EVALUATION OF A VISUAL FEEDBACK TOOL FOR SPELLING ERRORS OF LEARNERS OF JAPANESE DURING TYPING

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ABSTRACT

Typing in Japanese is a difficult process for novice and intermediate learners of Japanese due to the writing system of the Japanese language and its comparatively involved input method on a keyboard. Considering that spell checkers, which enable the user to check and correct their own errors and select the correct kanji word, are designed for native speakers, the learners of Japanese as a foreign language (JFL) may not recognize their spelling errors and are thus unable to self-correct using this built-in tool.

The present study addresses this problem and conducts an experiment to evaluate the effectiveness of a visual feedback tool by its error recognition rate on the learners spelling errors when typing in Japanese. The participants were 46 beginner level JFL learners in a third semester Japanese course, and the majority consist of native speakers of Chinese or English. The participants participated in two experimental sessions. In both sessions, participants were audio recorded while reading aloud a list of words in Japanese for pronunciation analysis and screen recorded while typing the same list of Japanese words. These recordings are used to analyze the characteristics of error patterns in both pronunciation and typing. During the typing sessions, visual feedback is provided to the participants via a customized dictionary tool when participants make a spelling error.

The results show that regardless of the native language, the learners have difficulty on certain words that include long vowels or double consonants. The recorded error patterns align with the findings of previous studies (Hatasa, 2001; Nakazawa, 2003; Tsuchiya, 2000), and the visual feedback showed an average error recognition rate of 76% of the participants' spelling errors. The participants also assessed the dictionary tool in terms of usability, and their responses indicate that such tools are very useful during typing. The researcher concludes that using a visual feedback dictionary tool is effective in recognizing the spelling errors of the learners when typing, and it increases the learner's awareness of spelling accuracy.

CHAPTER 1. INTRODUCTION

Unlike the languages that use an alphabet, typing in Japanese is a complex process due to its writing systems. Even if the native speakers of Japanese type without difficulty, typing in Japanese with correct spelling may require significant practice for non-native speakers. Novice and intermediate level learners of Japanese may make spelling errors during typing. Regarding these spelling errors, this study aims to evaluate the effectiveness of a visual feedback system for erroneous keyboard input of beginner JFL learners during typing. In this study, visual feedback refers to providing a correct spelling of a *kanji* word together with *kanji* itself on the screen when a student makes a spelling error on anticipated *kanji* during typing.

In an alphabetical language keyboard setting, each key is dedicated to a single letter or character. However, in Japanese keyboard setting, a character appears only after pressing one, two or three keyboard keys in the correct order. Moreover, typing consist of two major steps. In the first step, should be mapping sounds to syllabic symbols to create a word in *hiragana* or *katakana*. In the second step, a word that is written in *hiragana* which is a phonogram, should be converted to a *kanji* (ideogram) word. The correct spelling of the phonogram characters is necessary to convert the word to the target *kanji* word (Hatasa, 2005; Kubota, 1999).

Until the first word processor with a *kana*-to-*kanji* (i.e. phonogram to ideogram) conversion function on a display was publicly unveiled by Toshiba in 1978 (Kawada et al., 1979), handwriting was the only option for the general public to write in the Japanese language. Even so, the first word processor was not targeted to the general public, and it was only in the mid-1980s that word processors became accessible to the public. In the following decade, computers and the internet became widespread and started to be used for educational purposes in Japanese language education as well. Increasing the use of computers among JFL learners thus created new skills, such as typing in Japanese (Hatasa, 2005).

The necessary condition for correct *kanji* conversion is a combination of human mechanical skill and machine function, in addition to the knowledge of *kanji* and the knowledge of spelling. The native speakers of logographic languages such as Japanese, Chinese, and Korean can be assumed to gain this ability naturally. However, even if Japanese native speakers type without difficulty, they may commit spelling errors during keyboard input as well. In such cases, the computer's typing system recognizes the anticipated word or *kanji*, and it can correct the user's

misspelling. However, such systems are created for native speakers' common errors on keyboard input. On the other hand, the JFL learners' spelling errors may differ from native speakers' errors.

A few studies have analyzed the common spelling errors of JFL learners during keyboard input and suggested different ideas to detect and reduce the spelling errors by providing corrective feedback (Hatasa, 2001; Nakazawa, 2003; Tsuchiya, 2000). Spelling errors by JFL learners during keyboard input in previous studies show that the JFL learners tend to make similar spelling errors. Generally, students have difficulties with glides, long vowels, and double consonants when typing (Dixon, 2010; Hatasa, 2001; Nakazawa, 2003; Tsuchiya, 2000). In addition to these findings, instant visual feedback ideas on the computer were suggested in order to reduce students' spelling errors during the typing process (Hatasa, 2001; Tsuchiya, 2000). Nevertheless, none of the previous studies have tested the suggested improvement or visual feedback tools by experiment. This study aims to fill this gap and test the effectiveness of providing visual feedback to JFL learners by modifying an existing computer user dictionary.

Another aspect of the spelling errors may derive from the pronunciation of the JFL learners on specific syllables. Thus, in this study, I analyzed the relation between pronunciation and spelling by comparing participants' typing screen recordings with their voice recorded pronunciations of the same words. However, this comparison is kept limited in order not to lose the main purpose of the study.

Whether related to the pronunciation or to the language competency of the learner, spelling errors should be analyzed in order to improve students' spelling accuracy. Tsuchiya (2000) comprehensively analyzed JFL learners' spelling errors and suggested a potential spell checker software for JFL learners. However, the participants of Tsuchiya's study were more advanced level learners of Japanese as a second language. The current study concentrates on beginner level JFL learners who have studied three semesters of Japanese course at the university level in the United States. Hatasa (2001) examined students' spelling errors on *kanji* words, in addition to *hiragana* words, during the typing process and describes a comprehensive dictionary for JFL learners based on the learners' Japanese proficiency level, which aims to provide visual feedback during typing. Another important issue that Hatasa (2001) raises is that a dictionary can be modified according to the spelling error patterns of the learners.

The need to examine the actual results of spelling errors of beginner JFL learners during typing in Japanese is the primary motivation for this study. The participants for this study are JFL

learners at an American university, and of the 46 participants, the native language backgrounds include the following: 22 English speakers, 16 Chinese speakers, 3 Korean speakers, 2 Chinese and English speakers, 1 Vietnamese speaker, 1 Portuguese speaker, and 1 Polish speaker.

This study is concerned with improving beginner JFL learners' spelling accuracy during typing. This is important from two perspectives. Firstly, when the learner has a spelling error and gets immediate visual feedback on the screen, the learner may learn from their errors and may be able to reduce them in the long term. Furthermore, this improvement might be transferred to the spoken language maybe potentially reducing the students' pronunciation errors. However, a long-term study is required to explain these potential outcomes.

The second important point is about defining the scope of such a dictionary tool, which has been described here as a visual feedback tool. The results give some insight into the potential benefits of the visual feedback tool for typing. However, a comprehensive analysis will provide more information on the feasibility of such a tool.

The research questions are as follows:

1. Do the pronunciation errors and the spelling errors of the students during typing differ? If so, how?
2. What are the most common keyboard input errors of native speakers of Chinese and English during the typing session?
3. To what extent is the visual feedback tool on keyboard effective on recognizing spelling errors of the learners of Japanese during typing?
4. What are the learners' attitudes towards a visual feedback tool during typing in Japanese?

Aiming to answer the above questions, the thesis is as follows: in Chapter 2, previous studies on Japanese keyboard input, pronunciation instruction, and visual feedback in foreign language education are reviewed. In Chapter 3, the methodology of the research explains how the study was conducted. In Chapter 4, the results of the experiment are analyzed. Chapter 5 is the discussion and the conclusion, which includes the implications and limitations of the study that explain the deficiencies and special cases and a discussion of potential further study in the future.

CHAPTER 2. LITERATURE REVIEW

The following literature review will discuss the four major points. First, the history of word processors in Japan and use of word processors in Japanese as a foreign language (JFL) teaching will be discussed. Secondly, pronunciation learning practices in JFL education and common pronunciation errors of learners of JFL will be reviewed. Following part is discussing about corrective feedback types and their effects on second language education. Final part focuses on previous research about the difficulties that Japanese language learners encounter when typing in Japanese and a review of studies on corrective feedback for spelling errors when typing in Japanese.

2.1 Overview to Word Processing in Japanese

2.1.1 History of Word Processor in Japan

By April 2020, there are more than 4.5 billion of active internet users around the world (Clement, 2020). Conducting a task on internet or on a computer requires input and the keyboard input is one way of them which is described as typing as well. This situation is same for Japanese people too. However, even a basic keyboard input that enables *kana-kanji* conversion in Japanese was not possible on a word processor until December 1978, when Toshiba released its first word processor JW-10, after spending eight years of trial and error period in research and development stage (Mitsufuji, 2003). This was nine years after the first English-language word processor was marketed in the United States by IBM (Gottlieb, 1995). Although other Japanese electronics companies had developed different systems for the same purpose, they had different input methods other than *kana-kanji* conversion, such as pen-touch input, an associated two stroke method, and independent keyboard methods that are suitable to the input of Japanese characters.

In fact, the first typewriter with Japanese keyboard was invented in 1930s. However, it was massive in size and inefficient in terms of productivity as the typist had to move their hand to type each character (Kawada, 1990). Also, such devices were not common and commercially accessible for public use. Publishers or printing business experts were the main users of such tools. Even though it required a desk on which to place its big monitor, keyboard, and other attachments, the JW-10 was a revolutionary step as a word processor thanks to its *kana-kanji* conversion function.

This effective functionality motivated other Japanese electronics companies to concentration on the development of new word processor models. In time, Toshiba word processors with QWERTY keyboard design became more popular than the rival products with different input methods. The main reason this superseded other keyboard input methods was that it targeted a wide range of user groups. *Kana-kanji* conversion with QWERTY design served the needs of journalists, engineers, and office specialists well. Gradually expanding its market share of the word processors in Japan led the QWERTY type input method to become a common design in the 1990s (Mitsufuji, 2003).

In 1985, after almost a decade since the first iteration, the word processor design had improved significantly in that the Toshiba Rupo JW-R10 was 3.5kg and 99,800 yen, whereas its first ancestor was 6.3 million yen with a weight of 220 kg (Mori, 2003). Since the 1990s, personal computers with word processing software programs began to expand its market, and newer technology on word processing started to replace the old ones (Gottlieb, 2013).

2.1.2 Word Processing in Japanese

Until recently, computers have mostly been operated via keyboard and mouse. Even though recent technological devices are navigated by touch functions, speech recognition, and such, keyboards are still in use and typing seems to preserve its importance for a while. As a simple working definition, we can define typing as using letter/symbol buttons in a correct spelling order to display a target phrase. However, from this definition, we must understand that typing requires the full knowledge of the target letter/symbol system by the user. We must consider also that every language has its own unique letter and/or symbol system.

In the case of Japanese, the Japanese language has its own writing systems that are comprised of three scripts: *hiragana*, *katakana*, and *kanji*. Therefore, the keyboard input process in Japanese requires more steps than keyboard input in Latin-alphabet based languages. To demonstrate, if the user type in a Japanese keyboard with *hiragana* characters located on keys, they should first type the spelling of a word or phrase in *hiragana*. As Japanese uses three writing systems, the written *hiragana* spelling may need to be converted to a *kanji* word. In this case, the user must press the space key or conversion key to display a pop-up list of possible *kanji* words from the typed spelling, from which the writer can select the desired *kanji* word. This structure is designed for native speakers of Japanese.

Unlike the native speakers, word processing becomes more complex in the case of non-native speakers of Japanese. Hatasa (2001) describes the rationale of the complexity from different perspectives of the JFL learners. The primary issue is that typing requires two steps in the case of *romaji* (Latin alphabet) keyboard design. The user must type the *romaji* spelling of a *kana* character which enables a *kana* character to appear on the screen, and then the learner must press the *kana* to *kanji* conversion key in order to select the intended *kanji* among the other *kanji* words that pop up. However, in order for the *kanji* to appear in the pop-up list, the *romaji* spelling must be completely accurate; otherwise, the intended *kanji* will not be listed.

As stated in Kubota (1999), knowing how to pronounce a *kanji* correctly is essential to typing the desired word, since the spelling of Japanese *kana* characters is phonetic. When handwriting, the learners may know how to write the *kanji,* but learners cannot type the desired *kanji* word without knowing the exact pronunciation of it. Consequently, learners may try to type intended *kanji* with a different spelling, and it may result in either a lengthy time loss and frustration when the correct *kanji* word does not appear on the screen or selecting a wrong kanji.

2.2 Pronunciation Learning

2.2.1 Computer Aided Pronunciation Learning

In this section, we will take a brief look at instruction and learning of pronunciation in order to examine whether there is a link between typing errors and pronunciation errors of JFL learners. Due to the fact that the subjects of this study practiced pronunciation through a computer aided learning system (Speak Everywhere) in their Japanese course, the following studies focus on computer aided approaches to pronunciation learning.

Thomson and Derwing (2014) carried out a survey of 75 studies to show results about the "effectiveness of L2 pronunciation instruction" (p.328). The study supports the idea that instructions for pronunciation should focus on the intelligibility of learners' speech, rather than making native-like pronunciation the objective. However, in the case of Japanese, some of the pronunciation elements, such as duration of a syllable, matters when it comes to a long vowel or a double consonant case, to assure intelligible speech. The structure of the review takes different aspects into consideration, such as scope (e.g. suprasegmental or segmental), duration, and input type (computer assisted or classroom) of training. Additionally, the studies reveal that computer

assisted pronunciation training is used both through the application of traditional classroom activities by computer and by genuine technological ways in terms of input types. It emphasizes the individuality of the practice and points out "computer-based approaches" (p. 336) allow more learner-centered and affordable individualized instructions.

Pennington (1999) examines the opportunities and weaknesses of computer aided pronunciation, and the study emphasizes the necessity of improvements in pedagogy, rather than in technology. Similar to other computer assisted instruction studies (Dina & Ciornei, 2013; Lai & Kritsonis, 2006; Warschauer, 1996), Pennington points out that computer assisted instruction's stable and repeatable structure and immediate feedback function can be individualized and contributes to the motivation of the learner. On the other hand, Pennington stresses the limitations of pedagogy and the lack of link between the pronunciation and learners' other objectives "such as vocabulary, grammar, discourse and pragmatics" (p. 436) and gives improvement ideas by referring to non-standardized criteria for pronunciation evaluation by the software programs.

2.2.2 Instruction in Japanese Pronunciation

Many students want to acquire native-like pronunciation when learning Japanese, yet specific time for pronunciation is likely not available due to the time limitations of in-class instruction and the lack of instructor training in pronunciation teaching (Minematsu, Nakagawa, & Tagawa, 2012). As cited by Kawai and Hirose (1997), Taniguchi (1991) reports that based on a survey of 158 teachers of Japanese as a second language, the majority of the teachers gives pronunciation instruction for only a limited time (less than 10 hours throughout the course) due to the time constraint and only during the initial phase of an entry-level course.

Yoshida and Fukada (2014) emphasize that "repeating words after the instructor tends to be a tedious exercise to spend much time on in class" (p. 18) and focus on the importance of individualized online practice. The researchers conclude that online repeat-after practice for word accentuation was successful and classroom instructions are not enough for such acquisition.

2.2.3 Phonology and Possible Pronunciation Errors of Learners of JFL

After reviewing instruction in Japanese pronunciation, I aim to explain the relation between orthography and phonology, and major characteristics of the Japanese phonology related to this

study. Bassetti (2006), examines the relation between orthography and pronunciation of 18 students of Chinese as a Foreign Language. Findings in this study indicate that the spelling and pronunciation output of L2 learner are affected by four factors: learners' L1 phonology, L2 phonological input, L2 orthographic input, and L1 orthography-phonology conversion (OPC) rules, which is how L2 phonology is coded for the learners. Also, Kawai and Hirose (1997) found that native speakers of Chinese cannot distinguish short and long vowels. On the other hand, native speakers of English reduce or deletes short vowels due to the effect of English sound system.

The influence of learners' L1 phonology on L2 learning by transferring the native language characteristics has been repeatedly found (Hect & Mulford, 1982; Pennington & Richards, 1986). Ohata (2004), classifies phonological differences between Japanese and English by vowel types, consonant types, and syllable types in segmental aspects. Ohata states that English has more vowels and more consonants compared to Japanese, in addition to different syllable types of both languages which may cause pronunciation problems for Japanese learners of English.

On the other hand, non-native learners of Japanese tend to have difficulties during listening and pronunciation of long vowels, double consonants, nasal "n" and glides at the word level. Toda (1998) asked beginner and advanced level of learners of Japanese to distinguish the abovementioned sounds in voice recordings of Japanese native speakers' speech. Results show that beginner level learners did not correctly perceive these sounds and reported the incorrect duration of sounds as well. Toda notes that the connection between listening, aural comprehension competency and pronunciation should be further studied.

2.3 Corrective Feedback in Second Language Acquisition (SLA)

2.3.1 The Effect of Corrective Feedback in SLA

Giving feedback on learners' errors is another essential tool for the learners' improvement in SLA. Ahmadi Shirazi and Shekarabi (2014) examined three different feedback types on Iranian learners of Japanese as a foreign language on their written essays. Three feedback types include coding, translation and underlining on the correct usage of prepositions, adjectives and noun phrases. The findings indicate that underlining is the only effective direct feedback type for the learner uptake. Present study uses a salient visual feedback form during the typing process.

In terms of general feedback efficiency, DeKeyser (1993), as cited in Lyster and Ranta (1997), states that effectiveness of corrective feedback depends on various factors like "learner characteristics and contextual features in complex ways." (p. 39). Also, the study showed that more than half of the provided feedback led to uptake by the learners. In a study on written corrective feedback, Ellis (2009) describes a typology of feedback types as: direct, indirect (with or without locating the error), metalinguistic (with error codes or brief grammatical explanations), focused or unfocused (whether instructor tries to provide feedback for all errors or not), electronic feedback (error is marked and a hyperlinked attached next to it), and reformulation (rephrasing to make it sound native like).

In another study, Cotos (2011) narrowed the corrective feedback types to writing or typing skills and demonstrated that learners' interactions with an automated writing evaluation feedback software enabled learners to recognize and improve their writings in multiple attempts. Considering word level or sentence level evaluation, Hassanzadeh Nezami (2012) conducted an experiment to evaluate error types of EFL and learner uptake upon given feedback (recast, metalinguistic feedback, other types) by teachers in a chat log. This study shows that the majority of the learners notice the given feedback, however uptake was limited to a few learners.

2.3.2 Feedback on Japanese Pronunciation

As this study focuses on the spelling errors of the JFL learners during typing, the correct pronunciation of the word takes an important role in explaining any potential errors that both the spelling and the pronunciation have in common. In a survey, Todoroki and Yamashita (2009) found that the responses of 58 Japanese instructors indicate that pronunciation is attended to and corrected at mostly the segmental level, rather than accent, intonation and other pronunciation errors.

The following study shows the transition from traditional feedback to Computer Assisted Language Learning (CALL) applied feedback for pronunciation. Kawai and Hirose (1997) evaluated the efficiency of the CALL approach through software developed by their team for pronunciation instruction, specifically for double-mora phonemes. A mora is defined as:

> "a subsyllabic rhythmic unit that is phonemic in Japanese. Single-mora vowels (which form short or light syllables) and double-mora vowels (which form long or heavy syllables) are spectrally almost identical but their phone durations differ significantly." (p.133)

The response speed of the system used in this study to learner errors and learner's workload upon acquisition of the skills was measured, and the researchers conclude that the feedback to the learner upon pronunciation was "similar to professional instructors" (p. 142).

2.3.3 Written Feedback in Japanese Learning

The transition from traditional to modern technological methods in foreign language education takes place in providing written feedback as well. In a study, Ogata, Feng, Hada, and Yano (2000) analyzed the learners' written compositions that are shared to instructors via an online platform. Teachers corrected learners' errors by using the same platform, and then the software program checked the corrected composition again. This process resembles the traditional mark-up method of corrective feedback. However, its detailed data and standardized error explanations can be used as a data base for future implementations. The study also shows that there is learner uptake, based on reduction of revised errors in the following written compositions.

In a comprehensive study, Nagata (1993) used a natural language processing (NLP) analyzer on computer software which had two different corrective feedback types on participant errors. The first feedback type lists the errors such as missing particles or wrong particles, whereas the second feedback type provides a list of errors with detailed explanations. Learners' responses to the questionnaire indicates that the second type of feedback is very useful as it provides immediate feedback with explanation. This immediate feedback is found to be a useful tool this study, and this emphasis on the influence of immediate corrective written feedback is shared with my research.

2.3.4 Studies on Typing in JFL

Handwriting in ideographic or non-alphabetic languages can be more difficult for non-native learners. By having three different writing systems, Japanese is no different in its potential difficulty. However, with the inevitable spread of technological devices, such as computers, mobile phones, and tablets, typing has become increasingly useful and popular among the non-native language learners of Japanese. Thus, typing focused studies have gained more importance for integration of typing into teaching and learning. The following is a brief overview of such studies.

Kubota (1999) evaluates third year Japanese college students' feedback after four different assigned projects which require computer use in Japanese. The study results show that the students find typing easier and faster compared to handwriting. Also, using the computer makes correcting errors easier. However, the automatic *hiragana-kanji* conversion is found to be a difficulty by most students when it comes to choosing the correct *kanji*. In the present study, automatic conversion of *kana-kanji* is turned off from the computer settings to avoid any possible confusion for participants.

Dixon (2010) evaluates various items regarding typing and handwriting. The primary purpose is to compare student output in both handwriting and typing conditions in terms of accuracy, consumed time, computer's effect, and error types. Results indicate that the students tend to make fewer errors during typing than handwriting. Additionally, recorded writing errors are primarily from the phonological aspects of the words, such as using a long vowel instead of a short vowel, or vice versa, and misuse of double consonants. In the present study, I compare direct phonological errors with orthographical errors to explain any potential relation.

Tsuchiya (2000) comments on previous findings that the length of a vowel fluctuates even among Japanese native speakers, so that a learner may not memorize accurate phonology by listening to the pronunciation of a Japanese native speaker. Tsuchiya also adds that the time to study a word in *hiragana* and *kanji* is compressed in the case of JFL learners, which affects memorization of correct phonology negatively. In this study, Tsuchiya examined 173 JFL learners' keyboard input by providing a questionnaire on a computer screen and asking them to answer the questions by typing in Japanese. The participants are graduate or undergraduate students in Japan and the majority of the students are native speakers of Asian languages. In the findings, the insertion or omission of long vowels are the most frequent errors, regardless of the participants' L1. Tsuchiya suggests that a customizable input method should be considered based on the needs of JFL learners.

In another study, Tsuchiya et al. (2000), examines the keyboard input of 95 JFL learners comprised of undergraduate and graduate exchange students who were either already living in Japan for at least 1 year, or had lived in Japan for less than 1 year, if having studied Japanese for a long period. Participants are native speakers of Asian languages. The findings examine common errors of the participants and errors based on their L1. Based on the result of this study, the researchers suggest a user dictionary for JFL learners that can be customizable based on L1.

Tsuchiya's studies reported various ways to understand a trend of typing errors by JFL learners and the possible influence of their L1. However, several points should be considered regarding the suggestions in these studies. Firstly, the majority of the participants are the native speakers of Asian languages. In terms of generalization, findings may not be valid for the speakers of other languages. Next, the participants are JFL learners who are living in Japan which can be interpreted as studying the target language in an immersion context. From this perspective, exposure to the language in the country in which the target language is spoken may influence various factors independently or together, such as listening to a pronunciation of the same word from different sources or the frequency of typing due to the daily circumstances. Another important point is the impracticality of customizing a user input method based on the L1 of the JFL learner. This suggestion may seem ideal from a pedagogical point of view. However, it is likely unfeasible to customize an input method based on the scope of a study with limited number of participants. Besides, error types may vary among the speakers of same language due to different factors such as the study method and individual differences. Finally, there is no study that evaluates the use of the suggested input methods. I aim to fill this gap by conducting an experiment by using a similar input method and analyze the results. The methods for tracking the data that are used Tsuchiya's studies, such as screen recording, are implemented into the present study.

Another comprehensive study related to the present study was conducted by Hatasa (2001), in which the fact that the general Japanese keyboard setting used in computers are designed for native Japanese speakers is emphasized, and Hatasa asserts that learners struggle if they are not capable of correct spelling when typing in Japanese. In a general sense, Hatasa lists the main problems of JFL learners as having very limited vocabulary, weakness in *kanji* knowledge, misspelling, and inability to correct one's own input error. This study explores learners' *kanji* reading errors in a different setting by gamification. The participants are 11 native speakers of Chinese and 86 native speakers of English. The study indicates that "many of the cognitive errors were caused by incomplete phonetic knowledge of lexical items". The researcher emphasizes this limitation and proposes future research development by putting forward:

1. An input method for non-native speakers is necessary to recognize the typing errors of JFL learners.
2. Different tasks, such as recorded sentences and compositions of the students, should be used for analysis in order to understand other possible error types.

3. An improvement on the vocabulary filtering is required.
4. Providing corrective feedback needs a shift from word level to phrase level.

The present study aims to partially address these points. As a point of continuity, a modified input method is used for the current experiment. Secondly, a different task besides *kanji* reading is used. In this sense, the present study can be considered as a next step to the abovementioned study.

CHAPTER 3. METHODOLOGY

This study aims to explain what kind of spelling errors are seen during typing in Japanese using a linguistic categorization and evaluate the effectiveness of the visual feedback tool, as well as getting the post-experiment assessment of this tool by the participants. Regarding these aims, the researcher uses descriptive statistics by using the number of spelling errors and to evaluate the effectiveness of proposed tool through its error recognition rate. The participants' attitude toward this remedy (visual feedback tool) is measured based on Likert scale, and analyzed based on descriptive statistics.

3.1 Participants

The participants of this study are 46 students enrolled in fourth semester Japanese language course (Japanese 202) at a large American university in the Midwest. Initially, 56 participants were scheduled for the experiment. However, 9 students only attended to the 1st session and did not attend to the 2nd session. Also, 1 participant took the Session 2 at first, then Session 1 later, due to a communication mistake. Thus, data of 10 participants were excluded from analysis of the study. The demographic details of 46 participants can be seen in **Appendix D**. Most of the students have studied with the Japanese language textbook *Nakama 1* (Hatasa, Hatasa, & Makino, 2015) for their first and second semester Japanese-language courses (Japanese 101 and 102) and *Nakama 2* (Hatasa, Hatasa, & Makino, 2018) for their third and fourth semester courses. A few students enrolled in the course have a JFL background from different educational institutions.

The participants took a 50-minute instruction about typing in Japanese in their second semester (Japanese 102), and practiced input types such as *romaji* (Latin alphabet), different character combinations of *hiragana*, conversion from *hiragana* to *kanji*, and e-mailing in Japanese. The participating students were required to turn in some assignments such as letter, presentation in typed form, from time to time before this experiment. Also, the students were encouraged by their instructor to use Japanese when sending e-mails to their Japanese instructors. Thus, the participants can be considered to be familiar with typing in Japanese.

3.2 Material

The participants were given a list of 30 English words on a printed paper. All of the listed words are selected from the vocabulary lists in the *kanji* sections of *Nakama 1* and *Nakama 2* and were taught during Japanese courses from first semester to third semester. Most of the words are very commonly used throughout the Japanese courses (101, 102, 201), and the students have encountered the words during homework assignments, quizzes, and tests. Also, each kanji that consist of a word was taught in *kanji* instructional sessions and writing assignments. The word lists with Japanese equivalents are given in **Appendix E**. There are two different sets of word list for two experiment sessions. However, there were three words that are given in both sessions due to the limited *kanji* words studied before. The words りょこう, こうこう, けっこん are given in Session ,1 and given りょこう, こうこうせい, けっこんしき in Session 2. The Japanese translations of the listed words consist of two or three *kanji* characters. The researcher selected the words in Japanese, before giving the English equivalents. The rationale of the word selection is based on common pronunciation/spelling errors of the students as classified in Hatasa (2001). Mostly, different words were selected for the two different sessions. However, due to the limited *kanji* knowledge of the students, some identical words or derivatives are used in both sessions. Pronunciation recordings were rated by the researcher after each participants' recordings were saved. Likewise, typing analysis was carried out by the researcher.

3.3 Questionnaire

The students were required to fill out an information form on computer before starting the first pronunciation session and a questionnaire after end of the second typing session. Both forms are saved in Microsoft excel files. The information form asked for demographics such as gender, major, year in school, first language, the length of the Japanese study, and the frequency of typing in Japanese. The questionnaire for investigating the learners' attitudes toward use of visual feedback dictionary is created by modifying the questionnaire of Nakazawa (2003). The questionnaire consists of four items that are related to the used visual feedback tool and one open ended comment section, in order to get genuine opinions of the participants. The four items are marked on a five-point Likert scale ranging from 'strongly disagree' to 'strongly agree', 1 to 5, respectively.

3.4 Procedure

The experiment was conducted in the beginning 2020 Spring semester starting from the first day of the semester to until end of the second week, when the students started to study Japanese 202 level course. There were two sessions, Session 1 and Session 2, in the experiment. Each session had two parts; the first part was translating aloud the list of selected words from English to Japanese, while the researcher recorded the students' voices, and the second part was typing session, in which the computer screen was recorded while the students were typing. The time gap between the two sessions was between a minimum of four days and maximum of two weeks. The researcher provided an online scheduling file in order for the students to choose participation time and dates. The participants visited the researcher's office individually. The participants were told that there was no special prior preparation required for the study, and the typing is similar to *kanji* typing practice with previously studied *kanji* words.

In the first part, the students are given a list of English translations of words that were studied in the course, and the participants were expected to read aloud the Japanese translations of those words. During this time, students' pronunciation was audio recorded.

The researcher explained the reading aloud procedure to the students as follows:

1. First, please take a look to this word list a minute.
2. At first, I need you to read aloud each word's Japanese meaning from top to bottom in order. During this time, a voice recorder will be recording your voice. You do not have to count as one, two, three.
3. If you don't know a word, you can skip that word without saying anything and continue to read the next word's Japanese meaning aloud.
4. If you remember a word's meaning after you skip it, you can read aloud its number and add it. And then you can continue from the word you paused at originally.
5. All of the words in the list are the words that were studied in Japanese courses from 101 to 201. Also, all of the words should be in *kanji* words in Japanese.
6. Those *kanji* words consist of either two or three *kanji*s. There is no single *kanji* word in the list.

After the completion of this read aloud portion (pronunciation session), the participants were told that they were next required to type the Japanese equivalents of the same words on a software on the researcher's computer. The researcher verbally asked the students whether they know how

to type in Japanese before start of the typing part. The researcher explained that the participant can skip if they do not know the Japanese equivalent and record afterwards if they remember it after skipping. Also, the students were told that they were free to type the Japanese translation of a word, even if they had not remembered the Japanese equivalent of that word during the read aloud portion.

The researcher explained to the participants how to type in Japanese briefly with a brief practice. The researcher explained how the visual feedback tool works by demonstrating on a word that is not included in the list. The participants were told that when they receive visual feedback on the screen, they must delete and retype the word according to the given feedback in the parenthesis. The researcher observed the participants during the typing session from a certain distance to help if the student could not find the spelling of a Japanese letter (not word) after multiple attempts.

There was no time limit in either the read aloud or typing portions. The researcher stopped recording when the student finished their input on both read aloud and typing. Typing sessions took 7 minutes on average for the participants. Minimum duration for a typing session was 3 minutes whereas maximum was recorded as 23minutes. The process flow during the pronunciation and typing parts in Session 1 was repeated identically in Session 2. The participants completed the questionnaire and the survey after finishing Session 2.

3.5 Data Analysis

Data of typing and pronunciation sessions are transferred into MS excel sheets for the analysis and measurement. The researcher used descriptive statistics to explain research questions with frequency and proportions of the participants' errors and error recognition frequency of used tool. For the survey and questionnaire, frequencies and percentages are used to explain attitudes of the participants towards using the visual feedback tool during typing.

CHAPTER 4. RESULTS

4.1 Introduction

This chapter summarizes the results of typing errors, the effectiveness of the supportive feedback tool that is used during typing processes, and the students' attitudes towards the visual feedback dictionary tool. The taxonomy of the error types is shown in **Table 1**. The research questions of the present study are:

1. Are the pronunciation errors and the typing spelling errors of the students identical?
2. What are the most common keyboard input errors of native speakers of Chinese and English during the typing session?
3. Is the visual feedback tool on keyboard effective during typing?
4. What are the learners' attitudes towards a visual feedback tool during typing in Japanese?

Voice recordings for pronunciation and screen recordings for keyboard input are used in the analysis to find the answers. Regarding the data analysis, two major conditions should be considered before continuing to the study results. The first one, the researcher used only the first typing attempts of the participants in order to avoid possible impact of outliers on data. Outliers refers to cases when a participant repeats identical spelling error during the typing of a word multiple times. In such situation, multiple erroneous input of a word by individual participant would have an impact on overall frequency of total input numbers and might hinder the error trend of entire participants. Secondly, wrong word inputs by the participants are excluded from the core analysis. For example, if a participant typed がっこう as a Japanese equivalent for English word 'University', it is classified in the wrong word category. Thus, such wrong translations are excluded from keyboard input error categories (**Table 4**), due to its irrelevancy for the purposes of this present study.

The researcher discusses the analysis of data and make a comparison of pronunciation and spelling input of the students to clarify whether there is a relation between typing errors of the participants with the pronunciation errors. Initially used word list for data collection included 30 words per session but was modified for data analysis by decreasing word count to 27 words per session. Three words from the Session 1 word list and three from the Session 2 word list are

excluded after the experiment due to the fact that the participants' responses indicated lexical meaning ambiguity with these specific words. For example, some participants typed 紙 for 'Blank form(paper)', instead of 用紙.

In addition to the pronunciation and typing input comparison, the researcher analyzes the most common spelling errors in order to explain whether there is a relation between the participants' native language and their keyboard input errors. Additionally, because this study used a visual feedback tool, which can also be called dictionary tool, to make the participants recognize their spelling errors during the typing experiment, the researcher analyzed the error recognition rate of this tool to evaluate its effectiveness. The higher error recognition rates indicate better performance of the tool on participants typing errors.

Lastly, the subjects' responses to the survey are analyzed on a Likert scale to determine if the participants have a negative or positive attitude towards using a visual feedback tool on word processor during typing in Japanese. The participants also gave comments in an open-ended section about the dictionary tool that is used during the typing sessions.

4.2 Research Questions

4.2.1 Comparison of Errors on Keyboard Input and Pronunciation

This study collected 1996 keyboard inputs for typing analysis and 2329 reading input for pronunciation analysis from 46 participants in two sessions. All participant-produced errors are categorized according to the taxonomy in Table 1. The total of typing errors is 471 in the first keyboard input attempts of all participants, and a total of 216 pronunciation errors are found in the pronunciation recordings. From the analysis of first keyboard input attempts and pronunciation, it is found that frequent errors are related to long vowels, double consonants, voiced/devoiced consonants (Figure 1). Pronunciation errors are far fewer than typing errors. Typing error rates per person in Session 1 and Session 2 were 22% and 18%, respectively.

Table 1 Error Taxonomy

Problem Definition	Code	Example (Correct spelling in the parenthesis)
Glide Wrong Use	Gx	びゅういん（びょういん）
Glide Omission	-G	りこう（りょこう）
Glide Insertion	+G	ぎんきょう（ぎんこう）
Double Consonant Wrong Use	DCx	にっじゅぷん（にじゅっぷん）
Double Consonant Omission	-DC	けこん（けっこん）
Double Consonant Insertion	+DC	しゅっくだい（しゅくだい）
Voiced Consonant Wrong Use	VCx	ぜんけつ（せんげつ）
Devoiced Consonant	-VC	てんしゃ（でんしゃ）
Voiced Consonant	+VC	がいごく（がいこく）
Long Vowel Wrong Use	LVx	じゅしょう（じゅうしょ）
Long Vowel Omission	-LV	ここ（こうこう）
Long Vowel Insertion	+LV	りょうこう（りょこう）
P Sound Omission	-P	ぶんほう（ぶんぽう）
P Sound Insertion	+P	ぴょういん（びょういん）
Moraic Nasal Error	MN	こばん（こんばん）
Sound Errors	Sx	げっき（がっき）

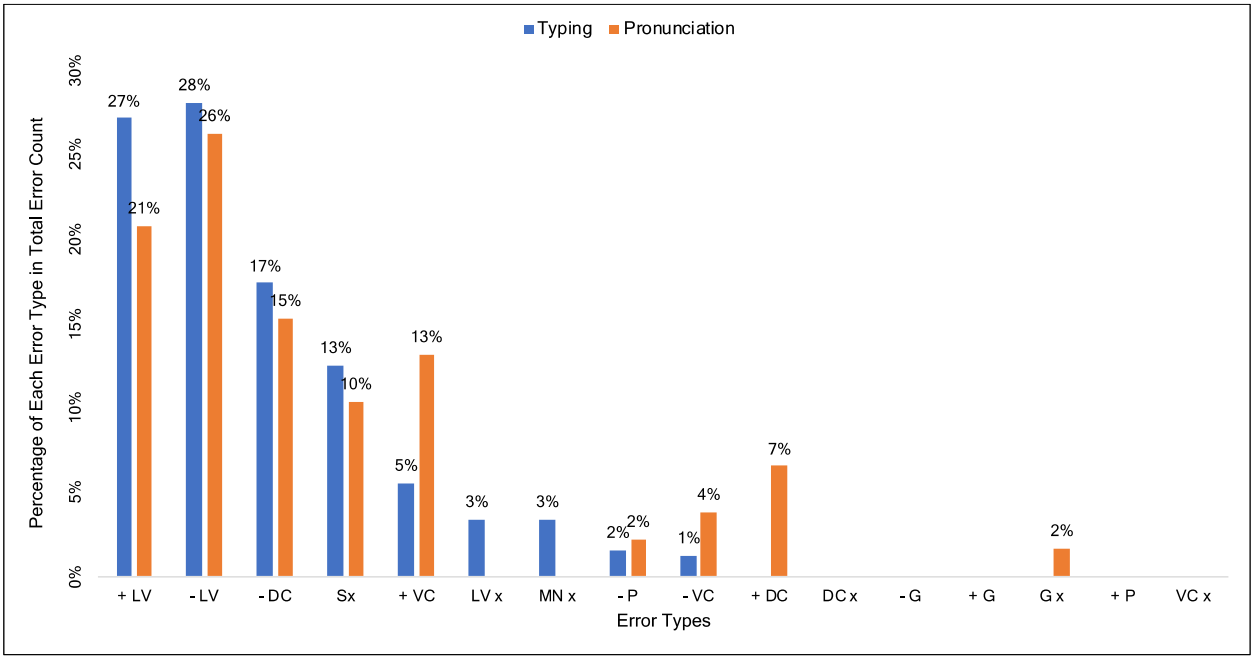

Figure 1 Error Trend of Keyboard Input and Pronunciation

Frequent errors during keyboard input and during pronunciation recordings are shown in Figure 1. The errors that are recorded only once are not written in most cases, and the main data analysis is comprised of analyzing the frequent error patterns. The largest portion of the errors are

long vowel errors (+LV, -LV), in both keyboard input and pronunciation sessions. Thereafter, omission of double consonants (-DC) and sound errors (Sx), voiced consonant (+VC) errors follow. Next, long vowel wrong use (LVx) and moraic nasal (MNx) errors repeated only during typing sessions. Omission of P sound (-P) and devoiced consonants (-VC) occurred in both typing and pronunciation session. Double consonant insertion (+DC) and glide wrong use (Gx) occurred only during pronunciation sessions.

Long Vowels (+LV, -LV, LVx)

Comparison of the long vowel category demonstrates that the participants' long vowels insertion errors are concentrated on specific words such as りょうこう, じゅうぎょう, としょうかん, かいようび, ばしょう, さんじゅうぷん . The **+LV table** in the Appendix A show the frequency of top +LV errors by comparing occurrence during keyboard input and pronunciation sessions. The table demonstrates that the participants made more typing errors than pronunciation errors on identical words.

Words with frequent long vowel omissions by the participants are shown in the **-LV table** in the Appendix A. The table shows that, although omitting long vowels appeared in a wider range of words than insertion of long vowel errors, there are frequent words such as じゅ（う）ねん, いっしゅ（う）, しゅ（う）まつ, じゅ（う）しょ, こ（う）こ（う） that the participants made frequent errors during both keyboard input and pronunciation sessions. In addition to this relation, long vowel omissions commonly occurred after a X ょ or X ゅ sounds. X refers to any sound in here and in the following sections when used as X ょ or X ゅ.

Another problem category in long vowels are mis-location of a long vowel. The frequent errors are seen on two words じゅうぎょ（う）and りょうこ（う）. This type of frequent error is seen on keyboard input only. Thus, there is no direct relation between keyboard input errors and pronunciation errors. Error counts and distribution can be seen in the **LVx table** in the Appendix A.

Double Consonants (-DC, +DC, DCx)

The analysis of double consonant omission (**-DC table**) shows that errors are mostly seen in four words as follows: い（っ）しゅう, け（っ）こん, にじゅう（っ）ぷん, が（っ）こう. Although the errors are concentrated on specific words, some words have significantly more typing

errors than pronunciation errors such as い（っ）しゅう, whereas words such as にじゅう（っ）ぷん、さんじゅう（っ）ぷん have almost equal frequency of errors in both pronunciation and keyboard input.

Insertion of a double consonant (**+DC table**) is not only an error that is only seen in pronunciation, but it also has very few examples, compared to the other error types. There are only three words in which the errors occurred multiple times: りょっこう，こっこう, and とっけい.

Sound Errors (Sx)

In the analysis of sound errors (**Sx table**), the most frequent error was insertion of a vowel in word かいようび. Following frequent errors include four words that have vowel substitution errors in both keyboard input and pronunciation sessions. Those words are ちゅがく instead of ちゅうごく and ちゅうごく instead of ちゅうがく, in addition to せんがつ， らいがつ. Other words in this error category occurred either during the keyboard input or pronunciation sessions.

Voiced/Devoiced Consonants (-VC, +VC, VCx)

More voiced consonant errors are recorded than devoiced consonant errors. It can be seen in the **+VC table** that frequent errors densely occurred on がいごく，ぶんぼう，ぎんごう. The error frequency both during keyboard input and pronunciation are equal or close for ぶんぼう and ぎんごう，whereas the frequency of errors during typing is significantly higher in the case of がいごく. These three words share a phonetic characteristic in that each word's first consonant is a voiced consonant.

Moraic Nasal (MNx)

In this data set (**MNx table**), the participants have only one word for moraic nasal error, きにょうび which occurred only during keyboard input session.

P Sound

The word list for data analysis has only three words that include P sound (**-P table**). Among these three words, ぶんぼう has the most frequent errors during typing. Thereafter, the erroneous spelling にじゅうふん occurred during the pronunciation session. However, another P sound error in typing is さんじゅうぶん, which is not included in the data analysis due to the limited range.

Glides (-G, +G, Gx)

The wrong use of glides occurred in two words and only occurred during the pronunciation sessions: しょくだい, and びゅういん (**Gx table**). These errors are the most frequently recorded problems and the problems are prioritized according to their frequency. The problems that are recorded only once in the same error pattern are not included in the frequent problems, with the exception that a single error is included, if there are not multiple errors in that specific error pattern.

4.2.2 Keyboard Input Errors based on Native Language

The most frequent keyboard input errors at first attempt of typing are classified according to the participant's native language of either Chinese or English (**Figure 2).** This indicates the trend of errors and possible transfer from the participant's native language while typing. Most typing errors of native speakers of both languages are related to missing long vowels, double consonants, and voiced/devoiced consonants. However, frequent words with keyboard input errors of the native speakers of English are different from the errors of the native speakers of Chinese (**Table 2**).

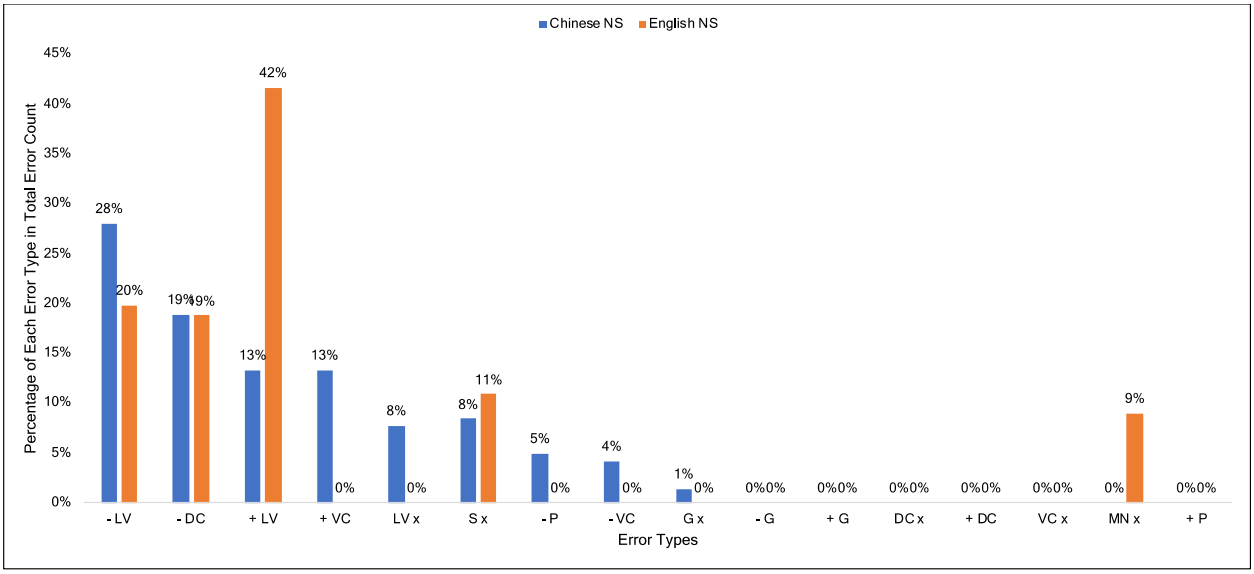

Figure 2 Keyboard Input Errors by Native Language

Among all 46 participants, the majority is divided into two groups as native speakers of Chinese (22) and English (16). There are 2 participants who are bilingual in Chinese and English. Regarding the second research question, native speakers of other languages (3 Korean, 1 Polish, 1

Portuguese, 1 Vietnamese) are excluded in this analysis. Typical error occurrence average by L1 are, 30% for Chinese NS, 18% for English NS, 30% for Korean NS, 20% for Chinese and English bilinguals, 25% for Vietnamese NS, 39% for Polish and 11% for Portuguese NS.

In comparing the two native speaker groups (Chinese NS and English NS), the most noteworthy difference is seen on long vowels. The most frequent error type by Chinese native speakers is long vowel omission (-LV) during keyboard input, which is double the number of the English native speakers' -LV errors. On the other hand, long vowel insertion is opposite in that English native speakers made 47 errors in this category versus a frequency of 21 errors by Chinese native speakers.

Apart from the sound errors (Sx) that are seen in both groups, only Chinese native speakers demonstrated multiple erroneous keyboard inputs in various error types such as voiced consonant, misplaced long vowel, P sound omission, devoiced consonant and wrong glide usage. However, moraic nasal errors during typing is only seen in the English speakers' group.

A list of words indicating the keyboard input errors of Chinese native speakers (**Frequent Input Errors of Chinese NS table**) and English native speakers (**Frequent Input Errors of English NS table**) can be found in the Appendix A. In order to explain a brief demonstration of error types that both Chinese NS and English NS have in common, the top two keyboard input errors from both groups are listed below (Table 2).

Table 2 Top 2 Keyboard Input Errors in Shared Error Types by L1

Error Type	Chinese NS	English NS
-LV	じゅ_ねん	しゅ_まつ
	にゅ_いん	じゅ_ねん
-DC	け_こん	い_しゅう
	い_しゅう	にじゅうぷん
+LV	としょうかん	りょうこう
	じしょう	じゅうぎょう
Sx	せんがつ	せんがつ
	さくべん	らいがつ

Among the most frequently occurring errors in the long vowel category, じゅねん is seen in both groups as a common long vowel omission error. Following the same tendency, double consonant omission error of い_しゅう, and sound error of せんがつ are shared among the most

frequent errors of both groups on related error types. However, long vowel insertion, which is the most frequent error type of English native speakers has a different situation. As can be seen in **Figure 2**, the top +LV errors of both groups differ from each other.

4.2.3 Effectiveness of Input Remedy aka Visual Feedback Dictionary Tool

The intervention of an input remedy on erroneous keyboard input was used by the participants, and the dictionary tool provided feedback 359 times out of a total 471 erroneous inputs during the typing sessions. The recognition rate analysis is based on 1st typing attempts and **Table 4** illustrates the details of keyboard input numbers of 1st attempts of the participants by category in order to evaluate effectiveness of the used remedy and possible improvement points. The details of total 1st attempt typing input are given in Table 3.

Table 3 Breakdown of 1st Typing Input Attempt Counts

		Session 1	Session 2
Student Number		46	46
Word Number		27	27
Input Numbers	Correct	772	753
	Caught	195	164
	Unanticipated	63	38
	Incorrect Selection	4	7
	Wrong Word	99	127
	Blank	109	153
	Total	1242	1242

The total keyboard input number is 1242 per session. Participants left blanks (252 in total) and typed irrelevant wrong word (226 in total) in some cases. These two categories are excluded from the calculation of the error recognition rate in **Table 4**. The distribution of errors by category recorded in the first attempts of both sessions are shown in the charts below (Figure 3).

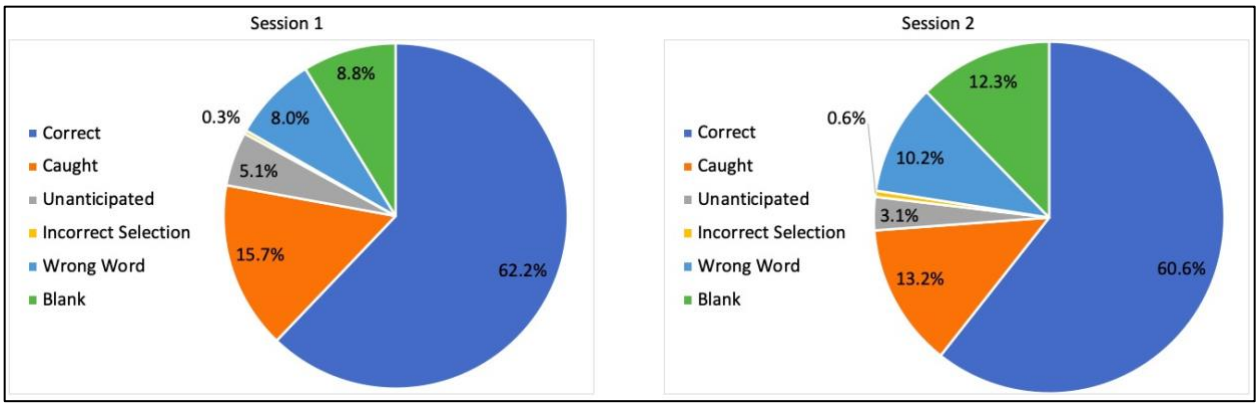

Figure 3 Distribution of Typing 1st Attempts by Input Category

The range of input categories that are required to evaluate the effectiveness of visual feedback tool include ‘Caught’, ’Unanticipated’, and ‘Incorrect Selection’ inputs, because ‘Correct’ input is successful from the start, and ‘Blank’ and ‘Wrong Word’ categories are related to the learners’ cognitive skills, which cannot be improved directly by the visual feedback dictionary. In this aspect, 21% and 17% of 1st typing attempts in Session 1 and 2, respectively, are analyzed in order to evaluate the effectiveness of the used remedy.

The effectiveness of the keyboard intervention, which is called a dictionary tool, is evaluated by the total keyboard input number of each word with its categorization as ‘correct’, ‘caught’, ‘unanticipated’ and ‘incorrect selection’. The definitions of each category are as follows:

Correct: The participant keyboard input is correct (Figure 4).

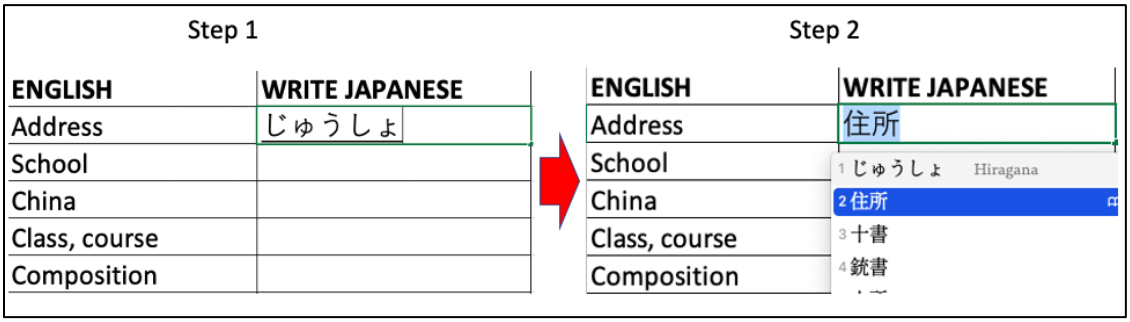

Figure 4 Correct Keyboard Input

Caught: The participant made a spelling errors during keyboard input and the dictionary tool pops up on the screen to give visual feedback to the participant (Figure 5).

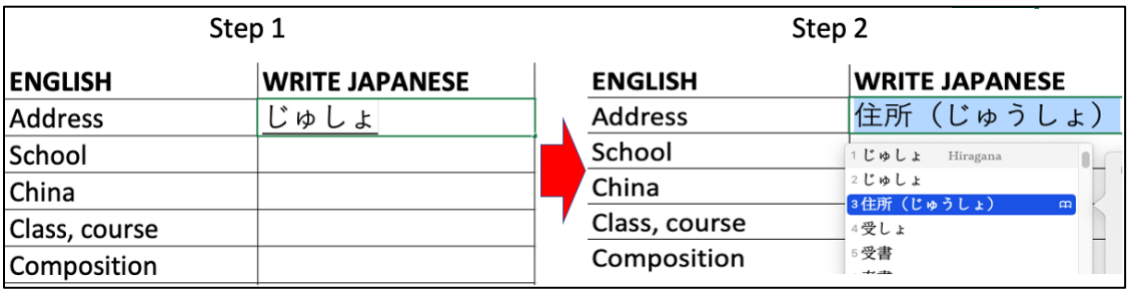

Figure 5 Keyboard Input Error Caught by Dictionary Tool

Unanticipated: The participant made a spelling error during keyboard input, but the dictionary tool did not pop up on the screen as the misspelled word with that specific spelling error was not included in the dictionary list. Thus, there was no visual feedback for the participant on the screen (Figure 6).

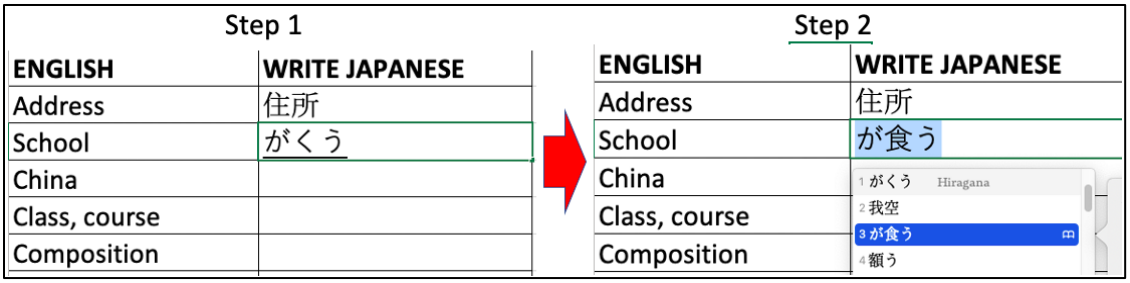

Figure 6 Keyboard Input Error Unanticipated by Dictionary Tool

Incorrect selection: The participant made a spelling error during keyboard input and converted the *hiragana* word into *kanji* without looking at other *kanji* options in the list. The dictionary tool has a visual feedback on an anticipated error. However, the participant did not look at the *kanji* candidate list, and as a result, visual feedback is not provided. Consequently, the participant chose the wrong *kanji* word due to a spelling error. Figure 7 demonstrates that although the learner should find the *kanji* from the list as shown in Step 3, they stop at Step 2 and choose a wrong kanji. This type of error derives from insufficient *kanji* ideographic knowledge.

Figure 7 Keyboard Input Error Incorrect Selection by User

The participants' keyboard inputs are analyzed based on the aforementioned four categories. The keyboard input count analysis includes only the first typing attempt of each word in two keyboard input sessions (**Figure 8** and **Figure 10**). An overview of keyboard input counts that are used for dictionary tool effectiveness evaluation is shown in Table 4.

Table 4 Keyboard Input Counts at 1st Typing Attempt

	Total Word Count	Correct	Caught	Unanticipated	Incorrect Selection	Wrong Word	Blank	Error Recognition Rate (%)
Session 1	27	772	195	63	4	99	109	74
Session 2	27	753	164	38	7	127	153	78

In a comparison of Session 1 and Session 2, a total of 27 words each are analyzed. Each category distribution is shown in the figure below.

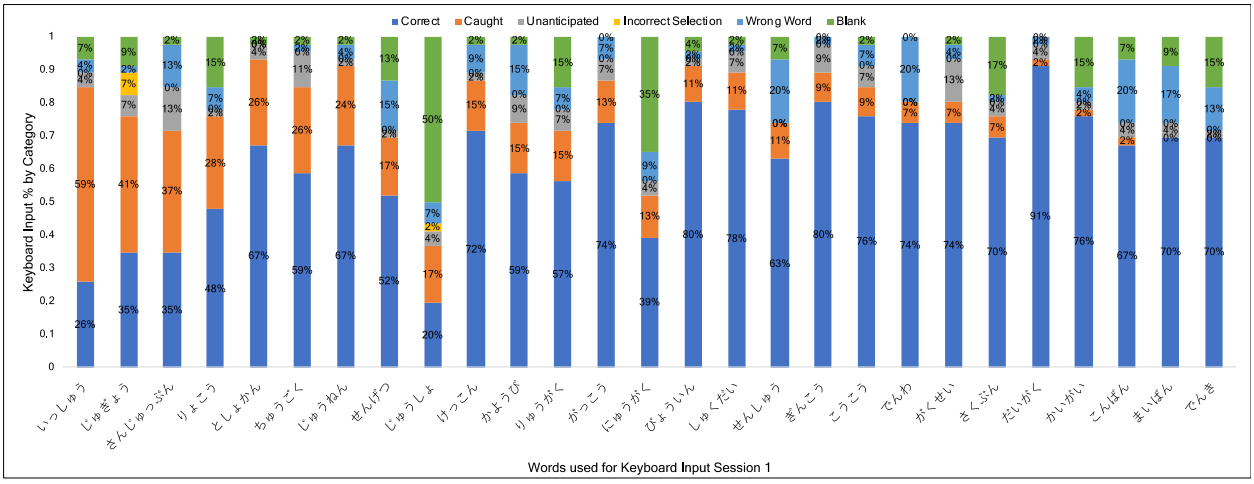

Figure 8 Breakdown of Keyboard Input 1st Attempt by Word- Session 1

In Figure 8, the words are ordered from left to the right based on caught error counts. In other words, they are ordered according to the percentage of provided visual feedback through the dictionary tool in total input count. Although there can be up to 46 inputs for each word, the total input count varies from word to word, as a result of some participants' blank input. Blank inputs are the words that the participant either did not recall or did not know the Japanese equivalent of the word. In Session 1, じゅうしょ and にゅうがく have most blank input during the typing and . Also, when the participants typed a totally different word than its correct Japanese equivalent, which cannot be counted as a spelling error, it is categorized as 'Wrong Word'. According to this data, the dark blue sections demonstrate correct keyboard input count, the orange sections demonstrate the erroneous keyboard inputs that are recognized or caught by the dictionary tool. Thus, orange sections are the indicator of dictionary tool effectiveness. The total counts of each category in the figure are: 772 'Correct', 195 'Caught', 63 'Unanticipated', 4 'Incorrect Selection', 99 'Wrong Word', and 109 'Blank'.

In detail, the error recognition rate is calculated based on the ratio by dividing 'Caught' and 'Incorrect Selection' counts by 'Caught', 'Unanticipated' and 'Incorrect Selection' counts. In other words, the formula is (Caught + Incorrect Selection) / (Caught + Unanticipated + Incorrect Selection).

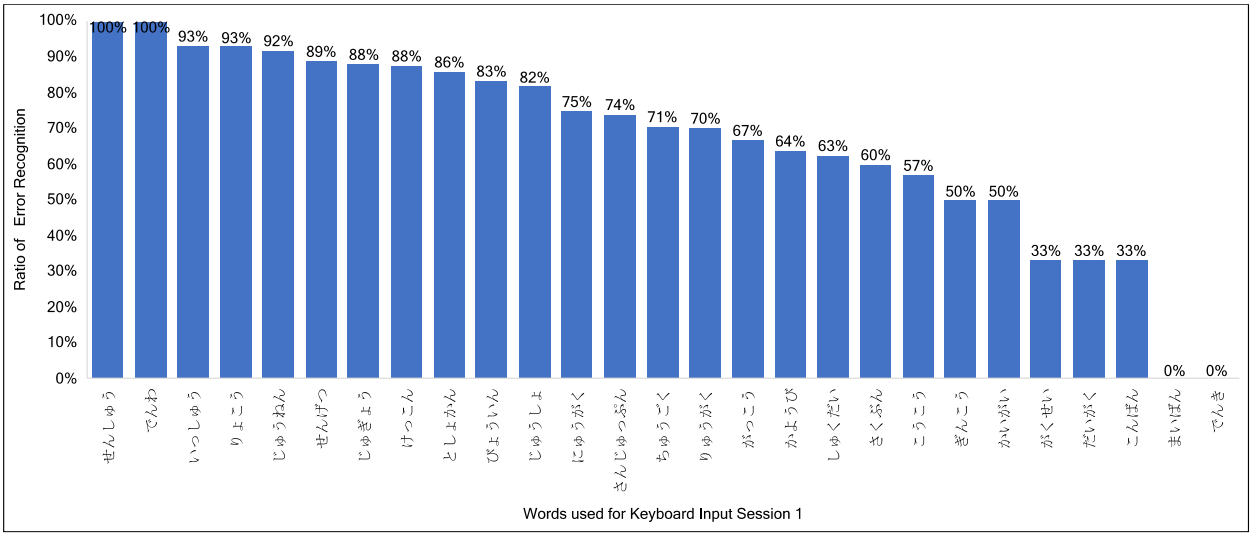

Figure 9 Error Recognition Rate on Keyboard Input by Word - Session 1

According to this data, the dictionary tool appeared and provided feedback to the participants above 70% of the time for the words that have frequent errors such as いっしゅう, じ

ゅうねん，さんじゅっぷん，けっこん, りょこう，としょかん，which are written in Table 3. However, a decrease in the error recognition rate is seen for some words such as でんき，まいばん，こんばん，だいがく and がくせい. Figure 7 indicates that those words have significantly more correct input than erroneous input numbers. It can be seen from both Figure 8 and Figure 9 that there is a relation between the effectiveness of the dictionary tool and erroneous input counts.

The keyboard input analysis of each word used during Session 2 is given in Figure 10.

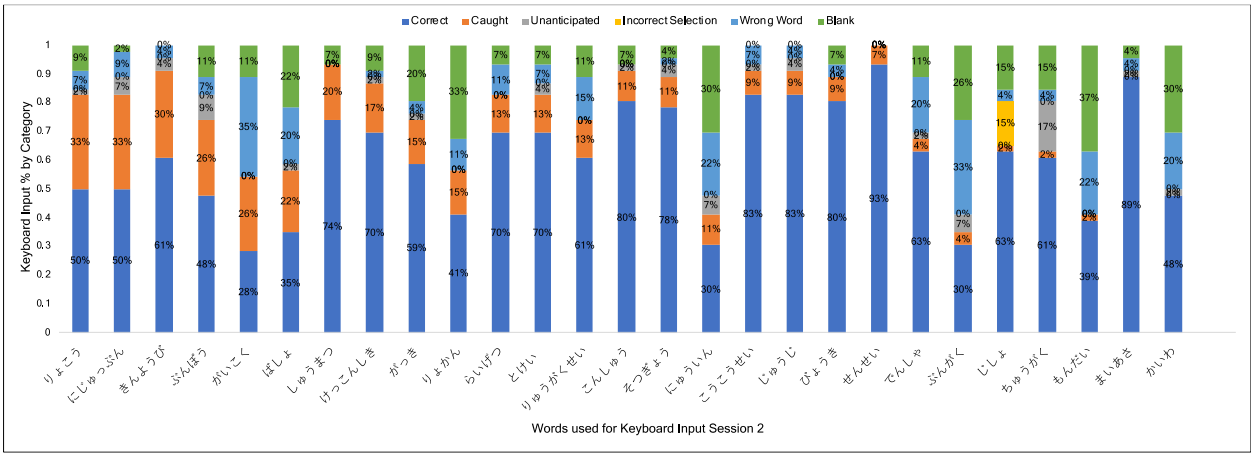

Figure 10 Breakdown of Typing Input at 1st Attempt by Word - Session 2

The words are listed in similar order to Session 1 analysis (Figure 8) based on the proportion of appearance of the dictionary tool during the typing sessions. The most frequent keyboard input errors occurred during the typing of りょこう，にじゅっぷん，きんようび，ぶんぽう. These words share include glides, double consonant and long vowels, which were mentioned as hurdle for the learners of Japanese (Toda, 2003).

The error recognition rate of the dictionary tool in Session 2 can be seen in Figure 11 below.

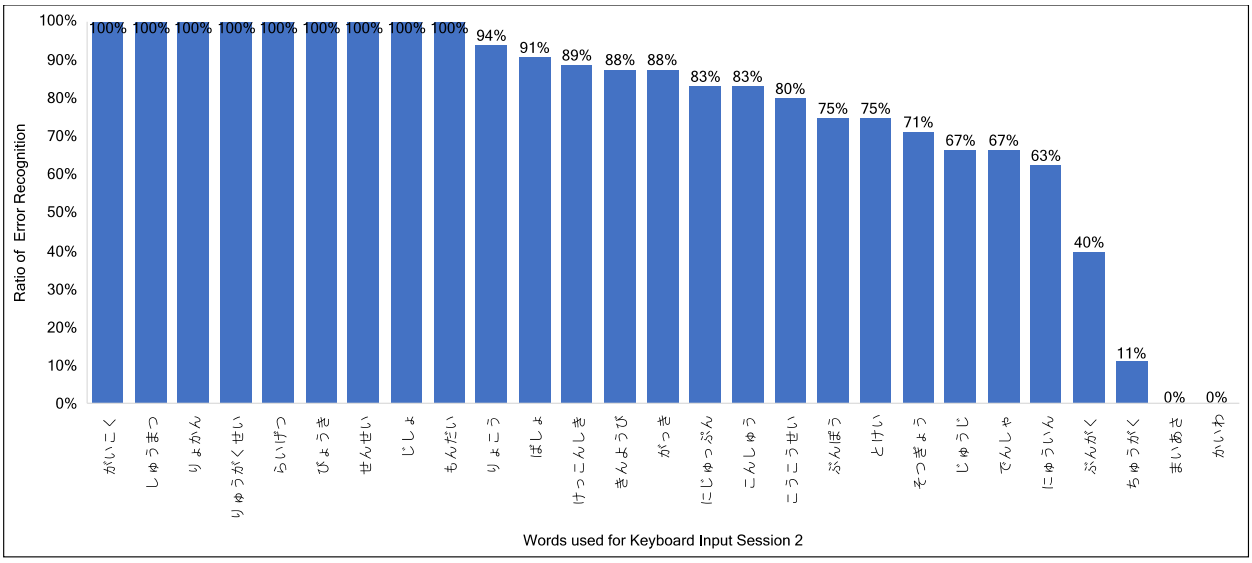

Figure 11 Error Recognition Rate on Keyboard Input by Word - Session 2

The error recognition of the dictionary tool indicates higher rates in Session 2 compared to Session 1. The total counts of each category in the figure are 753 ‘Correct’, 164 ‘Caught’, 38 ‘Unanticipated’, 7 ‘Incorrect Selection’, 127 ‘Wrong Word’, and 153 ‘Blank’. Visual feedback popped up on the screen 100% for nine words, whereas there are only two words with the same performance in Session 1. However, it has low performance for words such as ちゅうがく, appearing only once out of nine erroneous keyboard inputs.

A different aspect to explain the change of accurate typing performance of the participants from Session 1 to Session 2 is given by Figure 12 below.

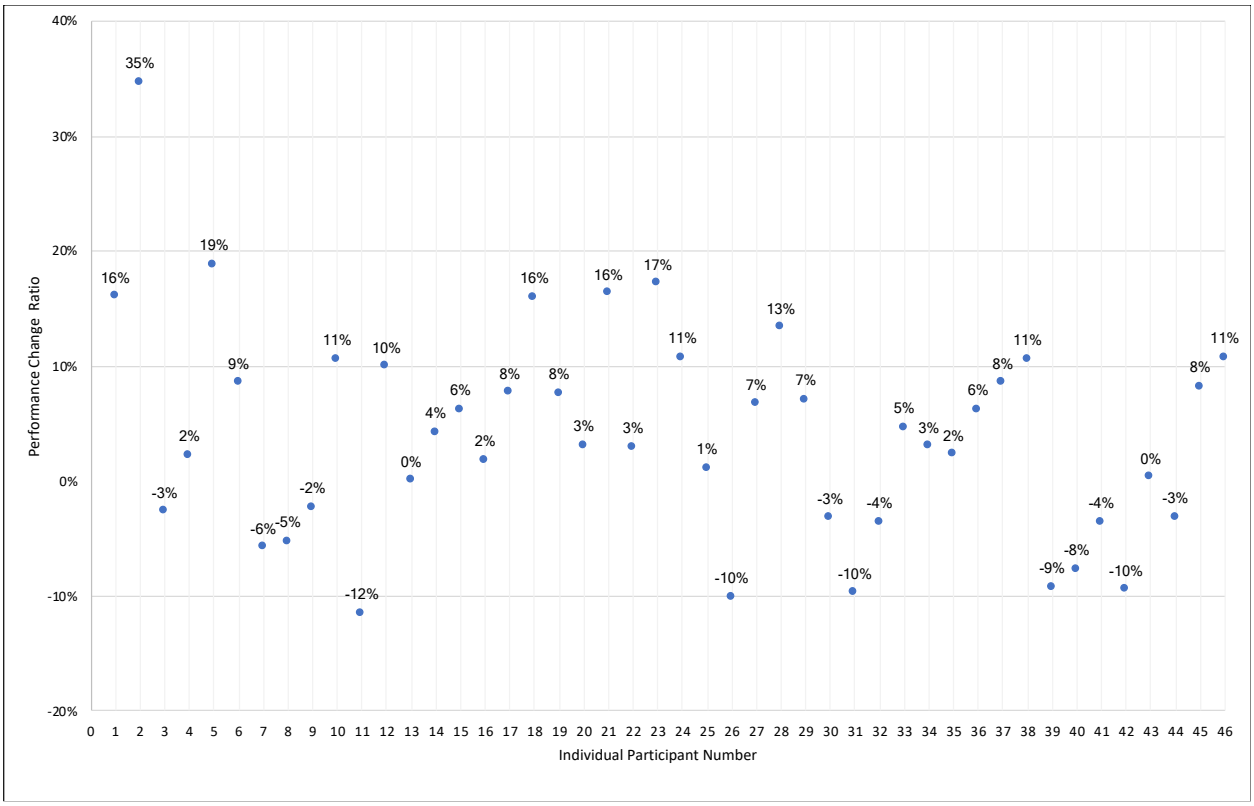

Figure 12 Change of Individual Accuracy Performance – from Session 1to Session 2

All keyboard input attempts of the 46 participants are analyzed, and it is found that 28 participants performed better in Session 2, whereas 14 have negative and two have no change. The improvement cannot be explained only by virtue of the visual feedback tool. Nevertheless, the participants' individual performance change between first and second session may still be an indicator of the effectiveness.

4.2.4 Participants' Attitudes toward Using a Visual Feedback Tool on Keyboard Input

The results of survey reveal that the majority of the participants have a positive attitude towards the dictionary tool. The Likert point scale range from 5 to 1 as 5 is strongly agree, 4 is agree, 3 is neutral, 2 is disagree and 1 is strongly disagree. The average Likert scale scores for each item is as follows:

Item 1) The Error Dictionary helped to increase my awareness of spelling during the experiment, average point is 4.5/5.

Item 2) I would feel more comfortable if my spelling was error free when using a similar tool, average point is 4.26/5.

Item 3) If I had similar error correction dictionary, I would try to use the corrected spelling of the words to improve my pronunciation when speaking, average point is 4.57/5.

Item 4) I would like to use a similar error correction dictionary tool when typing, average point is 4.57/5.

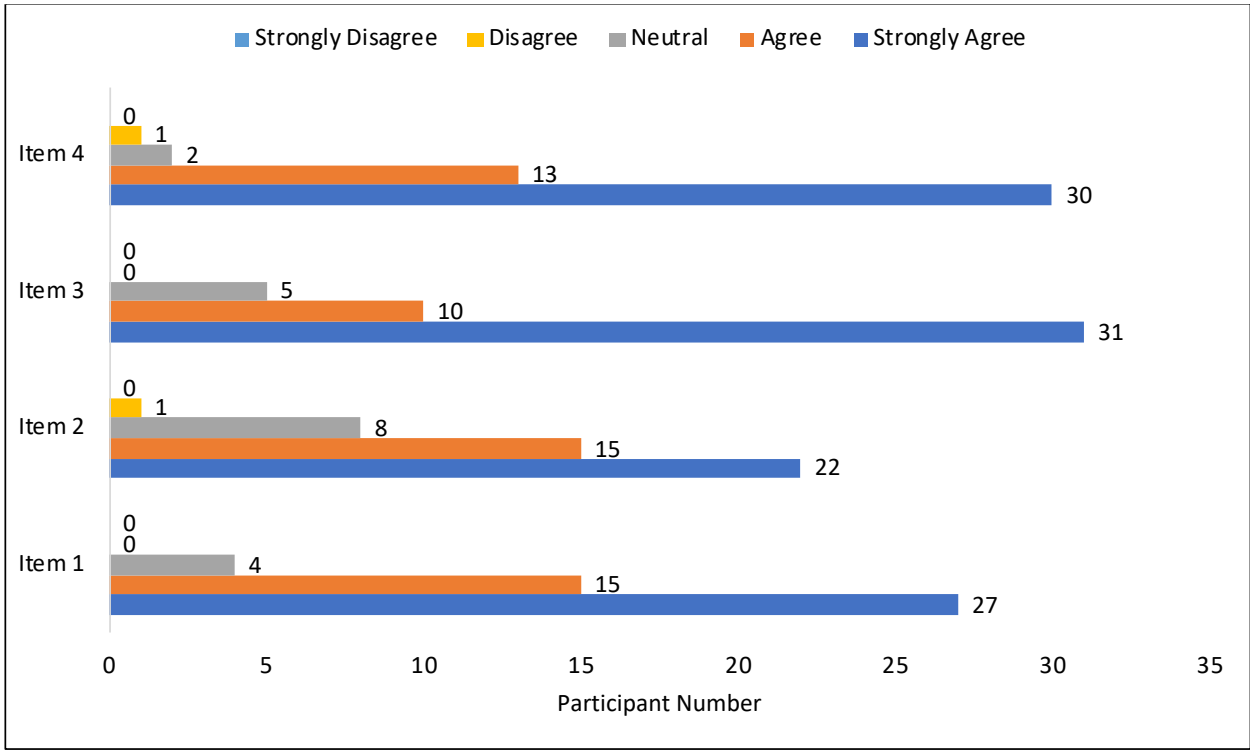

Figure 13 Frequency of Participants' Attitude Toward Used Visual Feedback Tool

For the first item, 59% of the participants responded as ‘strongly agree’, and 33% responded as ‘agree’, which equals to 92% on this item. On the other hand, only 9% responded ‘neutral’, and there was no response of ‘disagree’ or ‘strongly disagree.

On the second item, 48% of the participants responded as ‘strongly agree’, and 33% responded as ‘agree’. Compared to the first item, this item has a lower overall positive score with 81%, and ‘neutral’ responses take 17% of all responses. Only 2% of the participants, which is 1 participant responded as ‘disagree’. However, the participant did not write any comment that may give an opinion about this response.

On the third item, 67% of the participants responded as ‘strongly agree’ and 22% responded as ‘agree’. This item can also be interpreted as 89% of the participants indicate a positive attitude toward utilizing corrected spelling in speaking for a better pronunciation. Of all of the responses, 11% are ‘neutral’, and there is no ‘disagree’ or ‘strongly disagree’ responses in item 3.

On the last item, 65% of the participants responded as ‘strongly agree’, and 28% as ‘agree’. In total, 93% of all responses demonstrated an overwhelmingly positive attitude. 4% responded as ‘neutral’, and 2%, which equates to one participant, responded as ‘disagree’. The participant’s comment unveils the reason of ‘disagree’ response. The participant explains that they do not want to take time to correct their own errors as they want to finish any task quickly and added that they do not prefer to use such a dictionary tool in daily life, unless it is used in the classroom environment. Participants were also asked about their opinions in an open-ended section, and the all response can be found in the participant responses list in the Appendix C.

CHAPTER 5. DISCUSSION AND CONCLUSION

5.1 Introduction

The purpose of this chapter is to incorporate the results and findings of the present study into the construction of a helpful keyboard input method in word processing and discuss key details when using such tool. Firstly, the error types with frequencies in Chapter 4 are discussed in detail, and potential influences on the results and other circumstances that might affect the results are explained. Secondly, the findings on the effectiveness of the visual feedback tool are discussed and relevant implications are put forward. In the following part, the participants' opinions are discussed based on survey results. Lastly, related pedagogical implications, limitations of the study, and the directions for future research will be concluded.

5.2 Errors of the Participants on Pronunciation and Keyboard Input

The results indicate that although there are similarities between frequent error types and frequencies between the pronunciation and typing data, they are not identical in the subcategories (**Figure 1**). The results of present study show that most frequent errors are seen on long vowels, double consonants and glides, which are in line with the findings of Hatasa (2001), Toda (2003) and Tsuchiya (2000).

5.2.1 Long Vowels

When the most frequent -LV errors are analyzed (**-LV table**), it becomes apparent that omission of long vowels, such as in こんしゅ__, とけ__, ぶんぽ__ occurs in words in which the long vowel is located in the last syllable. Other example for omission of long vowel errors in the last syllable include がくせ and せんせ, even if they did not occur frequently.

Another error pattern in the category of omission of a long vowel was recorded in as じゅ__ねん, しゅ__まつ, びょ__いん, りゅ__がくせい. The first characteristic of these words is that the omitted long vowel is the part of a heavy first syllable. Another shared characteristic is that the long vowel in each word follows a X ゅ or X ょ sound.

Insertion of long vowels is the most frequent error type in the typing sessions, and the second most frequent in the pronunciation sessions. The error patterns can be explained in various ways in this category. Frequent errors are seen in the following words: りょうこう, じゅうぎょう, としょうかん, ばしょう, にじゅうぷん, じしょう (**+LV table**). The words りょうこう, じゅうぎょう originally have one long vowel in the last syllable and X よ, X ゆ sounds before the last syllable. It is possible that learners concentrate on the X ょ or X ゅ, and their phonological knowledge may be tenuous as we see in the -LV examples. Also, the long vowel in the last syllable of these words might cause learners to think that another vowel is necessary and may come only after the first syllable. This can be inferred from the frequency of the erroneous りょうかん. In spite of the fact that the first syllable of りょかん and りょこう are the same, the frequency of typing error in りょうこう is 16, whereas the frequency of りょうかん is 6.

The next pattern is found in the word pair of ばしょう and じしょう. Both words have two syllables, and there is no long vowel in the correct form. Learners insert a long vowel in the last syllable and following a glide ょ. Another word is としょうかん. It consists of three syllables and it does not have a long vowel in the correct form. However, learners tend to insert a long vowel after a glide ょ, not after the first syllable with one *kana*. As would be expected in Japanese, learners tend to insert a long vowel う after a glide of ゅ or ょ most of the time. These learner errors indicate that the perception of long vowels is strongly related with a following or preceding X ょ or X ゅ sound. This can also be explained as an L1 effect, which means whether long vowels are demonstrated phonologically in the learner's L1, as indicated in Tsuchiya (2000).

There is another error pattern in the word にじゅうぷん. The word consists of three syllables and an erroneous long vowel insertion after X ゅ sound. However, this time, the long vowel is replacing a double consonant っ. Another example of the same error pattern is seen on さんじゅうぷん. Due to the limited word examples in the experiment, the error pattern of replacing a double consonant with long vowel is limited to two words.

The above error patterns indicate that the learners might be unsure whether or not a long vowel is included in the word. Furthermore, when a long vowel う comes after the glides ゅ and ょ, the frequency of +LV or -LV errors were more frequent in this study. In other words, there might be an ambiguity of sound length of X ょ or X ゅ in the learners' knowledge. Nevertheless, further study should be considered to explain if there is a certain link between long vowel errors and glides in terms of their location in the word.

5.2.2 Double Consonants

The most frequent error was い＿しゅう by omission of double consonant (**-DC table**). However, this error is only seen in typing and not in pronunciation. This omission is seen before a syllable with a glide of ゅ, and majority of the -DC errors share this characteristic. This data supports the realization of a typing error relation with a glide ゅ. Another cause of this type of error might be the key sequence of a keyboard. If the learner does not push the consonant button twice, or in other method with using x, then hiragana sound, double consonant is not typed. Consequently, even though the phonetic memory of learners is correct, they may not be aware of their erroneous keyboard input.

Another frequent error pattern is seen in words such as け＿こん and が＿き. Although the words include neither long vowel nor glide, the double consonant is omitted. This might be explained by learners' cognitive error. That means, the learners might not be sure whether there is a double consonant or not in the word. On the other hand, frequent insertion errors +DC such as りょっこう, こっこう and とっけい are recorded only during pronunciation. This error type occurred less frequently than -DC. All three words have different error patterns and there is no significant difference in terms of occurrence frequency by participant's L1. Thus, they may not be classified based on a certain trend other than cognitive errors of the learners.

5.2.3 Voiced/Devoiced Consonants

Voicing (**+VC table**) and devoicing (**-VC table**) consonant errors were recorded during the sessions. Frequent voiced consonant errors are がいごく, ぶんぼう, and ぎんごう. All three words have voiced consonants in their first syllable, and learners tend to voice the second unvoiced consonant in the following syllable. Voiced consonant errors can be explained with an L1 effect or the phonetic closeness of p/b and k/g pairs (Nakazawa, 2003). Likewise, devoicing errors of てんしゃ and ぶんかく, supports this explanation. Hatasa (2001) indicates that the native speakers of Chinese tend to have voicing/devoicing errors due to the phonological gaps between Chinese and Japanese. **Figure 2** reveals that voicing and devoicing problems belong to Chinese NS.

5.2.4 Vowel Substitution

The errors in せんがつ and らいがつ can be explained with the reading habits of the months such as January and February in Japanese (**Sx table**). Learners may confuse these two different pronunciations. Another erroneous word pair is ちゅがく , which should be ちゅうごく in original form, and ちゅうごく, which should be ちゅうがく. In addition to long vowel omission, the learners mix up が and ご character. In practice, the word ちゅうごく is used frequently throughout the course, whereas ちゅうがく is a less frequent word. Thus, learners may be affected by a less frequently used word's similar pronunciation. Nonetheless, limited data is not sufficient to support this explanation and this error pattern can be a random error pattern.

5.2.5 Moraic Nasal (MNx)

For this error type, the experiment had only two words. The erroneous input きにょうび can be classified as mechanical error rather than a phonological error (**MNx table**). Students' keyboard input practice is predicted to solve this problem.

5.2.6 P Sound

The most frequent erroneous word ぶんぼう is the replacing P with B. Similar to voicing error, this also can be explained by L1 influence of certain student group (**-P table**). Another frequent error is seen as にじゅうふん or にじゅ（っ）ふん. It is difficult to explain certain causes in this word, because the last syllable has an irregular conjugation depending on preceding number. Thus, it may directly be a vocabulary caused error.

5.2.7 Glides (-G, +G, Gx)

Two erroneous words are recorded during the pronunciation sessions (**Gx table**). Regarding しょくだい and びゅういん , even though the learners' spellings are correct, they may not be aware that their pronunciation is not accurate. The distinction between the glides よ and ゆ may not be clear to the learners. Attention to such details is required during pronunciation or reading practices.

5.3 Keyboard Input Errors based on Native Language

The long vowel errors of native speakers of Chinese can be explained with an L1 effect. Additionally, a combination of a long vowel and preceding glides X ょ and X ゅ can be another cause for this type of error (**Frequent Input Errors of Chinese NS table**). The second most frequent error (-DC) may have different explanations. The error in the word け_こん may arise from unfamiliarity to typing. However, い_しゅう and さんじゅ_ぶん are likely caused by the multiple pronunciations of number conjugations. Number conjugations can be another hurdle for learners both phonetically and phonologically. Voiced consonant errors can be directly explained by L1 effect, as this type of error is only recorded by native speakers of Chinese. Also, Sakamoto (2003) explains the P and B phoneme differences in Japanese and Chinese, which supports the influence of an L1 effect.

The most frequent errors of native speakers of English were in long vowels and omission of double consonants (**Frequent Input Errors of English NS table**). Details of the errors at the word level reveal that a glide X ょ or X ゅ has a strong influence on the erroneous omission or insertion of a long vowel in a word. The omission of double consonants suggest that the majority of the errors are related to conjugated pronunciation of the numbers.

If we exclude several mechanical typing errors such as きにょうび、しゅうくだい, which may arise due to keyboard sequence, overall keyboard input errors have a trend with several important differences based on L1. As stated in the findings of previous studies (Hatasa, 2001; Toda 2003; Tsuchiya, 2000) that long vowels, double consonants, and glides are difficult for JFL learners regardless of their native language is supported with the findings of the present study.

5.4 Effectiveness of Input Remedy aka Dictionary Tool

Table 4 demonstrates that 359 erroneous keyboard inputs out of 471 are recognized by the used error dictionary tool. The error recognition rates in Session 1 and Session 2 were 74% and 78%, respectively. In other words, the average of 76% error recognition on spelling errors of the participants on their 1st typing attempts indicate that predicted error patterns that are used in dictionary tool are valid. The primary objective of using such a tool is improving learner's spelling by providing visual feedback on their keyboard input errors. When the visual feedback is provided on the screen, the awareness of the learner is triggered, and correcting the error manually can

eventually be linked to the learner's uptake in the long-term. Thus, the results of this study provide support that error dictionary can be an effective tool for learner's progress.

Hatasa (2001) conducted the experiment based on limited words that include both kanji words and conjugated verbs. Tsuchiya (2000) conducted an experiment to collect keyboard input error patterns by asking participants to type their answers to open ended questions. The present study only concentrated on kanji words to eliminate the complexity of verb conjugation related issues. In other words, controlled material is chosen in order to analyze the data and initiate a remedy for the target problem starting from a small scale.

5.5 Participants' Attitudes toward Using a Visual Feedback Tool on Keyboard Input

Participants' responses indicate that learners have a positive impression towards using a visual feedback tool when typing on a keyboard. The comments of participants (**Participants' Comments Table**) reveal that there are several positive and a few negative opinions. Positive comments include specific explanations, such as: such a tool helps the learners to memorize kanji spelling, provides guidance as to whether there is a long vowel or double consonant when they are not sure, increases their awareness about their weaknesses on *kanji*, reduces the frustration when the learner cannot find the *kanji* due to misspelling. When we take such specific user opinions into consideration, it is clear that learners can take greatly benefit from automated visual feedback. A few negative comments point out that relying on such supportive tools may cause the student to reduce their self-attention on spelling or that such a tool can be used for studied *kanji* in the course but if the learner want to use a new *kanji*, it may not help them. Another participant wrote that if a different *kanji* pops up when they type in hiragana which they do not know the meaning of *kanji* if the participant did not study it before. Consequently, they cannot learn a new kanji nor determine whether the new kanji anticipated one or not. One more comment mentions that the tool can help the user for certain error patterns. These negative comments indicate that some students may find the visual feedback tool confusing or misleading. Thus, a better design of the tool should be taken into consideration in future studies.

Overall comments and Likert evaluation results support the use of such visual feedback tool to help the learners on their spelling errors. I believe that involving the users from the start of a project to create such a tool and maintaining their participation is crucial to construct an effective product and to keep its validity within the changing learning conditions.

5.6 The Research Findings

Based on the quantitative analysis of keyboard inputs of the learners (**Table 3** and **Figure 3**) and the error recognition rate of the used remedy were 74% and 78% in Session 1 and Session 2, respectively (**Table 4**). An average error recognition rate of 76% indicates that using such a dictionary tool during keyboard input is effective in terms of recognizing the errors of learners and providing immediate visual feedback to the learners, which aims to improve spelling accuracy of the learners. The error types do not vary significantly among the learners of native speakers of Chinese and the native speakers of English, except deviation on a small number of error patterns (**Figure 2**). The results of error type analysis based on the learners' L1 indicate a resemblance with the results of Hatasa (2001), Tsuchiya (2000), Nakazawa (2003), and Dixon (2010). The finding is limited to keyboard input, and any impact on pronunciation improvement is not included in the objectives of this study.

5.7 Limitations and Directions for Future Study

JFL learners' spelling skills can be improved through utilization of different pedagogical methods, and the present study aims to support the use of an automated visual feedback during typing. However, one of the limitations in the study is the limited number of words and types incorporated into the materials. In this study, only *kanji* words are used, and verb conjugations are not included, which is important in terms of *kanji* – *kana* combined spellings. Thus, conjugated verbs or longer *kanji* words that consist of 4 *kanji* should be taken into consideration. Additionally, the words that are used in Session 1 and Session 2 are pairs, meaning a *kanji* in a word in Session 1 is shared in another word in Session 2. For example, 行 is a part of 銀行 in Session 1 and part of 旅行 in Session 2. However, such word sets are limited in the *kanji* study schedule of the learners' Japanese courses. Thus, a future study to examine the validity of the effectiveness should be conducted by considering various *kanji* words in addition to evaluation of learners' improvement on a single *onyomi* spelling.

One important point is the long-term evaluation of the dictionary tool effectiveness based on learners' spelling improvement on a single kanji *onyomi* (Chinese reading) reading. For example, in a pre-test, if the participant spells 旅行 as りょごう, the visual feedback appears as 旅行（りょこう）and gives the correct spelling of the second kanji. Thereafter, in post-test , if the same

participant spells 銀行 as ぎんこう, it can be seen as learner's uptake from previously provided feedback. If the student spells 銀行 as ぎんこ or ぎんごう, then it shows that there is no uptake by the learner. Thus, the dictionary tool is not effective in this specific example. Different word types such as *hiragana* + *kanji* combination words, *kanji* words, *katakana* words, in addition to sentence samples and composition samples of the participants that may affect uptake of the learners should be considered during experiment design and should be analyzed by recording of keyboard input in such a long-term study.

A different concern in the construction of the visual feedback dictionary is defining the error pattern range to be added into the word list, so that they are incorporated into the visual feedback. In other words, there were rare error patterns during the keyboard input portions of Session 1 and Session 2, in addition to frequent error patterns. It is the fact that not every error pattern can be included into the word list due to various individual errors. Thus, setting a cutoff value to define error pattern range was necessary in the present study. To this end, I defined the cutoff value statistically. The formula was to divide the frequency of an error pattern by the total input count for each word, and if the ratio was 5% or more, it was added into the dictionary tool as a new, anticipated error pattern. For example, if としゅうかん is recorded 1 time out of total 45 input count, it refers to 2% of total and was not added to the dictionary tool. However, this may not be the ideal cutoff value standard, because in a future study, there may be new error patterns that are plausible but rarely occur in the data. Thus, a future study should consider such crucial points in order to set a cutoff value for error patterns.

The logographic writing system of Japanese makes handwriting practice of *kanji* important, in order to memorize the *kanji* characters and *kanji* words. The present study compared the pronunciation errors and typing errors of the learners on *kanji* words to examine a possible relation or influence on each other in regard to *kanji* spelling. However, including handwritten *kana* spelling of the *kanji* words and analysis of the spelling errors on handwritten *kana* might be more effective in defining the learners' spelling errors and identifying a correlation between pronunciation, typing and *kana* writing. This may clarify other causes of the errors. Also, writing instruction in Japanese need to be reconsidered in regard to the changes in educational environment such as increasing use of online teaching and learning. Students are using laptops, tablet computers and mobile phones for various assignments and course tasks. Spelling and writing exercises in Japanese should also be integrated to digital tools. The ideas such as using a stylus pen on a touch

sensitive screen for kanji practices can be adapted. In a nutshell, students can do practice or submit writing assignments by using a mobile phone or tablet computer which through a software that can recognize key stroke order or shape of a kanji and give visual feedback upon the student's input. Another adaptation can be on pronunciation skills. If a speech recognition tool is modified and adapted for the learners of Japanese, the students can record and upload their voice to a software through mobile phone, tablet computer or laptop which may give instant feedback upon voice input. Incorporation of such tools that provide instant feedback will help the learners to evaluate the output of themselves and might lead to uptake in the long term. Consequently, such adaptations of new supportive tools in learning environment will bring new research areas into SLA. Furthermore, the findings of such future studies may help JFL instructors in the construction of pronunciation and spelling-focused instruction in the curriculum.

The ultimate aim of using different methods and tools is maximizing the learner's uptake. In this study, learner's uptake is not a primary objective due to the time limitation between the two different sessions and the limited number of sessions. It is the fact that possible external factors may affect learner's uptake, yet the effectiveness of such a dictionary tool in improving the learner's uptake should be examined in the long term.

5.8 Pedagogical Implications

According to the results of the present study, even though the learners have fewer errors in pronunciation, their lack of phonological knowledge appears in their spelling errors when typing, especially with long vowels and double consonants. Thus, increasing the time spent on typing instruction and the frequency of typing practice will enable the instructor to assess the students' competency in typing in Japanese, in addition to establishing a link between pronunciation and spelling through computer aided tools such as a visual feedback dictionary. Furthermore, practicing typing on keyboard will eliminate mechanical errors which are caused by unfamiliarity with the keyboard input in Japanese and may reveal the underlying problems on spelling errors.

Communication via internet is becoming more important nowadays due to unexpected conditions in daily life such as global pandemic crisis, and thus different set of skills in online education are becoming essential as well. There is no doubt that typing is an important skill that is a complex process in Japanese language, as previously mentioned in the introduction. Keyboard input practice for improving efficiency requires both instructor and learner involvement. As

technology infiltrates into daily life, people are becoming more adept at using technological devices and can implement new learning methods into their habits. Considering this, the instructors of JFL education may benefit from it. Typing on a Japanese keyboard is not limited to computers, such as desktop or laptops. Tablets and mobile phones are in high demand among the learners thanks to their portability. Computer aided tools such as the one used in the present study can easily be used by the instructors. Considering that the visual feedback dictionary is easy to create and modify, the instructor can create a computer file that includes studied *kanji* words and send it to the students. The learners can then easily install it onto their computer for use. A secondary finding of this study is that if the visual feedback dictionary file is used in an Apple computer, the user can also use it on an iPhone without further application. This feature naturally increases the use frequency of the visual feedback dictionary in learners' daily life, which may have a positive influence on learners' spelling improvement in the long-term.

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APPENDIX A. FREQUENT KEYBOARD INPUT ERROR TABLES

Frequent Long Vowel Insertion (+LV) Error Count

Error	Typing	Pronunciation
りょうこう	16	2
じゅうぎょう	14	4
としょうかん	11	7
ばしょう	10	
にじゅうぷん	9	4
じしょう	8	2
さんじゅうぷん	7	5
りょうかん	6	4
しゅうくだい	4	
さんじゅうっぷん	4	
じゅうしょう		4
にじゅうふん		3
かいわい		1

Frequent Long Vowel Omission (-LV) Error Count

Error	Typing	Pronunciation
じゅ__ねん	11	7
しゅ__まつ	8	2
いしゅ__	6	
こんしゅ__	5	1
じゅ__しょ	5	4
とけ__	5	
にゅ__いん	5	
にゅ__がく	5	
びょ__いん	5	1
ぶんぽ__	5	
りゅ__がく	4	3
りゅ__がくせい	4	
こ__こ__せい	3	3
じゅ__じ	3	1
せんしゅ__	3	2
ちゅ__がく	3	
がこ__	2	
ぎんこ__	2	
こ__こ__	2	
こ__ごう	2	
せんせ__	2	
びょ__き	2	
いしゅ__かん		3
いっしゅ__かん		5
がっこ__		1
かよ__び		1
ぎんご__		4
こうこ__		2
こっ__こう		3
じゅぎょ__		2
こ__こうせい		2
きんよ__び		1

Frequent Long Vowel Wrong Use (LVx) Error Count

Error	Typing	Pronunciation
じゅうぎょ＿	6	
りょうこ＿	5	

Frequent Double Consonant Omission (-DC) Error Count

Error	Typing	Pronunciation
い＿しゅう	14	
け＿こん	12	3
にじゅう＿ぷん	9	4
さんじゅう＿ぷん	7	5
い＿しゅ	6	
が＿き	5	2
が＿こう	2	2
が＿こ	2	
け＿こんしき		4
い＿しゅかん		3
さんじゅ＿ぷん		2
にじゅう＿ふん		3

Frequent Double Consonant Insertion (+DC) Error Count

Error	Typing	Pronunciation
りょっこう		6
こっこう		3
とっけい		3

Frequent Sound Error (Sx) Count

Error	Typing	Pronunciation
かいようび	10	2
せんがつ	7	5
ちゅがく	7	
らいがつ	5	5
ちゅうごく	3	4
でんは	3	
さくべん	2	
さくぼん	2	
さんしゅう	2	
ちゅうご		2
ちゅうねん		1
ぶんごく		1
るうがくせい		1

Frequent Voiced Consonant (+VC) Error Count

Error	Typing	Pronunciation
がいごく	9	4
ぶんぼう	5	6
ぎんごう	2	2
こごう	2	
ぎんご		4
げっこん		1
かいごく		5
げっこんしき		1
どけい		1

Frequent Devoiced Consonant (-VC) Error Count

Error	Typing	Pronunciation
てんしゃ	2	1
ぶんかく	2	
てんき		1
かいごく		5

Frequent Moraic Nasal Error (MNx) Count

Error	Typing	Pronunciation
きにょうび	11	

Frequent P Sound Omission (-P) Error Count

Error	Typing	Pronunciation
ぶんぼう	5	
ぶんほう		1
にじゅうふん		3

Frequent Glide Wrong Use (Gx) Error Count

Error	Typing	Pronunciation
しょくだい		2
びゅういん		1

Frequent Keyboard Input Error Counts of Chinese Native Speakers

Error	Frequency	Error Type	Error	Frequency	Error Type
け_こん	9	-DC	としょうかん	6	+LV
い_しゅう	8	-DC	かいようび	2	+Sx
が_こう	2	-DC	じしょう	5	+LV
さんじゅ _ぶん	3	-DC,-P,+VC	ばしょう	5	+LV
が_き、かっき	2	-DC,-VC	りょうかん	3	+LV
しょくだい	2	Gx	にじゅう_ぷん	3	+LV,-DC
じゅ_ねん	6	-LV	じゅうぎょ_	5	LVx
じゅ_しょ	4	-LV	りょうこ_	6	LVx
ちゅ_ごく	3	-LV	ぶんぼう	4	-P,+VC
りゅ_がく	2	-LV	せんがつ	2	Sx
にゅ_がく	2	-LV	でんは	2	Sx
にゅ_いん	5	-LV	さくぼん, さくべん	2	Sx
こんしゅ_	3	-LV	ちゅうごく	2	Sx
しゅ_まつ	3	-LV	てんしゃ	2	-VC
とけ_	3	-LV	ぶんかく	2	-VC
きんよ_び	3	-LV	こうごう	2	+VC
こ_こ_せい	2	-LV	ぎんごう	2	+VC
じゅ_じ	2	-LV	がいごく	8	+VC
せんしゅ_、さんしゅう	2	-LV, Sx			

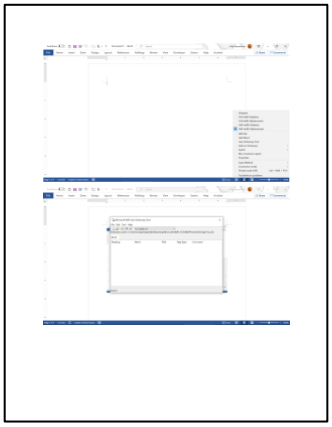
Frequent Keyboard Input Error Counts of English Native Speakers

Error	Frequency	Error Type	Error	Frequency	Error Type
い_しゅう	7	-DC	りゅ_がくせい	2	-LV
が_き	2	-DC	じゅうぎょう	8	+LV
さんじゅう_ぷん	5	-DC, +LV	としょうかん	6	+LV
にじゅう_ぷん	5	-DC, +LV	かいようび	5	+LV
ちゅ_ごく	3	-LV	りょうこう	10	+LV
じゅ_ねん	3	-LV	ばしょう	3	+LV
びょ_いん	2	-LV	りょうかん	3	+LV
しゅ_まつ	4	-LV	じしょう	2	+LV
にゅ_いん	2	-LV	きにょうび	9	MNx
ぶんぽ_	2	-LV	せんがつ	4	Sx
こんしゅ_	2	-LV	らいがつ	2	Sx

APPENDIX B. VISUAL FEEDBACK DICTIONARY GUIDE

MacOS Guide

Windows Guide



APPENDIX C. PARTICIPANT COMMENTS IN SURVEY

1. The error dictionary helps me memorize vocabs.
2. High light or bold the missing/incorrect part in the suggestion to be easier to spot the error. (Regex->Phyton method for comparison differences)
3. Dictionary tool did help me to recall and correct my misspelled words.
4. Interesting design! I usually type my composition on PC before I write it down on the paper, but I sometimes forget what kanji we have already learned and only write hiragana. I think if I can have this kind of dictionary which record every kanji we have learned and could correct them automatically; it would help a lot!
5. There are many wrong ways to spell a word so it's necessary to catch all of the possible or common mistakes. Otherwise, I think this tool is very useful to help students learn to type more accurately.
6. I like things to be fast so even if I make a mistake, I usually don't want to take the time to correct my mistakes. This is for daily use. For classroom use I would have no problem with using this.
7. For the most part, I am comfortable typing in Japanese because I mentally spell Japanese words using romaji already. However, if I had the pronunciation/spelling wrong, this tool helped me recognize easily that I had made a mistake.
8. I liked using this tool because it made me realize how much I need improvement in spelling, and I think this tool would be very useful to use incorporate into classes so that more students can fix their spelling as you learn more grammar and vocabulary.
9. The dictionary is pretty useful for learners when typing their homework as the predictions could be limited to the words in the word list. But sometimes, the predicted words aren't the ones I want to type in. Especially when the words are not common words. So I probably would use this tool when doing my homework or learning, but probably wouldn't use it when I use Japanese in practice since I could just try the possibilities or look it up when I need help.
10. The Error correction was useful during both my attempts at this test. This test also made me realize what chapters in need to review for vocab and kanji.
11. There could be the same pronunciation for different kanji, sometimes confusing.
12. I feel that I may have been less careful of checking the kanji myself because I was trusting the tool to check for me so I could correct any mistakes. I think if I used this tool regularly, I would see an increase in the incorrect kanji that I wrote, at least initially. Using a tool like this, I would be worried that the correction dictionary might not be complete.
13. If a different kanji popped up when I typed in the hiragana and I didn’t learn what it was, I didn't know if it was right or wrong.
14. Tooltips of common mistakes when people write out kanji may help with recognizing certain patterns.
15. I really liked the error correction dictionary because I often forget whether a word has a long vowel (e.g. ryo vs ryou). I really like how I get to see which words I misspell.
16. I think the experiment is helpful because it helps me review the vocabs and kanji I've learned
17. My biggest problem when typing Japanese is forgetting when a word has a long vowel or a small tsu. Distinguishing that in a program/error dictionary like this would greatly help language learners.

18. The correction tool is nice for me to correct my pronunciation, especially when the built-in typing method does not provide any correction for a mis-spelling word. It would be annoying when trying to find the correct spelling on our own and this spelling tool helps a lot in this situation.
19. Learning language is a process of practicing. This experiment is a wonderful way to raise my awareness of spelling of Japanese.
20. I would be lazy when creating my own error correction dictionary, so if there would be a app or software, it would definitely help. But I probably will not review it very often.
21. Personally, it would be great if there is English version of the definition
22. It would be really nice if it also worked for particles in sentences.
23. Generally, the Error Dictionary helps me a lot during typing.
24. It helps me a lot about typing issues when typing the Kanji comparing with English.
25. It's very helpful for both correct typing and speaking. Some details in kanji are always ignored. It can help me notice them.
26. The error correction is very useful.
27. Not only was this a very interesting experiment, but it also helped me brush up on vocabulary I may had forgotten or needed reviewing. Thank you!

APPENDIX D. DEMOGRAPHIC OF THE PARTICIPANTS

ID #	Gender	First Language	Year in School	Major	Frequency of Typing in Japanese	Studied Year#
1	F	Eng	Sophomore	Communication	Every other day	6
2	F	Eng	Freshman	Wildlife	Once a week	1
3	M	Kor	Junior	Neurosicence & Physiology	Few times/week	3
4	M	Chn	Junior	Communication	Once a week	1,5
5	M	Chn	Sophomore	Electrical Engineering	Not often	1,5
6	F	Chn	Sophomore	Linguistics	For homework	1,5
7	M	Chn	Junior	Animation	Usually	3
8	M	Kor	Sophomore	Sound for Performing Arts	Mostly every day for assignments	1,5
9	F	Chn	Graduate 1st	Hospitality & Tourism Management	For homework	1,5
10	M	Vtnm	Junior	Computer and Information Technology	Every day	1
11	M	Eng	Sophomore	Aerospace Engineering	Twice a month	1,5
12	M	Eng	Junior	Cybersecurity	Only in Jap course	3
13	NB	Eng	Sophomore	Visual Communications Design	Rarely	2
14	NB	Eng	Freshman	Japanese / Creative Writing	Occasionally, once every few weeks	2,5
15	F	Eng	Senior	Pharmacy	Rarely	1,5
16	M	Chn	Senior	Mechanical Engineering	4times a week 10 mins each	3
17	M	Chn/Eng	Sophomore	Creative Writing	Rarely	1
18	M	Eng	Junior	Robotics Engineering Technology	Once a week	2
19	F	Chn	Junior	Pharmacy	30 mins/week	2
20	M	Eng	Sophomore	Computer Science	3 times/week	4
21	F	Chn/Eng	Junior	Marketing and Finance	Not often	2
22	M	Eng	Sophomore	Electrical Engineering	Only for class assignments	1,5
23	M	Eng	Junior	Computer Science	Usually every day	1,5
24	M	Eng	Sophomore	Computer and Information Technology	30mins/2-3 Weeks	6
25	F	Eng	Junior	Computer and Information Technology	A few times a week	1,5
26	F	Chn	Junior	Public Relations	Twice a week	1,5
27	M	Eng	Sophomore	Actuarial Science	15 mins/day	1,5
28	M	Eng	Junior	Computer Science	Once a week	1,5
29	M	Chn	Senior	Mechanical Engineering	10 mins/day	2
30	F	Chn	Senior	Statistics	30 mins/week	1,5

31	F	Chn	Junior	Linguistics	Almost Never	2
32	M	Eng	Junior	Computer Science	20 mins/week	1,5
33	M	Chn	Senior	Computer Engineering	1 hour/week	1,5
34	M	Kor	Freshman	Global Studies	Sometimes	4
35	F	Eng	Sophomore	Computer Science / Japanese	Once a week 30 mins	2
36	M	Eng	Junior	Linguistics/French	1 hour/month	1,5
37	M	Prtgs	Senior	Computer Engineering	4times a week 20 mins each	1,5
38	M	Polish	Junior	Pre-medicine	1 hour/month	1,5
39	F	Chn	Senior	Communication	20 mins/week	1,5
40	F	Chn	Senior	Hospitality & Tourism Management	Every day	1,5
41	F	Chn	Junior	Interior Design	Almost Never	1,5
42	F	Eng	Senior	Global Studies	Almost Never	2
43	M	Chn	Freshman	Physics	Every day	0,5
44	F	Eng	Sophomore	Developmental & Family Science	Not often	1
45	F	Eng	Sophomore	Biology	Couple of times/week	1,5
46	M	Eng	Sophomore	Computer Science and Mathematics	Every day	2

APPENDIX E. WORD LISTS USED IN EXPERIMENT

	SESSION 1	
#	ENGLISH	JAPANESE
1	Address	住所
2	School	学校
3	China	中国
4	Class, course	授業
5	Composition	作文
6	Ten years	十年
7	Entering a school	入学
8	Every night	毎晩
9	Bank	銀行
10	High School	高校
11	Homework	宿題
12	Hospital	病院
13	Tuesday	火曜日
14	Last Week	先週
15	Library	図書館
16	Student	学生
17	One week	一週間
18	Overseas	海外
19	Phone	電話
20	Marriage	結婚
21	Study Abroad	留学
22	Electricity	電気
23	Thirty minutes	三十分
24	Tonight	今晩
25	Travelling	旅行
26	Last Month	先月
27	University	大学

SESSION 2	
ENGLISH	JAPANESE
Teacher	先生
Literature	文学
Exchange Student	留学生
Sick, sickness	病気
Semester	学期
High School Student	高校生
Ten o'clock	十時
Foreign Country	外国
Friday	金曜日
Middle School	中学
Vacation, travelling	旅行
Problem	問題
Next month	来月
Conversation	会話
Watch (e.g.wrist watch)	時計
To become hospitalized	入院
Location	場所
Grammar	文法
Graduation	卒業
Twenty minutes	二十分
Dictionary	辞書
Wedding ceremony	結婚式
Japanese style inn	旅館
Train (for transportation)	電車
Weekend	週末
Every morning	毎朝
This week	今週