply chain.
	T (Threat)	<ol style="list-style-type: none"> 1. Government policy rather emphasize on supporting the manufacturing than doing the research, designing products, developing software and building IT professionals. 2. There is no continuous support from government about researching and developing the products. 3. Political insecurity is the obstacle that affects the decisions of foreign investors. 4. It is the industry that has a rapid change as it concerns about technology and human behavior factors. 5. Investors and headquarters have a Second Production Base policy which shares the risk about investment, disaster, worker, and technology. Therefore, they relocated their manufacturer base from Thailand to other countries in ASEAN 6. Foreign businesses that have invested in Thailand take an important role in directing and specifying the design and producing technology. Manufacturers in Thailand are only responsible for only manufacturing and testing the products. 	<p>2. Conquest of weakness</p> <ol style="list-style-type: none"> 1. (W4+O4) Government and business sector need to focus on creating professionals in science and technology in order to adapt to the expansion of E&E industrial market in both foreign and domestic markets. 2. (W1+W2+O5) Drive the Thailand 4.0 policy by specified the curriculum providing the special knowledge about UI and HCI. 3. (W3+W5) Promote research and research center in UI and HCI field to E&E industry in Thailand. 4. (W5+W7+O4+O5) Promote industrial linkage between industry and university collaborating among government, education and business sectors. 5. (W7+O6) Foreign E&E enterprise (mostly Japanese) were invited to form joint venture with Local supplier to create transit knowledge. 6. (W8+O5+O8) Avoid making competitive price by adding high value add in the products but apply UI and HCI principle to be the leading electronic manufacturer country in ASEAN. <p>3. Dissolution of threat</p> <ol style="list-style-type: none"> 1. (T6+S2) Support the project of knowledge and abilities development and technical skills for E&E industrial workers. This can create Product Design Absorptive Capacity, as well as the overseas headquarters and investors. 2. (T4+S4) Connect Supporting Industry to E&E industry in Thailand to create Knowledge and Technology Transfer via facilitators such as supporting project from government, researching department in education institutes and researching department in private organizations. <p>4. Avoidance of threat</p> <ol style="list-style-type: none"> 1. (T3+W7) Increase context of E&E Cluster to help and support technology transferring under the politic situation, the uncertainty in investment support policy and the disjunction in government policy. 2. (T4+W3) The developing knowledge exchange of UI&HCI should be added to the E&E industrial or Cluster integration to adapt to Technology and Behavior Rapid Change. 3. (T5+W1) There are system, defense mechanism and resource maintenance in the E&E industrial group such as worker and production process, to adapt E&E manufacturing base relocation from headquarters to neighborhood countries due to the reason about cost and management

2.3.3 Logical model

Logic model is a systematic and visual way to present and share the understanding of relationships among resources that are needed to operate a program, as well as the planned activities and the results that are desired for achievement. Therefore, the process of the logic model for thinking through change includes:

- Identifying the problem(s) (What does the community need?)
- Naming the desired results (What is the vision for the future?)
- Developing the strategy for achieving the goal(s) (How can the vision be achieved?)

In this study, the logic model analysis was used to investigate the current situation of user interface design for the electronics industry in Thailand following as the detail as below.

First, the current problems must be identified by evaluate assumption that includes;

- 1) E&E products in Thailand are use design from Foreign investor like Japan and US There is no own interface design
- 2) Thailand is no official curriculum for UI, UX and HCI those subjects have been included in one of the subjects in the field of Science and Technology Engineering and Business Administration
- 3) The lacking of knowledge about UI, UX and HCI of Thai workers results in lacking of realization about the important of designing and product developing for more convenience usage.
- 4) Lacking of professionals with stronger IT and programming skills results in lacking of the professionals in UI, UX and HCI. IT and programming skills are considered as the important skills to create UI, UX and HCI.
- 5) Thai industry is still lack of cluster development and technology transfers between local supplier and International contractor.
- 6) High value added (HVA) in UI, UX and HCI and HCI of E&E industrial has been poorly managed.

Then, the strategies will be created to investigate the possibility of problem solving which were divided into 7 crucial strategies include;

- 1) Government and business sector need to focus on creating professionals in science and technology.
- 2) Government and education sectors should collaborate to support the UI and HCI curriculum, which is certified by the Ministry of Education.
- 3) Support Thailand 4.0, the policy that focuses on adding value to the designing and innovative development of products.
- 4) Foreign E&E enterprises (mostly Japanese company) are invited to form joint ventures with local business partners to serve innovation and knowledge transfer in interface design field.
- 5) Promote research in UI and HCI field through continuous cooperation between university-industry
- 6) Avoid making competitive price by adding high value add in the products but apply UI and HCI principle to be the leading electronic manufacturer country in ASEAN.
- 7) Support the development and further the ability of E&E industry to create Industrial Cluster. Then the knowledge about UI and HCI will be applied to create user interface standards in the most effective way.

After that, the expected output will be presented by crucial 5 points include;

- 1) Research on Interface design, UX/UI and HCI in Thailand will increase.
- 2) UX/UI and HCI curriculum are created to serve the demand of the industry.
- 3) The student with hand-on E&E industry experience and UX/UI and HCI skill will develop that fit corporate need in term of recruitment
- 4) The increase in transit knowledge ratio results in the increase in E&E market workers who have skills in UX/UI and HCI.
- 5) Products from Thailand have high value add results from the improved skills in UX/UI and HCI.

Finally, the evaluation in short-middle and long-term is significant to gain reliability as following;

- **Short- middle term outcomes**

- 1) Development employee who are skillful in designing and using of interface design, UX/UI and HCI to support the industry
- 2) Employee who are trained in a short and middle period can improve their Technical knowledge and can build innovative industry in Thailand.
- 3) The products of E&E industry from the main industry and supported industry have more value add due to the development of Interface design.
- 4) Having research data base about Interface design which allows the better people to access to the knowledge.

- **Long term outcomes**

- 1) There is specialist and verification center for the standard of interface design for E&E industry in Thailand and employee are skillful enough to provide their knowledge in ASEAN and the world in next step.
- 2) Interface design will have a standard for development own product and service for E&E industry of Thailand.
- 3) The E&E industrial products from the main industry and supported industry will be studied and designed for Thai users
- 4) There is a widely accepted university providing knowledge specially for Interface design certified by Ministry of Education.
- 5) There are many studies and research about Interface design which can be develop E&E industry to compete globally with other countries.

Table 4 Logical Model Analysis

The study on interface design development of electronic and electrical industry in Thailand				
Strategies			Assumption	
<ul style="list-style-type: none"> ● Government and business sector need to focus on creating professionals in science and technology in order to adapt to the expansion of E&E industrial market in both foreign and domestic markets. ● Government and education sectors should collaborate to support the UI and HCI curriculum, which is certified by the Ministry of Education. ● Support Thailand 4.0, the policy that focuses on adding value to the designing and innovative development of products. ● Foreign E&E enterprises (mostly Japanese company) are invited to form joint ventures with local business partners to serve innovation and knowledge transfer in interface design field. ● Promote research in UI and HCI field through continuous cooperation between university-industry ● Avoid making competitive price by adding high value add in the products but apply UI and HCI principle to be the leading electronic manufacturer country in ASEAN. ● Support the development and further the ability of E&E industry to create Industrial Cluster. Then the knowledge about UI and HCI will be applied to create new products and new services in the most effective way. 			<ul style="list-style-type: none"> ● E&E products in Thailand are use design from Foreign investor like Japan and US There is no own interface design ● Thailand is no official curriculum for UI, UX and HCI those subjects have been included in one of the subjects in the field of Science and Technology Engineering and Business Administration ● The lacking of knowledge about UI, UX and HCI of Thai workers results in lacking of realization about the important of designing and product developing for more convenience usage. ● Lacking of professionals with stronger IT and programming skills results in lacking of the professionals in UI, UX and HCI. IT and programming skills are considered as the important skills to create UI, UX and HCI. ● Thai industry is still lack of cluster development and technology transfers between local supplier and International contractor. ● High value added (HVA) in UI, UX and HCI and HCI of E&E industrial has been poorly managed. 	
Resources	Activities	Outputs	Short- middle term outcomes	Impact Long term outcomes
<ul style="list-style-type: none"> ● Government should offer any advice or policy to encourage Transfer knowledge from technology owners to create an incentive. ● Provide funding for support to research and develop in UI and HCI ● Promote industrial linkage between industry and university collaborating among government, education and business sectors. ● Promote professionals with stronger IT and programing. ● Formulate High value added (HVA) product and service development practical course which applying UX-UI and HCI knowledge. ● Ministry of Education register UI and HCI study as a special curriculum. 	<ul style="list-style-type: none"> ● Research center will be established by E&E industry fund which perform Community of Practices (CoPs) and Knowledge Facilitator. ● Formulating official curriculum for UI,UX and HCI subjects in Thailand. ● Promoting Internship programs and other hand-on opportunities in E&E industry. ● Determine the policy for transfer knowledge from investment country such as Japan, USA to local supplier. ● Conduct the trainings or seminars about UX-UI and HCI for workers to upgrade their skills which help adding high value add to products. ● Support in doing research between universities and industrial sectors. ● Provides sponsorship to high-performing Thai engineering student 	<ul style="list-style-type: none"> ● Research on Interface design, UX-UI and HCI in Thailand will increase. ● UX-UI and HCI curriculum are created to serve the demand of the industry. ● The student with hand-on E&E industry experience and UX-UI and HCI skill will develop that fit corporate need in term of recruitment ● The increase in transit knowledge ratio results in the increase in E&E market workers who have skills in UX-UI and HCI. ● Products from Thailand have high value add results from the improved skills in UX-UI and HCI 	<ul style="list-style-type: none"> ● Development employee who are skillful in designing and using of interface design, UX-UI and HCI to support the industry ● Employee who are trained in a short and middle period can improve their Technical knowledge and can build innovative industry in Thailand. ● The products of E&E industry from the main industry and supported industry have more value add due to the development of Interface design. ● Having research data base about Interface design which allows the better people to access to the knowledge. 	<ul style="list-style-type: none"> ● There is specialist and verification center for the standard of interface design for E&E industry in Thailand and employee are skillful enough to provide their knowledge in ASEAN and the world in next step. ● Interface design will have a standard for development own product and service for E&E industry of Thailand. ● The E&E industrial products from the main industry and supported industry will be studied and designed for Thai users ● There is a widely accepted university providing knowledge specially for Interface design certified by Ministry of Education. ● There are many studies and research about Interface design which can be develop E&E industry to compete globally with other countries.

2.3.4 Validation of Information

In order to complete the logical model, as well as to evaluate the possibility of strategy use for solving current user interface design problems in Thai's E&E industry, it is necessary to rely on specialists from the government, university and industrial sectors.

In addition, this logical model were verified by 20 specialists from 6 industrial specialists, counted as 30%, from 8 academic specialists, counted as 40%, and from 6 Officer of Industrial Economics specialists, counted as 30%.The evaluation topics were divided into 5 crucial topics include;

- 1) Logic Model element relates with each other in short-middle term outcomes or not.
- 2) Logic Model element relates with each other in long term outcomes or not.
- 3) This Logic model is possible for the short-middle-term outcomes or not.
- 4) This Logic model is possible for the long-term outcomes or not.
- 5) This Logic model is advantage to improve Thai's user interface design situation or not.

The evaluate result are shown in figure 5 as below.

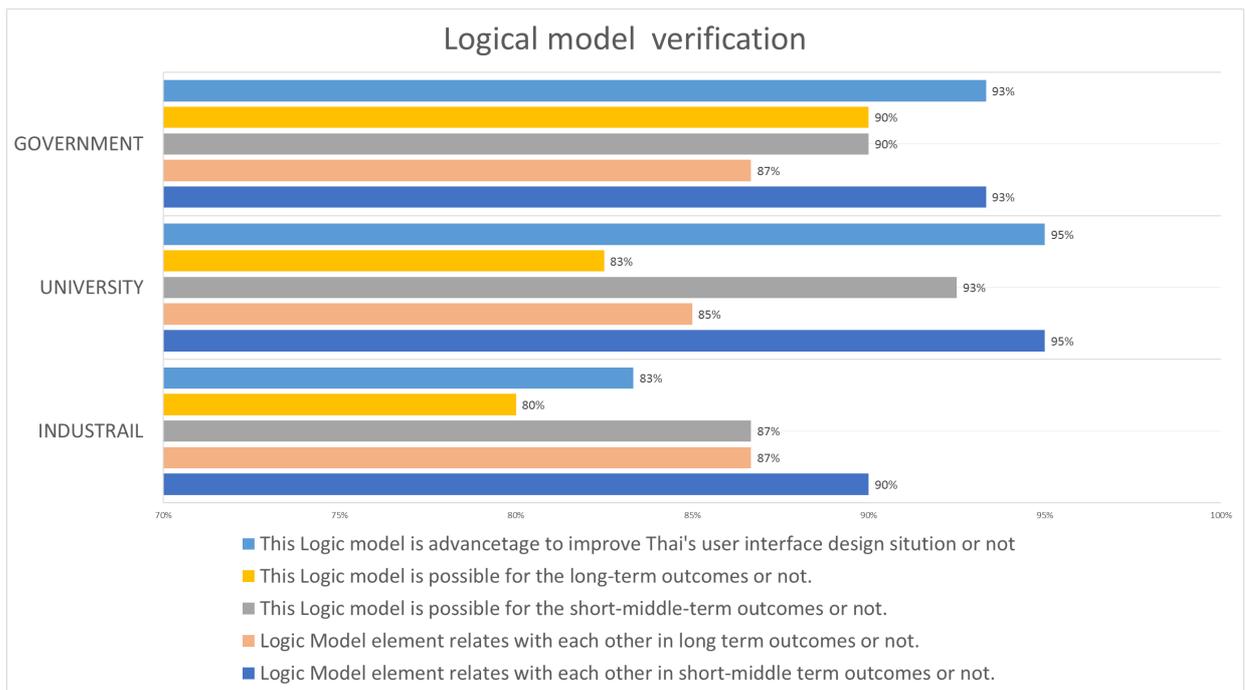


Figure 5 The logical model verification from Thai UI specialist

2.3.5 Validation Result

The result shows that all specialists trust in this logical model more than 80% in each topic. Moreover, it is found that this model has higher possibility to solve long-term problem than short-term problem. According to the survey and interview, there is no continuous support to improve interface design and no collaboration among the education and industrial sectors. Law of Thailand is likely to provide more benefit to investors which limit knowledge transfer between industrial sectors to educational institutes. Moreover, specialists suggest that a research and development center should be created in Thailand. Specialists should be hired to encourage the organization to see the importance of improvement and the development of electronic industries by creating value added. After that, knowledge should be provided to people who are interested in this matter so that they can apply such knowledge in their lives. Afterwards, workers should be trained to become specialists in the organizations. As well as, user interface is advantage for creating value added in future technology such as Pilot car and smart electronic appliance and so on. It can be summarized that currently Thai still lacks cooperation between government, private sectors, and education. it makes electronics industry can't develop for enough ability to design and create new products. Moreover, Thai also lacks workers in science and technology, which is an important base for creating specialists of user interface design, all sectors should realize this problem and solve it together, as well as support the development of products continuously for the best efficiency. Finally, increasing value added to products can provide advantages over competitors.

2.4 Conclusions

Currently, Thai electronic industry is mostly OEM (Original Equipment Manufacturer) or hire of work from international companies like Japan and USA. However, to continue being OEM status cannot improve interface design nor launch our own programs to be competitive with technology owner. After analysing problems and factors relating to electronic industrial improvement in macro level by applying SWOT, TOWS Matrix, and Logical model found that the main factors which affect to the improvement of interface design in electronic industry including;

- a) Thai electronic industry is using design from foreign investor.
- b) There is no official curriculum for interface design and HCI in Thailand
- c) There are only a few researches that relate to interface design and HCI
- d) Lack of realization about the important of designing and product developing for more convenience usage.
- e) Thai people lack IT and programming skills
- f) Lack of cluster development and technology transfers between local supplier and International contractor.

Regarding the factors mentioned above, there is no creation of interface design by Thai owner and

also no standard for electronic interface design in Thailand. Therefore, users are unable to use product in the most effective way. In order to make a big change to user interface design on electronic industry in macro level, Thai should start to take the action by collaborating with each other, whether from education sector, industrial sector and government sector. For example, research center will be established by E&E industry fund and government which perform Community of Practices (CoPs) and Knowledge Facilitator that increase the number of interface design research and researcher. so that they can handle high technology. Thereby, Thailand should transform from OEM to ODM (original design manufacture) which support transition to higher value-added production activity.

Chapter 3

Usability interface design in Thai Electronic Industry Problem Analysis

Chapter 3 Usability interface design in Thai Electronic Industry Problem Analysis

3.1 The problem of cross-cultural differences interface design

Nowadays, over half of the global software users are facing the problem that interface designs were created for their country of origin. The increasing awareness of this problem relates to the attitudes of users towards the design of user interfaces for international use. Nielsen indicated that diversity in languages still exists and the cultural differences among many regions remains. For instance, there are many software products created by US companies which are launched into the UK market by simply modifying the software to be suitable for their users. Even though the language in the US and UK is almost exactly the same, the cultural factors can cause differences in learning. Patricial Russo pointed out that the image recognition of a US mailbox makes British users confused as it looks like a British trash box. Examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow. Moreover, acceptance and approval signs such as a cross or check are that can often be seen on graphical interfaces in western cultures. However, a cross sign has a different meaning in Japanese. It refers to a lack of acceptance and is a disapproval sign. In addition, interpretation of color also has different meanings across cultural differences. For instance, the color of combustible waste trash in Japan is painted in red, while in Thailand, red means dangerous waste.



Figure 6 Waste disposal trash colors in Thailand



Figure 7 Waste disposal trash colors in Japan

From the above, it can be seen that words, colors, symbols, and other interfaces may not have universal meaning. Thus, in order to create a good user interface, designers need to understand the differences between regions in terms of cultural diversity and develop traditional designs by cooperating closely with natives from the target culture. Therefore, to create own user interface design in Thailand, cross-cultural elements during internalization and localization are important factors.

3.2 The effect of international and Localization design interface in products of electronic Thailand

Nowadays, many designs on interface are created for the global design that call “Internationalization design”. International design is the process of separating the culturally specific elements from a product; for instance, the separation of Japanese text from a program developed in Japan. [Russo, P., & Boor, S., 1993] Internationalization occurs when the product is developed. It is not common for development groups to focus only elements related to text, numbers date. On the other hand, Localization design is the process of infusing a specific cultural context into an existing internationalized product. For example, translating Japanese text and message into Thai for Thai user, Localization is limited for translating the text, date and number formats. However, creating a product that can speak well in another culture concern more than this. Thereby, the good interface design on product should present the user’s language, with words, phrases, and concepts familiar to the user rather than system-oriented terms. Therefore, developing of interfaces design in Thai is a challenge. Focus on the electric products, washing machine is the one of common use household electronic product which can be said every house should have at least one of washing machine. The Figure 8, 9, and 10 shown the few examples of current user interface of washing machine between U.S.A, Japan and Thailand. Illustrate that even the same categories of product have a different of pattern panel, word and symbolic.



Figure 8 The washing machine panel of U.S. domestic product



Figure 9 The washing machine panel of Thailand domestic product

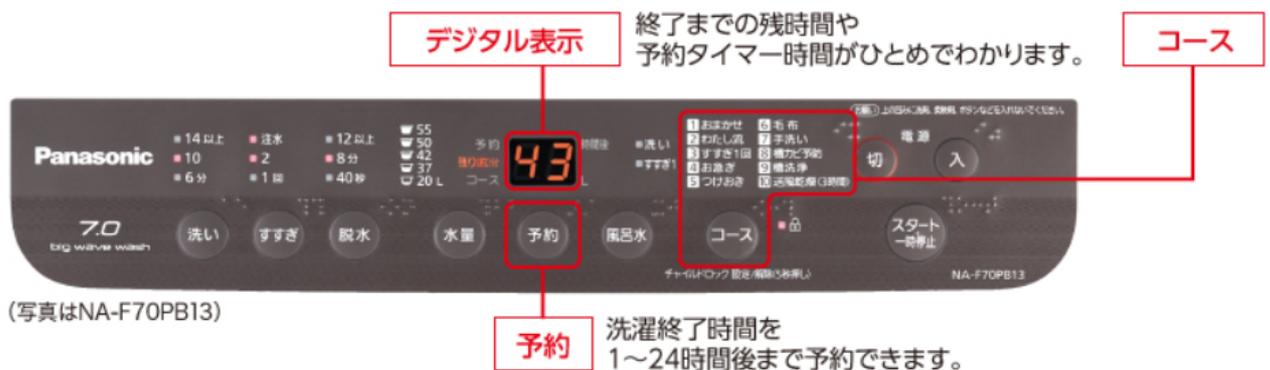


Figure 10 The washing machine panel of Japan domestic product

The characteristics of user interface were demonstrated through the design the word selection appropriation was validate by each inventors-selves which is internal concept understanding in each company. The design was chosen to meet the domestic customer inquiry only example in Japan domestic product control panel doesn't have any or English wording even the main functions such as on/off button or start and pause button. On the other hands, Thai domestic product has a bilingual panel with English and Thai highlighted on some sub-detail such as "Reserve", "Time Left", and

“Programs” which haven’t Thai wording only English wording were displayed. These are the gap between origin product panel and import product panel this lead the question that the product should have a standard design for each region or not.

Regarding to standard for usability design in Thai are developed under the auspices of the international Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC).

Thai electronic companies normally pass the ISO standard. However, Thai industry just operates following the standard from the headquarters such as Japan and United States. It makes attempts to create standards for the Thai user interface have long been failed because Thai users do not pay attention to utility of interface design.

3.3 The concept of international Organization for Standardization (ISO)

Attempts to create standards for the graphical user interface "drivability" have long been failed (IEEE, 1993). Therefore, standards for user interface design have led the guidelines of the conditions that designers anticipate whether to decide the enforcement of each approach.

A. Usage insurance

The International Organization for Standardization (ISO) defines usability in terms of efficiency, effectiveness and satisfaction. The usage assurance standards contain guidelines and specifications regarding how to prepare, run, and test use of documentation to ensure that products can be used. (Bevan, 2001)

B. Human centered design process

These standards describe the activities that should be carried out in order to achieve good user interface design and good usability. They provide a basis for defining good practice in usability and have wide applications.

The usability had controlled the scope and specification by the ISO specifies the purpose or purpose of the use of information technology in the ISO 9241-11 set, which is an ergonomic standard that involves Human work with computers by specifying goals as discussed in 3 aspects as follows:

- 1) Effectiveness is accuracy.
Integrity of the goals that users have achieved in the system scope
- 2) Efficiency is the quantity.
The resources that the system uses to achieve its goals completely.
- 3) Satisfaction is the ability
Convenience and user acceptance of the system

ISO 9241: Ergonomics include 7 principles of dialogue as follow;

- 1) Suitability for the task
- 2) Self-descriptiveness
- 3) Controllability
- 4) Conformity with user expectations
- 5) Error tolerance
- 6) Suitability for individualization
- 7) Suitability for learning

Which cover 3 elements of usability as follow;

- 1) Effectiveness
- 2) Efficiency
- 3) Satisfaction

Next, ISO 13407: Human-centered design process for Interactive systems. The contents of this standard, as the title implies, describe guidelines for human-centered design activities for computer-based interactive systems. From the perspective of humans (users), it describes what it means to develop a consistent interactive system and what to do to create products that are easy for humans (users) to use. Therefore, the international usability should meet the scope of these standard and also have to considerate for suitability of each domestic users. During the globalized product market that more than half of the world user are using the interface design that were originally design in foreign country. Nowadays, the icon is trending toward graphical interface instates of a word aiming to solve the gap of international user understanding. However, there still have a huge gap of connotations in universal case. For illustrating an example of check box respondent case are the good demonstration. For Japan user common understand the “x” symbol as “Reject” or “No” meaning in but in the same way this “x” symbol means “Check” or “Yes” in other countries. refers to (Auer, S., & Dick, E., 2007) Cultural differences manifest themselves in a culture’s choices of symbols, heroes, rituals and values. The commonness of icon was the most concerned for internationalization. In addition to deliver the meaning and capability of its functions the understanding of users is critical evaluation of icon quality. Even though, the implied meaning in each country Didn't understand and Recognized due to the cultural and cognitive of each user characters are significantly different. Since the 2000s this challenge had been wildly extreme awareness.

3.4 The standard on design of Thai user interface design

Currently, user interface design in Thailand have a standard for Supervise and control User safety in each category, various electrical appliances are operated under the supervision of Ministry of Industry. The General standard of Industrial product standards were launch as an announcement of

Ministry of Industry that all of the product in Thai market should follow. Refer to the lasted version of general standard of industrial product of washing machines was called: Industrial standard for washing machines used in residential: The security related specifications. Under standard number “มอก. 1463-2556” in 2013. There are a plenty of specification concerning about the safety of users. However, as for the notes of this standard, it is not taken into account “users who are lack of knowledge and experience”. In part of label there are some specification mentioned about the “Wording” and “Symbolic” for instance, “Open circuit position must display characters “เปิด” or “OFF” These translations of wording might be led to confusion for user because the contrast of selected wording between “Open circus” and “OFF”. One more example of symbolic as you know, all electrical appliances have a control panel. The main function is the exact standard, that is, the main function of the electrical control panel can be standardized. The main function as “ON” and “OFF” shall the starting point of the guideline of panel specification for wording and symbolic but there no specific requirement mentioned about these parts. Even these standards were developed based on IEC 6-417 and ISO 7000. There are some symbolic were described such as: Figure 11 have a definition of “Caution” and Figure 6 represent “Read manual”.



Figure 11 The example symbolic in Thai Electronic product standard 1



Figure 12 The example symbolic in Thai Electronic product standard 2

Moreover, after reviewed standard regulations there are no mention regulations or instructions for the design of the control panel, or the requirements standards of the instruction set and the definition. This makes it very clear that Thailand has never considered and controlled the design of the user interface of product before. Countries that inherit innovation and products from foreign countries must to create the standard for design. It very important to define and consider the translation rules including choosing the local language words in the command menu in order to increase safety of the mistakes

caused by the lack of knowledge and experience of consumers. Therefore, to understand the effect of international standard use towards user interface design in Thai electronics products. This study will create experiment for survey on current interface design on electronic products.

3.5 Experimental Procedure

This section will discuss the interface design patterns that currently use in Thai electronic products. The process of finding will create online questionnaire to receive user comment. The results from questionnaire will be used to determine the products that are a sample product on this experiment. After determine sample product, the survey on current design of user interface will be started by use checklist to evaluate the user interface design in each nation and brands. Then, the results can be summarized by statistical methods. Lastly, conclusion will explain all problems occurring from usage of foreign design without awareness of cross-cultural differences for user interface design in Thailand.

3.5.1 Create survey on the current situation of user interface design

In order to, understand the real situation the researcher will create a questionnaire to survey current design interface in electronic products. Which present in leading shops in Thailand by collecting Thai users' comment via online questionnaire. The survey methodology conducted to gather data involved the use of survey monkey, which is an online survey website. 195 Thai native speakers were participated in this survey. All of those 195 participants were analyzed after they were verified to be valid and complete without any unusual data or multiple responses.

The questions are divided in to 5 parts include;

- 1) Demographic information such as Name, Gender, Career and so on.
- 2) Top 5 most visited shops by Thai customers.
- 3) Top 5 most important electronic devices for everyday life.
- 4) This part was used to ask the opinions of users about the top five electrical appliances that are important for their lives
- 5) Top 5 most complicating electronic devices in using.
- 6) This part was used to ask the opinions of users about the top five electrical appliances are complex in terms of usability engineering design
- 7) Patterns of manual, frequency, and usage behavior.
- 8) Participants are asked to priority a list of devices ranging from no.1-10, in which no.1 represents the most important device for use in everyday life. After that, the participants order the devices based on their complicated functions from the viewpoint of user interface design problems, ranging from no. 1-10, in which no.1 represents the most complicated function. The results from questionnaire will be used to determine the products that are a sample product on this experiment.

Online questionnaire Design detail

ส่วนที่ 1 แบบสอบถามด้านประชากรศาสตร์ (Demography Information)

1. กรุณาระบุเพศของคุณ

please identify your gender

ผู้หญิง (Female)

ผู้ชาย (Male)

2. กรุณาระบุช่วงอายุของคุณ

please identify your age

20-24

35-39

25-29

40-44

30-34

45-49

3. กรุณาจัดอันดับของเครื่องใช้ไฟฟ้าที่มีความสำคัญต่อการใช้ชีวิตตั้งแต่ลำดับ 1-10
(ลำดับที่ 1 หมายความว่าอุปกรณ์นั้นมีความสำคัญมากที่สุดต่อคุณ)

Please ranking which the electronic product is important for your living life from 1-10

☰	▼	เครื่องปรับอากาศ
☰	▼	ตู้เย็น
☰	▼	ทีวี
☰	▼	หม้อหุงข้าว
☰	▼	เครื่องซักผ้า
☰	▼	ไมโครเวฟ
☰	▼	เครื่องฟอกอากาศ
☰	▼	เครื่องดูดฝุ่น
☰	▼	เครื่องล้างจาน
☰	▼	พัดลม

4. กรุณาจัดอันดับเครื่องใช้ไฟฟ้าที่คุณคิดว่ามีฟังก์ชันการทำงานซับซ้อนยากที่จะสั่งการผ่านเมนูคำสั่งตั้งแต่ลำดับ 1-10 (ลำดับที่ 1 หมายความว่าอุปกรณ์นั้นมีความสำคัญมากที่สุดต่อคุณ)

Please ranking which the electronic product is complex in terms of use

☰	▼	เครื่องปรับอากาศ
☰	▼	ตู้เย็น
☰	▼	ทีวี
☰	▼	หม้อหุงข้าว
☰	▼	เครื่องซักผ้า
☰	▼	ไมโครเวฟ
☰	▼	เครื่องฟอกอากาศ
☰	▼	เครื่องดูดฝุ่น
☰	▼	เครื่องล้างจาน
☰	▼	พัดลม

5. ปุ่มเมนูคำสั่งภาษาไทยช่วยให้ฉันสามารถเข้าใจฟังก์ชันการทำงานของอุปกรณ์

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

6. ปุ่มเมนูคำสั่งภาษาไทยช่วยให้ฉันสามารถสั่งการอุปกรณ์ได้รวดเร็ว

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

7. หากเปรียบเทียบกับเมนูคำสั่ง ในปัจจุบันฉันคิดปุ่มเมนูภาษาไทยจะช่วยให้ฉันสามารถใช้งานอุปกรณ์ได้อย่างมีประสิทธิภาพมากกว่า

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

8. หากเปรียบเทียบกับเมนูคำสั่ง ในปัจจุบันฉันคิดปุ่มเมนูคำสั่งภาษาไทยจะช่วยให้ฉันสามารถเข้าถึงการใช้งานอุปกรณ์ได้มากกว่า

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

9. ปุ่มเมนูคำสั่งภาษาไทยช่วยให้ฉันสามารถสั่งการอุปกรณ์ได้รวดเร็ว

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

10. ในภาพรวมฉันคิดว่าปุ่มเมนูคำสั่งภาษาไทยมีประโยชน์สำหรับฉัน

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

11. ฉันพบว่าปุ่มเมนูคำสั่งภาษาไทยนั้นมีความง่ายต่อการใช้งาน

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

12. ฉันพบว่าปุ่มเมนูคำสั่งภาษาไทยนั้นมีความง่ายต่อการเรียนรู้ที่จะใช้งาน

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

13. ฉันพบว่าปุ่มเมนูคำสั่งภาษาไทยมีความชัดเจนกว่าทำให้สามารถเข้าใจวิธีการใช้งานได้ดีกว่าเมนูคำสั่งในปัจจุบัน

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

14. ฉันพบว่าปุ่มเมนูคำสั่งภาษาไทยมีความชัดเจนและง่ายต่อการใช้งานมากกว่าเมนูคำสั่งในปัจจุบัน

ไม่เห็นด้วยทั้งหมดกับเรื่องนี้	ไม่เห็นด้วยเป็นส่วนมาก	เห็นด้วยบางส่วน	เห็นด้วยเป็นส่วนมาก	เห็นด้วยทั้งหมดกับเรื่องนี้
<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

3.5.2 Determine on experimental sample

The results indicated that the top five electronic devices that are most important for Thai users are refrigerators, air conditioners, rice cookers, washing machines, and electronic fans respectively. However, the most sophisticated devices in terms of usability design are washing machines (76.4%), air conditioners (71.4%), televisions (66.7%), microwaves (58.5%), and air purifiers (57.9%) respectively. Regarding the result, it points out that the first five devices are the devices which have many command buttons and can make the user become confused. However, the most sophisticated devices in terms of usability design are washing machines. According to the questionnaire, it is found that the problem that confuses participants the most is the language on command buttons which sometimes uses duplicated or unclear terms. Moreover, they mix between Thai and English language so users cannot distinguish between the function of one particular button and other buttons. Furthermore, symbols appearing on the menu are more difficult to understand. The next step, the researcher will analyze the design that becomes an obstacle for the user from the viewpoint of usability improvement. In this experiment, the washing machine is considered to be a representative device which has bad usability design regarding the user satisfaction survey. Therefore, this research conducts a survey of user interface design on the menu screen of washing machines launched in a leading department store in Thailand.

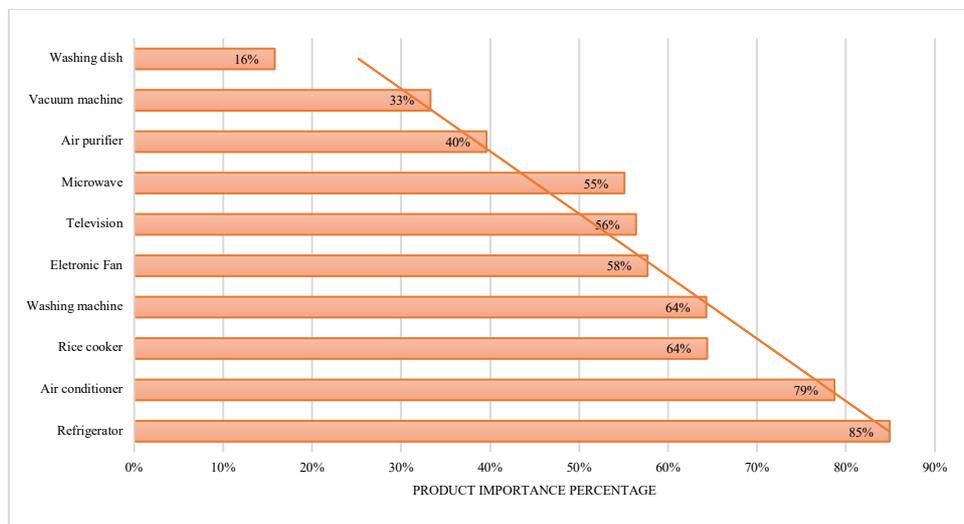


Figure 13 The most important device for use in everyday life shown by graph

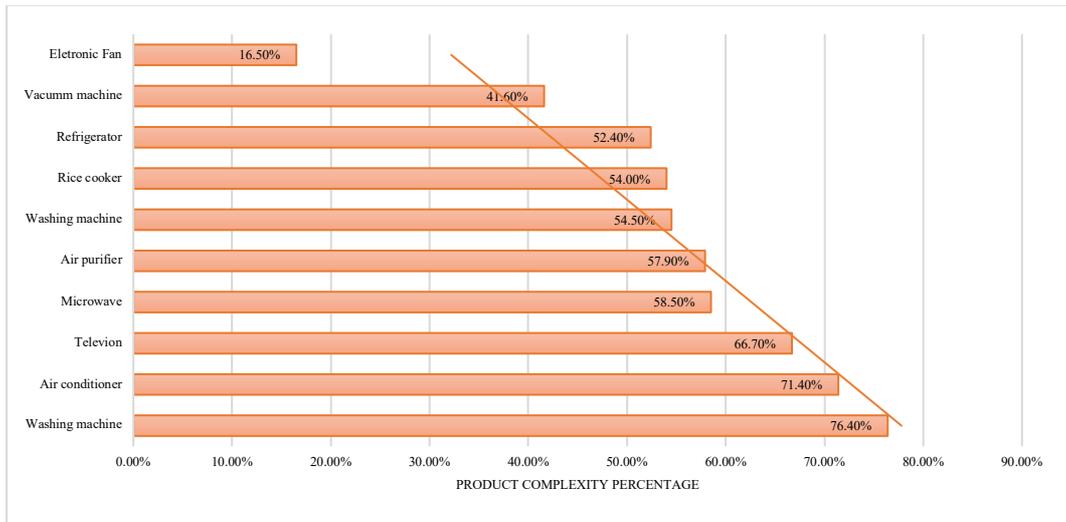


Figure 14 The order of devices that have the most complicated function in the viewpoint of users

3.5.3 Identify the sampling number

Random sampling was carried out in accordance with Taro Yamene's sample group specification. The simplified formula. (Yamane, 1973) was applied to determine the sample size in this study, where n is the sample size, N is the population size, and e is the level of precision.

$$n = \frac{N}{1 + e^2}$$

$$n = \frac{63}{1 + (0.05)^2}$$

$$n = 56$$

Therefore, researchers specified the confidence as 95% and found that 56 models from 63 models sold in Thai electronics stores were chosen to be the sample group for this experiment. Those 56 models are the representatives of bad usability design on electronics products. Those samples contain electronics products from Japan, Korea, and western countries. The model ratio of each brand can be seen in Figure 15 as below;

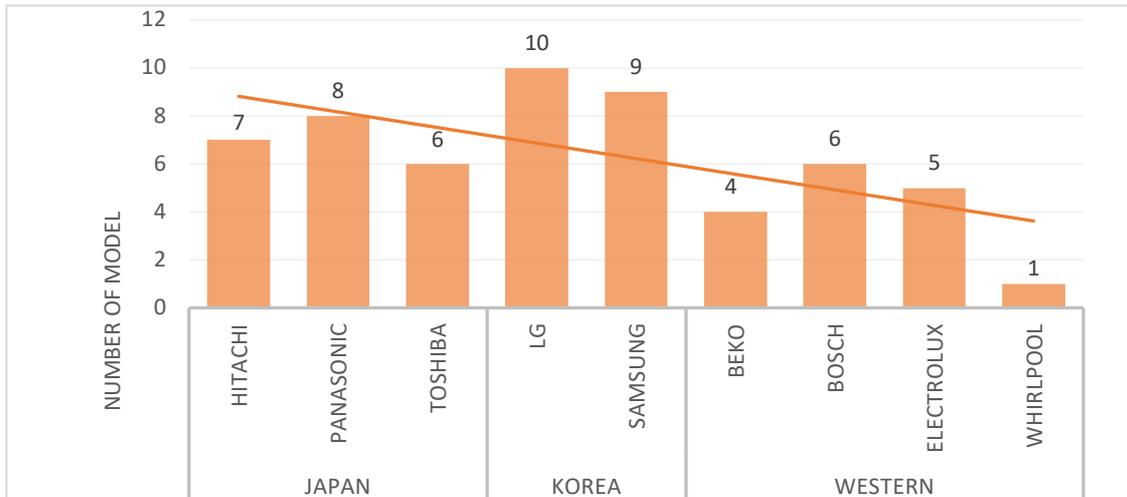


Figure 15 The sampling model ratio of electronic products in this experiment

3.5.4 Create checklist creation

To survey current command menus which are used on washing machines, a checklist was created. The details on the buttons such as On/Off which show both Thai and English, and also symbols were noted. In cases where there was no word or symbol, the researcher had to put X in the checklist.

Usability Design Checklist					
NATION	BRAND	MODEL	ENGLISH	THAI	SYMBOL
JAPAN	HITACHI	BD-W80WV	Power On/Off	เปิด-ปิด	⏻
JAPAN	HITACHI	BD-W80WV	Allergy Care	ลดสารก่อภูมิแพ้	X

Figure 16 The sample of a check list for recording the current user interface design data

3.5.5 Statistical analysis

In order to find the relationship between independent and dependent variables, the statistical tooling was conducted to analyze and examine the design of user interfaces on the control panel screens used in washing machines. Then, data were collected and evaluated by 2-way ANOVA and t-test.

3.6 Results

3.6.1 Considering product brand divided by country design

The result of analysis shows that Korean products have the highest average ratio of Thai language appearing on the screen, at 30.64%. The second highest is Japanese and western products, at 19.8% and 15.21% respectively. The P value is 0.000 which is less than 0.05 meaning the differences in product nationality have a significant effect on the average ratio of Thai language content appearing on the screen.

Table 5 DESCRIPTIVE

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Japan	120	.1980	.26929	.02458	.1493	.2467	.00	1.00
Korea	80	.3064	.31443	.03515	.2364	.3763	.00	1.00
Western	160	.1521	.25394	.02008	.1125	.1918	.00	1.00
Total	360	.2017	.27910	.01471	.1728	.2306	.00	1.00

Table 6 ANOVA analysis

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.271	2	.636	8.502	.000
Within Groups	26.693	357	.075		
Total	27.965	359			

Moreover, the multiple comparisons analysis result shows that Korean products have a significantly higher average ratio of Thai language appearing on the screen than Japanese and western products.

Table 7 Multiple comparisons

(I) Nation	(J) Nation	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Japan	Korea	-.10838*	.03947	.006	-.1860	-.0308
	Western	.04587	.03302	.166	-.0191	.1108
Korea	Japan	.10838*	.03947	.006	.0308	.1860
	Western	.15425*	.03744	.000	.0806	.2279
Western	Japan	-.04587	.03302	.166	-.1108	.0191
	Korea	-.15425*	.03744	.000	-.2279	-.0806

*. The mean difference is significant at the 0.05 level.

3.6.2 Considering product brands from the same nation

A. Japanese products

The results of analysis show that from 120 samples and three brands (Hitachi, Panasonic and Toshiba) of Japanese products, statistical testing for F indicated a value of 0.105 which exceeds 0.05 meaning that each brand has no significant statistical difference in the average ratio of Thai language appearing on the screen.

Table 8 Japanese products descriptive

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
					Hitachi	40		
Panasonic	40	.2055	.27015	.04271	.1191	.2919	.00	1.00
Toshiba	40	.1308	.23853	.03771	.0545	.2070	.00	1.00
Total	120	.1980	.26929	.02458	.1493	.2467	.00	1.00

Table 9 Japanese products ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.326	2	.163	2.296	.105
Within Groups	8.304	117	.071		
Total	8.630	119			

B. Korean products

The results of analysis show that from 80 samples and two brands (LG and Samsung) of Korean products, statistics of the t-test with a value of 0.566 and thus exceeding 0.05, mean that each brand has no significant statistical difference in the average ratio of Thai language appearing on the screen.

Table 10 Korean products group statistic

Brand	N	Mean	Std. Deviation	Std. Error Mean
Average LG	40	.2860	.30103	.04760
Samsung	40	.3268	.32985	.05215

Table 11 Korean products independent samples test

t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
					Lower	Upper
-.577	78	.566	-.04075	.07061	-.18132	.09982
-.577	77.357	.566	-.04075	.07061	-.18134	.09984

C. Western products

The results of analysis show that for 80 samples of four brands (Beko, Bosch, Electrolux and Whirlpool) of western products, the statistical F test value of 0.002 is less than 0.05 which means that each brand has a significant statistical difference in the average ratio of Thai language appearing on the screen.

Table 12 Western products descriptive

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Beko	40	.2455	.33835	.05350	.1373	.3537	.00	1.00
Borsch	40	.1905	.24046	.03802	.1136	.2674	.00	1.00
Electrolux	40	.1353	.20109	.03179	.0709	.1996	.00	1.00
Whirlpool	40	.0373	.16088	.02544	-.0142	.0887	.00	1.00
Total	160	.1521	.25394	.02008	.1125	.1918	.00	1.00

Table 13 Western products ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.947	3	.316	5.291	.002
Within Groups	9.306	156	.060		
Total	10.253	159			

To summarize, the number of Korean washing machines using a Thai menu button to describe each function on the screen menu exceeds that of other countries' brands. It is considered that neither Japanese nor Korean home appliances have significant differences in using interface design between brands. However, the user interface design of western brands shows differences. The group from western countries contains global brands from various countries. Beko is from Turkey, Bosch is from Germany, Electrolux is from Spain and Whirlpool is from Italy. Therefore, user interface designs in

this group are different. In order to find the internal relationships among the western group about Thai language use on the screen menu of washing machines, this research is going to propose the multiple comparisons analysis. The results of the multiple comparisons analysis show that the Beko and Bosch brands have a significantly higher average ratio of Thai language appearing on the screen than the Whirlpool brand. Moreover, the Beko brand has a significantly higher average ratio of Thai language appearing on the screen than the Electrolux brand.

Table 14 Washing machine western brand

(I) Brand	(J) Brand	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Beko	Borsch	.05500	.05461	.315	-.0529	.1629
	Electrolux	.11025*	.05461	.045	.0024	.2181
	Whirlpool	.20825*	.05461	.000	.1004	.3161
Borsch	Beko	-.05500	.05461	.315	-.1629	.0529
	Electrolux	.05525	.05461	.313	-.0526	.1631
	Whirlpool	.15325*	.05461	.006	.0454	.2611
Electrolux	Beko	-.11025*	.05461	.045	-.2181	-.0024
	Borsch	-.05525	.05461	.313	-.1631	.0526
	Whirlpool	.09800	.05461	.075	-.0099	.2059
Whirlpool	Beko	-.20825*	.05461	.000	-.3161	-.1004
	Borsch	-.15325*	.05461	.006	-.2611	-.0454
	Electrolux	-.09800	.05461	.075	-.2059	.0099

From table 14 which show as below, we can rank the greatest use of Thai language on screen menus in the western brands group. Beko has the most use of Thai language on screen menus. Next are Bosch, Electrolux, and Whirlpool respectively. After investigating, it is found that even though the Beko brand was only recently established in Thailand in 2013 and was still not a famous brand at that time, its selling strategy involved improvement of design to make their product easier to use. Especially for electronic devices, since 2019 all Beko product menus have been provided in Thai. As a result, presently Beko is the best-selling western brand in Thailand. From the above mentioned, it can be said that the development of user interfaces by using Thai language satisfies customers and affects the decisions of customers. To develop a user interface design for only Thai users is one of the factors that accelerates customer satisfaction and decision making.

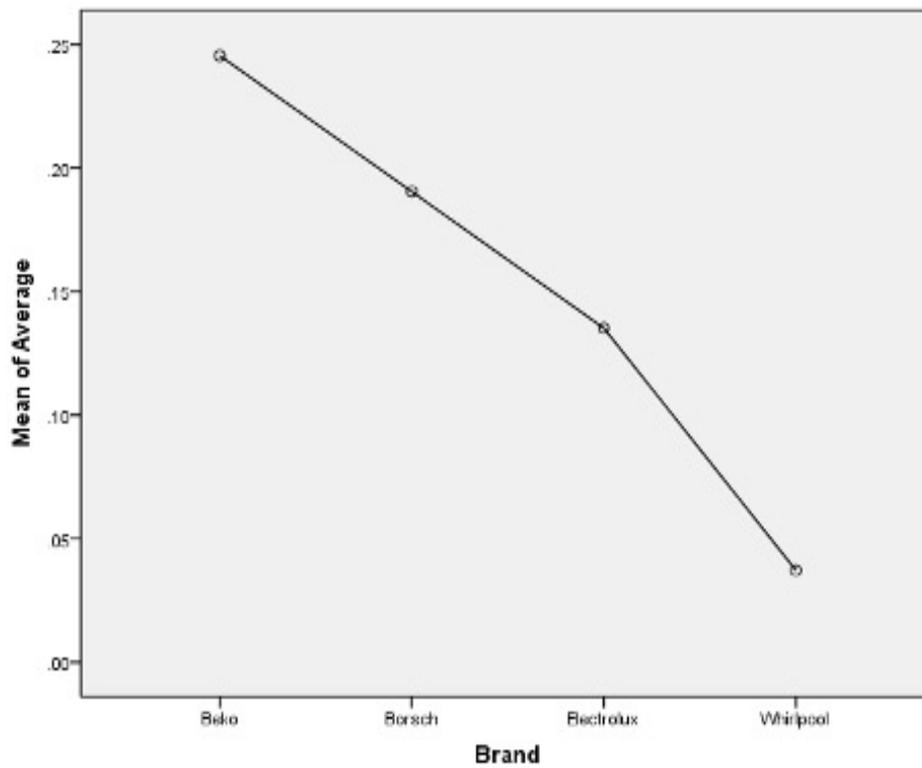


Figure 17 The average using of Thai language on screen menu in western brand group

Moreover, this research also studies word categories that are often used on screen menus of washing machines. After selecting a common word, it is found that three commands that use the same Thai word are:

- The 1st: Cotton
- The 2nd: Temp
- The 3rd: Water Level

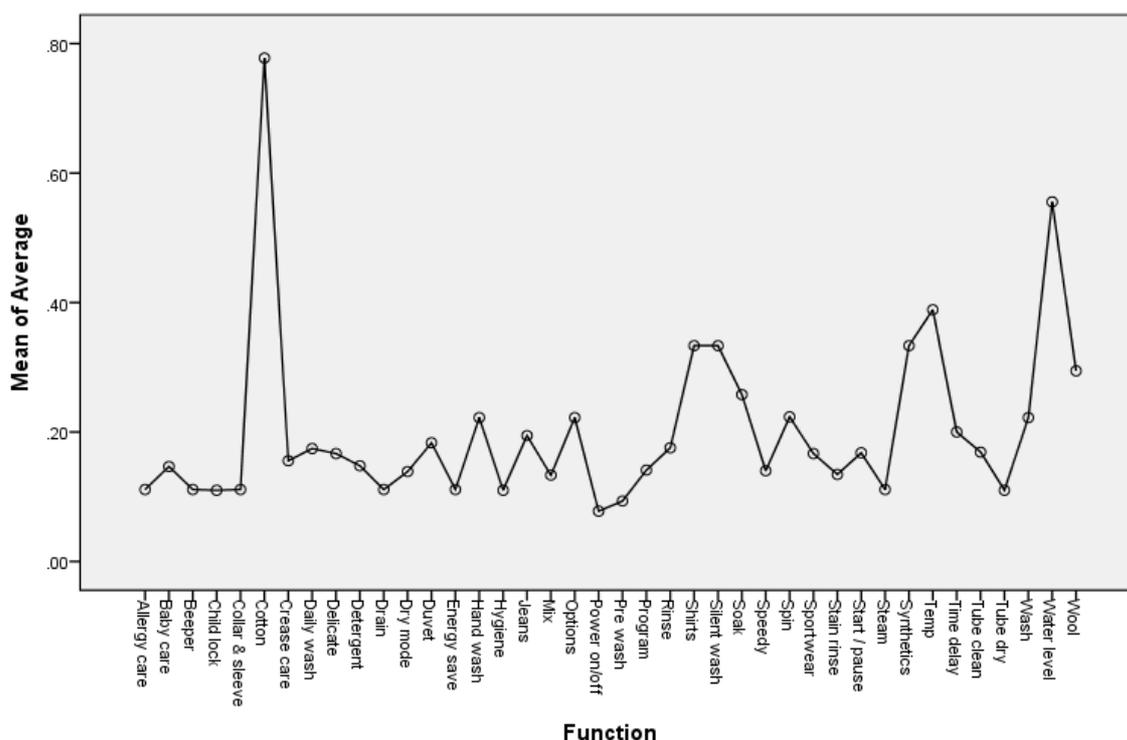


Figure 18 The average use of the same Thai word on screen menu in each function

In addition, it is found that the word “Cotton” has a significantly higher average ratio on the screen of washing machine than other functions. Therefore, it can be said that the function “Cotton” is generally used in various brands and nations. “Cotton” is written in transliteration which is similar to Japanese Katakana. This helps Japanese people’s cognition better than using English. Moreover, it helps to reduce misuse in the case that users have limited knowledge in English. Previous research pointed out that Japanese people understand Katakana better than Kanji as on-yomi that are transferred from Chinese (Tamaoka and Miyaoka, 2003) Therefore, it can be assumed that transliteration can accelerate cognition better than foreign languages.

3.7 Conclusion

Presently, it is known that words appearing on electronic devices are Thai words that were translated from the brand owner’s language. However, it is found that Thai is no standard in translating the original words based on each owner’s language. That means Japanese, Korean, and western groups have different words, but brands under the same nation have similar words. Therefore, this problem makes users to become confused and they need to take time to adapt to new things when they change product used. From that reason, interface design in Thai is against the principle of user- friendly design that users should be able to access new devices easily. Furthermore, it is found that on the same screen

menu, there are both Thai and English languages, as well as symbols. This causes cognitive overload that confuses users. Lastly, this research found out Thai words that can be used as standard words on washing machines such as “Cotton”, “Temp”, and “Water Level”. These words have high ratios in use, even in different national brands. Therefore, these three words are considered to be set as standard words appearing on screen menus in all brands of washing machines in the future. To improve the Thai user interface, the development and creation of standard words on electronic devices is a must, because they upgrade the satisfaction of users when using the devices.

Chapter 4

User Interface Design

Chapter 4 User Interface Design

4.1 The concept of usability design

To understand truly about the objective of this study, this chapter presents the definition, significance, principles and process of creating user interface design. This research proceeds upon the means that review previous studies and select the relative studies in order to determine the guideline of making user interface design suited with Thai people. Nowadays market around the world were forced to run in to digital market era which high market tension of innovative product so when the market changed the product had been also hanged. In the new circumstance with interrupt along user and product are not happen in physical way but also in conceptional also play the main role in usability engineering. The diversity of product categories affects to the complexity of user interface design. Usability evaluation is the key of design and develop the system. (Madan, A., & Dubey, S. K., 2012) It can be said that usability will help detecting system error and poor user interface so that we can develop and solve the problem occurring from the usability design. (Peute, L. W., & Jaspers, M. W., 2007) Regarding the number of related Research, it indicates that usability and quality relates with each other. (Bevan, 1995) Nielsen's a specialist designer of Web Usability said that "Bad usability equal no customer." Therefore, usability is a quality how convenience user interfaces are used Nielsen's (1994). This indicates that the importance of usability not only affects the quality of the system, but also affects the ability to communicate the system's capabilities and respond directly to user satisfaction. Oztekin, et.al,2009 proposed usability assessment and design of web-based information systems (UWIS) by doing the Quality and web-based information service evaluation from the viewpoint of usability. The result shows that quality and usability of web-based information system service have a significant correlate relation. Moreover, Oztekin, et.al, 2010 has been developing to prove that there is a relation between usability and quality by creating a usability checklist for E-learning system. The checklist contained quality and usability evaluation by applying structure equation modeling to evaluate the checklist result. As the result, the quality and usability of E-learning system have a very close relation. Therefore, it can be said that the improvement of Usability is to improve the quality of product and system during the design process.

4.2 Important of usability

Usability is the efficiency and satisfaction that the user has achieved in that environment (ISO9241). Usability is something that works well when it works as expected (Spolsky, A. J. ,2008). Usability is a quality that is measured by the ease of use of the interface. Which includes the development of ease of use in the design process (Nielsen, 2003). [Nielsen, Usability 101: Introduction to usability., 2003] had mentioned that there are 5 components of meaning of usability which are:

I Learnability

The system should be easy and support user rapidly done with the system. The commonness of system should be discussed on these topics according to learnability sometimes required a personal skill. To reach out the command or information should not require the background of knowledge and specific experience.

II Efficiency

The system should be efficient therefore if user have experience enough with the system the high level of productivity can be produced. By the way, the system should convey all of capability of system to experienced user. The maximized efficiency of all the function should fluently.

III Memorability

The system should be easy to memorable in another meaning the understanding with the system should deserve for all ranges of user and various scenarios. In-experienced, On-experienced and un-experienced should have the equal level of memorability of system means the system should easy to remember since user have non-experienced on its then when user are using the system the logical, pattern and display should easy to remembers and an experienced user should easy to recognize the system when they interact with the system after a period of time.

IV Correctness

The system should have less error so user will have low possibility to make an error during using the system. In another meaning the system should understand the mistake and slip logical of users. To prevent those kinds of issue it needs to design the system the early phase and the system should assess the mind decision of users.

V Satisfaction

The system should serve a good experience and satisfy user. The intangible validation is the challenge for the system with are all-time validate by various users.

Usability is a concept derived direct to the user experience. It shows the differences in user levels that can be achieved to meet the specified goals. Besides, Usability was also considered as a tool used to measure efficiency and satisfaction with efficiency being the accuracy and completeness of the accomplished user meets the final objectives. The Efficiency section indicates that the resources used by users are related to accuracy and completeness in order to complete the work as targeted. The targeted target and Satisfaction are identifying the results of individual comfort and satisfaction Including other people's aspects. The Usability should be defined in various dimension. In 2000, explained the usability [Han, S. H., Yun, M. H., Kim, K. J., & Kwahk, J., 2000] was defined in two dimensions are the objective performance and subjective images or impressions which both were highlighted in designing and evaluating consumer electronic products as the key factors. The study also had mentioned that Usability considered in this way is not only conceived of as ease of use but

also equally involves efficacy, i.e., effectiveness in terms of measures of (human) performance. Based on [Han, S. H., Yun, M. H., Kim, K. J., & Kwahk, J., 2000] The Usability definition contains two meaning are:

- Easily to a specified level of subjective assessment.
- Effectively to a specified level of (human) performance.

The ability for user interaction that can be used easily and efficiently covered all ranges of user, user support to meet the specified task range within the specified environmental situation. Moreover, the usability also had mentioned about the tools which is Usability Evaluation Methods (UEMs) to evaluate Web applications. However, this method is not satisfied customer needs enough so it will be leaded to critical problem for website owner. Usability and user experience are two important factors in developing a personalized product that is tailored to customer needs. There are various evaluation methods to improve the product during the user-centric development process. The evaluation of usability today can be summarized as every method that can help to understand how to improve the usability of the system in order to investigate usage problems in all types of applications, or even Until understanding the long-term use products in the branch to inform the new generation of products. [Da Silveira, G., Borenstein, D., & Fogliatto, F. S. (2001)., 2001]

4.3 The changes of Usability from the past to current situation

Since 1980s when Usability engineering was developed Usability testing is widely accepted as a fundamental method for evaluating products and systems. In the initial stages, Usability design focuses mainly on usability. Evaluation is only looking at the effectiveness of the product. Not yet considering the satisfaction and effectiveness of the product use only by those products Is a hardware product and also restricting the use of those involved with the system only. With the rapid development of information technology can be unlocked, internet technology has played an important role in every face of the industry including user interface. Software has become another system that must be designed and developed. Causing usability to have a challenge in one scenario that is completely different from the existing system. [Nielsen, Usability engineering., 1994] are described generation of user interface as show in Table 15 During rapidly digitized environment, digital technology became the critical technology engine for forcing the whole part of Usability design. While functionality is not the main factor affecting customer decisions and serves satisfaction longer. New product development to market should consider and focus on designing user interface for the new digital era. Furthermore, to survive and the maximum value transfers to users surely that products must adjust quickly adopt as a first industry definitely are "Electronic products". proposed the trending of Usability testing is still alive and at the turn of the 21st century it is an important method that evolves to suit the technology of the day. In the 21st century, 'quick and clean' usability testing methods are needed, to provide valid and reliable data on how well people use products and systems, and how they like using them

(Wichansky, 2000). Furthermore, considering through the new customer journey user will interact with electronic device more frequently. In the past, people may surround by any appliances but nowadays not only one of part them, but it was considered as be a part of customer life. User interface are play a key important role in everyone daily life. These are effect to their perception to consider importance level attention to the user interface. The system not only responds to the efficiency but must support A broader user group in some occasion, the system is expected to respond across users via the same platform, such as the use of a single user device from x and z generation or user from Asia user and European user in the same interface, which Is a very challenging aspect of the usability perspective

Table 15 Summary of the generations of computer and user interface Modified from (Nielsen, 1994)

Generation	Hardware technologies	Operating Mode	User types	User Interface paradigm
From 1945 (Pre-history)	Mechanical electro-mechanical	For calculation cannot be really used	The inventors themselves	None (Limit to access only important things from hardware)
1945 - 1955 (Pioneer)	- Vacuum tube - Heavy m/c	One user one time at one machine	Expert, Pioneers	Programing Batch
1955-1965 (Historical)	Computer had more realizable and can use outside lab	Batch	- Technocrats - Professional Computerists	- Command Languages
1965-1980 (Traditional)	Integration of circuits. Computer became more criteria to meet business needs.	Online processing system	- Expanding to non-computer skill user (Bank teller)	- Full screen - Level of menu From fill-in
1980-1995 (Modern)	Very-Large-Scale Integration. (VLSI) Personal computer	Single user	- Business professional - Hobbyist	WIMP (Window, Icon, Menus and Pointing device)
1995-2000	- Wafer scale - integration. User may buy many	Networked single user and embedded systems	Everyone	Non-command-based interfaces
2000 – beyond	Web-based integration Mobile era	- Internet - Web-based applications	- Anonymous user	Dynamic interface

Chapter 5

Cognition Process

Chapter 5 Cognition Process

5.1 Memory system

According to Cognitive semantics, the meaning of words is repeated, especially in the form of picture schemas, in which these processes are abstract. With natural infrastructure Built on topological and geometrical structures, these processes often work together with perception memory and semantic meaning (Gärdenfors, 2004). In this chapter will gives an overview of related research area in cognitive information processing which were used to represent the research method. The research will be analyzed and presented about the relation between cognitive information processing and usability design for create and develop user interface design in Thai electronic and electrical industry. The brain processing is controlled by another controller. In computers, controllers are called software. The ability to manage and control the processing of the brain is when the person is aware of their own thoughts and has the ability to control them to do what they want. This perception is officially known as metacognition. Atkinson and Shiffrin (1968) present the memory system theory that divided memory system into 3 Stores s sensory memory, short-term memory (STM) and long-term memory (LTM).

Sensory memory

Sensory memory is the basic information keeping which maintains the original and natural form of the stimulus. This sort of memory will be last for only 1-3 seconds, waiting to be made decision whether this stimulus is worth keeping. If it is, it will be encoded to Short-term memory (STM) which is controlled by the recognition and attention.

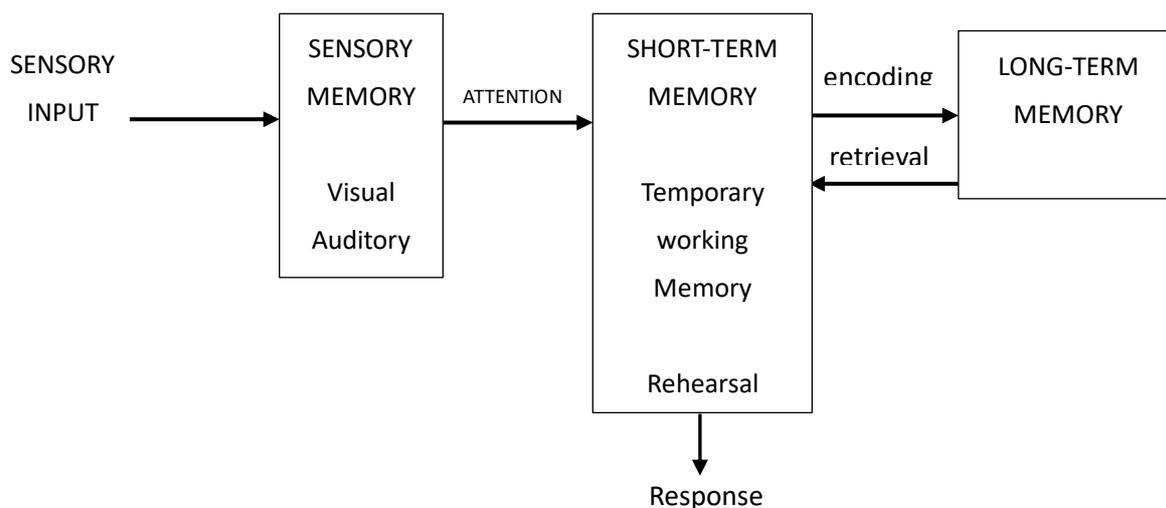
Short-term memory (STM)

Short-term memory (STM) plays an important role in learning. After the stimulus encodes to the STM which has limited capacity, it will be washed off by the brain very shortly if lack of recitation and repetition. Psychologists have studied about STM and the report shows that it lasts only 20 seconds or between 15-30 seconds, sometimes it is also known as Working memory since we only need it just for the short period in information processing. Before the brain decides to keep something in the Long-term memory (LTM), it will classify and organize the information in order to merge them with the previous memories. Appropriate organization helps reducing the workload of the brain when those memories are recalled using.

Long-term memory (LTM)

Long-term memory (LTM) help to extend the available time for STM, those memories must be processed and transformed to LTM. This process is called Encoding which can be done by recitation. After doing Rote learning, such as multiplication table recitation, the information will be moved to LTM which has almost permanent memory. Moreover, apart from recitation and rote learning show

there is the elaborative operations process that uses for meaningful learning. Learners need to try merging new experience to the current information kept in LTM beforehand. It is typical that the current LTM will have an influence on the new experience. LTM has unlimited capacity that can keeps large amount of information as a network. If the new information does not match with current network, it will be separated to the new network. The LTM will separately keep images and languages but remain relating to each other.



Source: Driscoll, M. P. (1994).

Figure 19 Transferring information along Short memories STM and LTM

Referring to individuals who are aware of their knowledge and abilities and then use them to control their thinking processes and create strategies that will help them achieve their wishes. The main elements of metacognition include motivation, intention, intention, and other self-control techniques. It can be seen that the thought process begins with that interest. For example, if students realize that if they concentrate on the teacher, they can achieve a good score, students will control themselves and listen closely to what they are teaching. Next is awareness. Awareness is that when students hesitate in their information, they will wait until it is confirmed. Next is strategy. Strategy is when students realize that they don't remember what the teacher said, it will lead to discovering techniques such as lecture, note taking or using poetic information, acronyms and codes. Therefore, basic knowledge of metacognition consists of personnel, work, and strategy, which are followed by the following subset.

- 1) Knowing a Person, it includes beliefs about individual differences, differences between individuals, and the University of Awareness.
- 2) Knowing the obligations, It includes knowledge about the working conditions framework and job descriptions.

- 3) Knowledge of strategy It includes knowledge of special metacognitive strategies and the benefits of their strategies for work. Metacognition can be divided into 3 type
- a Open knowledge is knowledge about the factors that influence work
 - b Process knowledge is knowledge of processes and operations.
 - c Conditional knowledge is knowledge about places, matters that limit reason and working conditions.

5.2 Cognitive Psychology

Cognitive is a process that occurs after the stimulation of the senses and is interpreted as meaning by using knowledge. The experience and understanding of the person Perception are learned. Therefore, if there is no learning or experience, there will be only a touch. For example, Little Boy has never learned or experienced about computers before. A friend pointed out that he only touched the eye and the ear but didn't recognize what they saw in the eye and heard in the ear. The nerve system is a basic issue to study the cognition ability, adaptation and response from the environment factors. The nerve system is divided into 2 main parts, the central nervous system (CNS) and peripheral nervous system (PNS). The peripheral is the center of neural fibers which perform as connectors between external to central nervous system (CNS). The study of peripheral nervous system (PNS) is necessary because the main function of peripheral nervous system (PNS) is to transfer information between central nervous system (CNS) and nerves lying outside of the CNS, whether it be outside part of body such as skin, eye, ears, and inside part of body such as heart muscle and stomach. Robert J. (1996) described the function of brain that brain is the main and center of human organ that control all senses, thoughts, movements. The movement information can be described via the connecting structure between network of neurons to the spinal cord, which gathers a series of interconnected neurons into the bundles of neural fibers that extend from the brain down through the center of back. Moreover, the spinal cord branch to the nerves of the PNS, such as those going to the internal organs, the arms and the legs. Moreover, Robert J. (1996) also referred the concept of information exchange ways which are direct communication of nervous system call receptor and effector. Receptor is to receive all sensory information (sight, hearing, smell, taste and touch) from outlying nerves of the PNS. Then transfer data to CNS, spinal cord and the brain consecutively. Effector is responsible for transmitting motor information from the CNS to PNS such as muscle movements regarding how the body should act in response to the information they receive. Usually, this information comes from the brain. Therefore, the spinal cord has influence effect to routing sensory and motor information. To summarized, the nervous system is the first step which make human understand the working processes of brain and cognition relation. Moreover, nervous system allows human to understand the working process of cognitive information ranging from sensations to encoding in long-term memory process which will be mentioned herein after.

5.2.1 Cognitive information concept

Persuasive cognitive theory that visual cognition can be developed using teaching and learning processes together with activity analysis and activity synthesis. Training can be done by starting with the simplest steps and participating in an environment that inspires knowledge and understanding.

The visual perception process consists of 4 main functions as follows;

5.2.2 Image receiving function

This function is a process from receiving data from the surrounding environment until being organized. This process includes the ability to differentiate what you see (vision), the ability to focus quickly and continuously (accommodation). The ability to combine what you see in both eyes is Single image (Binocular) fusion) the ability to meet the eyes to focus on something (convergence), the ability to perceive the depth of images and be able to see them in 3D (Stereopsis). Visibility. Generally, an area can be seen from the center about 65 degrees above 75 degrees, below 65 degrees inside and 95 degrees together. An important skill of controlling eye movements (Oculomotor skills) is fixation, which is the act of focusing or concentrating on something and seeking eye actions to track moving objects. Saccadic or Scanning eye movement is the ability to move the eye quickly from one thing to another out in the visual field.

5.2.3 Eye recognition function

Understanding things or imagining what should be done Intellectual abilities will have more or less skills. Depending on the specific neural network or brain structures, most memory skills are in the Temporal Lobe and Frontal Lobe. The human brain consists of Many neural networks. Important neural networks Is a memory network that is important for many higher-order cognition activities related to cognitive processes, including;

- a. Attention
- b. Perception,
- c. Memory
- d. Movement
- e. Language understanding
- f. The ability to process images and dimensional relationships (Visual and spatial processing)
- g. Decision making
- h. Problem solving

Intellectual ability is not stable can changed and can be developed at any time when the brain structure changes, there is a link to changes in cognitive function. Having guidelines for intellectual development Therefore important Especially the dimension-related ability and the ability to meaning Eye detection is an essential step in many applications such as human-computer connections, iris

recognition, driver drowsiness detection, safety, and biology. (Bhoi, N., & Mohanty, M. N., 2010)

It is the ability to process and then use the information of what you see to do something.

- 1) Visual interest is the ability to keep your focus on what you are watching. Children can develop this skill by practicing and learning.
- 2) Image memory is the ability to remember what you see. Essentially, it will coordinate with previous experience.
- 3) Visual discrimination is the ability to discern what you see. It has the following subset
 - a. Awareness is an action in which you can specify what you have seen before.
 - b. Pairing is an action where you put 2 things related to each other
 - c. Sorting is an action that groups things that are invisible.

In addition to the topics discussed above, the visual recognition function can be divided into 2 additional parts.

- 1) Section 1 Material Perception The visual perception of that object is controlled by the temporal lobe in the brain which consists of the following:
 - a. Pattern stability is the ability to recognize and distinguish the shape of an object, even if it has been moved to a different position, direction, and size change.
 - b. Closing the image is the ability to recognize objects that you have seen before, even if they are in an incomplete state.
 - c. Background is the ability to separate images or objects from backgrounds and things.
- 2) Section 2 Spatial perception is the visual perception related to the position of objects that can be related to the environment. This is controlled by the parietal lobe in the brain, which consists of the following:
 - a. Position in space is the ability to sense the direction and position of objects. Gives an understanding of entry, exit, top, bottom, back, left and right. It also helps in memorizing letters. For example, people can remember similar characters by looking at the direction of each letter in their writing style. (Inbound and outbound)
 - b. Spatial relationships are the ability to recognize relationship patterns in order to make accurate motion plans.
 - c. In-depth perception is the ability to calculate the distance between objects, such as depth and appropriate distance recognition when reaching out to an object.
 - d. Terrain orientation is the ability to distinguish objects and connect various positions of objects, such as the ability to remember directions and create a map.

5.2.4 Visual images / visualization

Imagery is an image that uses information from visual elements to visualize it as an awareness.

Person's perception, images, ideas, and objects are extremely important for their ability to create

problem-solving strategies and other skills. recognition is to design one-way teaching media based on the theory or principles of eye perception.

5.2.5 Hand-eye coordination (Including motor with image)

Hand-eye coordination is the ability to link eye and hand movements. It is a movement skill that can be stimulated by visual stimulation. It is very important for the development of writing skills as well as the speed of the visual motor. To evaluate the usability design problem many researches were study the cognitive information processing based on the theory of Atkinson and Shiffrin (1968).

In this research also study the theory of Atkinson and Shiffrin (1968) in order to understand the working process of cognitive information processing methods to create experiment task in word cognition on the electronic product in Thai industry market. The test will set up word task as an accelerator which is activated via Visualization (visualization will explain in next step) process. This is to evaluate the cognition ability that relates to commanding and controlling of electronic devices appearing on control panel menu in Thailand.

Concepts The idea of using eye perception principles for object recognition is to design one-way teaching media based on the theory or principles of eye perception.

5.2.6 Eye recognition relation with memories

For Education technology and teachers should be out pattern with us or teaching media, taking into account the following situations

- 1) Consider the level of ability to perceive the slopes or of the learner, especially the sensory eye that will be perceived
- 2) Design to present one thing that the learner is not familiar with or unfamiliar before, then the method should be used the comparison method
- 3) Design the substance with a simple step uncomplicated. If there is a lot of content, it should be divided into children, no more than 7 groups. According to the research, it is found that people are much more aware of their eyes by looking at objects' maximum of 7 objects.
- 4) Must consider that students have chosen what they perceive on), so should design a substance to match the expectations of color assistants to learn what is not necessary. Should be displayed and colors stimulated.
- 5) The substance should be designed with emphasis on the size of the color "on the danger of light intensity, color contrast or size may use new things that are different from the original, such as using color images. Instead of black and white or per animation range instead of still images, etc. "out.
- 6) The form of a substance should be continuous, as humans. The regulatory system may use symbols to show the order of precedence or blue to show continuity, perceive color via.

- 7) Use image guide for the learners to recognize and that the cell interpretation of the content, such as the design of the substance.
- 8) Colors are not equal in attracting people's eyes. As for the above, most colors produced by long wavelengths such as red and yellow are more attractive to colors than short-wavy colors such as purple and blue. Regarding colors that are in the student's preference for each level, small children will like bright, bright colors. Colors that are noticeable in the distance are white, yellow, and green. Attention of color learners that are next to each other, if they have the same brightness, will not be as interesting as using contrasting bright colors such as white on a black background.
- 9) Graphic material design should take into account the pattern of the lines that Have dimensions both vertical and horizontal rather than ordinary straight lines, vertical and horizontal shapes give a stable feeling diagonally or tilted to give a feeling of dynamic movement. Display the distance or boundary.
- 10) The space in the picture or on each displayed page, each page should be spaced appropriately. The content or image should not be packed too tightly. The use of dividing into columns may not be suitable for young children because of muscles. The movement of the eyes has not yet fully developed.
- 11) The perception of the size of the object seen is inversely proportional to the distance, objects that are closer to see are larger and distant objects see smaller, while the size of the object is relative to the background if the background is large, the object will look small.

To proposes enhancing users' recognition and memorable. The main aim of the general teaching process is to provide learners with the most effective learning, learning to be successful and must have a cognitive process as the first component and perception that Correctness is the cornerstone of learning. There are 4 Recognition is the connection between content acquisition to knowledge, understanding and memory. Educational institutions believe that teaching and learning materials the main components of teaching and learning as a medium for bringing content, content, subject content, text, images, concepts, but problem-solving avenues to learners. The channel, especially the way it is perceived, is the most important way, because most people use it in everyday life the most. Receivers from most visual perceptions, if they are well and quickly perceived, it will help the learning to be more effective. The eye is, therefore, a must for educators and educators to be aware of and use as a basis for message design and visual design. materials or other types of media that focus on the visual space so that the teaching and learning materials are of the highest quality.

5.3 Cognitive information processing methods

Atkinson and Shiftrin (1968) also mention the information processing will start, when the information is received though human brain via 5 sensations (sight, hearing, smell, taste and touch), there will be a process in order to convey the new memory to proper patterns of memories and wait to be recalled

for using. The steps are shown as below. First, sensory process will start when the brain has acknowledged the new information, the brain will not keep this it immediately, but it will transform the information to be in the form of codes. For example, when students hear what the instructors said, the brain does not memorize the voice, but keep as codes instead before transferring to the short-term memory (STM). The second process call storage process. It is to transform codes in short-term memory (STM) to long-term memory (LTM) where the brain will reorganize their storage in order to make new information coordinate well with the current memories and for conveniently recall in the future. For example, when noting the objects such as pens, glasses, dishes, erasers, bowls, pencils, and rulers, human brain will classify those objects into 2 groups. The first group is stationary (pens, erasers, pencils and rulers) and the second is container (glasses, dishes and bowls). Then the brain will memorize this information by Memory trace. The last process is retrieval process is the retrieval of the information that stored in LTM to STM. If the information that is recalled matches with the memorized, that means the information was permanently memorized. However, if they do not match, it means the information is forgotten. It can be said that the capability of information processing depends on the ability of the brain to store the data in LTM which has an influence on learning new experiences. Therefore, memory is considered as the basic elements in learning of every knowledge in the world. To sum up, memory presents itself as the connecting tool that links between cognition and user experience. More than 70% of human sensory can experience comes from the visual sense, and 30% from the other senses. This ability is very important for the cognitions and the competency of movement plans, Visual perception will be completed by the support of both perception and cognition as well as the past experiences of each person. It can be said that visual perception comes from the ability of brain improvement and the personal experiences in the past.

Chapter 6

Thai language system

Chapter 6 Thai language system

6.1 The meaning and importance point of language

Humans have always been interested in studying languages. They study the origin and also the rules for using language as communicating tool. Every language has its own rules which differ from the others ones. Even though researcher aim to study just some parts of a language, it is necessary that they should study and understand the others parts such as Phoneme, Word, Meaning, Native Speaker competence and etc., too. Therefore, in order to understand a language profoundly and do the research efficiently, researcher should better gain basic knowledge of that language as much as possible before they conduct the study strategies. Previous research indicated that to comprehend any language structures and rules clearly such as voices, grammars, sentence makings, word orderings and language patterns will help learners to approach the language level and gain more cognition which will lead them to be experts in that language.

Languages can be divided into 2 categories

- 1) Non-Verbal Language is a type of communication which is no writings or verbal actions included. It is the language which humans communicate by their gestures or feelings expressed on their faces or symbols which they agreed to understand with other members.
- 2) Verbal Language is a type of communication using writings and verbal actions to impart with each other's. Each society will create their own structures, patterns of voice and meanings which they agreed to comprehend among members in their society. Therefore, they can express their feelings, attitudes and also both concrete and abstract things by verbal language. This kind of language is produced systematically. It has rules and grammars which members in a society need to learn so that they can utilize correctly and properly.

6.2 Relevant Terminology

Syntax came from an obstacle or Prefix. "Syn-" means "to include or to participate". When "Syn" joint with "tax", the meaning of Syntax is about word ordering in a phrase, sentence and sentence structure. Trask, 1993 pointed out that Syntax is the branch of grammar dealing with the organization of words into larger structures, particularly into sentences; equivalent to the study of sentence structure. Language includes the ability to form phrases and sentences by gathering morphemes and words together. The part of grammar will represent speakers' knowledge of these structures and their formation is called Syntax. Syntax is the study of the elements and principles of sentence construction.

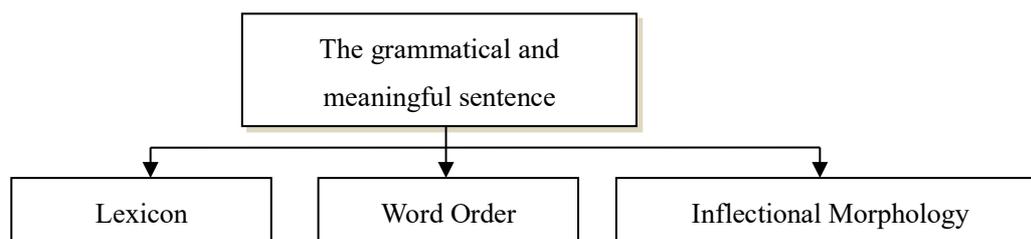


Figure 20 The component of syntax

According to the Figures 20, it can clearly be seen that if researcher would like to study Syntax, it is also necessary to understand Lexicon which is to study Words Classes. Moreover, it is also essential to comprehend Word Ordering as it is important for analyzing and making sentences so that those sentences will be created correctly in terms of structures, meanings and grammars. Regarding the meaning of Syntax mentioned above, its meaning and scope can be summarized that Syntax is the study of the relation among words in a phrase and sentence. Words will be gathered to form a phrase or a sentence using for communicating. Therefore, in order to complete this research, it is necessary to understand the relation of Syntax which is described as below.

- 1) Grammar is the rules of transforming the patterns of words to form a sentence. Grammar consists of 3 main parts; Syntax, Lexicon and Semantics.
- 2) Lexicon is vocabularies and phrases which have special usage and meaning. They also can be added Prefixes and Suffixes. Lexicon is also recognized to be used for setting grammars and structures of sentences as below.

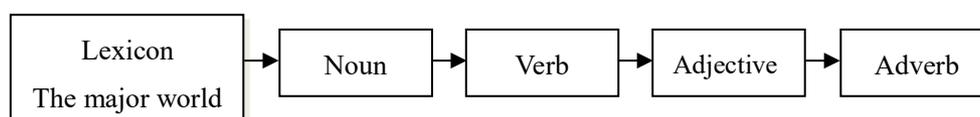


Figure 21 The element of lexicon

- 1) Morphology is the study of patterns and structures of Morpheme, the smallest unit of language grammar. Morpheme takes an important role that helps learners to understand the rules of sentence structures easier because when studying Morphology, learners need to study Inflectional Morpheme (the study of Function of Word in sentences), too. Therefore, Morphology study includes Sentence Level, Phrase Level, Word Level and the smallest level of language, Morpheme Level.
- 2) Semantics is the study of meaning not only for the meaning of vocabularies, but also the meaning of Morphemes which is used for connecting the meaning of words in a sentence.
- 3) Phonology is the study of voice system and to analyze the function of voice in languages in order to know how voice system operates.

- 4) Competence: Syntax rules come from the competence of native speakers. Speakers can know automatically whether word ordering in the sentence is correct or not. Word ordering between Thai and English are different as you can see from the example below.

(a) I went to school

(b) *went I school to

English native speakers can notice immediately that the sentence (b) is incorrect.

(a) เขาไปโรงเรียน (He went to school)

(b) *เขาโรงเรียนไป (He school went to)

Like English native speakers, Thai people also notice that the sentence (a) is correct and (b) is wrong. Hence, the meaning of Competence in term of linguistic can be referred as being an expert in one's own language. This ability of native speakers allows them to create sentences with grammatically correctness and the language they produce will be judged as the standard. Therefore, when linguists determine to study any languages, they will prioritize the competence of native speakers.

- 5) Performance is that when native speakers communicate their language in their everyday lives. In the real situation, there are possibilities that even native speakers can speak incorrect grammars. Even though they are considered as experts, there are some flaws and imperfections in their usage such as Slang language used on Social Medias. It is natural that language can be changed over time and some cases are changed following speaker's lifestyles.

6.3 Languages Typology

Languages in the world are classified into 4 patterns by morphological type as followings

- 1) Isolating Language is a language which each word consists of a single morpheme such as Chinese, Thai, Vietnam, and so on.
- 2) Agglutinative Language is the language that has a morphological system which each morpheme corresponds to a single lexical meaning such as Japanese, Turkish and so on
- 3) Inflected or Synthetic Language is the language that forms and suffixes can be changed following time and sentence structure such as English, Latin, Greek, and so on.
- 4) Polysynthetic Language is higher level of synthetic languages and composed with many morphemes in sentence such as Classical Ainu in Japanese or Eskimo language.

6.4 Word Order Typology

Languages are classified by typology for expressing the syntactic elements such as subject, verb, and object which includes 6 logical possibilities and over 75% of languages in the world appears that subject is set to be in the first position of the sentence.

Table 16 Structure of word order system

SVO	the dog	ate	my homework.
SOV	the dog	my homework	ate.
VSO	ate	the dog	my homework.
VOS	ate	my homework	the dog.
OVS	my homework	ate	the dog.
OSV	my homework	the dog	ate.

- 1) SVO is the most common word ordering which is used approximately 40% of world's languages found in English, Chinese, Vietnamese, Thai, Spanish, Russian, Swahili, and so on.
- 2) SOV is also a common word ordering which is used approximately 35% of world's languages found in Japanese, Korean, German, Georgian, Cherokee, Tibetan, Eskimo, Turkish, Lakota, Quechua, and so on.
- 3) VSO is found less than 25% which are Hawaiian, Classical Arabic, and so on.
- 4) OVS appears less than 1% Found in Caribe family of languages in the Amazon basin.
- 5) OSV is a rare word ordering found in Amazonian languages.
- 6) OSV is found less than 1% which are Xavante, Apurina and a few Amazonian languages.

The importance of Word order typology

- 1) To provide valuable grammatical information to languages for studying
- 2) To classify languages which are not appropriate for traditional classifications
- 3) To provide historical data which can be used to make cross-linguistic generalizations and reconstruct proto “mother” languages.

6.5 Thai Language

Thai Language is used by about 65 million people in Thailand and who are interesting to study in Thai language. Thai Language is closely with Lao, and northern slags are more or less mutually intelligible with Lao. Thai vocabulary includes many words from Pail, Sanskrit and some words are transcribed with foreign languages. Using foreign languages transcribing is widespread but still keeps the origin of Thai reading and writing form such as Computer, Fax and etc. Thai language is included in the group of Isolating Language which has a unique pattern called Single Word or sometimes known as Monosyllabic Language. The pattern is compound many syllables to form a complete word and sentence but still keeps the original form of each word. However, there is a change in meaning if the words switch their positions in a sentence. For instance, “Ants eat a fish” and “A fish eats ants”. The meaning of these 2 sentences is totally different because of the position switch. Moreover, the nature of Thai language does not have spaces in a sentence and words will be written continuously until the

end of the sentence that sometimes led to ambiguity. For instance, the same character in one string was analyzed words in different meaning. Occasionally, Thai reader read all along the sentence until they find out what those words really mean or use the influence of final consonant to separate words. Word separation is the basic procedure of natural language processing for analyzes voices, for example, when a human communicates with other people, the word will be analyzed by cognitive processing that help listeners to understand the correct meaning and purpose of the speaker. In the same way, it also benefits for reading processing because it will help reader to understand easier and to develop the cognitive processing to identify words and meaning for reading passages in papers or screens. For that reason, word separation also important to identify words and meanings in Thai language in order to develop the skill to separate words as faster.

6.6 Thai language characteristic

- 1) Thai language consists of 44 consonants which 21 are initial consonant sounds and 32 are basic vowels written in number of position that relates to consonant. (Upper, Lower, Front and Back). Furthermore, the vowel is pronounced after the consonant regardless of the visual orientation of the graphemes.
- 2) Thai language is a single world language and each word has a complete, self-contained meaning and sometime has several meaning (homophone and homograph)
- 3) Thai language does not have spaces in a sentence and words will be written continuously until the end of sentence
- 4) Thai syntax is SOV category. (Subject + Verb + Object)
- 5) Word ordering in Thai language is very important because it relates to the change in meaning in case words are ordered in the wrong positions.
- 6) Thai language has space as punctuation for both writing and speaking. Thus, if the space is put in the wrong position, it will affect to the meaning as well.

“อาหารอร่อยหมดทุกอย่าง” means to all dishes are so delicious!

“อาหารอร่อย-หมดทุกอย่าง” mean to Delicious dishes are all run out.

- 7) Thai language does not have verb inflection. Tense can write only word “will” and “already” at the beginning and the last of sentences respectively.

Table 17 Verb inflection in Thai language

Present	I go to school
	ฉัน ไป โรงเรียน
Part	(Yesterday), I went to school
	เมื่อวานฉัน ไป โรงเรียน(แล้ว)
Future	(Tomorrow), I will go to school
	พรุ่งนี้ฉัน(จะ) ไป โรงเรียน

6.7 Thai Consonant

Thai consonants are classified into three classes include with middle consonant, high consonant and low consonant, that help to identify the tone of a syllable. The sounds represented by some consonants change when they are used at the end of a syllable and some consonants can only be used at the beginning of a syllable. When 2 consonants are written next to each other, it often causes errors in reading if readers are unable to classify which consonant performs as a final consonant or an initial consonant. For example, “ตากลม” and “ตากลม”, these 2 words are totally the same. However, if we analyze in detail about consonant “ก”, it can be classified into 2 words and 2 meanings. If “ก” is considered as an initial consonant, it will be pronounced as Ta-Krom which means “big round eyes” but if “ก” is considered as a final consonant, it will be pronounced as Tak-rom which means “to expose to the wind” Sometimes readers cannot understand the sentences correctly. For example, “เห็นตากลมอยู่ริมชายหาด” it can be (A) He is standing with wide eyes at the beach, and (B) He is standing at the beach, exposing to the wind. After considering the context of the sentence, (B) has more possibility to be correct. As a result, readers need to pay attention in observing final consonants in order to prevent the misunderstanding. Beside the multifunction of consonant which can be both consonant and final consonant, the same consonant can be pronounced differently when it changes its position. For example, “บน” (Bon) means “Up” and “กบน” (Kop) means a frog. Although, these 2 words use the same consonant but when the position of “บ” changed, it also effects on the pronunciation.

Table 18 The comparison differing in function of final consonant

Symbol	Initial consonant	Final Consonant	Class	Symbol	Initial consonant	Final Consonant	Class
ก	k	k	M	น	n	n	L
ข	kh	k	H	บ	b	p	M
ค	kh	k	H	ป	p	p	M
ค	kh	k	L	พ	ph	h	H
ค	kh	k	L	ฝ	f	f	H
ฆ	kh	k	L	พ	ph	p	L
ง	ng	ng	L	ฟ	f	p	L
จ	j	t	M	ภ	ph	p	L
ฉ	ch	ch	H	ม	m	m	L
ช	ch	t	L	ย	y	y	L
ซ	s	t	L	ร	r	n	L
ฌ	ch	ch	L	ฤ	rue	-	-
ญ	y	n	L	ฤๅ	rue	-	-
ฎ	d	t	M	ล	l	n	L
ฏ	t	t	M	ฤ	lue	-	-
ฐ	th	t	H	ฤๅ	lue	-	-
ท	th	t	L	ว	w	w	L
ฒ	th	t	L	ศ	s	t	H
ณ	n	n	L	ษ	s	t	H
ด	d	t	M	ศ	s	t	H
ต	t	t	M	ห	h	h	H
ถ	th	t	H	พ	l	n	L
ท	th	t	L	อ	**	*	M
ธ	th	t	L	ฮ	h	H	L

Chapter 7

Review of Literature

Chapter 7 Review of Literature

To understand core concept of development on Thai user interface design, Previous research indicated that cognitive information process can be a key to solve user interface design problem in Thailand. Therefore, to understand truly about the objective of this study, this chapter proceeds upon the means that review previous studies and select the relative studies in order to determine the guideline to create own user interface in Thai electronic industry.

7.1 Collins, A. M., & Quillian, M. R. (1969) Study

7.1.1 Retrieval time from semantic memory. *Journal of verbal learning and verbal behavior*

In order to improve and design user interface to develop cognitive process in Thai language on electronic and electrical product, this study will present the previous research of Allan M. (1969) to be a guideline for improving methodology of this research. Allan M. (1969) presented retrieval time from semantic memory by taking simulation model for storing semantic information in a computer memory presented by Quillian (1967) to evaluate Retrieving information time in person. This experiment stimulated that a person has only 3 levels of information that show as developed model of Quillian (1967), this information were stored on each of the nodes.

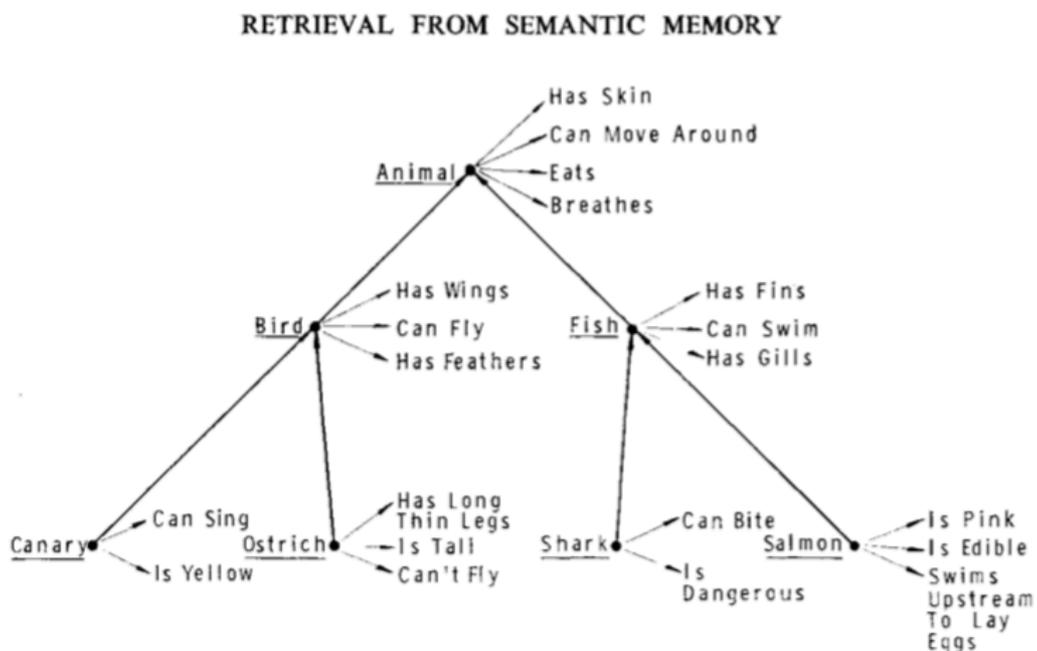


Figure 22 Illustration of the hypothetical memory structure for a 3-level hierarchy

During the processes of Retrieving information to make decision “A canary can sign” must start from node canary, then retrieve the 2 properties which are A canary “can sign” and “is yellow” that has been stored and checking the related result. After that, to judge whether “A canary can fly” human needs to move up one level to bird before the person can retrieve the property about flying.

Therefore, the person should require more time to decide that “A canary can fly” than decide that “A canary can sign” Similarly, a person should take some time to decide that “A canary has skin” because this fact is understood as animal, which is next step from canary. Moreover, sentences that contain node’s superset such as “canary is a bird” or “A canary is an animal” should take different time to judge depended on the number of levels separating the memory nodes they talk about. To inspect the processes of retrieve information in semantic memory, this research has 3 hypotheses

- 1) To retrieving a property from a node and moving up a level in a hierarchy take a person time.
- 2) The time to retrieving a property from a node and moving up a level will be additive. The spent time depends on the finishing time of previous process. It can be said that when moving a level is followed by moving up another level and when moving up a level is followed by retrieving a property at the higher level.
- 3) The time to retrieve a property from a node is independent of the level of the node, although different properties may take different time to retrieve from the same node.

	Sentence type	True sentences	Sentence type ^a	False sentences
Expt 1, 2-level	PO	Baseball has innings	P	Checkers has pawns
	P1	Badminton has rules	P	Ping pong has baskets
	SO	Chess is chess	S	Hockey is a race
	S1	Tennis is a game	S	Football is a lottery
Expt 1, 3-level	PO	An oak has acorns	P	A hemlock has buckeyes
	P1	A spruce has branches	P	A poplar has thorns
	P2	A birch has seeds	P	A dogwood is lazy
	SO	A maple is a maple	S	A pine is barley
	S1	A cedar is a tree	S	A juniper is grain
	S2	An elm is a plant	S	A willow is grass
Expt 2, 2-level	PO	Seven-up is colorless	PO	Coca-cola is blue
	P1	Ginger ale is carbonated	P1	Lemonade is alcoholic
	SO	Pepsi-cola is Pepsi-cola	SO	Bitter lemon is orangeade
	S1	Root beer is a soft drink	S1	Club soda is wine

^aThere were no distinctions as to level made for false sentences in Expt 1.

Figure 23 The test stimulus sentences contain true and false sentences equally

Therefore, to prove this hypothesis, the researcher will set up sentences that state property relation (P sentence) and state superset relation (S sentence) by fixing “A canary can sing” as PO sentence, “A canary can fly” as a P1 sentence and “A canary has skin” as a P2 sentence. Similarly, “A canary is a canary” would be a SO sentence, “A canary is a bird” would be a S1 sentence and “A canary is an animal” would be a S2 sentence. Reaction time (RT) was used to measure retrieval time from semantic memory by deciding which sentences are true and which are false. It is believed that the increase in time from SO to S1 should be the same as from PO to P1 since both increases are a result of moving from level O to level 1. Likewise, the time increase from S1 to S2 should equal the time increase from P1 to P2. Therefore, the hypothesis is that the increasing time must be the same (from PO to P1, P1 to P2, SO to S1, and S1 to S2). The tests will have true and false sentences equally. This research was divided into 3 experiments. In each part, it included 8 participants who had no idea about the nature of the experiment. The stimulus sentences were displayed on the cathode ray tube, and the time and recording of response in each participant were recorded under program control. The participants were asked to sit in front of the cathode ray tube. Both point fingers standby at the button located on the left and right. The response occurred when it detected $\frac{1}{4}$ movement of Microswitch. The sentence appeared on the cathode ray tube for 2 seconds interrupted with a blank page before the next page was shown. Participants had to press one button if the sentence was generally true and press another button if the sentence was generally false as accurately and quickly as possible. Participants had to make their decision within 4 seconds. Sentence types were separated into 2 kinds of semantic hierarchies which are 2 levels and 3 levels of semantic information sentence. The system randomly showed true and false sentences. The sentences contained 2 general kinds; property relation (P), and superset relations (S).

- a Experiment 1 includes 2 level semantic hierarchies for 128 sentences and 3 level semantic hierarchies for 96 sentences*
- b Experiment 2 includes 2 level semantic hierarchies for 128 sentences which totally different from the experiment 1*
- c Experiment 3 includes 3 level semantic hierarchies for 96 sentences which duplicated with experiment 1. This required another group of participants and never attended participants in experiment 1 and 2.*

Category names for each S1 and S2 sentence were created by required 2 persons for generated data for instance, “Tennis is _____” $\frac{3}{4}$ of answers gained from them were set as Category name of this experiment. Verbs generated in properties sentence were “is”, “has” and “can”. After the verb “is” must be followed by adjective, after the verb “has” must be followed by noun, and after the verb “can” must be followed by verb. Moreover, PO sentence was chosen that had a property which was clearly

identifiable information. This experiment fixed that generated P1 or P2 needed to bring out the most important property and fixed that all verb must be only “is”, “has” and “can”. For example, “rule” was deemed to be the most important property for “game”. To judge whether badminton has rules or not, the correct process of retrieve information was to think consider that badminton is a game and games have rules. Therefore, badminton have rules is true. In experiment 1 false sentence were divided between superset and properties. The false sentences in experiment 2 were additional restriction of verb. The properties of the false PO sentences were selected to contrast a property of the instance. Furthermore, the result of experiment 3 shown in table 1, “Coca-Cola” is “blue” contrast a property of Coca-Cola, which is brown or caramel-colored. In contrast, the properties of false P1 sentence were selected to contrast a property of the superset. In addition, the relation of false SO and S1 sentence can be described by Fig1. The false SO sentences occur by informing that one instance of a category was equal to another, such as “A canary is an ostrich.” The false S1 sentence was created by selecting a category one level up from the instance, but from a different structure, such as “A canary is a fish”. The research of Allan M. indicated the experiment result of the word Mean of reaction time only correct responses data. In addition, in order to explain the relation of time related to retrieve information, the research divided results into 1. Deciding a sentence is true and 2. Deciding a sentence is false consecutively. The average time of 3 experiments were shown in Fig. 24

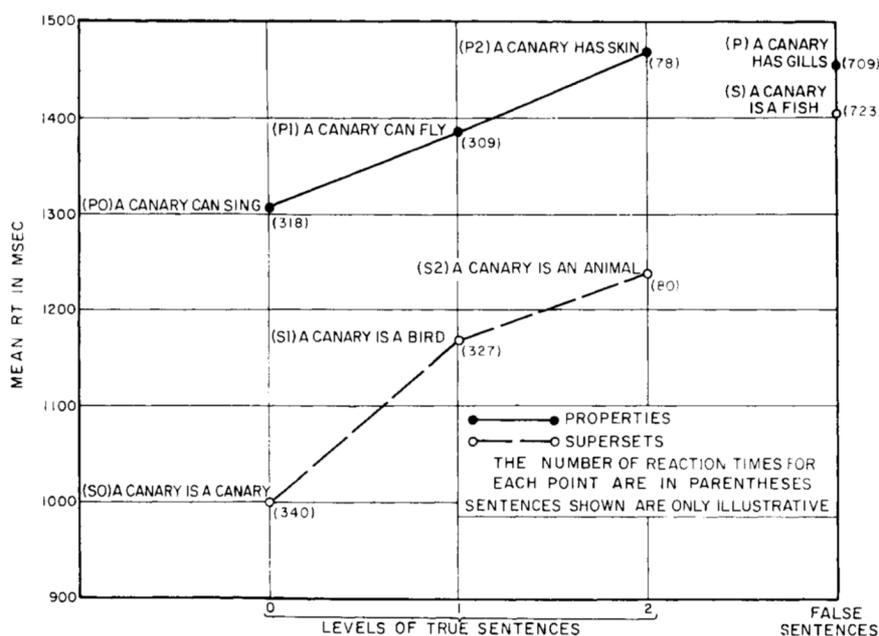


Figure 24 Average reaction times for different types of sentence in 3 experiments

7.1.2 Deciding a sentence is true

To evaluate the results, the analyses of variance were divided to 2 separate as 2-level run and 3-level run. For The 2-level data shown the different between P sentence and S sentence were significant, the difference between level (PO, P1 and SO, S1) was also significant but the interaction data not quite significant. For The 3-level data shown the different between P sentence and S sentence were significant, the difference between level (PO, P1 and SO, S1) were also significant but the interaction data not significant. The previous hypothesis indicated that reaction time for PO, P1, P2 sentence and SO, S1, S2 sentence should be same and being a parallel Reaction time curve line. However, the result of PO time ended up differently from the expectation. Due to the confusing of some participants when running sentence on the CRT at one time, they did not understand the purpose of sentence and it caused error for this experiment. To sum up, Allan M. informed that time to move from node to superset spent totally 75 msec. It can be said that the average reaction time came from retrieving information from PO to P1, P1 to P2 and SO to S1, S1 to S2. Moreover, the difference in average timing among S1 and P1 and between S2 and P2 were 225 msec. in average. It was the actual time that spent in retrieving a property from the node in each level. It can be summarized that processes of retrieving information in computer can find properties at a node before moving up one level to its superset. Therefore, the average time 75 msec. was the time that spent for 2 processes which are time for searching properties and time for moving up to the super set.

7.1.3 Deciding a sentence is False

Human has various strategies to judge whether any sentences are true or false. In the hypothesis, human judge something as false when finding some contrast in their memories. For example, if logo Coca-Cola is blue, participant will find some connection in their memories. When they find out that a property of Coca-Cola logo is brown or caramel-colored, it contradicts the sentence. Therefore, to prove the conflict in the hypothesis of Allan M., research created false sentence in experiment 2 and assumed that reaction time should increase from PO to P1 found for true sentence might also be found for false sentence. The result showed that the reaction time increase 7 msec. Similarly, false SO sentence should produce faster time than the false S1 sentence due to the lower number of properties in SO sentence comparing to S1 sentence. Moreover, this experiment also assumed that participants tried to connect their memories to subjects and predicate of the sentence. For instance, the patch “canary -> bird -> animal -> has skin” connects the two parts of “A canary has skin”. When they found the connection path, they will consider whether it related to the sentence or not. After participants checked to a certain number of levels all connection found having been rejected, the participant will then response false. Moreover, under this hypothesis, the time for false sentence will be longer and highly variable depending upon how many connective paths the participants have to check out before

rejecting the information. For instance, “Gin is wet”, the participant might path a connection between “gin” and “wet” through the path “gin is dry” and “dry is not wet” participant will reject and consider that this sentence is not true. However, if studied deeper connection, the participant will find the patch “gin is liquor”, and “liquor is liquid” and “liquid is wet” and it meant this sentence is true. The important point of this finding wants to emphasize is that even though a contradiction can be used to reject a path, it cannot be used to the truth of information. In addition, Allan M. mentioned the process to decides that an information is false dose not seem to be very simply.

In conclusion, Allan M. indicated that, a computer system was created and designed to keep and store semantic information. To keep general information with superset nodes can save more budget than keeping as individual nodes. However, the mentioned storage system costs in wasting more time to process retrieving information. When the model was applied for human using well-organized hierarchies that were part of the culture, there was an agreement between the predictions and the data. There is no clear image about how people judge which statements are true or false. The current hypothesis only assumes that people have to spend time checking out all interpretations that may be possible. In addition, other reaction time is also observed and made prediction in such hierarchies. For example, if participant is asked to judge which animals are considered as common category what common category. The reaction time should show supersets that participants have to make the decision. (need to judge between fish and bird, Vs shark and bird, Vs shark and canary).

The reaction time should be parallel. Moreover, if using a path in retrieval to increase its accessibility temporarily, then they would expect that to understand “A canary is bird” will be spent less time than to understand “A canary can fly” and “A canary can sing”. There are many related experiments which the results were pointed out more precisely on the structure and processing of human semantic memory.

7.2 Gärdenfors (2011) Research

7.2.1 Semantics Based on Conceptual Spaces

The study of Gärdenfors (2011) use conceptual spaces to model the semantics of natural language. In particular, it looks at how he sought to develop a theory of conceptual spaces to provide a semantic framework that is superior to traditional models. To do this, Gärdenfors included the crucial elements of actions and events in the theory. These elements are the key components for many basic sentences and were not factored into previous models. Gärdenfors' theory also models nouns, adjectives, prepositions, and verbs in the conceptual space, thereby allowing word classes to be explained in terms of cognitive mechanisms.

7.2.2 Conceptual Spaces

A conceptual space has three spatial dimensions: height, width and depth. Within this space are various geometric shapes that represent the “quality dimensions” of a particular word. For example, some of the quality dimensions for the word apple are its shape, color, texture, and taste. Whereas, for other words the quality dimensions may be non-physical in nature, such as an emotional state like happy or sad. Once the various quality dimensions have been chosen for a word they can be modelled as shapes. For example, the quality dimensions of color are hue, brightness and saturation; these can be modelled as three shapes in the conceptual space. Hue is represented as a circle that contains all the colors in a standard color wheel style layout. While saturation and brightness are simply lines in the conceptual space that represent the varying degrees of saturation and brightness. The individual points that make up these geometric shapes are specific values for the different quality dimensions. Therefore, the word “green” can be represented by three single points in the conceptual space. One point will be located on the hue circle, a second point will be located on the saturation line and a third point will be located on the brightness line. In this way, words can be represented as objects consisting of a set of points on one or more geometric shapes. This allows a word to be analyzed by looking at the positions of its points in the conceptual space. It also allows the similarity of words to be compared, since the points for words that a similar will be spatially close in their respective quality dimension shapes. Furthermore, Gärdenfors proposes that to analyses an action or event it is essential to include forces as quality dimensions. These force dimensions can be physical, such as push and pull, or abstract, such as psychological or social forces. Quality dimensions can be grouped into two: integral or separable. Integral dimensions are those where when a value is assigned to one of them a value must also be assigned to another dimension. In a sound for example, the pitch dimension must also have a loudness dimension. Dimensions that and not integral are known as “separable”, since their value can be set without involving another dimension. However, separable dimensions can still be affected by other dimension, for example the color of fruit can vary with its ripeness dimension. Sets of integral dimensions that are separable from all other dimensions are known as “domains”. The color domain, for example, consists of the integral dimensions of hue, saturation, and brightness. Whereas the taste

domain consists of the sweet, sour, bitter, and salty dimensions. In Gärdenfors' model, adjectives represent properties (usually in a single domain), nouns are clusters in the conceptual space (usually involving multiple domains). Verbs can be modelled and analyzed in the force domain since they are action based and therefore cause (force) the modification of a word's parameters.

A conceptual space is therefore made up of a range of domains. Domains are important because they allow for the definition of properties and concepts. A property is a convex region of space in a single domain, and concepts are collections of properties in one or more domains. The "apple" concept, for example, has a strong link between sweetness in the taste domain and sugar content in the nutrition domain. However, it has a weaker link between redness in the color domain and sweetness. Furthermore, if two objects located in a conceptual space are part of a concept, then any object positionally between them in the conceptual space will also be part of that concept. The use of conceptual spaces and domains allows for inferences that cannot be made with other theories in psychology and linguistics, such as frame theory or prototype theory. This is because the geometry of the conceptual space allows for links between words to be more easily seen by examining the position of the points that define words in the space.

7.2.3 Actions & Events

Actions can be represented by the pattern of forces that generate an action. For example, the forces involved in walking are simply a person pushing on the ground in a certain pattern. Therefore, if the force strengths and directions are known it can be determined whether a person is running or walking. Gärdenfors postulates "the fundamental cognitive representation of any action consists of the pattern of forces that generates it". This includes representing non-physical actions, such as crying, using psychological forces, such as sadness, instead of physical forces. An action category can be represented as a convex region in action space, similar to the way that properties are a convex space in a domain. This allows Gärdenfors conceptual space model to become a tool for analysing the dynamic properties of actions. It also allows for the investigation of similarities between actions by examining their point positions in the conceptual space. For example, the points on the geometric shapes representing quality dimensions in a conceptual space will be closer together for running and walking than for running and throwing.

Gärdenfors created a two-vector model of events that represents them as complex structures in the action space involving an "agent" and a "patient". These are material or non-material objects that can also be represented as points in the conceptual space. An agent is an animate or inanimate object that causes an event to happen, independently of other events. The agent is represented by an action in the force domain that is created by a pattern of forces, these cause the properties of a patient to change. The action of an agent can be bounded, with a fixed start and end, or unbounded with no set limits. For example, walking can be an unbounded action that creates an event which is an on-going "process". The agent's location can also be assigned by including a physical space domain. This can

be used to define when an agent is also the patient, such as in walking, where the force comes from the person themselves, in this case the position in space of the agent is the same as the patient. The patient can be an animate or inanimate object, it can also have an emotional state and a force vector. In the case of a patient the force is a counter-force to the action force. For example, an agent can push on a door using an action force, while a door can resist opening if it is locked by a using a counter-force. As shown in this example the force can be without intention, in the case of a closed door, or it can be with intention, if a person was pushed and consciously resists. This process can be expressed as a simple force vector equation: $r = f + c$. Where r is the resultant force vector, f is the agents force and c is the counter-force of the patient. Therefore, an event is simply the mapping between an action and change in a patient space due to r . Events are a very important because the basic components of a sentence are typically a subject, object, and verb (action), and the combination of these results in an event. In Gärdenfors model, these three are represented by the agent, patient and force vectors. Therefore, by mapping the differences between these as they change in a conceptual space Gärdenfors is able to describe the semantics of events. Previous frameworks have used only image schemas where words are represented as mental pictures in a spatial structure. Gärdenfors model improves on these by taking into account qualitative dimension and factoring in the very important aspects of actions and events.

7.2.4 Conclusion

Gärdenfors innovative approach of using conceptual spaces to model the semantics of natural language provides a more comprehensive framework than previous models. The wide array of quality dimensions that can be used to represent words as geometric objects allows for incredible flexibility when modelling words. The grouping of dimensions, properties and concepts provides a rich toolset that can be analysed mathematically by mapping changes in position on within the conceptual space. Gärdenfors inclusion of forces by using a two-vector model to describe actions and events is crucial to a complete understanding of language. Moreover, Gärdenfors use of agents, patients, and forces to represent subjects, objects, and verbs is a significant step that provides the basis for a complete theory of semantics.

7.3 Quillian, R (1967) Research

7.3.1 Computers in Behavioral Science, Word Concepts: A Theory And Simulation Of Some Basic Semantic Capabilities

In order to understand the Basic Semantic Capabilities, this paper summarizes the work of Quillian (1967) about computer models based on the structure of human memory that are used to simulate human-like language behavior. To do this, the complex relationships between words and the way that they are retrieved from memory needs to be included in the model. This process is not as simple as merely defining the words, as would be the case in a dictionary, it requires that an extensive network of associated words be considered so that the meaning of sentences can be determined. Additionally, the relative strength of these associations between words needs to be factored into the model so that a more accurate representation of actual human memory processes is produced. To simplify this complex process, the model is only designed to include factual information, and does not include “feelings” about words or other human-like emotional considerations. Therefore, the model aims to define only the structure of memory, and its retrieval process, rather than being a complete model of all factors involved in memory and language such as physiological factors and personal experiences with words.

7.3.2 Concepts

To simulate human style memory, a “model memory” is created that can be used in a computer program to determine the meaning of words. This model memory is built up by recoding information from a dictionary into a complex network of elements and interconnected associations. Each word in the model memory is represented by a node. These nodes are separated into individual planes, where each plane has one patriarchal word called a “type node”, and multiple “token nodes” which are words that represent the meaning of the type node word. The token nodes in each plane are words that help to define the meaning of the patriarchal word for that plane. Additionally, all planes are linked to other planes via their token nodes, and the links have varying strengths depending on the closeness of the association between the words that they link. In this way, a complex network of words and links to associated words is created, so that the meaning of a one word can be determined by looking at all the related words in their network. To process a sentence, the meaning of each word needs to be determined one by one by looking at the associated words in its own plane and the planes that it is linked to by the token nodes. These associated words are then also processed to look at the words they link to on other planes. In this way, a hierarchical tree of increasingly remote meanings for the original word is built up. This large dataset of meanings forms the ingredients that are used to determine the actual meaning of each word in the sentence. In real world terms, it can be thought of as asking a person to look up all the definitions of a particular word, and then asking them to also looking up all the definitions of those definition words, and so on. This means that a huge amount of words needs to be considered down the chain of links. The complexity of the problem is increased since some words

have several meanings that depend on the context of a sentence. For example, the meaning of the word “plant” could mean “a living organism” or “a building with machinery” or “to put something in the ground”. This means that the word plant should have 3 separate planes in the model, with each plane representing a different meaning of the word. Therefore, when the model is used to understand a full sentence it needs to use a temporary placeholder in the process until it can determine which of the three meanings for “plant” should be used.

Figure 25 below shows the three planes in the model memory that represent the meaning of the word “plant”. The type node (plant) is shown in the top left of each plane. This is linked to the token nodes for the three different meanings of the type node. The connections between nodes can be conjunctive (AND) or disjunctive (OR). The dotted links represent associations between token nodes on a plane and token nodes on the plane for other words in the model memory.

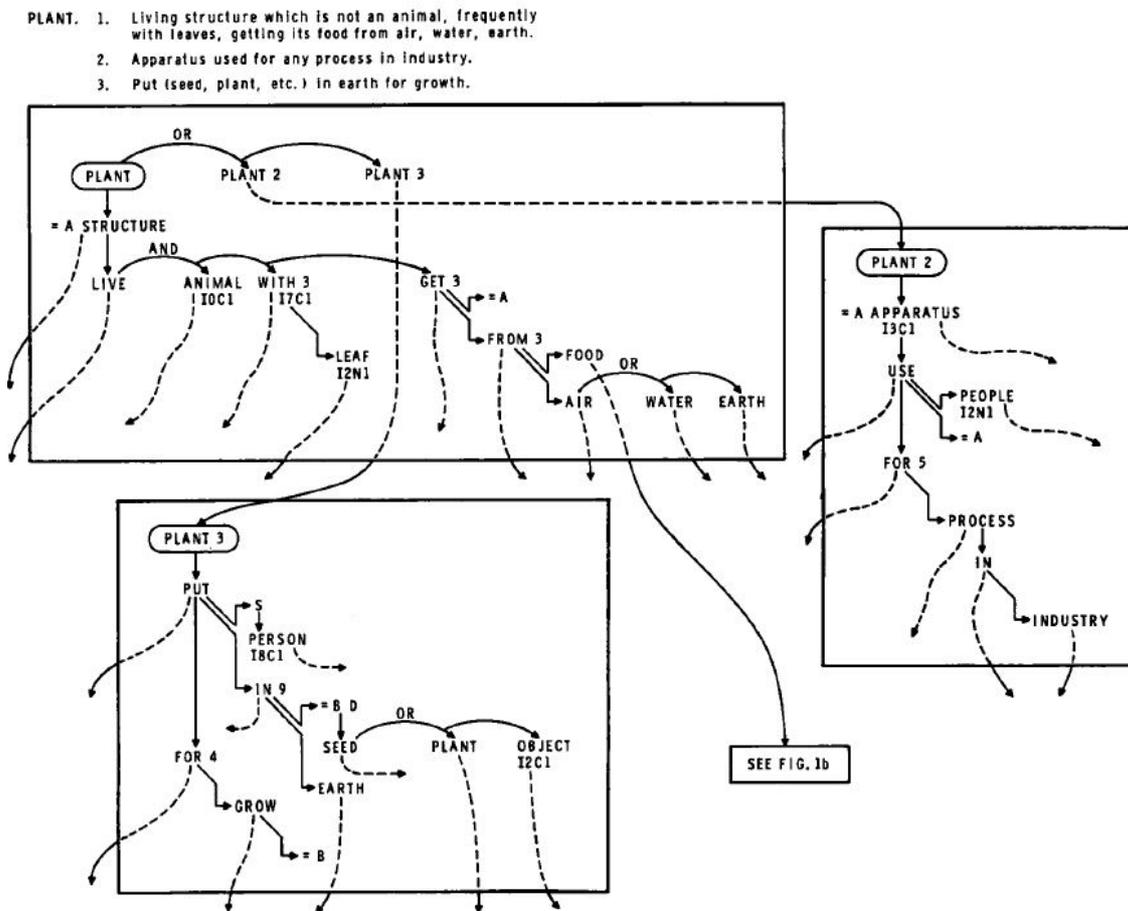


FIG. 1a. Three Planes Representing Three Meanings of “Plant.”

Figure 25 The three planes in the model memory (Quillian, 1967. p5)

When creating a plane from the various definition sentences certain words are ignored. For example, words such as "a, six, or, is, and very" as well as all grammatical inflections are not turned into tokens on the plane. Additionally, all pronouns and words that refer to previous words in the definition are replaced by explicit references to the earlier words. This referencing is shown in the diagram by the symbols "= A" and "=B". Furthermore, certain nodes on a plane are marked as being variable parameters. For example, the letter "D" is the parameter symbol for a direct object, such as "seed". The letter "S" is the parameter symbol for a subject, such as "person" is the subject in plane 3 of the diagram.

7.3.3 Methods

In programming terms, the nodes in the model memory should be thought of a "property", and not actual words or visual representation of things. These nodes (properties) have variables (attributes) with a range of values that represent the strength of the links it has to other nodes in the model memory network. In this model of semantic memory there is no predetermined hierarchy of superclasses and subclasses, therefore any word can appear in any plane or position within a particular network. The method that is used to test the model has four parts. Firstly, the program compares and contrasts the meanings of two words using semantic information in the model memory. The program then outputs an answer in the form of a sentence, without caring about being grammatically perfect. A fluent speaker is then given the same two words and also asked to compare and contrast them and give the answer as a sentence. Finally, the experimenter manually compares the two results to see if the machine's answer has the same basic meaning as the human answer. If incorrect, then part of the program or the model memory structure it uses is revised, and further tests are performed to see if the result improves. This test-correct-retest cycle is a standard research method for error correction. The process is run using the Information Processing Language (IPL) and involves three separate programs. The first program transforms input data (definitions) into IPL form and links them to create the network of nodes. The second program compares and contrasts the two words and outputs the result as a combination of nodes and links. Then the third program uses that output to generate a sentence in English that expresses the meaning of the two words.

7.3.4 Results

The program was tested on very small model memories built from only 50 to 60 word definitions (approximately 5,000 IPL cells). This meant that when the program searched for the meaning of a word, the proliferation down the chain of associated network nodes terminated early when no definition could be found for a word in the chain. However, even with this limited amount of information the program could almost always successfully produce a meaningful sentence. For example, when the model was use to compare and contrast the words "Earth" and "Live" it produced

the sentence “Earth is planet of animal”. Apart from the grammatical errors, that were expected, the result still has the correct meaning. A human test subject in the same experiment might answer “The Earth is a planet that has animals living on it”. In that case, the experimenter would conclude that the results matched and therefore the model was successful.

The results demonstrated that four assumptions can be made regarding memory models for word concepts and meanings. Firstly, the network of links between a word and its possible meaning is potentially very large, since one word is associated with many other words. Secondly, the way that meaning of a word is determined can be found from many different paths through a network of associated nodes linked to that word. Thirdly, this method of using a large network of nodes and paths gives flexibility when defining the meaning of words. This allows for much more expressive and varied responses from the model, compared to simple dictionary definition. Finally, the words within the model should be represented as properties to give them the flexibility to simulate human memory by allowing varying strengths between associated words.

7.3.5 Future Research Suggestions

Larger memory models should be tested in the future that contain definitions of all the words in the English language. This will allow a complete network of nodes to be built up for any word without early termination of the propagation down the node chain. Additionally, improved dictionary definitions can be used that are broader and include more “clue words” which can help define the likely concepts of a word. Furthermore, psychological elements could be factored in based on existing or future psychology theories about how memory works. This is required so that the subtle, unconscious processes involved in real human memory retrieval are better understood and accounted for in the model memory. Moreover, the memory model can be used to test other memory dependent functions that are not language related, this may help give insights in the functioning of the brain and how it can be successfully modelled in a computer program.

7.4 Ikeda (2011) Research

7.4.1 A Visual Ergonomic Study on the interface design based on the cognitive characteristics of text information

Ikeda (2014) Investigated Language information processing has direct relation to Semantic access (cognitive processes) It used Character form and Phonological information processing to be able to understand Visual Character. When reading, Character Characteristic will be used for indentifying the word and Phonological information processing will perform as a stimulus which helps readers to read faster. Eye-tracking experiment is one of the techniques which is helpful for investigating the cognitive information processing that can help readers to separate words in the sentence. The test has been done in Thai language which is categorized in the group of Isolating Language. Even though it is included in different group of language, in terms of Morphological processing, Phonological processing and Cognitive processing, Thai language is similar to others groups. Generally, Morphological characteristics is like the Visual Point used for indentify words. For example, English separates each word by spaces. Therefore, researcher made an assumption that in Thai language, observing of Tone mark can help reader to separate words like the function of spaces in English. That in Thai language, observing of Tone mark can help reader to separate words like the function of spaces in English.

7.4.2 Experimental method

The experiment analyzed participants' eyes movement via Free View device. They were asked to sit on chairs with 120cm. away from the screen and read variety of sentences. Experimental equipment and experimental landscape are shown as below figure.

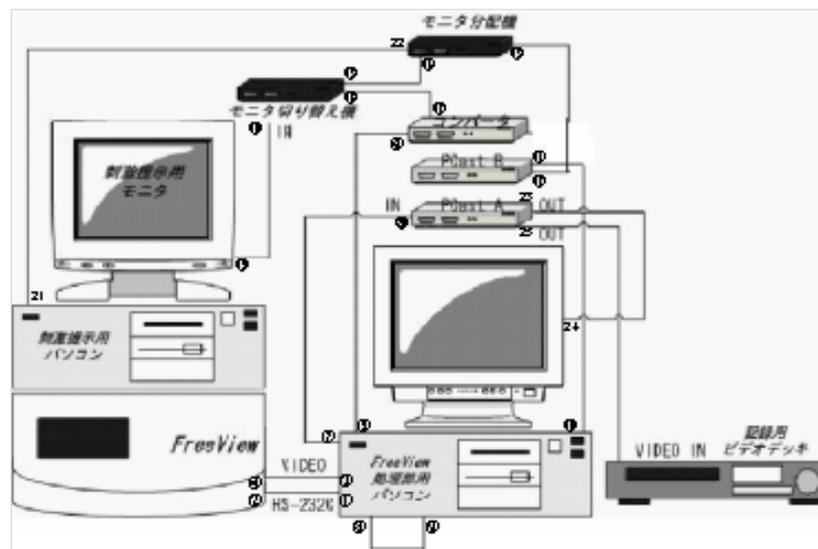


Figure 26 The equipment and experimental landscape

Stimuli were used in this experiment for analyzing the complexity of grammars and the levels of vocabulary were arranged by easy, intermediate and advanced. For the easy level, participants will be tested by the textbooks of 3 grade student. For the level of intermediate and advanced, they will be tested by novels and academic articles or papers respectively.

7.4.3 Problem analysis

To analyze an assumption was conducted following the standard of cognitive processing steps which are Morphological processing, Phonological processing, Cognitive processing. During the experiment, researcher found and pointed out some results of the Morphology test and the cognitive stimulating of Tone that some results turned out to be different from the assumptions. However, for the result of eyes movement, it showed that eyes always focused on the final consonant so it can be proved that final consonant is very important for cognition of Thai language.

7.4.4 Result

The result indicated that eye tracking measurement on Thai language showed that eyes would concentrate to the final consonants in order to identify words.

7.5 Fujiera (2011) Research

Researcher made the assumption of this research that human has competence in understanding the meaning of word (languages) by observing images (alphabets). Therefore, they conducted the eyes movement measurement in order to analyze the relation of meaning cognition by Visual fixation. If the meaning cognitive processing relates to Visual fixation, researcher can refer the result as the evidence to prove that Visual fixation helps readers to relate images with the meaning of words. As Katagana and Kanji were considered having different cognition, there was an assumption that the result of Visual fixation will be different, too.

7.5.1 Experimental Method

When observing the Word target and try to find the related meaning from the image, the measurement of eye movement began in order to analyze the result of Visual fixation cognitive processing. To process the cognition via Word Target presented as the form of Katagana and Kanji, word identification will help to identify the meaning and then link the meaning to the image which had related meaning with the word target (Yee & Sedivy,2006). The result showed that different alphabets also affected on the difference in eye movement. The experiment was conducted by preparing 2 set of vocabulary (Katagana and Kanji) with 12 words per each (ratio of the relation is Katakana: 3.9, Kanji: 4.0) concerning the frequent of Subjective writing. Refer to Ukita (1996), the word target of Kana was chosen from foreign language which was often written in Katagana. 4 images will be used for each test which half of them came from 2 set of vocabulary with totally different in meaning and pronunciation. (called Non-related image). The example of the first test can be seen as below (Test of matching the meaning which relates to Kanji)



Figure 27 The experimental stimulus

Word Target indicated the relation between the images of ashtray and cigarette; whereas the others 2

images, arm and pumpkin, did not concern with the Word target at all. Participants were requested to comply the test by choosing 1 word that relates with the Word Target. Meanwhile, researcher recorded the time since the images appeared until participants finished choosing the answer. The results were evaluated into 2 portions which were the relation of the meaning and time spent for answering each question. The patterns of the test were described as below.

1) The test with no condition control

This pattern showed non-related images and participants had to choose an image which the meaning matched with the Word Target.

2) The test for finding the relation in meaning

This pattern showed images which one of them had the meaning relates to Word Target.

3) The test with non-related meaning

This pattern showed the images which the meaning did not match with any of Word target. Refer to the summary of the test, participants spent longer time to answer when using Visual fixation. Therefore, it can be assumed that Visual fixation had an effect on word target cognition processing. Moreover, after analyzing Visual fixation graph intensively, researcher also found that there was a method of prioritizing in processing of Kana and Kanji. The main purpose of the second experiment is to analyze the different in processing between Kana and Kanji. Researcher will replace the related image by other images relating in Morphology (writing form and pattern was similar to the Word target) as the example below.

1) The test with no condition control

This pattern showed images which one of them had the meaning relates to Word Target.

2) The test for finding the relation in Morphology

This pattern showed the images which the meaning match with the word that is similar to Word target in terms of writing form and pattern.

3) Test of Non-related

This pattern showed none of the images had the meaning that matched with Word target.

7.5.2 Conclusion of the experiment

The research of vocabulary cognition of Japanese has been done by measuring the eye movement on images. Still, there is no report of the result and no proof of reliability. However, if there were only 7 alphabets, the result of eye movement can be processed immediately (Rayner & Beretra,1979)

To choose related image by only observing the word target was so difficult. However, it is easier for Kanji because Kanji's original characters itself came from images. In fact, testing by Image

identification is unable to measure the time accurately because there were possibilities that some mistakes and accidents occurred during the test. However, Visual fixation can help researcher to measure the time. By using Visual fixation, eye movement showed that there was cognitive processing to find the word with related meaning. Even though Word identification by using images still has not been verified yet, the analysis of Visual fixation showed that it can be the new tool used for doing the research of word cognitive by observing. Time spent for word identification which had related meaning can be illustrated by graph. Visual fixation result received from the first experiment showed that time for processing answer in each question spent at least 480ms. In second experiment, for the pattern of non-related meaning, found that time for processing answer of Katagana in each question spent between 350-420ms and 400-450 ms. for Kanji. It can be concluded from the result of Visual fixation graph that the processing result between Katagana and Kanji were different and the cognitive processing by observing in Japanese can be measured by using Visual Fixation.

7.6 Tomomizu (2013) Research

7.6.1 An experimental study on the word superiority effect of Thai language

Tomomizu (2013) has been done an experiment by making an assumption about the Cognitive Processing superiority in Thai language based on Ikeda's study. Final consonant takes a significant role in cognitive processing because the same Character strings can be different in meanings. To set the functions of final consonants, it is impossible to be done only by observing vocabularies. Therefore, this research will also conduct the test by making an assumption that Can cognitive processing of Thai language be succeeded by observing only final consonant. The methods of the test will be shown as below.

Experiment 1

Do the test of Word superiority effect by adapting the test to Reicher's experiment (1969). Reicher's experiment has been done by using images identification method as stimuli. Then requested participants who are Thai native speakers to do the test about reading and writing of words with "Tua Karan". The test was divided into 3 main levels; Beginner, Intermediate and Advanced based on language competence of each participants. The test was set Literacy Level arranged by easy, intermediate and advanced. For the easy level, participants will be tested by the textbooks of 3 grade student. For the level of intermediate and advanced, they will be tested by novels and academic articles or papers respectively.

Table 19 The example article used for the test

Regular word	Non-word
การจัดตารางการผลิต	รตลิกข์ำดาร์งภผาดาร์
อุตสาหกรรม	ตมสทรอรูกา
โรงงาน	างรนง
การผลิต	กถผาดร
ผู้วิจัย	วียผู้จ้

Experiment 2

Inspect the Paradigm as same method as the previous experiment. Choosing 2 groups of words with and without final consonant and set them as the target word.

Table 20 The example article used for the test

words with final consonant	words without final consonant
หาก	อยู่
ดีขึ้น	ต่ำซ้ำ
ปัจจุบัน	จะ
การวางแผน	ทำให้
เครื่องประดับ	กำลัง

7.6.2 Result

The result shows each word has its own meaning. Even reading in Thai, final consonant also has a high influence on new word cognitive acceleration.

อุตสาหกรรมเครื่องประดับมีอัตราการเจริญเติบโตอยู่ในระดับ
ค่อนข้างสูงซึ่งถ้าหากสามารถลดการส่งมอบล่าช้า โดยการปรับ
ปรุงการวางแผนและการจัดการการผลิตให้ดีขึ้นกว่าในปัจจุบัน
นั้นความสามารถในการแข่งขันของอุตสาหกรรมเครื่องประดับ
ก็จะดีขึ้นและเป็นแนวทางในการปรับปรุงเพื่อประยุกต์ใช้กับ
อุตสาหกรรมที่คล้ายคลึงกันได้ ปัญหาสำคัญที่พบในโรงงานตัว
ตัวอย่างคือการวางแผนและจัดการการผลิตจะใช้ประสิทธิภาพ
อันเป็นหลักการกำหนดขั้นตอนรายละเอียดการผลิตที่ชัดเจน
ทำให้การติดตามงานไม่มีประสิทธิภาพและไม่ทราบกำลังกา
รผลิตที่แท้จริงจึงทำให้การจัดการการผลิตเป็นไปอย่างไม่เห
มาะสมทำให้เกิดปัญหาการผลิตไม่ทันตามกำหนดและการส่ง
มอบงานล่าช้าผู้วิจัยได้จัดทำคู่มือการใช้งานเครื่องจักรมาตรฐาน
การทำงานและหาเวลามาตรฐานของแต่ละผลิตภัณฑ์เพื่อที่จะ
นำมาคำนวณหา กำลังการผลิตที่แท้จริงของโรงงานตัวอย่างแ
ละได้ทำ

Figure 28 Thai article used for the test

Chapter 8

The Study on the Cognitive Process of Non-kanji Isolating Language by Image Identification Task

Chapter 8 The Study on the Cognitive Process of Non-kanji Isolating Language by Image Identification Task

8.1 Introduction

Eyes tracking was providing a more direct and continuous measure of lexical activation. By using semantic priming paradigm, it could provide insight into the lexical processing. This chapter provides support for models of spoken word recognition. Semantic relatedness effects occurred regardless of whether the lexical item which is pictured in the display. It was shows that activation of semantic information associated with a spoken word and its phonological competitors and demonstrate that transient semantic activation is sufficient to impact visual attention. Phonological processing should occur in Japanese Kanji words as well as in Kana words.

Therefore, this chapter were created the experiment divide into 2 experiments show as follow; Experiment 1 performed concurrent articulation or finger tapping during a semantic processing task of Kana words. Concurrent articulation was found to eliminate the phoneme number in the control condition. However, finger tapping was not. This result indicates the effectiveness of concurrent articulation in articulatory suppression. In Experiment 2, the materials were changed to Kanji words and performed as the same task. The results showed no phoneme number effect even in the control condition and the reaction time in the concurrent. articulation condition was delayed significantly. These results suggest the existence of automatic phonological processing of Kanji words. The relationship between word recognition and eye movement in Japanese language system was different from English. The target languages, kana and kanji were considering to measure the eye movement by using image. It was suggested that the similarity of the notation is meant activation and related. From both the experimental results, the difference between a process for kana and kanji were show influence in the fixation time. The investigating of Eye Tracking by using eye camera in the experiment. The objective is to study the differences of the capacity in informational receiving among English, Japanese and German language. The result showed that three languages had the capacity in informational receiving at 50 bits. However, Thai language was recorded as 88 bits. Regarding the experiment, it was clearly seen that the cognitive investigation guideline was extremely significant. The result of eye tracking measurement on Thai language showed that eyes would concentrate to the final consonants in order to unidentified words [5]. In Thai language, each word has its own meaning. The final consonant show a high influence on words cognitive process. In Japanese Kanji and Kana, The test and the investigation of cognitive processing were conducted by using image identification tasks. The outcome indicated that Kanji and Kana have no similarity in cognitive patterns at all. Kana tended to be understandable based on personal cognition ability. Meanwhile, people understand the meaning of Kanji by their alphabet shapes.

8.2 Objectives of the experiment

- 1) To be able to measure the cognitive processing in Thai language by using image identification task.
- 2) To measure the result of cognition of Thai language by using the test of image identification task.
- 3) To study the influence of final consonant for Thai language by comparing the answering time recorded between words ending with and without final consonant.

8.3 Experimental



Figure 29 Example of the screen in experiment

In this study, Thai language processing and verification influence on final consonant (Tuasakot) was investigated by using image identification tasks. In experiment, words were divided into 5 groups (Unrelated meaning, related meaning, Homonym, and Homophone). In each group, final consonant (Tuasakot) and non-final consonant (Non-Tuasakot) were mixed with others word. 57 of Thai people were employed as participants. Participants were required to choose images which match with the meaning of words. The result was evaluated by timing and the number of the correct answers. The

Figure 29 shows the example of experiment using an application to investigate the cognitive information processing in Thai language.

A. Experimental Procedure

Participants required to follow the procedure by starting install an application on their Smartphone. The test screens as shown in Fig 2 started immediately after participants finished registering their name and personal accounts. Words would popped up at the centre of the screen and participants required to choose the images which match with the meaning of words as fast as possible by touching those images on the screen with their fingers. Participants were required to do the test continuously with the limited time. The system was operated randomly by choosing the words with the equal ratio among 4 patterns until the test finished. The experimental process shows as following.

- 1) After install the application, participants required to fill their names in the blank.
- 2) Press the start button.
- 3) After pressing start button, the test screens will show
- 4) different images and 1 word at the center of the screen. Participants required to choose only 1 image which match with the meaning of the word.
- 5) By choosing of images, it showed the response of cognition in Thai language.
- 6) The test was continuing until the start screen reappears.
- 7) Once the start screen shows up again. It means the test was finished.

本日はご協力頂き、ありがとうございます。

「StartButton」を押すと、
問題が始まります。
問題では中央に単語が表示されます。
その単語が示す絵を選択してください。
絵を選択すると次の問題に移行します。

正答は問いません。
ゲーム感覚で行なってください。

Thank you for your
cooperation to our research.

When you touch "start",
the experiments will start.

One word appears in the center.

Please select the picture
correspond to the word,
as FAST as you can.
When you select a picture,
next session will start immediately.

名前を教えてください
Please fill in your nickname.

StartButton

Show Result(Administrator Only)

Figure 30 The Registered Experimental screen

Table 21 The record of time spent on answering the test divided by the conditions of each word groups

No	Average time (second)									
	Tuasakot	Non Tuasakot	Controlled Tuasakot	Uncontrolled Non Tuasakot	Graphical	Non Graphical	Homophone	Non Homophone	Semantic Related	Not Related
1	5.173	5.757	6.506	4.437	5.851	7.642	4.343	5.151	3.393	4.818
2	1.495	1.545	1.468	1.626	1.41	1.447	1.656	1.519	1.483	1.761
3	3.008	2.821	2.266	1.497	3.815	2.973	2.997	3.684	3.557	2.724
4	1.493	1.661	1.445	1.45	1.621	1.739	1.461	1.538	1.32	1.989
5	1.62	1.493	1.338	1.413	2.02	1.59	1.769	1.496	1.423	1.407
6	2.083	2.003	1.551	2.532	2.086	1.733	2.841	1.933	1.38	2.082
7	2.34	2.026	4.056	2.276	1.618	1.987	2.271	1.714	1.425	2.21
8	2.331	4.032	2.703	4.514	1.784	2.393	2.646	7.955	1.626	2.205
9	2.241	2.328	2.124	2.585	1.877	1.772	2.813	3.148	1.825	2.151
10	2.332	2.844	3.414	3.093	1.951	2.644	2.37	2.63	1.66	3.172
11	1.302	1.472	1.324	1.285	1.26	1.342	1.252	1.323	1.37	1.744
12	3.008	3.396	2.378	2.609	3.031	4.116	4.124	5.234	2.569	2.646
13	4.415	11.231	3.554	4.651	6.341	14.16	5.025	14.191	3.425	18.87
14	4.205	2.938	1.716	1.406	0.63	1.366	2.551	1.823	2.504	8.229
15	2.368	3.45	1.627	2.44	4.702	3.161	2.089	1.997	2.503	7.777
16	3.213	3.323	3.287	4.099	4.781	4.039	3.413	3.54	2.674	2.386
17	2.942	3.008	3.246	2.357	2.615	3.21	2.975	3.012	2.62	3.19
18	2.217	2.673	2.091	1.758	1.951	2.131	2.657	4.202	2.861	2.645
19	2.53	2.329	2.329	2.259	2.102	2.573	2.634	2.083	2.025	2.259
20	1.569	1.767	1.59	1.683	1.752	1.686	1.518	1.775	1.469	1.947
21	2.001	1.708	1.812	1.48	3.11	2.348	2.23	1.372	1.217	1.256
22	1.879	2.317	1.282	1.617	1.25	1.402	1.255	3.345	7.843	4.167
23	4.949	5.758	4.163	5.585	6.91	7.404	5.349	5.509	2.79	6.364
24	2.6	5.157	2.212	3.209	3.569	6.413	3.013	6.775	1.921	3.116
24	2.6	5.157	2.212	3.209	3.569	6.413	3.013	6.775	1.921	3.116
25	1.393	1.493	1.525	1.788	1.361	1.482	1.246	1.519	1.286	1.429
26	2.018	2.406	3.483	2.095	1.957	2.724	1.773	2.174	1.793	2.397
27	3.113	3.115	2.848	3.086	3.011	2.667	3.641	3.947	2.64	2.978
28	1.513	1.457	1.299	1.31	2.517	1.464	1.47	1.554	1.141	1.386
29	1.734	2.115	1.896	2.353	1.601	1.867	1.752	1.985	1.544	2.438
30	2.604	3.301	2.592	2.698	4.064	4.555	2.704	3.641	1.787	2.582
31	4.417	6.538	4.668	8.749	10.591	7.506	3.477	6.252	0.805	5.283
32	1.514	1.961	1.483	1.639	1.789	1.669	1.344	2.384	1.625	2.215
33	1.417	1.821	1.518	1.493	1.441	2.053	1.327	1.58	1.14	2.244
34	4.136	4.589	3.913	4.129	11.824	5.764	2.308	7.132	8.71	3.453
35	2.237	2.634	2.113	2.297	1.81	3.496	1.953	1.692	1.877	2.538
36	1.662	1.74	1.311	1.437	1.621	1.651	1.712	1.784	1.637	2.059
37	1.529	1.61	1.537	1.55	2.029	1.46	1.462	2.011	1.288	1.675
38	3.269	10.971	4.589	4.124	5.457	7.548	3.982	26.984	1.94	14.707
39	5.344	5.794	6.223	7.604	12.878	9.044	4.836	3.565	2.455	5.165
40	2.174	2.418	1.189	2.759	2.403	2.61	2.37	2.513	2.402	2.353
41	5.04	5.485	6.511	6.288	5.673	6.476	5.101	4.514	2.942	6.232
42	1.572	1.959	1.485	1.607	1.729	1.871	1.575	3.15	1.752	1.384
43	1.496	1.891	1.565	1.717	1.651	2.128	1.467	2.196	1.207	1.552
44	2.773	4.065	3.082	3.848	2.969	2.67	2.506	3.359	2.926	7.026
45	1.358	1.578	1.416	1.566	1.312	1.648	1.289	1.645	1.186	1.426
46	3.027	5.544	3.566	4.219	4.063	5.234	2.674	7.296	2.14	5.251
47	1.539	1.647	1.371	1.653	1.792	1.745	1.728	1.344	1.305	1.929
48	1.43	1.699	1.372	1.775	1.338	1.777	1.595	1.589	1.267	1.88
49	1.585	1.858	1.587	1.885	1.857	2.137	1.489	1.678	1.824	1.598
50	2.027	1.987	2.451	2.651	2.231	2.3	1.956	1.632	1.524	1.435
51	1.453	1.737	1.349	1.744	1.705	1.731	1.345	1.682	1.572	1.794
52	1.359	1.447	1.358	1.331	1.48	1.456	1.298	1.334	1.308	1.494
53	1.637	2.865	1.546	1.669	1.525	2.954	1.756	3.384	1.543	3.11
54	2.12	2.921	1.821	2.325	2.747	3.306	2.578	3.571	1.423	2.141
55	1.442	1.574	1.365	1.544	1.32	1.5	1.672	1.627	1.123	1.693
56	2.397	2.188	4.641	1.837	1.427	2.373	1.935	2.144	2.321	2.037
57	7.042	7.031	3.741	3.094	22.6	6.268	7.13	11.761	3.021	9.923
Avg.	2.503	3.131	2.489	2.662	3.365	3.27	2.486	3.712	2.129	3.472

8.4 Results

The result of average time spent on answering between final consonant and non-final consonant were analysis by t-test analysis. Table 1 shows the average of time spent on answering the test. Table 2 and 3 shows the result of average time spent on answering between words with final consonant and non-final consonant. The result of 2 group was found significantly different ($p=0.002<0.01$). Moreover, the analysis showed that related meaning group was also found significantly different ($p=0.002<0.01$).

Table 22 t-test shows the result of average time spent on answering the test between words with final consonant and non-final consonant

	Mean Value	
	Final Consonant	Non-Final Consonant
Average	2.50	3.13
Variance	1.57	4.45
The number of observation	57.00	57.00
Pearson's Correlation coefficient	0.75	
Significant different	0.00	
Degree of Freedom	56.00	
t	-3.31	
P(T<=t) one side	0.00	
t boundary value one side	1.67	
P(T<=t) two side	0.00	
t boundary value two side	2.00	

Table 23 t-test shows the result of average time spent on answering the test in related meaning group

	Mean Value	
	Final Consonant	Non-Final Consonant
Average	2.13	3.47
Variance	1.85	10.33
The number of observation	57.00	57.00
Pearson's Correlation coefficient	0.28	
Significant different	0.00	
Degree of Freedom	56.00	
t	-3.25	
P(T<=t) one side	0.00	
t boundary value one side	1.67	
P(T<=t) two side	0.00	
t boundary value two side	2.00	

Table 24 t-test shows the result of average time spent on answering the test of words with final consonant

	Mean Value	
	Final Consonant	Non-Final Consonant
Average	2.29	2.13
Variance	3.16	0.99
The number of observation	33.00	33.00
Pearson's Correlation coefficient	0.53	
Significant different	0.00	
Degree of Freedom	32.00	
t	0.61	
P(T<=t) one side	0.27	
t boundary value one side	1.69	
P(T<=t) two side	0.55	
t boundary value two side	2.04	

The cognitive process can be understood by patterns or shapes of alphabet and sound. The previous research found that fluctuate results depended on the types of language and alphabet shapes. Thai language consists of 18 vowels, 42 consonants and tones which its sound and transcription (a written record of words or symbols) are formed by gathering consonants, vowels and tones together. The structure of Thai syllable must be consisted of (consonant + vowel) or (consonant + vowel + consonant). For the latter pattern, last consonant will be operated as final consonant which can be the key that changes the meaning of words. Regarding to this fact, consonant plays an important role for the reading process because it was used for differentiating between normal consonants and final consonants. However, final consonant has its own pattern. Thus, cognitive investigation guideline is very important and helpful in reading comprehension. In Transcription of final-consonant, Thai language will be written as a long sentence without space to guide that it is the end of the words like English. With regard to the above mention, final consonant is very significant for the cognitive information processing in Thai language because it works as same as TRIGGER which can indicate words. The result of the experiment was found that the average time spent on answering the test between final consonant and non-final consonant was ($p= 0.002<0.01$). It emphasizes that final consonant has a high influence on cognitive processing in Thai language. According to the result of the test analysis for each groups of word, the average time spent on answering the test between words with final consonant and without final consonant showed that related meaning group was at

($p = 0.002 < 0.01$). The concentration of Target image. The words with related meaning will support the cognitive processing in Thai language and also has a high influence on cognitive acceleration.

The cognitive information processing in Thai language based on the result of the test. The words that relates in meaning make faster cognition. Follow to the previous research, final consonant will be operated as Trigger which can shorten the time for image identification task. We can measure the difference of time spent on answering the test by the cognitive processing which can be done by cognitive stimulation. The pattern of stimulation resulted from the using of final consonant will be shown in table 24. As a result, it was clearly saw that the average result between words with final consonant and non-final consonant are considerably different ($p = 0.54 > 0.01$). Words in Related meaning group with final consonant tended to gain language cognitive processing faster than words non final consonant, which also spent even longer time. It shows that final consonant has a high influence on cognitive processing in Thai language. The eye tracking in order to process information by using images. The result was found similar to the previous research even the images used in this study were different from the previous one. This study can be analysed that time spent on answering the test between words with final consonant and non-final consonant by using images are different. The result is almost all the same with the initial research which emphasize that final consonant is extremely important for the cognitive processing in Thai language.

8.5 Conclusion

The result of this test got the same conclusion as the previous research which was tested about the image identification. Final consonant has a high influence on cognitive processing in Thai language. it works as same as TRIGGER which can indicate words like space in English and Kanji in Japanese. Consequently, final consonant was become important factor that stimulates the cognition process for Thai people. The researcher will take properties of final consonant to create experiment in next step.

Chapter 9

The effect of final consonants in the cognitive process of Thai Language

Chapter 9 The effect of final consonants in the cognitive process of Thai Language

9.1 Introduction

This chapter studied the cognitive processing and influence of Thai final consonants in morphological level. This experiment has taken the result of Eiling and Julie (2006)'s and Phenpimon (2015) experiments to create a new experiment by using word identification tasks. Experiment were separated into 2 experiments. The first one was to find the relation between word and word and another experiment was to find the relation between word and sentence. The condition used for testing was divided into 4 patterns which were;

- Types of question divided by single words and sentences
- Type of option word or word choices divided by word with consonant and without consonant
- The level of difficulty divided by 3 levels; easy, middle, hard
- Type of word was divided to 4 types; Uncontrolled, Homophone, Homograph, and Semantic

The test will be done via websites on a computer system for the most accurate time recordings for the time spent on answering questions and for greater convenience in collecting the data from the sample group. in order to verify the difference in time spent answering and correcting data, as there is no direct measurement. Therefore, the time spent on selected word and correctness ratio was the most important variable in the cognitive processing test. System will record the time for each question, starting when a question appears and ending when the participants choose an answer. After that the system will save the data and summarize all 48 questions to verify the differences in cognition in each condition. Then the result was analyzed by 2 ways ANOVA and t-test that is statistical significance indicates the difference between three group averages. However, the test was unable to be measured directly, therefore, the difference of time spent on processing. The results will offer guidelines for create standard of Thai user interface design.

9.2 Objectives of the experiment

1) To study the influence of final consonants which affects cognition.

The assumption is that the words with final consonants will be recognized faster and more corrected than the words without final consonants because the final consonants work as a stimulator to improve the speed of cognition.

2) To study the influence of word difficulty level which affects cognition.

The assumption is that word difficulty in each level will have the different result in both timing and accuracy in answering questions.

3) To study the influence of kind of word which affects cognition.

The assumption is that 4 kinds of words has the difference in result.

9.3 Experimental method

This experiment used website to create Word Identification Task in order to find the differences of cognition processing in Thai language. The conditions were put to both with final consonants and without final consonant to test the relation between words or contexts in a sentence and then request Thai native speakers to do the test that divided into 2 Experiments.

To consider about the Word level used for both first and second experiments, the complexity of grammars were arranged into 3 levels; easy, intermediate and advanced. For the easy level, participants will be tested by the textbooks of primary school student. For intermediate, they will be tested by novels, articles from magazine, advertisements and media. For advanced, they will be tested by academic articles and research. The test had totally 48 questions, 2 experiments divided by 24 per each. All word levels, easy, intermediate and advanced will be mixed in each experiment equally (8 words for each level). The condition used for testing was divided into 4 patterns which were; Uncontrolled, Homograph, Homophone and Related semantic. Words target used for the test were both ended with and without final consonant. Researcher had recorded the time that participants spent on answering questions and the correctness ratio.

Table 25 The test conditions in Experiment 1 and 2

Condition	Easy Level		Middle Level		High Level	
	Word with Consonant	Word without Consonant	Word with Consonant	Word without Consonant	Word with Consonant	Word without Consonant
Uncontrolled	1 item	1 item	1 item	1 item	1 item	1 item
Related Homophone	1 item	1 item	1 item	1 item	1 item	1 item
Related Homograph	1 item	1 item	1 item	1 item	1 item	1 item
Related semantic	1 item	1 item	1 item	1 item	1 item	1 item

9.3.1 Experiment 1

Experiment 1 will test the relation between words by setting key words and request participants to choose the answers among 4 option words. The objective is that participants can choose the answers that relate with the key words appearing on the screen.

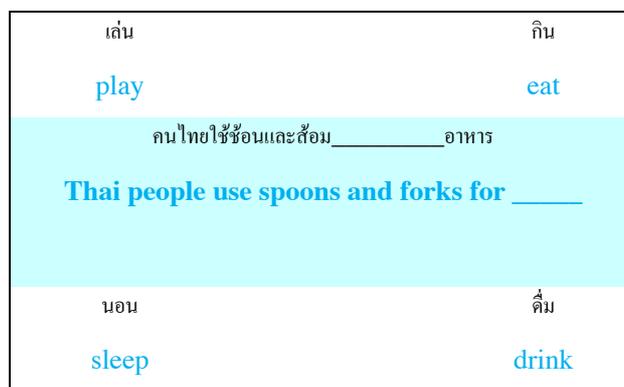


Figure 31 The pattern of first experiment

According to the Figure31, it showed the pattern of first experiment. Word target was set in the middle and participants were required to choose one of the 4 choices option word. Each question was different follow to the conditions mentioned previously. Refer to the sample question shown as above, Word target is “Food” so the related word will be “Eat”. “Drink” can be confused but it typically used for beverages.

Experiment stimulus

The condition used for testing was divided into 3 patterns.

1) Uncontrolled

Set the choices which have no related word and fix only one choice which had related word with Word target.

2) Homophone

Set the choices which had similarity in pronunciation and fix only one choice which had related word with Word target.

3) Homograph

Set the choices which had similarity in homograph and fix only one choice which had related word with Word target

4) Related meaning

Set the choices which had similarity in meaning and fix only one choice which had related meaning with Word target.

Table 26 Experiment 1 in uncontrolled condition

Condition	Target Word	Correct answer	Incorrect answer			Target word	Target word
		Option Word			Final consonant	Difficult Level	
Uncontrolled	ทาน	อาหาร	น้ำ	เล่น	นอน	with	low
	eat	food	water	play	sleep	final consonant	
Uncontrolled	กา	ดำ	ไก่	ฟ้า	ขา	without	low
	crow	black	chicken	blue	leg	final consonant	
Uncontrolled	เปล่ง	เสียง	งาน	พูด	เงิน	with	mid
	utter	sound	work	speak	money	final consonant	
Uncontrolled	วาทะ	ไพเราะ	เนื้อหา	ภาษา	ศาลา	without	mid
	speech	beautiful	content	Language	pavilion	final consonant	
Uncontrolled	แสง	ตะวัน	พงไพร	หัสติน	นรชาติ	with	high
	light	sun	forest	elephant	person	final consonant	
Uncontrolled	ใส	วารี	นภา	ทิวา	พนา	without	high
	clear	water	sky	day	forest	final consonant	

Table 27 Experiment 2 in Homophone condition

Condition	Target Word	Correct answer	Incorrect answer			Target word	Target word
		Option Word				Final consonant	Difficult Level
Related Homophone	เวลา	กาล	กาน	การ	กานต์	with	low
	time	period	prune	task	dear	final consonant	
Related Homophone	หนังสือ	หน้า	น่า	นา	หนา	without	low
	book	page	should to do	field	bushy	final consonant	
Related Homophone	ผู้หญิง	ครรภ์	คัน	คันต์	คันซ์	with	mid
	women	pregnant	itch	scripture	Fragrance	final consonant	
Related Homophone	ปลูก	หญ้า	ย่า	ยา	หย่า	without	mid
	grow	grass	grandmother	medicine	divorce	final consonant	
Related Homophone	แหลมคม	ขวรค์	ชิ้นจ์	ขัน	ขันซ์	with	high
	sharp	knife	piece	crow	group	final consonant	
Related Homophone	สูง	ค่า	ข้า	ฆ่า	ขา	without	high
	high	value	I	kill	leg	final consonant	

Table 28 Experiment 2 in Homograph condition

Condition	Target Word	Correct answer	Incorrect answer			Target word	Target word
		Option Word				Final consonant	
Related Homograph	มุน	กลม	จิตใจ	เวท	ดั่งดูด	with	low
	round	circle	mind	spell	charm	final consonant	
Related Homograph	เพลลา	ล้อ	เวลา	นาฬิกา	พารา	without	low
	axle	wheel	time	second	town	final consonant	
Related Homograph	กรี	กุ้ง	ช้าง	วิ่ง	ยกทัพ	with	mid
	rostrum	shrimp	elephant	run	move the troops	final consonant	
Related Homograph	แทน	ดูแล	หญ้า	รอ	ไป	without	mid
	cherish	care	grass	wait	go	final consonant	
Related Homograph	ปรัก (ประ-หรััก)	ซาก	เงิน	ธนาคาร	ทรุดโทรม	with	high
	be ruined	one thing remains	sliver	bank	decadent	final consonant	
Related Homograph	ครุ (คะ-รุ)	ครู	ศึกษา	คำ	ดู	without	high
	teacher	teacher	education	dispraise	reprehend	final consonant	

Table 29 Experiment 1 in Related Semantic Condition

Condition	Target Word	Correct answer	Incorrect answer			Target word	Target word
		Option Word				Final consonant	
Related	ราชสีห์	สิงโต	สมิง	ขาล	พยัคฆ์	with	low
Semantic	lion	lion	tiger	tiger	tiger	final consonant	
Related	มหาสมุทร	ทะเล	แม่น้ำ	บ่อน้ำ	ลำน้ำ	without	low
Semantic	ocean	sea	river	pool	canal	final consonant	
Related	ลูกสาว	บุตร	ก้นยา	บุตร	บ้งอร	with	mid
Semantic	daughter	daughter	young girl	child	women	final consonant	
Related	แม่น้ำ	ธารา	วารี	วารี	อาไป	without	mid
Semantic	river	river	water	water	water	final consonant	
Related	ดอกบัว	ปทุม	นุชบา	นุพจน์	นุปลา	with	high
Semantic	lotus	lotus	flower	flower	flower	final consonant	
Related	พระอาทิตย์	สุริโย	อำไพ	ทิวา	ทิวา	without	high
Semantic	sun	sun	light	day time	day time	final consonant	

9.4 Experiment 2

Experiment 2 will Test the relation between words and contexts in the sentence. The objective is that contexts can stimulate the cognition faster than words. Therefore, the key sentences were set and participants had to choose the answers among 4 option word which relate to the key sentence.

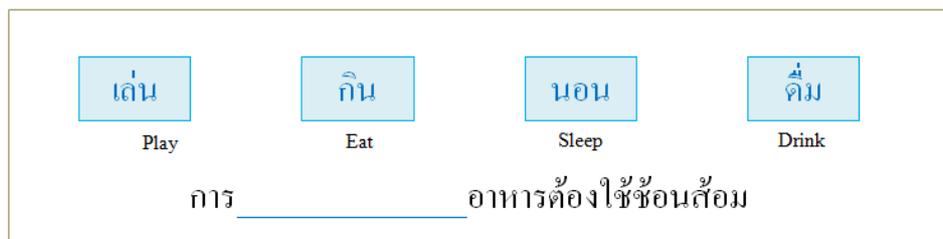


Figure 32 The pattern of second experiment

Experiment stimulus

To consider about the Word level used for the experiments they were arranged into 3 levels; easy, intermediate and advanced. For the easy level, participants will be tested by the textbooks of primary school student. For intermediate, they will be tested by novels, articles from magazine, advertisements and Medias. For advanced, they will be tested by academic articles and research. The test had totally 48 questions, 2 experiments divided by 24 per each. All word levels, easy, intermediate and advanced will be mixed in each experiment equally (8 words for each level). The condition used for testing was divided into 4 patterns as shown below.

1) Uncontrolled

Set the choices which have no related meaning and fix only one choice which had related meaning with Word target.

2) Homophone

Set the choices which had similarity in pronunciation and fix only one choice which had related meaning with Word target.

3) Homograph

Set the choices which had similarity in homograph and fix only one choice which had related meaning with Word target.

4) Related meaning

Set the choices which had similarity in meaning and fix only one choice which had related meaning with Word target.

Figure 33 The Experiment 2 in uncontrolled condition

Condition	Target word	Correct answer	Incorrect answer			Condition	
		Option Word	Option Word	Option Word	Option Word	final consonant	Difficult Level
Related Homophone	ทาน	อาหาร	ดื่ม	เล่น	นอน	with final consonant	low
	eat	food	drink	play	sleep		
Sentence	คนไทยใช้ช้อนและส้อมทานอาหาร					with final consonant	low
	Thai people use spoons and forks for eating.						
Related Homophone	กา	ดำ	ไก่	ฟ้า	ขา	without final consonant	low
	crow	black	chicken	blue	leg		
Sentence	กามีขนสีดำปกคลุมทั่วทั้งตัว					with final consonant	low
	Crow is entirely covered with black feathers.						
Related Homophone	เปล่ง	เสียง	งาน	พูด	เงิน	with final consonant	mid
	utter	sound	work	speak	money		
Sentence	พวกเขาเปล่งเสียงไชโยพร้อมเพรียงกัน					with final consonant	mid
	They utter "Cheers" together.						
Related Homophone	วาทา	ไพเราะ	เนื้อหา	ภาษา	ศาลา	without final consonant	mid
	speech	beautiful	content	language	pavilion		
Sentence	วาทาที่เปล่งออกมาช่างไพเราะเสนาะหู					with final consonant	mid
	The speech is very impressive and beautiful.						
Related Homophone	แสง	ตะวัน	พงไพร	หัตถิน	นรชาติ	with final consonant	high
	light	sun	forest	elephant	person		
Sentence	ตะวันสาดแสงทองลอดช่องเมฆ					with final consonant	high
	The sun shines through the cloud.						
Related Homophone	ไหล	วารี	นภา	ทิวา	พนา	without final consonant	high
	clear	water	sky	day	forest		
Sentence	เวลาเปรียบเหมือนวารีมีเคยหยุดไหล					with final consonant	high
	Time is like water flow which never stops running.						

Table 30 Experiment 2 in Homophone condition

Condition	Target word	Correct answer	Incorrect answer			Condition	
		Option Word	Option Word	Option Word	Option Word	final consonant	Difficult Level
Related Homophone	เวลา grow	กาล grass	กาน grandmother	การ medicine	กานต์ divorce	with final consonant	low
Sentence	อุโมงค์ข้ามกาลเวลาพาไปยังอีกภพหนึ่ง Time travel tunnel sends people to another world.						
Related Homophone	หนังสือ book	หน้า page	น่า should to do	นา field	หนา bushy	without final consonant	low
Sentence	หนังสือเล่มนี้มีทั้งหมดหนึ่งร้อยหน้า This book contains 100 pages.						
Related Homophone	ผู้หญิง women	ครรภ์ pregnant	คัน itch	กัณฑ์ scripture	กันท์ Fragrance	with final consonant	mid
Sentence	ผู้หญิงคนนั้นกำลังตั้งครรภ์ That woman is pregnant.						
Related Homophone	ปลูก grow	หญ้า grass	ย่า grandmother	ยา medicine	หย่า divorce	without final consonant	mid
Sentence	เขาปลูกหญ้าไว้หน้าบ้าน He plants some grasses at the front of his house.						
Related Homophone	แหลมคม sharp	ขวรค์ knife	ชิ้นจ๋ piece	ขิ่น crow	ขิ่นธ์ group	with final consonant	high
Sentence	ขวรค์เล่มนั้นมีความแหลมคม That knife is very sharp.						
Related Homophone	สูง high	ค่า value	ข้า I	ฆ่า kill	ขา leg	without final consonant	high
Sentence	หุ้นวันนี้มีค่าสูง Stock market is high today.						

Table 31 The Experiment 2 in Homograph condition

Condition	Target word	Correct answer	Incorrect answer			Condition	
		Option Word	Option Word	Option Word	Option Word	final consonant	Difficult Level
Related Homograph	มุน round	กลม circle	จิตใจ mind	เวท spell	สิ่งจูด charm	with final consonant	low
Sentence	ลูกฟุตบอลมีความมนกลม The shape of football ball is round.						
Related Homograph	เพล axle	ล้อ wheel	เวลา time	นาที second	พารา town	without final consonant	low
Sentence	เพลเป็นส่วนประกอบของล้อ Axle is one of the wheel components.						
Related Homograph	กริ the rostrum	กุ้ง shrimp	ช้าง elephant	วิ่ง run	ยกทัพ move the troops	with final consonant	mid
Sentence	เขาโดนกริกุ้งแทงนิ้ว He got the rostrum of the shrimp stunk on his finger.						
Related Homograph	แทน cherish	ดูแล care	หญ้า grass	รอ wait	ไป go	without final consonant	mid
Sentence	เขากอยดูแลหวงแทนเธออยู่เสมอ He always takes care and be jealous of her.						
Related Homograph	ปรัก (ปะ-หุรัค) be ruined	ซาก one thing remain	เงิน sliver	ธนาคาร bank	ทรุดโทรม decadent	with final consonant	high
Sentence	ซากปรักหักพังเหล่านี้คือหลักฐานทางโบราณคดี These ruins are evidences of Archaeology.						
Related Homograph	ครู (ละ-รุ) teacher	ครู teacher	ศึกษา education	ตำ dispraise	ดู reprehend	without final consonant	high
Sentence	ครูศาสตร์เป็นสาขาเฉพาะของอาชีพครู Education is the special field of study for teachers.						

Table 32 Experiment 2 in Related Semantic Condition

Condition	Target word	Correct answer	Incorrect answer			Condition	
		Option Word	Option Word	Option Word	Option Word	final consonant	Difficult Level
Related Semantic	ราชสีห์ lion	สิงโต lion	สมิง tiger	ขาล tiger	พยัคฆ์ tiger	with final consonant	low
Sentence	ราชสีห์เปรียบคิงพญาสิงโตผู้ยิ่งใหญ่ Lion king is like a great lion.						
Related Semantic	มหาสมุทร ocean	ทะเล sea	แม่น้ำ river	บ่อน้ำ pool	ลำน้ำ canal	without final consonant	low
Sentence	มหาสมุทรเป็นทะเลใหญ่ของโลก Ocean is a huge sea of the world.						
Related Semantic	ลูกสาว daughter	บุตรี daughter	ก้นยา young girl	บุตร child	บ้งอ women	with final consonant	mid
Sentence	บุตรผู้นั้นเป็นลูกสาวของท่านนายกรัฐมนตรี That woman is a daughter of the Prime Minister.						
Related Semantic	แม่น้ำ river	ธารา river	วาริ water	วารี water	อาไป water	without final consonant	mid
Sentence	แม่น้ำโขงเปรียบเป็นมหาธาราแห่งอุษาคเนย์ Khong River is the great river in South East Asia.						
Related Semantic	ดอกบัว lotus	ปทุม lotus	บุษบา flower	บุหงัน flower	บุปผา flower	with final consonant	high
Sentence	ในสระบัวเหล่าปทุมช่อพริ้วไหว In the canal, a group of lotus flower is in bloom.						
Related Semantic	อาทิตย์ sun	สุริโย sun	อำไพ light	ทิวา day time	ทิพา day time	without final consonant	high
Sentence	สุริโยฉายแสงดุจอาทิตย์เจิดจ้า The sun shines so bright like a bright sun.						

9.5 Participant

100 Thai-Nichi Institute of Technology students were required to participate.

9.6 Experimental Procedure

Participants were required to follow the procedure of the test via <http://www.touchthailanguage.com>. The first screen shows the register screen. That explains the purpose and procedure of the experiment in order to make sure the participant and researcher understand in the same way. After the participant reads and endeavors to grasp information on the register screen. Then, please fill your name for registration in the experiment and press the start button. After that, the test screen will appear. The test will be started from the first experiment, which was to find the relation between word and word. The second experiment was to find the relation between word and sentence. The test will begin right after finishing the first one and the number of questions and patterns were all the same for these 2 experiments.

When the test screen of the first experiment appeared, the word target will be popped up at the center of the screen. Participants needed to choose only one answer out of 4 option words which had related meaning to the word target by pressing their fingers to the selected words. The measurement of cognition will start after the test screen appeared and end when participants chose the answers. The test ended when participants completed all 24 questions. After completing the first experiment, the test screen of the second experiment appeared. Participants needed to choose only one answer out of 4 choices which had related meaning to the sentence target and context as much and fast as possible by pressing their fingers to the selected words. The measurement of cognition will start after the test screen appeared and end when participants chose the answers. The test ended when participants completed all 24 questions. As soon as they finished the second experiment, it means the test of cognitive processing in Thai language was finished. The experimental process is as follows.

- 1) After opening the test site, participants were required to fill their names in the blank.
- 2) Press the start button.
- 3) After pressing the start button, the Experimental 1 will show at the center of the screen.
- 4) Participants are required to choose only 1 word that relates with the word target. It showed the response of cognition in Thai language.
- 5) The Experimental 1 is continuing until the screen Experimental 2 appears.
- 6) When Experimental 2 shows at the center of the screen. Participants are required to choose only 1 word that matches with contexts in the sentence. It showed the response of cognition in Thai language.
- 7) The test was continuing until the summary score screen appears.
- 8) When the test score appears that means the experiment was finished.



ขอขอบคุณสำหรับความร่วมมือ

Thank you for your Cooperation

การทดสอบนี้มีวัตถุประสงค์เพื่อวัดระดับความสามารถในการรับรู้โดยใช้แบบทดสอบการเลือกคำ

This research investigates the cognitive processing and influence of final consonant and non-final consonant by using word identification.

The Experiment was divided into 2 tests

แบบทดสอบถูกแบ่งออกเป็น 2 ประเภท

แบบทดสอบที่ 1 จะทำการวัดความสัมพันธ์ระหว่างคำกับคำ

Experiment 1 will test the relation between words and word

แบบทดสอบที่ 2 จะทำการวัดความสัมพันธ์ระหว่างคำกับประโยค

Experiment 2 will Test the relation between words and contexts in the sentence.

กรุณาเลือกคำที่สัมพันธ์กับคำหรือประโยคที่ปรากฏให้เร็วที่สุดเท่าที่สามารถทำได้

ระบบจะเริ่มจับเวลาตั้งแต่แบบทดสอบปรากฏจนกระทั่งท่านทำการเลือกตอบ

Participants are required to choose answer which had related meaning to word and sentence target as fast as possible.

กรุณาระบุชื่อเพื่อเริ่มทำแบบทดสอบ

Please fill in your name for register

START

Figure 34 The register screen of test



Figure 35 The summary score screen when experiment was finished

9.7 Experimental Results

Each language in the world must consist of language system, meaning and structure in order to create the cognition of that language. This research focus on the cognitive process in Thai language cause the nature of Thai language does not have spaces in a sentence like English and not have kanji character in Japanese and words will be written continuously until the end of the sentence that sometimes lead to ambiguity therefore, This problem were investigated by many researchers who are interesting in Thai cognitive process. Ikeda (2012) investigated the Thai language reading test by using Eye tracking experiment. The result showed that final consonants which have unique patterns are very important for the cognitive information processing in Thai language. Tomomizu (2013) point out that final consonants have a high influence on the word cognitive acceleration. Moreover, Aso (2016) investigated the cognitive process of Thai language and verification influence of final consonants by using image identification tasks. The test result indicated that final consonants have a huge influence on the cognition of Thai language because final consonants (Tuasakot) make accelerated cognitive process which stimulates the cognition. This research was study the cognitive processing and influence of final consonant and non-final consonant by using word identification tasks to verify the difference of time spent to answering and corrected data consists of 4 main variables;

- 1) Types of question divided by single words and sentences
- 2) Type of option word or word choices divided by word with consonant and without consonant
- 3) The level of difficulty divided by 3 levels; easy, middle, hard
- 4) Type of word was divided to 4 types; Uncontrolled, Homophone, Homograph, and Semantic

In order to analyze the relation between independent and dependent variables, researchers applied the statistic tooling which are Graphical, Two-way ANOVA and T- Test for clarify and summarize the result of the experiments. The result shows as followings

Table 33 Time of answering the question and correct ratio from 100 participants

No.	TYPE	Condition	Consonant	Level	T	F	TIME
1	WORD	Uncontrolled	WITH	1	98	2	3.10
2	WORD	Uncontrolled	WITHOUT	1	62	38	4.30
3	WORD	Uncontrolled	WITH	2	98	2	4.37
4	WORD	Uncontrolled	WITHOUT	2	79	21	3.85
5	WORD	Uncontrolled	WITH	3	97	3	2.95
6	WORD	Uncontrolled	WITHOUT	3	81	19	5.59
7	WORD	Homophone	WITH	1	96	4	3.04
8	WORD	Homophone	WITHOUT	1	89	11	4.74
9	WORD	Homophone	WITH	2	98	2	3.39
10	WORD	Homophone	WITHOUT	2	73	27	4.31
11	WORD	Homophone	WITH	3	65	35	5.71
12	WORD	Homophone	WITHOUT	3	93	7	2.62
13	WORD	Homograph	WITH	1	83	17	4.72
14	WORD	Homograph	WITHOUT	1	41	59	5.05
15	WORD	Homograph	WITH	2	81	19	4.57
16	WORD	Homograph	WITHOUT	2	66	34	4.56
17	WORD	Homograph	WITH	3	40	60	5.32
18	WORD	Homograph	WITHOUT	3	36	64	4.65
19	WORD	Semantic	WITH	1	92	8	3.50
20	WORD	Semantic	WITHOUT	1	96	4	3.17
21	WORD	Semantic	WITH	2	82	18	3.96
22	WORD	Semantic	WITHOUT	2	61	39	4.99
23	WORD	Semantic	WITH	3	84	16	4.02
24	WORD	Semantic	WITHOUT	3	57	43	4.93
25	SENTENCE	Uncontrolled	WITH	1	99	1	3.93
26	SENTENCE	Uncontrolled	WITHOUT	1	90	10	3.87
27	SENTENCE	Uncontrolled	WITH	2	100	0	3.84
28	SENTENCE	Uncontrolled	WITHOUT	2	89	11	3.86
29	SENTENCE	Uncontrolled	WITH	3	100	0	3.28
30	SENTENCE	Uncontrolled	WITHOUT	3	84	16	6.54
31	SENTENCE	Homophone	WITH	1	100	0	2.12
32	SENTENCE	Homophone	WITHOUT	1	91	9	3.57
33	SENTENCE	Homophone	WITH	2	99	1	3.98
34	SENTENCE	Homophone	WITHOUT	2	86	14	3.43
35	SENTENCE	Homophone	WITH	3	50	50	4.76
36	SENTENCE	Homophone	WITHOUT	3	86	14	3.11
37	SENTENCE	Homograph	WITH	1	100	0	3.47
38	SENTENCE	Homograph	WITHOUT	1	87	13	6.10
39	SENTENCE	Homograph	WITH	2	99	1	3.35
40	SENTENCE	Homograph	WITHOUT	2	83	17	4.08
41	SENTENCE	Homograph	WITH	3	68	32	8.21
42	SENTENCE	Homograph	WITHOUT	3	69	31	4.51
43	SENTENCE	Semantic	WITH	1	89	11	5.49
44	SENTENCE	Semantic	WITHOUT	1	80	20	5.02
45	SENTENCE	Semantic	WITH	2	85	15	5.44
46	SENTENCE	Semantic	WITHOUT	2	57	43	7.58
47	SENTENCE	Semantic	WITH	3	85	15	5.43
48	SENTENCE	Semantic	WITHOUT	3	50	50	5.80

9.7.1 The analysis of the correctness ratio statistic in answering question by graph

Experiment1

The result of the experiment 1 found that from 100 of the participants, the correct items ratio of words with consonants appeared higher than words without consonants in the test of relationship with Word part. The average number of participants who answered correctly for words with consonants was 87 persons; whereas words without consonants was only 74 persons. It can clearly be seen that consonant has more influence at the accuracy in answering questions than words without consonants.

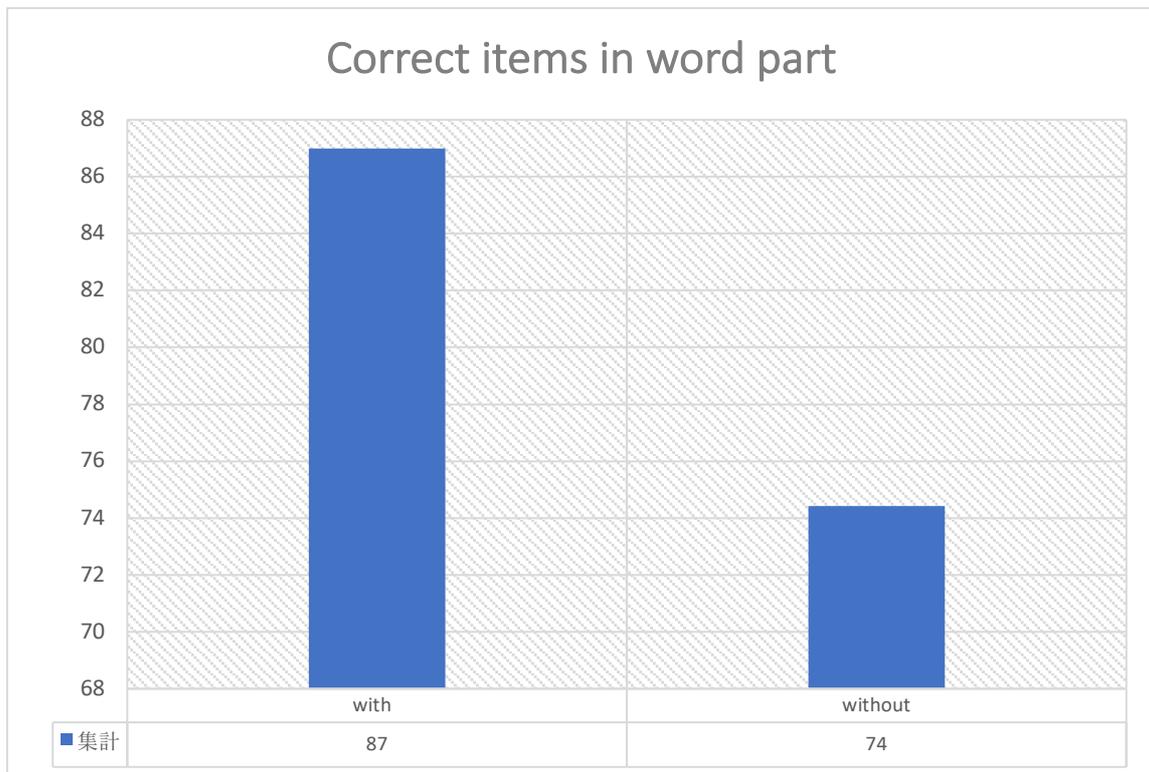


Figure 36 The proportion of correct items between word with consonant and word without consonant in experiment 1 (word part) from 100 participants

Experiment 2

The result of the experiment 2 found that from 100 of the participants, the correct items ratio of words ending with consonants was almost the same with words without consonants in the test of relationship with Sentence part. The average number of participants who answered correctly for words with consonants was 90 persons; whereas words without consonants was 79 persons. It shows that Sentence patterns offered more understanding and drove the accuracy ratio to be higher in both with and without consonants.

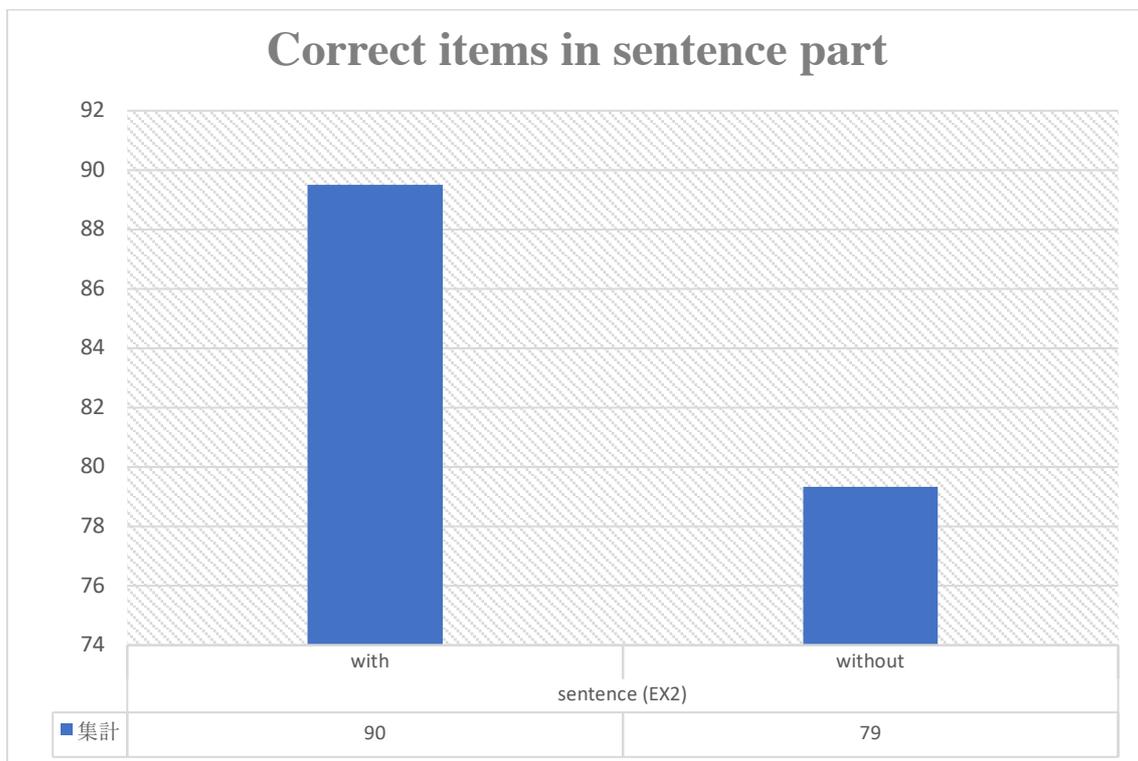


Figure 37 The proportion of correct items between word with consonant and word without consonant in experiment 2 (sentence part) from 100 participants

Summary data of correct items

The result found that from 100 of the participants, the correct items ratio of words ending with consonants appeared higher than words without consonants. The difficulty and complexity of words also had a direct effect on the answering. Moreover, by comparison with the correct items ratio between experiment 1 and 2, it was found that the ratio of experiment 2 (test of relationship with Word part) was higher than the former one (test of relationship with Sentence part). It is proved that Sentence patterns offered more understanding and cognition than an isolated word.

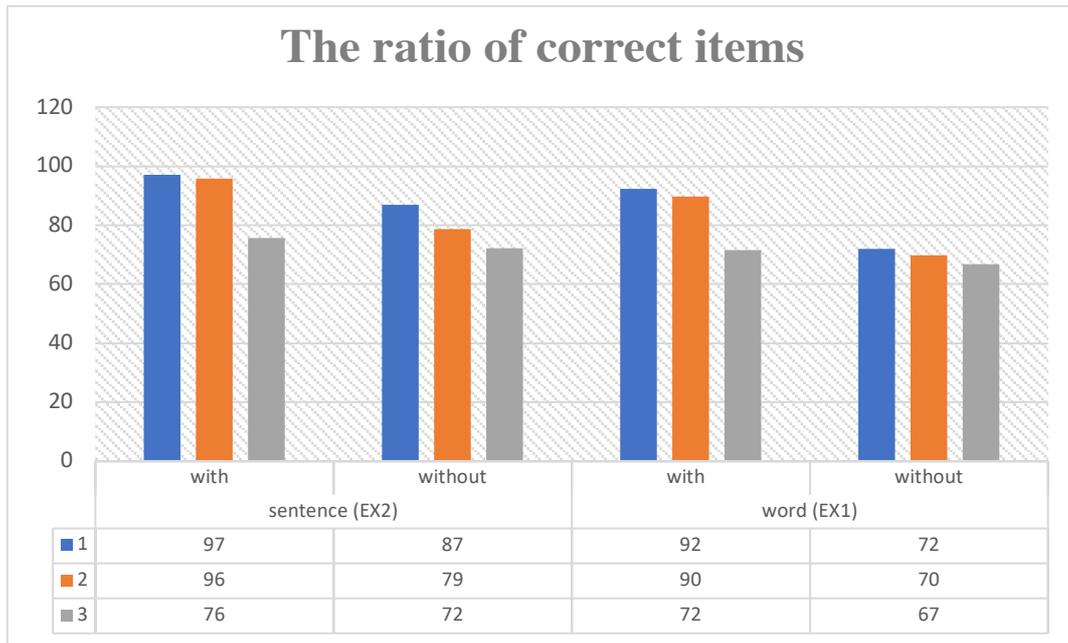


Figure 38 The number of participants that answered correctly between experiment 1 and 2 are related

9.7.2 The analysis of the timing ratio statistic in answering question by graph

Experiment 1

The result of the experiment 1 found that from 100 of the participants, the answering time ratio of words ending with consonants appeared less than words without consonants in the test of relationship with Word part. This result was in accordance with the previous research which the average time spent on answering for words with consonants was 4.05 seconds; whereas words without consonants was only 4.40 seconds. It can clearly be seen that consonant has more influence at the answering time than words without consonants.

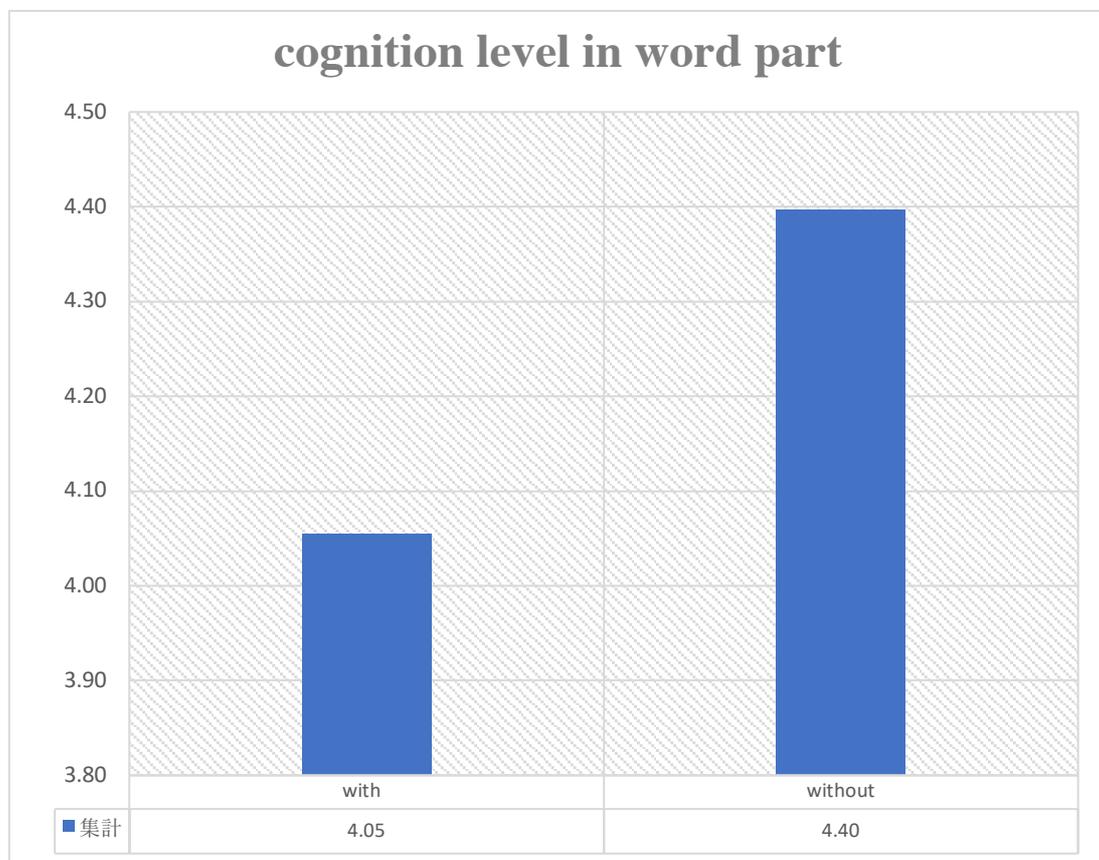


Figure 39 The proportion of time to answering between word with consonant and word without consonant in experiment 1 (relation between word) from 100 participants

Experiment2

The result of the experiment 2 found that from 100 of the participants, the answering time ratio of words ending with consonants appeared less than words without consonants in the test of relationship with Sentence part. This result was in accordance with the previous research which the average time spent on answering for words with consonants was 4.44 seconds; whereas words without consonants was only 4.79 seconds It can clearly be seen that consonant has more influence at the answering time than words without consonants. Time spent on answering the questions was considered as the key of Thai language cognition.

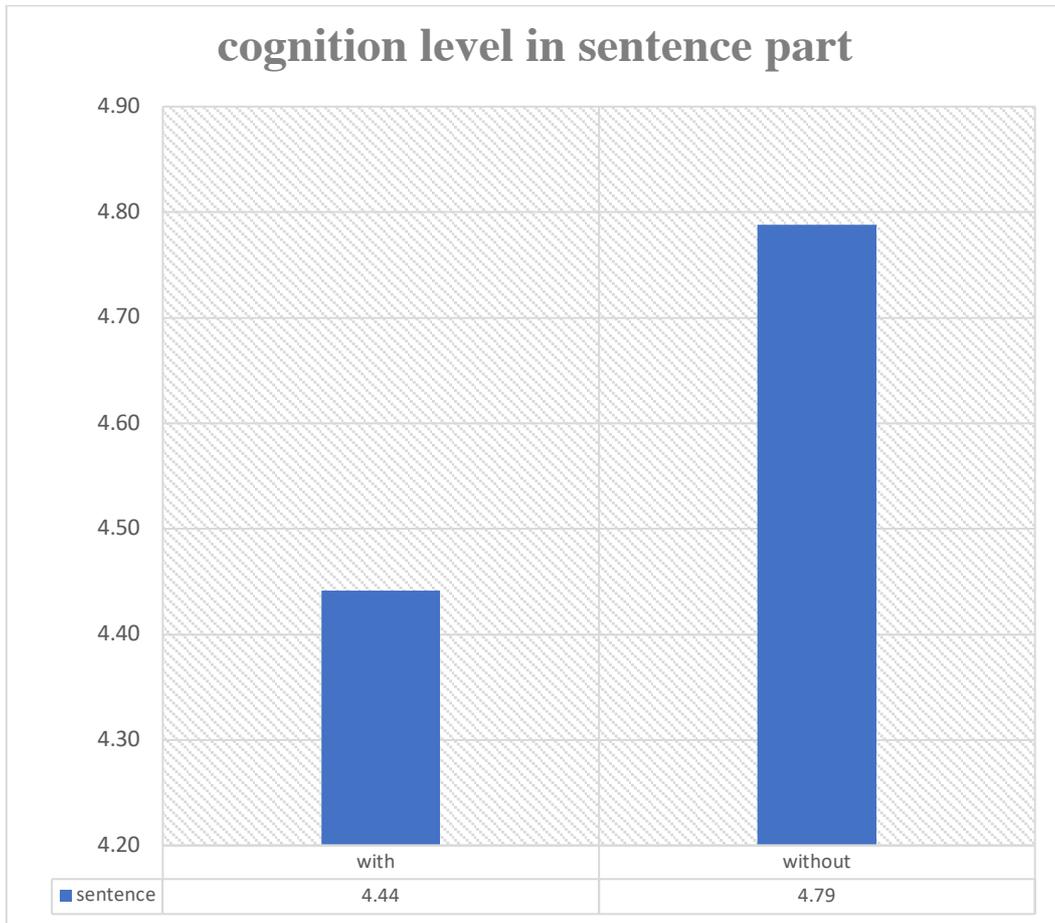


Figure 40 The proportion of time to answering between word with consonant and word without consonant in experiment 2 (The relation between word and sentence part) from 100 participants

Summary data of time to answering

The result found that from 100 of the participants, the words ending with consonants produced more rapidity in cognition than words without consonants. Also, the difficulty and complexity of words had a direct effect on the answering, measured by the time recorded during the test. Moreover, by comparison with the cognition ratio between experiment 1 and 2, it was found that the cognition ratio of experiment 1 (test of relationship with Word part) spent less time than the experiment 2 (test of relationship with Sentence part). It means that Sentence patterns served as complement and offered more understanding in meaning; however, they did not help much about the rapidity in cognition when comparing to the test result of relationship with Word part.

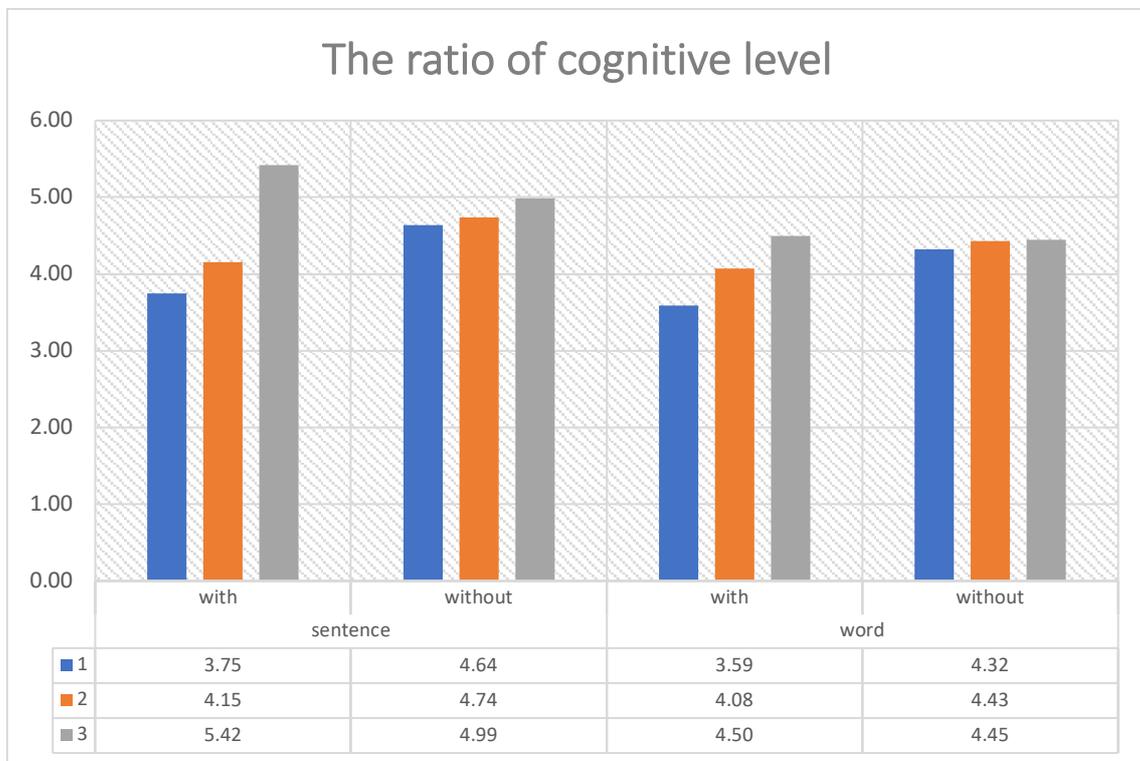


Figure 41 The proportion of time to answering between word with consonant and word without consonant in experiment 2 (The relation between word and sentence part) from 100 participants

9.8 Statistical analysis

9.8.1 The analysis of the correctness ratio statistic in answering question by 2 ways ANOVA

The analysis of the relation between independent variables and correctness ratio in answering questions consists of 3 main variables:

- 1) Types of questions divided by words and sentences
- 2) Types of word choices divided by words with final consonants and words without final consonants
- 3) The levels of difficulty: easy, middle and hard

Table 34 Dependent Variable: correctness ratio

TYPE	Consonant	Level	Mean	Std. Deviation	N
word	without	easy	72.00	25.338	4
		middle	69.75	7.890	4
		hard	66.75	25.382	4
		Total	69.50	19.309	12
	with	easy	92.25	6.652	4
		middle	89.75	9.535	4
		hard	71.50	24.772	4
		Total	84.50	17.250	12
	Total	easy	82.13	20.280	8
		middle	79.75	13.414	8
		hard	69.13	23.357	8
		Total	77.00	19.476	24
sentence	without	easy	87.00	4.967	4
		middle	78.75	14.705	4
		hard	72.25	16.661	4
		Total	79.33	13.459	12
	with	easy	97.00	5.354	4
		middle	95.75	7.182	4
		hard	75.75	21.577	4
		Total	89.50	15.883	12
	Total	easy	92.00	7.171	8
		middle	87.25	14.048	8
		hard	74.00	17.944	8
		Total	84.42	15.305	24
Total	without	easy	79.50	18.708	8
		middle	74.25	11.937	8
		hard	69.50	20.093	8
		Total	74.42	17.034	24
	with	easy	94.62	6.140	8
		middle	92.75	8.447	8
		hard	73.63	21.626	8
		Total	87.00	16.416	24
	Total	easy	87.06	15.554	16
		middle	83.50	13.823	16
		hard	71.56	20.278	16
		Total	80.71	17.728	48

Table 35 Tests of Between-Subjects Effects

Dependent Variable: correctness ratio

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5286.917 ^a	11	480.629	1.824	.086	.358
Intercept	312664.083	1	312664.083	1186.706	.000	.971
TYPE	660.083	1	660.083	2.505	.122	.065
Consonant	1900.083	1	1900.083	7.212	.011	.167
Level	2109.042	2	1054.521	4.002	.027	.182
TYPE * Consonant	70.083	1	70.083	.266	.609	.007
TYPE * Level	50.042	2	25.021	.095	.910	.005
Consonant * Level	452.042	2	226.021	.858	.433	.045
TYPE * Consonant * Level	45.542	2	22.771	.086	.917	.005
Error	9485.000	36	263.472			
Total	327436.000	48				
Corrected Total	14771.917	47				

a. R Squared = .358 (Adjusted R Squared = .162)

I Hypothesis test

- 1) The types of question elements can be separated into words and sentences

H_0 = The correctness ratio in answering questions between words and sentences has no different result

H_1 = The correctness ratio in answering questions between words and sentences has the difference in result

The confidence level = 95% specify = 0.05, Statistic analysis result $F=2.505$ and $Sig. = 0.122$

As $Sig.$ is higher than 0.05, it means that H_0 is accepted. It can be summarized that the correctness ratio in answering questions between words and sentences has no different result.

- 2) The element conditions that relate to final consonants can be divided into words with final consonants and words without final consonants.

H_0 = The correctness ratio in answering questions between words with final consonants and words without final consonants has no different result.

H_1 = The correctness ratio in answering questions between words with final consonants and words without final consonants has the difference in result.

The confidence level = 95% specify = 0.05, Statistic analysis result $F=7.212$ and the value of

Sig. = 0.011. As Sig. is less than 0.05, it means that H_0 is rejected and accept H_1 . It can be summarized that the correctness ratio in answering questions between words with final consonants and words without final consonants has the considerable difference in result.

- 3) The element conditions that relates to the difficulty can be divided into easy, medium and hard

H_0 = The average difficulty of all 3 word groups has no different result.

H_1 = The average difficulty of all 3 word groups has the difference in result.

The confidence level = 95% specify = 0.05, Statistic analysis result $F=4.002$ and the value of Sig. = 0.027. As Sig. is less than 0.05, it means that H_0 is rejected and H_1 is acceptable. It can be summarized that the average difficulty of all 3 word groups has the considerable difference in result

- 4) The coordination between types of question and final consonant conditions

H_0 = No coordinated actions between types of questions and final consonant conditions

H_1 = Have coordinated actions between types of questions and final consonant conditions

The confidence level = 95% specify = 0.05, Statistic analysis result $F=0.266$ and the value of Sig. = 0.609. As Sig. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions between types of questions and final consonant conditions.

- 5) The coordination between types of question and the difficulty of words

H_0 = No coordinated actions between types of questions and the difficulty of words

H_1 = Have coordinated actions between types of questions and the difficulty of words

The confidence level = 95% specify = 0.05, Statistic analysis result $F=0.95$ and the value of Sig. = 0.910. As Sig. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions between types of questions and final consonant conditions

- 6) The coordination between final consonant conditions and the difficulty of words

H_0 = No coordinated actions between final consonant conditions and the difficulty of words

H_1 = Have coordinated actions between final consonant conditions and the difficulty of words

The confidence level = 95% specify = 0.05, Statistic analysis result $F=0.858$ and the value of Sig. = 0.433. As Sig. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions between final consonant conditions and the difficulty of words

- 7) The coordination among 3 independent variables

H_0 = No coordinated actions among 3 independent variables.

H_1 = Have coordinated actions among 3 independent variables.

The confidence level = 95% specify = 0.05, Statistic analysis result $F=0.086$ and the value of Sig. = 0.917. As Sig. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions among 3 independent variables.

Table 36 Multiple Comparisons

(I) Level	(J) Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
easy	middle	3.56	5.739	.826	-11.09	18.21
	hard	15.50*	5.739	.036	.85	30.15
middle	easy	-3.56	5.739	.826	-18.21	11.09
	hard	11.94	5.739	.130	-2.71	26.59
hard	easy	-15.50*	5.739	.036	-30.15	-.85
	middle	-11.94	5.739	.130	-26.59	2.71

The multi comparison table shows the matching test of people has the difference correctness ration in answering questions. After analyzing, the average ratio in easy level is different from hard level. The hard level has the correctness ration in answering questions lower that easy level.

Table 37 Correct score

Correct score

Level	N	Subset	
		1	2
hard	16	71.56	
middle	16	83.50	83.50
easy	16		87.06
Sig.		.130	.826

With reference to the table shown above, the average correctness ration in answering questions of each group remains equal. It can be divided into 2 groups: hard level and middle level; middle level and easy level.

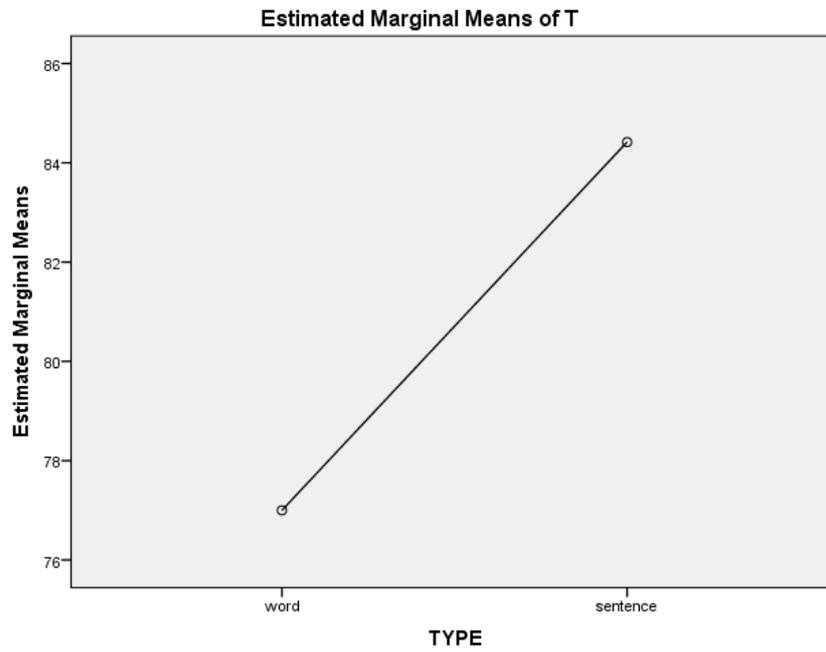


Figure 42 The graph illustrates the relation of the correctness ratio in answering questions between words and sentences

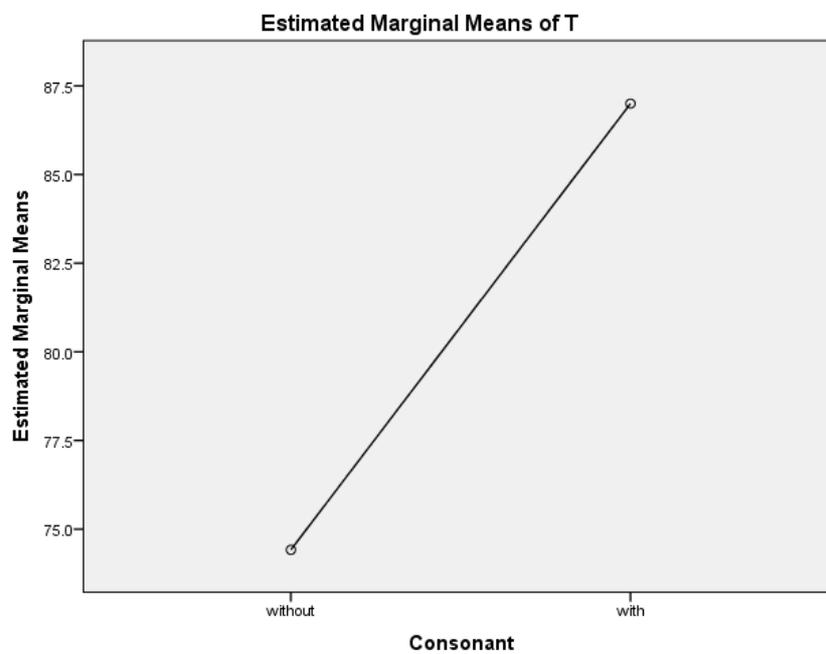


Figure 43 The graph illustrates the relation of the correctness ratio in answering questions between word with and without final consonant conditions

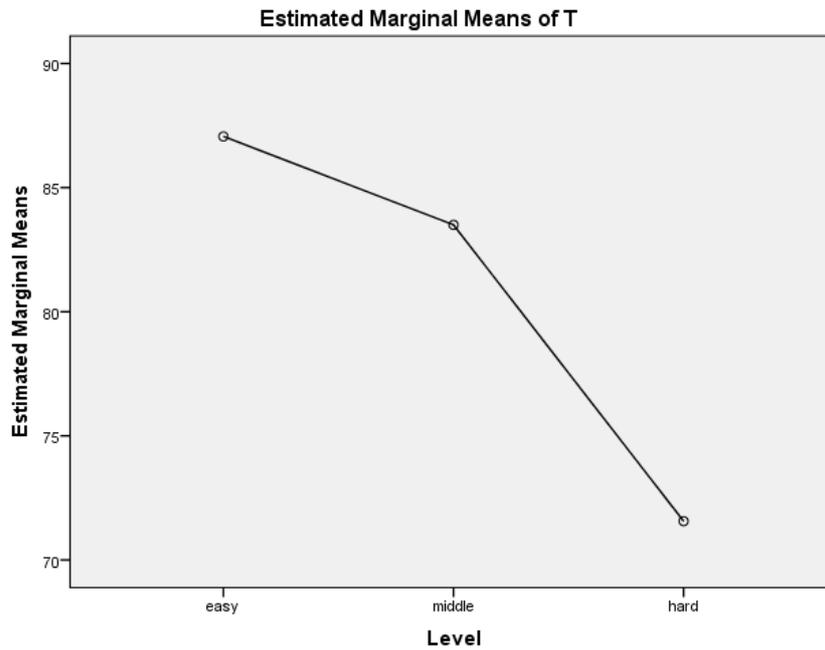


Figure 44 The graph illustrates the relation of the correctness ratio in answering questions which changes following the difficulty of word

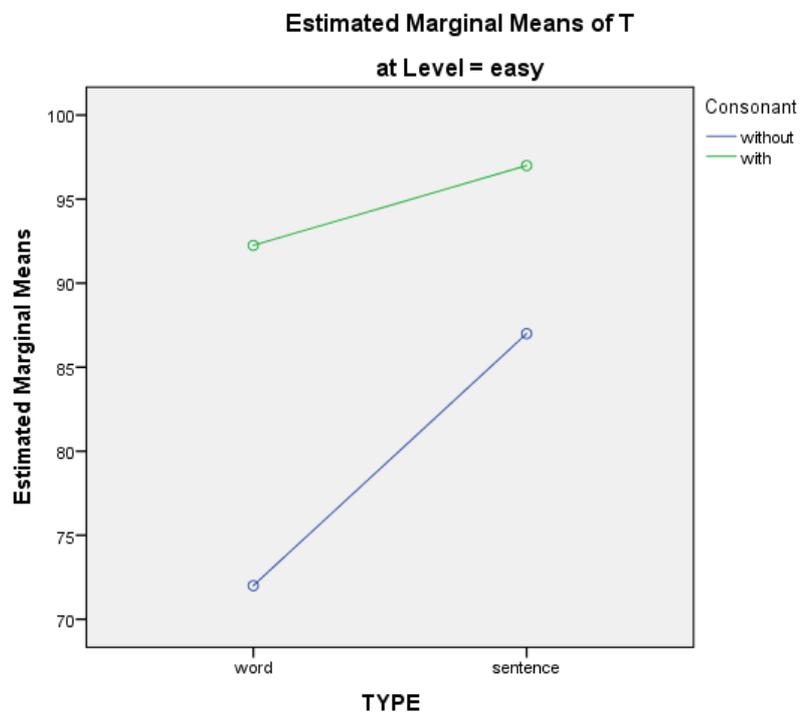


Figure 45 The graph illustrates the relation between types of questions and final consonant conditions which has influence on the answers for easy level

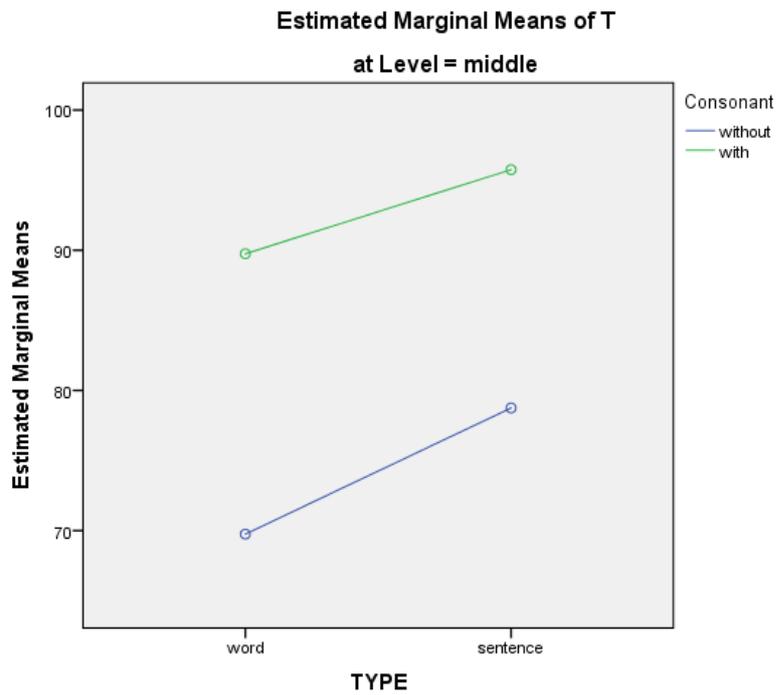


Figure 46 The graph illustrates the relation between types of questions and final consonant conditions which has influence on the answers for middle level

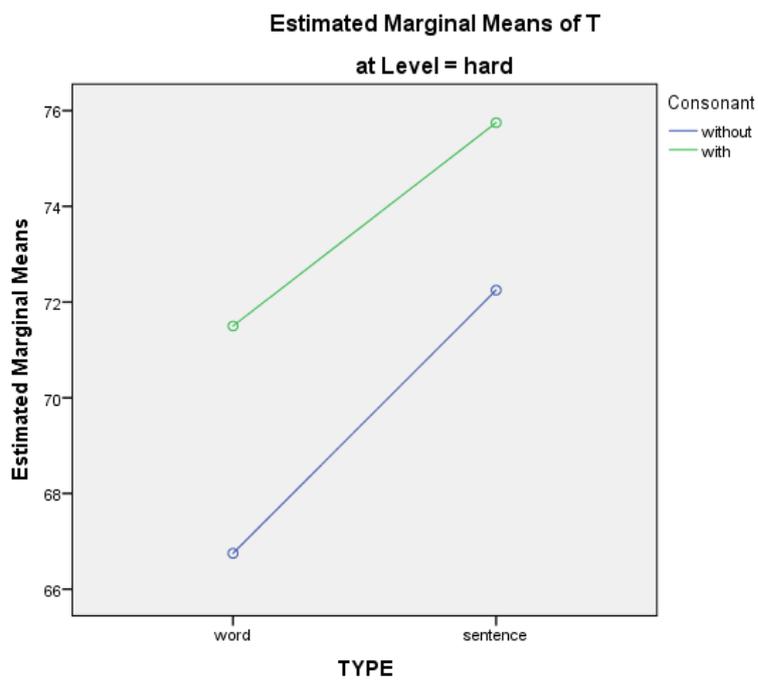


Figure 47 The graph illustrates the relation between types of questions and final consonant conditions which has influence on the answers for middle level

The results showed consonants and word levels which affect the correctness in answering questions. As the 95% confidence level, consonants are significant ($p = .011 < .05$), and word levels are significant ($p = .027 < .005$). It can be summarized that both variables directly affect the correctness in answering questions.

The analysis of the differences in the groups by applying independents sample test (t-test)

A. The differences in the group between words with and without final consonants

Table 38 Group Statistics between words with and without final consonants

Consonant	N	Mean	Std. Deviation	Std. Error Mean
Correct without	24	74.42	17.034	3.477
item with	24	87.00	16.416	3.351

In case of considering the value of Mean, it is found that words with final consonants has the influence on the correctness in answering questions. Based on 100 of participants, words with final consonants has 87% of correctness ratio. In contrast, words without final consonants has 74.42% of correctness ratio.

Table 39 Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	.56	.46	-2.61	46.00	.01	-12.58	4.83	-22.30	-2.86
Equal variances not assumed			-2.61	45.94	.01	-12.58	4.83	-22.30	-2.86

Moreover, in analyzing the test result of relationship by t-test at the confidence level is 95%, it is found that F-test =0.56 and the value of significant = 0.01. As Significant is less than 0.05, so it can be summarized that the factor of words with and without final consonants has an influence on the correctness in answering questions. In case of considering the value of Mean, it is found that words with final consonants has the higher correctness ratio in answering questions than words without final

consonants. It can be summarized that words with final consonants support the competency of cognition more than words without final consonants. Final consonant presents itself as the Trigger in Thai language as it supports the cognition. Furthermore, it performs like ‘Space’ in English which is used to separate words and sentences correctly and helps readers to understand Thai language easier.

B. The differences of word levels in the group by applying independents sample test

The differences of word levels in the group can be divided into easy, middle and hard. This research studied the comparison for 3 pair, easy-middle; easy-hard; and middle-hard.

1) Test to compare between easy and middle level.

The table as below show the test of the average score in answering questions between the words which have different difficulty levels by using Independents Samples Test to compare between easy and middle level.

Table 40 Group Statistics between easy and middle level

	Level	N	Mean	Std. Deviation	Std. Error Mean
T	easy	16	87.06	15.554	3.889
	middle	16	83.50	13.823	3.456

In case of considering the value of Mean of word level between easy-middle, it is found that based on 100 of participants, the average ratio of correctness in easy level is 87.06%; whereas the average ratio of correctness in hard level is 83.50%.

Table 41 Independent Samples Test

	Levene's Test for Equality of Variances	t-test for Equality of Means								
		F	Sig.	t	df	Sig. (2- tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
T Equal variances assumed	.017	.896	.685	30	.499	3.563	5.202	-7.062	14.187	
Equal variances not assumed			.685	29.592	.499	3.563	5.202	-7.068	14.193	

Moreover, to analyze the test result of relation by statistic of t-test at the confidence level is 95%, it is found that F-test =0.017 and the value of significant. = 0.0499. As significant is higher than 0.05, it can be summarized that word level between easy and middle has the equal influence on the correctness in answering questions.

2) Test to compare between middle and hard level

The table as below show the test of the average score in answering questions between the words which have different difficulty levels by using Independents Samples Test to compare between middle and hard level.

Table 42 Group Statistics between middle and hard level

	Level	N	Mean	Std. Deviation	Std. Error Mean
correct	middle	16	83.50	13.823	3.456
	hard	16	71.56	20.278	5.069

In case of considering the value of Mean of word level between middle-hard, it is found that based on 100 of participants, the average ratio of correctness in middle level is 83.50%; whereas the average ratio of correctness in hard level is 71.56%.

Table 43 Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	4.046	.053	1.946	30	.061	11.938	6.135	-.592	24.467
Equal variances not assumed			1.946	26.465	.062	11.938	6.135	-.663	24.538

Moreover, to analyze the test result of relation by statistic of t-test at the confidence level = 95%, it is found that F-test =4.046 and the value of significant is 0.061. As significant is higher than 0.05, it can be summarized that word level between middle and hard has the equal influence on the correctness in answering questions.

3) Test to compare between easy and hard level

The table as below show the test of the average score in answering questions between the words which have different difficulty levels by using Independents Samples Test to compare between easy and hard level.

Table 44 Group Statistics between easy and hard level

Level	N	Mean	Std. Deviation	Std. Error Mean
T easy	16	87.06	15.554	3.889
hard	16	71.56	20.278	5.069

In case of considering the value of Mean of word level between easy-hard, it is found that based on 100 of participants, the average ratio of correctness in easy level is 87.06%; whereas the average ratio of correctness in hard level is 71.56%.

Table 45 Independent Samples Test

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
Equal variances assumed	3.383	.076	2.426	30	.021	15.500	6.389	2.452	28.548
Equal variances not assumed			2.426	28.112	.022	15.500	6.389	2.415	28.585

Moreover, to analyze the test result of relation by statistic of t-test at the confidence level is 95%, it is found that F-test =3.383 and the value of significant = 0.021. As significant is less than 0.05, it can be summarized that word level between easy and hard has the unequal influence on the correctness in answering questions. Easy words have the higher correctness ration than the hard words. Therefore, the word levels affect directly to the cognition of Thai language.

Summary of the correctness ratio statistic in answering question

According to the analysis by statistic tooling, researchers found that words with final consonants works as the accelerator of competency in cognition of Thai language. It helps learners to receive more precise information than words without final consonants. By this, it means final consonants work as the Space used for separating words and sentences in Thai language easier, as well as helping learner to separate words in sentences. Furthermore, word levels have considerable influence on the cognition of Thai language. The harder they are, the higher opportunities of error can occur.

9.8.2 The analysis of the timing ratio statistic in answering question by 2 ways ANOVA

The analysis of the relation between independent variables and time spent on answering questions consists of 3 main variables:

- 1 Types of questions divided by words and sentences
- 2 Types of word choices divided by words with final consonants and words without final consonants
- 3 The levels of difficulty: easy, middle and hard

Table 46 Descriptive Statistics

Dependent Variable: TIME

TYPE	Consonant	Level	Mean	Std. Deviation	N
word	without	easy	4.3173	.82213	4
		middle	4.4281	.47489	4
		hard	4.4462	1.28179	4
		Total	4.3972	.83515	12
	with	easy	3.5896	.78165	4
		middle	4.0752	.51914	4
		hard	4.4987	1.26158	4
		Total	4.0545	.90813	12
	Total	easy	3.9535	.83834	8
		middle	4.2517	.49774	8
		hard	4.4725	1.17773	8
		Total	4.2259	.87099	24
sentence	without	easy	4.6366	1.15741	4
		middle	4.7380	1.91671	4
		hard	4.9889	1.50653	4
		Total	4.7878	1.41782	12
	with	easy	3.7500	1.39133	4
		middle	4.1533	.89797	4
		hard	5.4202	2.06588	4
		Total	4.4412	1.56978	12
	Total	easy	4.1933	1.27605	8
		middle	4.4457	1.42048	8
		hard	5.2046	1.68965	8
		Total	4.6145	1.47353	24
Total	without	easy	4.4769	.94493	8
		middle	4.5831	1.30330	8
		hard	4.7176	1.32702	8
		Total	4.5925	1.15533	24
	with	easy	3.6698	1.04825	8
		middle	4.1142	.68031	8
		hard	4.9595	1.65946	8
		Total	4.2478	1.26963	24
	Total	easy	4.0734	1.05032	16
		middle	4.3487	1.03309	16
		hard	4.8385	1.45688	16
		Total	4.4202	1.21340	48

Table 47 Levene's Test of Equality of Error Variances^a

Dependent Variable: TIME

F	df1	df2	Sig.
1.142	11	36	.360

According to the test, the equality of the variance valued at Sig 0.360. If the result is higher than 0.05, it means that all groups has the equality in the variance.

Table 48 Tests of Between-Subjects Effects

Dependent Variable: TIME

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	11.272 ^a	11	1.025	.637	.785	.163
Intercept	937.825	1	937.825	582.816	.000	.942
TYPE	1.812	1	1.812	1.126	.296	.030
Consonant	1.426	1	1.426	.886	.353	.024
Level	4.806	2	2.403	1.493	.238	.077
TYPE * Consonant	4.720E-5	1	4.720E-5	.000	.996	.000
TYPE * Level	.712	2	.356	.221	.803	.012
Consonant * Level	2.293	2	1.147	.713	.497	.038
TYPE * Consonant * Level	.222	2	.111	.069	.933	.004
Error	57.929	36	1.609			
Total	1007.026	48				
Corrected Total	69.201	47				

a. R Squared = .163 (Adjusted R Squared = -.093)

Hypothesis Testing

- 1) The types of question elements can be separated into words and sentences

H_0 = the timing ratio in answering questions between words and sentences has no different result

H_1 = the timing ratio in answering questions between words and sentences has the difference in result

The confidence level = 95% specify $\alpha = 0.05$, Statistic analysis result $F=1.812$ and significant = 0.296,

As $\alpha > 0.05$, it means that H_0 is accepted. It can be summarized that the timing ratio in answering questions between words and sentences has no different result.

- 2) The element conditions that relates to final consonants can be divided into words with final consonants and words without final consonants.

H_0 = the timing ratio in answering questions between words with final consonants and words without final consonants has no different result.

H_1 = the timing ratio in answering questions between words with final consonants and words without final consonants has the difference in result.

The confidence level is 95% specify $\alpha = 0.05$, Statistic analysis result $F=0.886$ and the value of significant. = 0.353. As $\alpha > 0.05$, it means that H_0 is accepted. It can be summarized that the timing ratio in answering questions between words with final consonants and words without final consonants has no difference in result.

- 3) The element conditions that relate to the difficulty can be divided into easy, middle and hard

H_0 = the average difficulty of all 3 word groups has no different result.

H_1 = the average difficulty of all 3 word groups has the difference in result.

The confidence level is 95% specify = 0.05, Statistic analysis result $F=1.493$ and the value of significant = 0.238. As significant is less than 0.05, it means that H_0 is accepted. It can be summarized that the average difficulty of all 3 word groups has no difference in result.

- 4) The coordination between types of question and final consonant conditions

H_0 = No coordinated actions between types of questions and final consonant conditions

H_1 = Have coordinated actions between types of questions and final consonant conditions

The confidence level is 95% specify = 0.05, Statistic analysis result $F=0.000$ and the value of significant = 0.0996. As significant is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions between types of questions and final consonant conditions.

- 5) The coordination between types of question and the difficulty of words

H_0 = No coordinated actions between types of questions and the difficulty of words

H_1 = Have coordinated actions between types of questions and the difficulty of words

The confidence level is 95% specify = 0.05, Statistic analysis result $F=0.221$ and the value of significant = 0.803. As Sig. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions between types of questions and final consonant conditions

- 6) The coordination between final consonant conditions and the difficulty of words

H_0 = No coordinated actions between final consonant conditions and the difficulty of words

H_1 = Have coordinated actions between final consonant conditions and the difficulty of words

The confidence level is 95% specify = 0.05, Statistic analysis result $F=0.713$ and the value of

significant = 0.497. As Sig. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions between final consonant conditions and the difficulty of words

7) The coordination among 3 groups independent variables

H_0 = No coordinated actions among 3 independent variables.

H_1 = Have coordinated actions among 3 independent variables.

The confidence level = 95% specify = 0.05, Statistic analysis result $F=0.069$ and the value of significant. = 0.933. As significant. is higher than 0.05, it means that H_0 is accepted. It can be summarized that no coordinated actions among 3 independent variables.

Table 49 Multiple Comparisons

Dependent Variable: TIME

(I) Level	(J) Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
easy	middle	-.2753	.44849	.829	-1.4204	.8698
	hard	-.7651	.44849	.247	-1.9102	.3800
middle	easy	.2753	.44849	.829	-.8698	1.4204
	hard	-.4898	.44849	.556	-1.6349	.6552
hard	easy	.7651	.44849	.247	-.3800	1.9102
	middle	.4898	.44849	.556	-.6552	1.6349

Based on observed means. The error term is Mean Square (Error) = 1.609.

The multi comparison table shows the matching test of people has the difference timing ration in answering questions. After analyzing, the average ratio in easy level is different from hard level. The hard level has more average timing ration in answering questions than easy level.

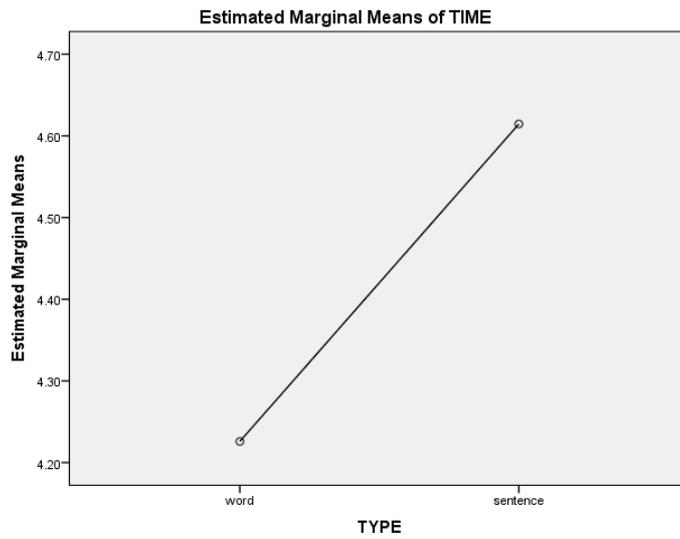


Figure 48 The graph illustrates the relation of the timing ratio in answering questions between words and sentences

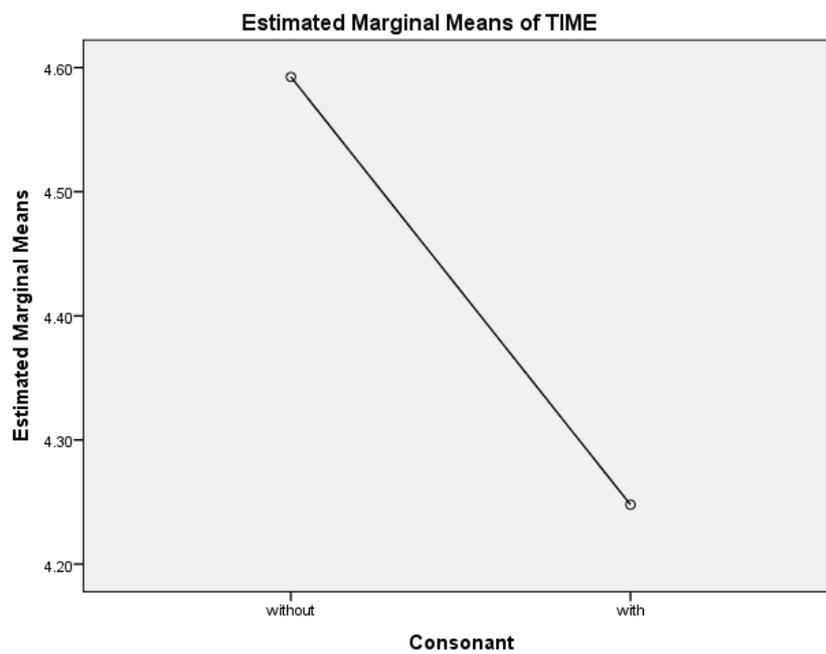


Figure 49 The graph illustrates the relation of the timing ratio in answering questions between types of questions and final consonant conditions

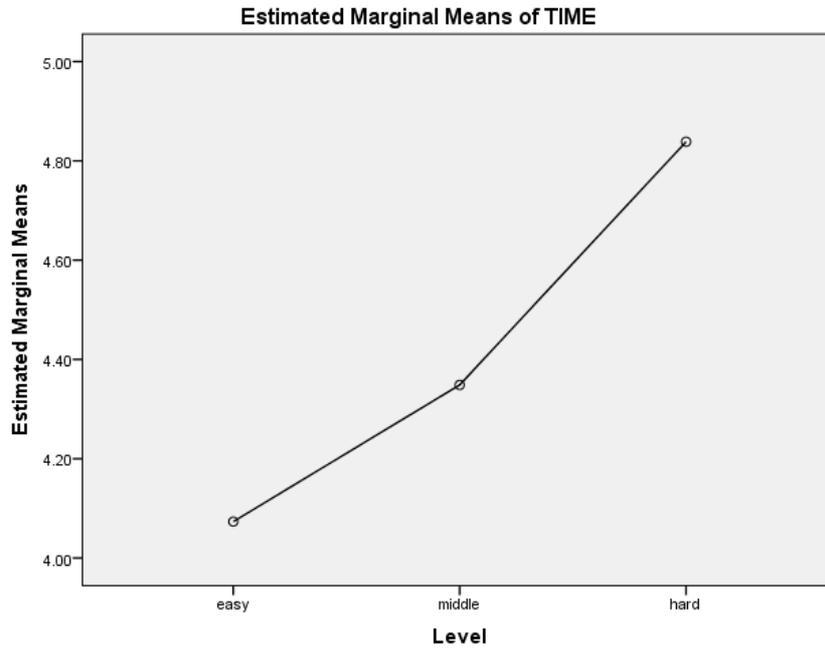


Figure 50 The graph illustrates the relation of the timing ratio in answering questions which changes following the difficulty of word

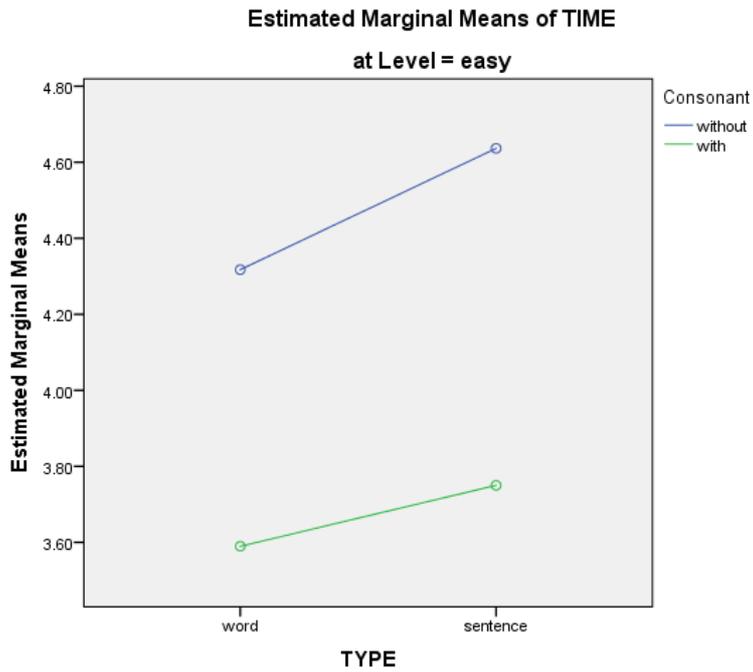


Figure 51 The graph illustrates the relation of the timing ratio in answering questions which changes following the difficulty of word

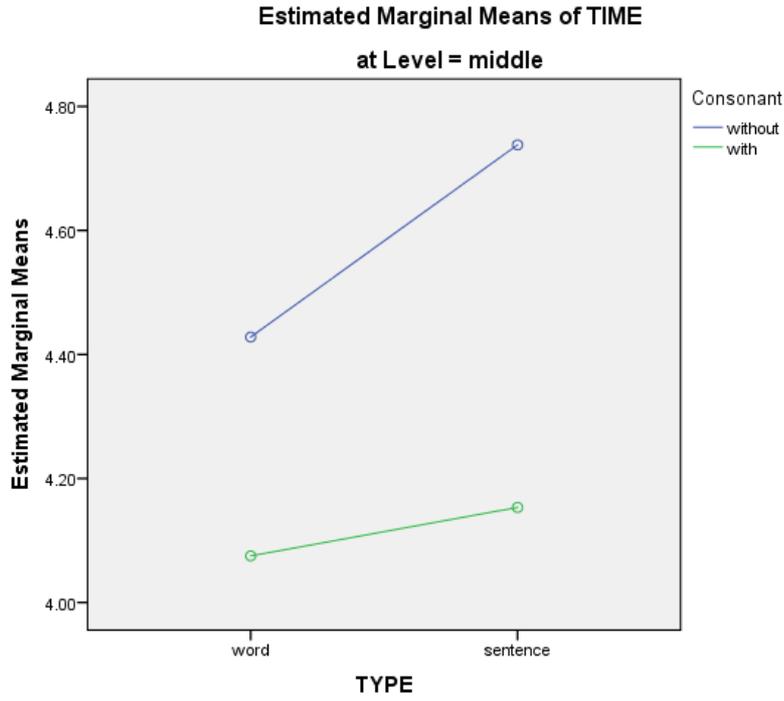


Figure 52 The graph illustrates the relation between types of questions and final consonant conditions which has influence on the answers for middle level

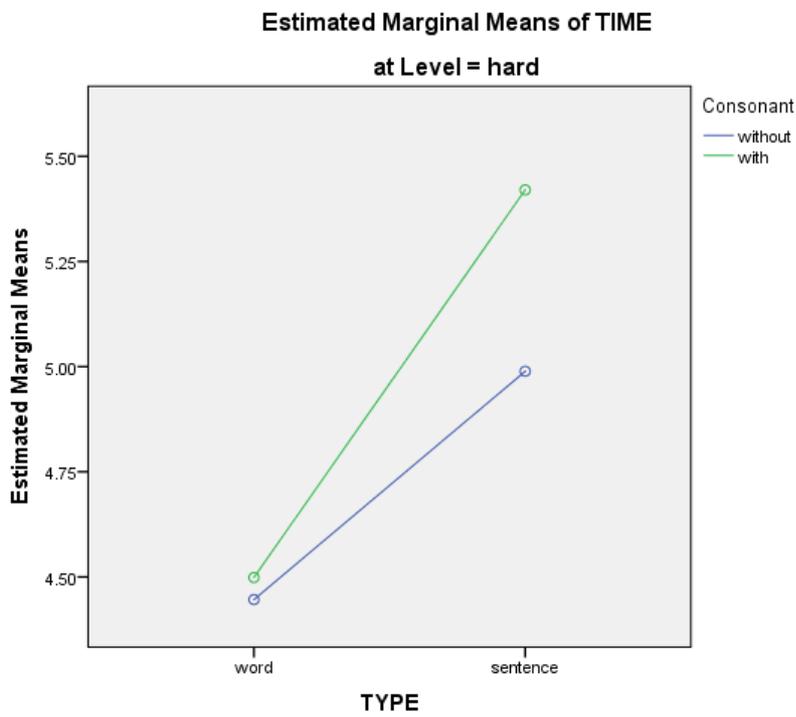


Figure 53 The graph illustrates the relation between types of questions and final consonant conditions which has influence on the answers for hard level

Summary of the correctness ratio statistic in answering question

According to the analysis by statistic tooling at the confidence level is 95%, time spent on answering questions of 3 groups of independent variables, which consist of Types of questions (words and sentences), types of word choices (words with final consonants and words without final consonants) and the levels of difficulty (easy, middle and hard), has no difference in the average time spent on answering questions. In case of considering the value of Mean in each group, it is found that questions with isolated words spent less time in answering than questions with sentences. Moreover, words with final consonants also spent less time in answering questions than words without final consonants. Timing ratio spent on answering questions varies to the difficulty of words. The harder they are, the more time will be spent. To be summarized, words with final consonants spent less time in answering questions than words without final consonants, and questions with isolated words also spent less time in answering than questions with sentences. Furthermore, the word level is one of the factors that supports the cognition of Thai language.

9.8.3 The analysis of the difference of words

Each language in the word is unique. However, one thing that is considered having the similarity due to the limit of language is the Words. Words can be divided into 3 groups which are Semantic word, Homophone and Homograph. Some assumptions indicated that difference in words affects the time and correctness in answering questions. Thereby, this research analyzed the relation in the group which has different kinds of word by using statistic tooling called One way ANOVA to explain and summarize the experiment. With the confidence level is 95%, the result shows as followings.

The analysis of the timing ratio statistic in answering 1 ways ANOVA

The analysis of the timing ratio statistic in answering 1 ways ANOVA by analyzing the relation of independent variables that relates to the average timing ration in answering questions.

The independent variables as words were divide into 4 categories

- 1) Uncontrolled Word
- 2) Homophone
- 3) Homograph
- 4) Semantic

Table 50 Descriptive of Time

TIME

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
					Lower Bound	Upper Bound			
					8) Uncontrolled	12			
Homophone	12	3.7308	1.01515	.29305	3.0858	4.3758	2.12	5.71	
Homograph	12	4.8829	1.28561	.37112	4.0660	5.6997	3.35	8.21	
Semantic	12	4.9449	1.18749	.34280	4.1904	5.6994	3.17	7.58	
Total	48	4.4202	1.21340	.17514	4.0678	4.7725	2.12	8.21	
Model			1.13377	.16365	4.0904	4.7500			
Fixed Effects				.29629	3.4773	5.3631			.24403
Random Effects									

Table 51 Test of Homogeneity of Variances

TIME

Levene Statistic	df1	df2	Sig.
.091	3	44	.965

According to the test, the equality of the variance valued at Sig 0.965 If the result is higher than 0.05, it means that the variance of each group is equal

Table 52 Time ANOVA

TIME

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	12.642	3	4.214	3.278	.030
Within Groups	56.559	44	1.285		
Total	69.201	47			

The hypothesis testing

H₀ = The average timing ratio in answering questions among 4 words group has no different result

H₁ = The average timing ratio in answering questions among 4 words group has the difference in result

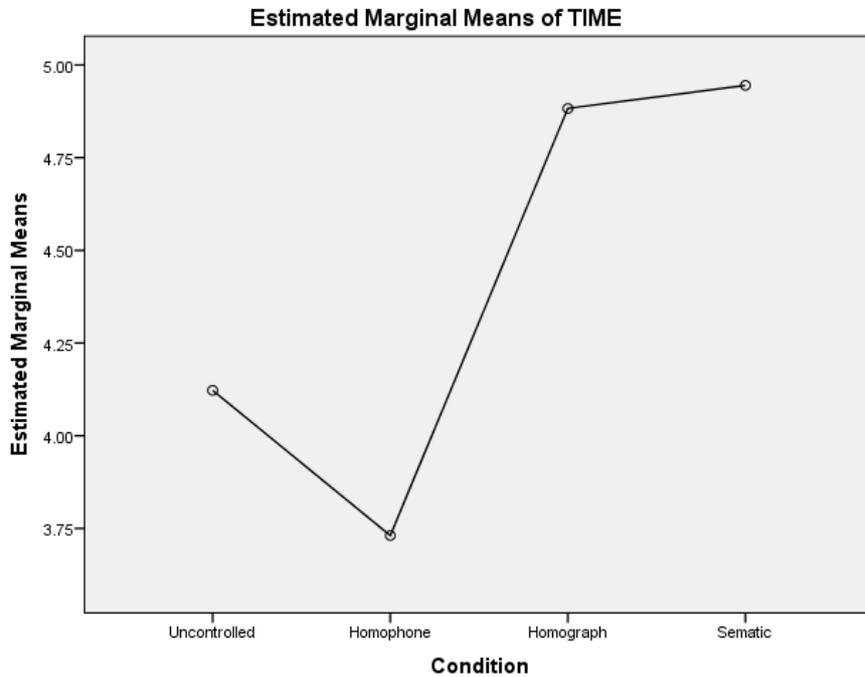


Figure 54 The graph illustrates the relation of independent variables that relates of time to answering questions

The confidence level is 95% specify = 0.05, Statistic analysis result $F=3.278$ and significant = 0.030. As significant is less than 0.05, it means that H_0 is rejected and accept H_1 instead. It can be summarized that the average timing ratio in answering questions among 4 words groups has at least 2 groups that different in result. After analyzing the value of Mean, Homophone has the least average timing ratio in answering questions and Semantic has the highest average timing ratio in answering questions.

The analysis of the correctness ratio statistic in answering 1 ways ANOVA

The analysis of the correctness ratio statistic in answering 1 ways ANOVA by analyzing the relation of independent variables that relates to the average timing ration in answering questions.

The independent variables as words were divide into 4 categories;

- a Uncontrolled Word
- b Homophone
- c Homograph
- d Semantic

Table 53 Descriptive Correct data

Correct data

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Between-Component Variance
					Lower Bound	Upper Bound			
					Uncontrolled	12			
Homophone	12	85.50	15.359	4.434	75.74	95.26	50	100	
Homograph	12	71.08	22.142	6.392	57.02	85.15	36	100	
Semantic	12	76.50	15.734	4.542	66.50	86.50	50	96	
Total	48	80.71	17.728	2.559	75.56	85.86	36	100	
Model Fixed Effects			16.645	2.403	75.87	85.55			
Random Effects				4.233	67.24	94.18			

Table 54 Test of Homogeneity of Variances

Levene Statistic	df1	df2	Sig.
1.982	3	44	.131

According to the test, the equality of the variance valued at Sig. 0.131. If the result is higher than 0.05, it means that the variance of each group is equal.

Table 55 Correct data ANOVA

Correct data

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2580.750	3	860.250	3.105	.036
Within Groups	12191.167	44	277.072		
Total	14771.917	47			

The hypothesis testing

H_0 = the average correctness ratio in answering questions among 4 words group has no different result

H_1 = the average correctness ratio in answering questions among 4 words group has the difference in result

The confidence level is 95% specify = 0.05, Statistic analysis result $F=3.105$ and significant = 0.036. As significant is less than 0.05, it means that H_0 is rejected and accept H_1 instead. It can be summarized that the average correctness ratio in answering questions among 4 word groups has at least 2 groups that different in result.

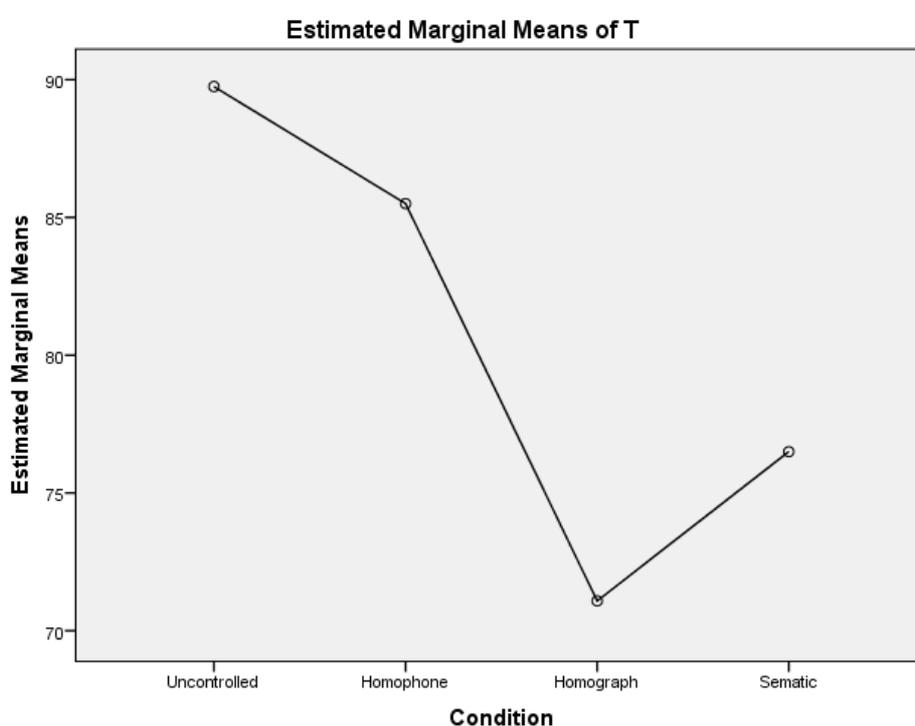


Figure 55 The graph illustrates the relation of independent variables that relates to the correctness ration in answering questions

9.9 Conclusion

The objective of this research is to find out the important of final consonant that has an influence on the cognition of Thai language. According to the analyze done by the statistic tooling, words with final consonants has the considerable importance in the cognition, whether it be the competency in receive precise information or learning faster than words without final consonants. Final consonants work as the Space in English used for separating words and sentences in Thai language easier. It works as the accelerator of competency in cognition of Thai language and helps learners to receive more precise and faster information. Moreover, this study has done the types of questions comparison

that help learners to better approach the data. Questions with isolated words spent less time in answering than questions with sentences; however, questions with sentences have the higher correctness ration than questions with isolated words. The result of time and correctness varies to the difficulty of words following the rule in the test. The last on is that similarities and homographs cause more errors in cognition and spent more time in answering question than homophones. In conclusion, it can be claimed that to design the practical Interface data in Thai language, it is suggested that special feature of final consonants should be applied to support the cognition as it gains the correctness. To identify words, it is necessary to pay attention to the difficulty of words and avoid using homographs and similarities in order to prevent the confusing.

Chapter 10

Conclusion

Chapter 10 Conclusion

This research aims to create principle and standard of user interface design by studying cognitive process in Thai language. The beginning of this research came from the observation of hardware and software of electronic industry in Thailand and found that there are various designs. On the menu screens, there are Thai and English languages mixed, together with pictures and symbols. Moreover, technical terms for each brand use different words. The hypothesis is that there is no own interface for Thai electronic product because there is no principle and standard of user interface design. Therefore, to prove the hypothesis, researcher creates experiments to find the answer.

First of all, researcher surveyed current situation in electronic market in Thailand in order to analyze causes of problems of user interface in Thai electronic industry. The research aims to explain the significant role of user interface that can improve electronic industry. The methods were done by applying observational analytic study to do SWOT analysis, then made strategies by applying TOWS Matrix and Logical Model respectively. After that, researcher made short-term, mid-term and long-term strategies to solve problem of user interface in Thai electronic industry. The result of study shows that currently, electronic industry in Thailand is OEM (Original Equipment Manufacturer) or hired of work from international owners such as Japan, USA and others countries. However, being OEM limits the development of interface or program design to be competitive with technology owners from other countries because Thailand relies on the technology from those countries. The main problem is that the lack of support from government, private sectors and also education sectors. For example, there is no support to do transit knowledge so interface design in Thailand has no chance to be developed. Moreover, there is no curriculum for students who interest in usability. Only a subject in Information technology or computer system science available. As result, Thai people have limited knowledge and have only a few research to study and refer. In addition, Thai people do not realize that to have their own interface design is really important. Thereby, researcher proposed that Thai people should start taking actions by collaborating with each other, whether from education sectors, industrial sectors and government sectors and upgrade themselves to be ODM (original design manufacture) The result from the study is presented to experts from private sectors, government sectors, and education sectors who relates in electronic industry. Those experts will evaluate the possibilities and provide some comments to improve the research. The result is that experts agreed with the methods in this research. Moreover, specialists suggest that a research and development center should be created in Thailand. Specialists should be hired to encourage the organization to see the importance of improvement and the development of electronic industries by creating value added. After that, knowledge should be provided to people who are interested in this matter so that they can apply such knowledge in their lives. Afterwards, workers should be trained to become specialists in the organizations. As well as, user interface is advantage for creating value added in future technology such as Pilot car and smart

electronic appliance and so on.

It can be summarized that currently Thai still lacks cooperation between government, private sectors, and education. It makes electronics industry can't develop for enough ability to design and create new products. Moreover, Thai also lacks workers in science and technology, which is an important base for creating specialists of user interface design, all sectors should realize this problem and solve it together, as well as support the development of products continuously for the best efficiency. Finally, increasing value added to products can provide advantages over competitors.

Next, to find out the fact and to prove the hypothesis, research did a survey in electronic market by collecting command wordings appearing on the screen from sampling products, then compare the wordings from each brand. The methods of selecting of brand came from a survey of 195 users to find out what electronic devices are the most important for daily used and what are the most complicated function to understand. Washing machine are voted to be the most complicate device because users need to take longer time to understand all functions than other devices. The result from the comparison of washing machine in different brands but under the same nation shows no significant differences. However, the comparison of washing machine in different nation shows really significant differences in interface design. This is because Thai manufacturers have no standard for interface design. Producers only translate languages from technology owner to Thai language. Therefore, in order to create same standard, Thai people need to create standard for user interface design which all manufacturers need to comply. In order to create standard for user interface design, this research aims to create and improve command wordings on electronic devices by using washing machine as a bad user interface design. For solving problems, researcher study previous research to find the approach. It is necessary to study Brain system, Cognition process, Language system and the principle of user interface. Therefore, researcher needs to study related field to create experiments.

The first experiment is to compare cognitive ability between word with and without final consonants by using image identification task. The difference of time spent on choosing image was very important as it could measure the cognitive processing. In experiment, words were divided into 5 groups (Unrelated meaning, related meaning, Homonym, and Homophone). In each group, final consonant (Tuasakot) and non-final consonant (Non-Tuasakot) were mixed with others word.

The result shows that final consonant is very significant for the cognitive information processing in Thai language because it works as same as TRIGGER which can indicate words. Participants spent less time to answer if those words have final consonants. This means final consonant accelerate cognition process in Thai language. The experiment shows the same result as previous research. Lastly, to use final consonant as one of the factors to create standard of user interface, this research also did another experiment to analyze effect of final consonants in the cognitive process of Thai Language by using word identification task and summarize the result by recording the time that participants spent in answering questions. Moreover, this experiment also focus on data accuracy. The

result shows that words with final consonants showed considerable importance in cognition than words without final consonants. As final consonants work similar to the 'space' in English, which is used for separating between word and word in Thai language easier, it works as an accelerator of competency in cognition of Thai language whether in competency to receive precise information or learning faster than words without final consonants. Therefore, final consonant is deemed to be one of the most important factors to help designing Thai interface for devices and tools which command buttons or signs are displayed in Thai. Next, in order to select which words are proper or improper to use for creating user interface design, this experiment also test by divided words into 4 categories which are Uncontrolled, Homophone, Homograph, and Semantic. It is found that word that should be avoided in designing Thai user interface is semantic and homographs word cause more errors in cognition and required more time in answering question. To design good Interface is not to make user confused because it can cause misunderstanding when using the devices. Finally, this research also tested hard words and easy words that affect to cognitive process of Thai people. The words are divided into 3 levels: easy, middle, and hard. The results of time and correctness varied according to the difficulty of words level. It shows that good Interface needs to consider about the difficulty of words when explaining the information on the devices. If words are not suitable for the user's competency, it will affect to the cognitive competency in both speed and accuracy in answering questions. To sum up, the result from this research will be presented to electronic companies and universities like Panasonic (Thailand) Co.,Ltd., Thai Samsung Electronics Co.,Ltd, Kasetsart University and Thai-Niichi Institute of Technology. This is to encourage business sectors and education sectors realize the problems and use the data from this research to solve problems of user interface design in Thai electronic industry. Then Thai companies can transform themselves from OEM to EDM by having high value add to product and can be competitive manufacturers in the future.

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7. 著者名: Pichit Ngamjarussrivichai, Wuttipong Panitsettakorn, Phenpimon Wilairatana, Konosu Tsutomu
論文タイトル: Designing a Social Commerce Diagnosis Techniques Based on Earned Value Management: Case Study of Thai Cosmetics Manufacturing Company
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