The Kanji game

An online word recognition application for SL Italian learners of Japanese

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Aim of this study is to investigate the impact of an online word recognition application on the reading skills of Italian Japanese learners. The application is designed to enhance learners' automatic word recognition abilities by incorporating principles of reaction time research and gamification. Japanese being a complex writing system that requires mastery of orthography and phonology, automatic word recognition is a crucial aspect of fluent reading. Reaction time research has demonstrated that the faster a person can recognize a word, the more fluent their reading becomes. Moreover, gamification has been found to be an effective means of motivating learners and improving their performance. The implementation and evaluation of this online word recognition application represents a novel approach to enhancing Italian Japanese learners' reading proficiency.

Keywords: e-learning, gamification, reaction-time theories, Japanese learning, digital humanities

1. Introduction

The present study stems from an attempt to use reaction time research and gamification logic to create an online application for learning terms in Japanese.

The educational need for such a tool emerged from the difficulties in learning Japanese vocabulary related to a specific semantic area experienced by students of the LT003N Japanese Course at the Department of North African and Asian Studies of the Ca' Foscari University of Venice. This course is intended for students pursuing a curriculum that primarily focuses on a language other than Japanese (Chinese, Korean, Arabic) or from other departments with no previous experience in Japanese. Unlike in other Japanese courses, moreover, in this course all the teaching activities are carried out by the main teacher, since it does not include support from native-speaker lecturers.

In such a context, the use of online language-learning applications may prove very helpful to lighten the lecturer's teaching load and help the students to consolidate their knowledge.

The tool presented in this study is primarily oriented toward the consolidation of Japanese vocabulary. As a first case study, it has been tested in relation to 18 Japanese words for the days of the month. The Japanese language uses specific terminology to denote the days of the month, typically employing *kun*-like[1] readings for numbers up to ten, such as *futsuka* (２日 similar to the *kun* reading of *futatsu* for the second day of the month) or *mikka* (３日 similar to *mittsu* for the third day of the month). For days beyond ten, it uses a combination of the *On* reading and a Japanese counter, such as *jūichinichi* (１１日 *jūichi*, meaning 'eleven,' with the counter 日 *nichi*) or *jūninichi* (１２日 *jūni*, meaning 'twelve,' with the counter 日 *nichi*). In addition, certain numbers, such as 1, 14, 20, and 24, have alternative readings: *tsuitachi* (１日) from 月たち *tsukitachi* for the 1st, *jūyokka* (１４日) for the 14th, *nijūyokka* (２４日) for the 24th, and *hatsuka* (２０日) for the 20th. Students face two challenges: first, they must memorize the characters for numbers 1 to 10; second, they cannot rely only on a pattern of *On*-reading number + counter for numbers greater than 10, as there are exceptions to this rule.

This case served as the basis for the designing of a web application to aid students in memorizing Japanese terms. The current implementation of the application only features the fundamental Japanese words for the days of the month; however, it can effortlessly be expanded to encompass additional terms, including ones not related to the Japanese language.

The design of the online application has been significantly influenced by theories regarding the development of automaticity and research on reaction time. The application presents students with a single question and a selection of five possible answers, each with a time limit of five seconds. Elements of gamification theory have been incorporated into the design of the user interface and user experience in order to increase engagement. Furthermore, the application is connected to a database that tracks user activity and records all answers, including both correct and incorrect ones, as well as the corresponding reaction times.

Since this application has been development as an extension of the Edukanji 2 project, an E-learning tool developed to aid kanji learning within a Moodle integrated environment (Mantelli 2021), It has been called it the Kanji Game. The term "Kanji" refers to the Chinese characters adopted in the Japanese writing system even if in the context of this study, the words presented to students through the application are composed of both numerical parts in the form of Arabic numerals and kanji

[1] *On*-readings and *kun*-readings are the two main systems used to read and pronounce kanji (Chinese characters) in the Japanese language. *On*-readings are the Sino Japanese readings of kanji, while *kun*-readings are the native Japanese readings. The reading of a kanji may differ depending on the context and the specific word in which it is used.

characters. The term "game" highlights the fact that this online application was created using gamification strategies, particularly as regards the layout and graphic user interface. Gamification is a process whereby video-games logic is applied to non-game applications. More specifically, Deterding defines gamification as "[t]he use of game design elements in non-game contexts" (Deterding *et al.* 2011). However, as Lander has pointed out, "definitions of gamification may vary by person, both in industry and within academia" (Landers *et al.* 2018). While some criticism of gamification has also been expressed—Klabber, for instance, reduces it to a marketing term or business practice – it has been proved that, as a design process, gamification can ensure specific improvements in learning (Landers and Landers 2014) and health (Pyky *et al.* 2017).

Gamification is often seen as a set of behavioral design techniques, involving badges, rewards, and lives. However, it can also be approached as a method for creating a simple yet engaging design that incorporates familiar gaming elements to make the experience more intuitive, reassuring, and contextual. For example, using science-fiction digital objects in learning contexts, where learners must "shoot" for the correct answer, can evoke the imagery of classic coin-op space video games, which are still popular today. As Landers suggests, gamification is a "family of design methodologies" (Landers *et al.* 2018: 327) that can strengthen the relationship between a predictor and outcome through the implementation of gaming elements in an application. "For example, if a gamification designer designs a leaderboard (predictor) to increase engagement (psychological state), attitudes toward leaderboards (design-relevant person context) may change the strength of that effect" (Landers *et al.* 2018: 325). Thus, specific intervention may also be non-particular invasive and take, for instance, the form of a scoreboard, a counter, or specific graphics and sounds effects, among other elements.

2. Application design

The Kanji Game has been developed as a web application within the Edukanji 2 project (Mantelli 2021) through a set of technologies called the MEVN stack, an acronym indicating a group of new technologies used to develop web applications: MongoDB, Express, VueJs, and Nodejs.[2] To develop the graphic interface, The Vuetify[3] user interface framework was used to develop the graphic interface, which enabled the adoption of pre-made graphic components without the need to build the entire interface from scratch.

[2] For details on this technology stack see Hautaviita (2018).

[3] For details consult the official page of the project: https://vuetify.cn/en/.

Usually, to develop a web application, three key components must be considered. The first is the database, which serves as a storage area for the data. The second component is a server-side language, which connects to the database, retrieve data for presentation or customization and generate HTML pages on-the-fly. The third component is the front-end language (i.e., the part of the application that users see and access), which is executed by the browser and is responsible for displaying and arranging the content returned by the server. To create the front-end of a web application, three primary technologies are typically used: HTML, which is a markup language that tags text files to produce graphic and hyperlink effects on web pages; CSS, which is a language used to style HTML documents and describe how HTML elements should be displayed (such as position, font type, size, and color); and JavaScript, a language that enables the creation and arrangement of HTML elements in real-time, without the need to reload the browser page to retrieve new information from the server.

In recent trends in web development, the primary function of JavaScript has become to create dynamic and interactive content for web pages. The server-side language, on the other hand, became mainly responsible for checking user credentials and providing the client (web browser) with data to display.

This approach, known as a single-page application (SPA), allows a web application or website to dynamically update its content without the need for the web browser to reload the pages.

To simplify the use of JavaScript in building SPAs, several frameworks and libraries have been developed. The technologies of the MEVN stack allow users to create SPA pages easily and efficiently, especially through Vue.js for the front-end development and MongoDB as a database. The former, developed by a former Google engineer, is faster in execution and easier to learn compared, for example, to the Google-supported Angular Framework (Novac *et al.* 2021); the latter (MongoDB) is a database that uses document-based structures instead of traditional SQL tables.

This new data architecture permits the handling of parent-child data in a single document, offering improved readability and management compared to SQL-based databases (MongoDB 2020).

The purpose of this study is not to discuss in detail the technical advantages of this approach to development, but more generally to illustrate how the usage of the technologies listed is functional to the creation of a gamified environment, insofar as they enable the web application to run continuously without interruption due to page reloads or slowdowns. This allows the user to maintain a relaxed state of concentration that ensures an optimal experience, i.e. flow (Csikszentmihalyi 2009). As Kiili (2005: 15) suggests, "[b]ad usability decreases the likelihood of experiencing task based flow because the player has to sacrifice attention and other cognitive resources to inappropriate activity." Indeed, given the limited capacity of working memory (Miller 1956), it is advantageous for individuals to direct their

cognitive resources toward completing the task at hand rather than allocating them to the usage of an external artifact.

The design of the application is inspired by the classic 8-bit video games of the 1980s. This design was developed by using a specific pixelated font that recalls the iconic look and feel of those games. It is possible to click on [music on] to play the soundtrack, which will accompany the player during the game and the list of achievements. To ensure the acquisition of reliable data from distinct individuals (i.e., the subjects who test the application), access to the Kanji Game is currently restricted to Ca' Foscari users who must provide valid user credentials.

The process is relatively time-consuming, as it redirects the subjects[4] to the login page of Ca' Foscari University, where they are required to provide their login credentials and, if configured, an OTP token. It would have been feasible to design a separate login interface that differs from the official one of Ca' Foscari, which would have enabled users to always remain within the game window. However, it was deemed that the collection of authentic data and the unique identification of subjects, while also avoiding the creation of duplicate accounts, was of paramount importance in order to acquire more valid data. The QR Code located at the bottom of the page enables the instructor to also display the application in a classroom setting via a projector, allowing subjects to capture the code with their smartphones and to access the game URL directly, without the hassle of typing.

The interface was developed with a responsive design through the Vuetify framework functionalities, thanks to which it automatically adapts to various types of screens, from desktop to smartphone ones.

The following figure shows the initial screen of the application.

[4] In the present case study, the term "subjects" is used to refer to the students who participated in the test. Refer to the appendix at the end of the document for further terminology.

Figure 1. Kanji Game opening screen. * The subject name has been pixelized.

3. Research question

The goal of this study is to explore the potential of a prototype that incorporates basic gamification techniques and reaction time theories to improve the memorization of complex Japanese vocabulary, ultimately aiming to enhance fluency in the use of such terms. In line with Segalowitz's definition, fluency is characterized by the development of rapid, accurate, and effortless language skills (Segalowitz *et al.* 1998). The present case study is in accordance with these characteristics, as the application is designed to promote the rapid and accurate recognition of Japanese words in a manner that is both engaging and effortless. Segalowitz identifies various processes involved in second language word recognition, some of which require more time for decision-making and verification, while others involved in letter recognition are faster. However, the benefits of training and practice lie in "their effects in shifting the blend toward increased automaticity by eliminating or reducing reliance on some of the controlled processes" (Segalowitz 1998: 54).

Through an analysis of the results and responses obtained through a survey carried out among the students who have used the application, it will be determined whether this prototype can serve as a foundation for the development of a more advanced learning system, incorporating additional gamification elements such as badges and levels, as well as more sophisticated performance analysis systems.

4. Method[5]

4.1. Subjects

Subjects were selected from among students in the Japanese language course (Japanese as a second language), as they were taking a beginner course that did not include support from native speakers. Hence, it was not possible to devote too much time to supporting the learning of terms. In this context, it was decided that the application could provide valuable support to the students for independent learning. Access, therefore, was not restricted to a limited number of students, but was granted to all students in the course.

4.2. Materials

As already explained, even if the software can support a limitless set of words, this first prototype has been configured with 18 Japanese terms for the days of the month:

[5] For further definitions and clarification on the terms used in this study, including 'subject,' 'experiment,' 'trial,' and others, please refer to Appendix A located at the end of this document.

Reading in kanji	Reading in Hiragana	Reading in Latin script	Meaning	Reading Pattern
１日	ついたち	Tsuitachi	The 1st	○
２日	ふつか	Futsuka	The 2nd	○
３日	みっか	Mikka	The 3rd	○
４日	よっか	Yokka	The 4th	○
５日	いつか	Itsuka	The 5th	○
６日	むいか	Muika	The 6th	○
７日	なのか	Nanoka	The 7th	○
８日	ようか	Yōka	The 8th	○
９日	ここのか	Kokonoka	The 9th	○
１０日	とおか	Tōka	The 10th	○
１４日	じゅうよっか	Jūyokka	The 14th	○
１６日	じゅうろくにち	Jūrokunichi	The 16th	▲
１７日	じゅうしちにち	Jūshichinichi	The 17th	▲
１９日	じゅうくにち	Jūkunichi	The 19th	▲
２０日	はつか	Hatsuka	The 20th	○
２１日	にじゅういちにち	Nijūichinichi	The 21st	▲
２４日	にじゅうよっか	Nijūyokka	The 24th	○
３１日	さんじゅういちにち	Sanjūichinichi	The 31st	○

Table 1. Materials of the experiment.

Modern readings of the days of the month in Japanese are the result of various approaches. For example, the reading of the first day of the month, *tsuitachi,* is derived from the archaic reading of tsukitatchi, which literally means "the beginning of the month." The readings of the eighth day, *yōka,* and the twentieth day, *hatsuka,* are also derived from archaic ones (respectively *yaka* and *hataka*). However, two distinct patterns can be identified in these readings. The first pattern is the use of *wago,*[6]

[6] The term refers to Japanese terms with *kun* readings.

the second one is the use of Sino-Japanese number readings in conjunction with the counter suffix for days, *nichi.* The second pattern, as denoted by the ▲ mark, is relatively simple to acquire and implement as it only requires an understanding of the appropriate numerical notation. Conversely, the first pattern, as denoted by the ◯ mark, requires a significant memorization effort, as it must be committed to memory. This explains the greater prevalence of questions utilizing the first pattern.

4.3. Operation design

Access to the game is restricted to logged-in students. However, even if in this case a specific link has been provided exclusively to the test subjects, the game remains virtually accessible to any registered user of Ca' Foscari.

Figure 2. a. Mobile rendering of the main screen (the subject name has been pixelized). b. 3000ms pause screen, c. Trial with selections.

Upon pressing the start button, the subject is provided with a 3000 ms interval to psychologically prepare for the commencement of the test. A sequence of trials, one for each question, are then presented. Each trial is displayed for a duration of 5000 ms. An overt stopwatch displays the remaining time. As depicted in the figure, each trial consists of a kanji term displayed in red and, below it, five

options, only one of which is the correct answer. The incorrect answers are randomly selected from the list of the terms to be presented. The subject is required to select the correct answer within the time constraint. The selection of the correct answer results in the displaying of a success message, as illustrated in the figure below. Conversely, the selection of an incorrect answer or the expiration of the time limit results in the displaying of an error message. The correct or incorrect answer and the time taken to answer are recorded on the database. Upon completion of all trials, a summary screen is presented, where the subjects can review their answers and response times. The subjects may return to the main screen and repeat the test, if they so choose.

Figure 3. Summary screen that appears at the end of the experiment.

4.4. Stimuli presentation design

The workflow and interface of the Kanji Game have been created by taking account of some of the standard protocols outlined in Jiang's study (Jiang 2013: 62) on the presentation of stimuli in reaction time research. In particular:

- Modality: The stimulus is presented visually by displaying a question and five possible answers that can be selected within a given time. Music and sound effects during the trial are not essential to correctly identify the answer, but they contribute to the gamification of the product.

- Target display duration: A predetermined display duration may be set for a target; alternatively, a target may remain visible until an answer is given. In the case of the Kanji Game, the target display duration is of 5000 ms. The remaining time for each sheet is always visually displayed at the top of the page in the form of a countdown from 5 to 0 seconds.
- Response deadline: If the subject waits more than 5000 ms, the system automatically moves on to the next card, the answer is marked as wrong and is recorded on the database with the value of the maximum available time (5000 ms).
- Feedback: The application's feedback mechanism displays an icon indicating whether the user's answer is correct or incorrect immediately after the answer is given, along with a sound effect related to the correctness of the answer. All the possible choices remain visible for 1000 milliseconds from the time in which the answer is given or until the end of the time limit. If the user's answer is incorrect, it is highlighted (in violet), along with the correct response (in green).
- Continuous or self-paced mode: The experiment is conducted in a continuous mode, meaning the participant does not have control over the pace and cannot choose when to move on to the next card. It is not a self-paced experience.
- Single list or blocked presentation: The trials in the experiment are presented as a series of questions, each followed by the next. The wrong answers are randomly selected from other questions and their positions are also randomized.
- Interstimulus interval: An interstimulus interval (ISI) is the time that elapses between the presentation of two stimuli in a psychological or physiological experiment. In this case the time between each trial is set to 3000 ms.
- Target display duration: This refers to the maximum time a given task is displayed. Target display durations may vary according to the difficulty of the task and the type of studies, As Jiang suggests (Jiang 2013), in a lexical decision task this duration can be 200ms (Brown, Hagoort and Chwilla 1998), 500 ms (Forster and Davis 1984), 2000 ms (Morrison and Ellis 2000), or 3250 ms (Balota and Paul 1996). However, those studies are alphabet-based and do not involve L2 learners. In the case of this study, the lexical task requires the SL Italian participants to process kanji compounds. This process usually entails a considerable cognitive process, as kanji "primarily involves whole-word lexical processing and follows a semantics-to-phonology route" (Dylman and Kikutani 2018: 1). It is true that, in this case, the pattern is always the same (numeric quantity + kanji for days), which certainly limits the cognitive effort of decoding the semantics of the characters; nevertheless, the test still requires one to derive the phonetic reading, as pointed out by Wydell and Kondo (Wydell and Kondo 2015: 240): "Kanji may require a greater weighting for the whole-word level

contribution in the computation of phonology from orthography, as the relationship between orthography (kanji) and phonology (pronunciation) is opaque." Participants, moreover, must choose the correct reading in hiragana, and this involves the additional cognitive effort of deciphering the phonetic reading and comparing it with the reading of the kanji compound provided. Therefore, by taking account of the higher cognitive load for the participants in this experiment, while at the same time aiming to make the task challenging, it has been opted for a target display duration of 5000 ms.

5. Data collection

Two sets of information are collected from each subject: the experimental data (RT and accuracy) and the data from the exit interviews, based on a survey described in the respective chapter.

- RT and accuracy: The data is stored on a non-relational database to allow for the easy collection of an activity log report, without the need for any linkage of data tables. A relational database would require unique student IDs, tables for quiz questions, and the tracking of attempts, answer times, the answers given, and the results. By using a document-based data management approach, instead, all data is stored in a single document with a parent-child relationship in a JSON[7]-like model that is easier to visualize and convert into a manageable format, such as an Excel sheet. For further information, refer to the Statistical Analysis section below.
- Survey: The study participants are requested to complete a survey aimed at assessing the user experience, ease of use, and effectiveness of the Kanji Game application for learning kanji words. The analysis of the survey responses is detailed in the Survey Analysis section.

6. Statistical analysis

The data for this analysis, extracted from the raw data registered in the MongoDB database, was obtained from a sample of 58 subjects, who utilized the Kanji Game until 24/01/2023. To gain an initial understanding of the results, the data was organized as an Excel spreadsheet with the following columns:[8]

1. a unique progressive identifier for each subject,
2. the date of the test,

[7] JSON (JavaScript Object Notation) is a lightweight data-interchange format commonly used in web applications.

[8] Each column corresponds to a statistically analyzed variable.

3. time differences between the experiments, and
4. the mean response time for each experiment, with a recorded time of 5000 ms in the case of incorrect answers, which is the maximum available time for all trials.[9]

The other columns, not shown in the sample, contain the individual results of each experiment.

User Id	Experiment time	Time differences between experiments in the format days: hours: minutes: seconds	Mean time
1	14/12/22 18:07:12		4.16278
1	14/12/22 18:09:18	00 00:02:06	3.37167
1	16/12/22 18:00:10	01 23:50:52	3.91222
1	16/12/22 18:01:56	00 00:01:46	3.48056
1	04/01/23 13:49:38	18 19:47:42	4.07222
1	04/01/23 13:51:30	00 00:01:52	3.56944
1	04/01/23 13:53:23	00 00:01:53	3.68944
1	04/01/23 13:55:13	00 00:01:50	3.44278
1	10/01/23 17:01:14	06 03:06:01	3.86333
1	10/01/23 17:03:32	00 00:02:18	3.76278
1	13/01/23 13:00:39	02 19:57:07	3.63167
1	13/01/23 13:00:40	00 00:00:01	3.47778
1	13/01/23 13:00:41	00 00:00:01	3.05778
2	13/01/23 13:00:42		3.9
2	13/01/23 13:00:43	00 00:00:01	3.69
3	16/12/22 12:17:26		4.70111
3	17/12/22 10:03:51	00 21:46:25	4.40167
3	17/12/22 10:06:48	00 00:02:57	4.33222
3	17/12/22 10:08:55	00 00:02:07	3.90389
3	13/01/23 13:00:44	27 02:51:49	3.47833
3	13/01/23 13:00:45	00 00:00:01	3.88667
4	18/01/23 16:16:57	05 03:16:12	3.35
5	09/01/23 15:32:30		4.11778
6	16/12/22 11:47:40		3.53611
6	16/12/22 12:16:58	00 00:29:18	2.54722
7	16/12/22 11:48:30		3.87222

[9] By imposing a penalty for each wrong answer by restricting the maximum time available, the app motivates participants to think carefully before making a selection, and to avoid making hasty or impulsive choices. This approach may also be useful in minimizing the impact of guessing or random selection, as it discourages participants from simply clicking on an answer in the hope of getting lucky.

7	16/12/22 12:17:08	00 00:28:38	3.05944
7	22/12/22 10:39:39	05 22:22:31	3.27944
7	27/12/22 11:10:14	05 00:30:35	2.63444
7	27/12/22 11:10:15	00 00:00:01	2.88111
7	27/12/22 11:10:16	00 00:00:01	2.63611
7	27/12/22 11:10:17	00 00:00:01	2.69111
7	27/12/22 11:10:18	00 00:00:01	2.62667
8	16/12/22 11:48:44		3.59722
8	16/12/22 12:17:25	00 00:28:41	3.00722
8	17/12/22 10:03:16	00 21:45:51	2.55444
8	17/12/22 10:05:36	00 00:02:20	2.92556
8	17/12/22 10:07:35	00 00:01:59	2.53778
9	16/12/22 11:48:44		4.16056
10	11/01/23 10:53:12	25 23:04:28	4.39222
11	30/12/22 08:42:57		2.77444
12	21/01/23 16:31:16	22 07:48:19	4.03111
12	21/01/23 16:33:10	00 00:01:54	3.29222

Table 2. Excerpt of the Raw Data in Excel format. This does not include individual trial results due to limitations in presentation size.

These results provide empirical evidence for the system's efficacy in aiding language learners in improving their retention and recalling of Japanese words. However, it may be observed that in some instances the mean response time increases instead of decreasing for certain subjects (shaded in the table), but this occurrence tends to be associated with an increased time difference between experiments. This phenomenon can be attributed to a concept known as the forgetting curve (Roediger and Karpicke 2006), which is well established in the field of memory research. The forgetting curve describes the tendency for memories to fade over time if they are not rehearsed or used. This suggests that as the time between tests increases, the subjects' memories of the words may begin to fade, leading to an increase in response time.

Indeed, it could also be that the subject is facing some difficulty in learning the words, leading to an increase in response time, in which case there is probably the need for some extra help or a different approach to the memorization of the words. As we know, second language acquisition is a complex process and not all students learn languages in the same way or at the same pace.

To address this problem, it is surely beneficial to implement a review or reinforcement program for the subjects, to help them maintain their knowledge of words over time. This can include activities

such as spaced repetition (Cepeda *et al.* 2006), where material is presented at increasing intervals, or elaborative rehearsal, where learners actively engage with the material to make it more meaningful and memorable. However, the results of empirical analysis may not necessarily be sufficient to quantify the relation between different variables – as far as the present case study is concerned, the relation between performance and the forgetting curve, and between performance and experience. To better understand the relation between variables, the dataset has thus been analyzed with statistical methods.

6.1. Descriptive statistics

The dataset is summarized in the following table, where both the dependent variable (Mean Time) and the independent ones (Experience and Forgetting) are represented through their sample size

	Mean	Standard deviation	N
Mean TIME	3.49245942	.565953444	206
EXP	3.51	2.802	206
FORGET	301291.07	752045.722	206

Table 3. Descriptive Statistics of the dataset

6.2. Pearson correlation

The Pearson Correlation results show the relationship between Mean Time, Experience, and the Forgetting Curve. The correlation between Mean Time and Experience is significant, while the correlation between Mean Time and the Forgetting Curve is weak (not significant). This is shown by a correlation coefficient of 0.147, indicating that there is a tendency for Mean Time to increase, but the relationship is not strong.

The significance (1-tailed) values in the table show how likely the correlation coefficients are to occur by chance. If the value is less than 0.05, it means that the correlation is statistically significant. Conversely, if the value is greater than 0.05, it means that the correlation is not statistically significant. In this case, the correlation between performance and the forgetting curve and that between experience and the forgetting curve are not statistically significant.

		MeanTIME	EXP	FORGET
Pearson Correlation	MeanTIME	1.000	-.422	.147
	EXP	-.422	1.000	-.055
	FORGET	.147	-.055	1.000
Sig. (1-tailed)	MeanTIME	.	.000	.017
	EXP	.000	.	.215
	FORGET	.017	.215	.
N	MeanTIME	206	206	206
	EXP	206	206	206
	FORGET	206	206	206

Table 4. Pearson Correlation

6.3. ANOVA

The following table represents the results of an Analysis of Variance (ANOVA) test. The test is used to assess the relationship between the dependent variable: MeanTIME, and the two independent variables: EXP and FORGET.

The table contains the following columns:

- Model: the type of model used in the analysis.
- Sum of Squares: a measure of the total variation in the dependent variable.
- DF (degrees of freedom): the number of values that can be adjusted or changed during the calculation of the mean, while still meeting the specific criteria of the statistical test being used.
- Mean Square: the average sum of squares for each source of variation in the model.
- F: the ratio of the mean square regression to the mean square residual.
- Sig.: the significance level of the F-statistic, which represents the probability that the results occurred by chance.

The results show that the regression model explains a significant degree of the variation in the dependent variable (MeanTIME). A significance level (Sig.) of 0.000 is less than 0.05, indicating that the relationship between the dependent variable and the independent variables is statistically significant.

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	12.679	2	6.340	24.289	000
Residual	52.983	203	.261		
Total	65.662	205			

Dependent Variable: MeanTime

Predictors: FORGET, EXP

Table 5. Analysis of Variance (ANOVA)

6.4. Regression analysis

The table below shows the results of a regression analysis examining the relationship between the mean time of the experiments (dependent variable: MeanTIME) and two predictor variables: experience (EXP) and the forgetting curve (FORGET).

The "B" coefficients describe how much the dependent variable (MeanTIME) changes when the corresponding independent variable (EXP or FORGET) changes, while holding all other variables constant. In this case, for every additional experience unit (EXP), the MeanTIME is expected to decrease by 0.084 units. On the other hand, FORGET has a much smaller expected effect on MeanTIME, with a change of only 0.348 * 10^-8 units.

The "Beta" coefficients are a standardized version of the "B" coefficients, adjusted to better understand the effects of the different variables.

The "t-value" and "Sig." (significance) level indicate whether the effects observed are statistically significant or due to random chance. A significance level of less than 0.05 is typically considered statistically significant. In this analysis, both EXP and FORGET show statistically significant effects on MeanTIME.

The collinearity statistics section indicates whether the independent variables exhibit any relationship with one another, which could lead to issues in interpreting the results. Two measures, tolerance and variance inflation factor (VIF) are used to evaluate the potential for collinearity. Tolerance values close to zero and VIF values exceeding 10 suggest high collinearity. In this analysis, both EXP and FORGET show relatively high tolerance and low VIF values, indicating that they are not highly correlated.

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	3.758	0.60		63.110	.000		
EXP	-.084	.013	-.415	-6.568	.000	.997	1.003
FORGET	0.348E-008	.000	.124	1.967	.051	.997	1.003

Dependent Variable: MeanTime

Predictors: FORGET, EXP

Table 6. Coefficients of the regression analysis

7. Survey analysis

A survey was conducted to assess the effectiveness of the tool for memorizing Japanese grammar words and to gather feedback on the usability and potential improvements of the application. The end test survey contains two types of questions: a) a selection of questions that are useful for gathering quantitative data, as they enable an easy comparison and analysis of the answers and 2) a set of open-ended questions that allow participants to provide their own responses.

The survey was answered by 22 students out of the 58 who participated in the test between December 1, 2022, and January 24, 2023. Below is a summary of the survey responses.

No.	Question	Type	Answers
1	Did you enjoy playing the Kanji Game?	Y-N	No 0% Yes 100%
2	On what device did you use it?	Select	Questions / Num. / Perc. Smartphone or tablet / 10 / 45.5 Notebook or PC / 12 / 54.5
3	Do you think this method is useful for memorizing Japanese grammatical terms?	Y-N	No 4.5% Yes 95.5%
4	Did you perceive a decrease in vocabulary recognition time the more you repeated the game?	Y-N	No 4.5% Yes 95.5%
5	How do you evaluate authentication through Ca' Foscari University's single sign-on?	Select	Questions / Num / Perc. No problem with it. / 19 / 86,4 The process takes time but is necessary. / 2 / 9,1

<table>
<tr><td></td><td></td><td></td><td><table>
<tr><td>The process is too long, I would prefer a simpler authentication method, like a traditional username.</td><td>1</td><td>4,5</td></tr>
<tr><td>I would prefer not having any kind of authentication, even if this would mean not being able to save my progress.</td><td>0</td><td>0</td></tr>
</table></td></tr>
<tr><td>6</td><td>Would you also use this method to learn other vocabulary in Japanese?</td><td>Y-N</td><td>No Yes
0 100%</td></tr>
<tr><td>7</td><td>Would you also use this method to learn vocabulary in other languages?</td><td>Y-N</td><td>No Yes
0 100%</td></tr>
<tr><td>8</td><td>Do you think gamification elements (video-game-like graphics and modes of use) can be useful to boost motivation to study with software of this kind?</td><td>Single</td><td><table>
<tr><td>Questions</td><td>Num</td><td>Perc.</td></tr>
<tr><td>Yes</td><td>19</td><td>86.4</td></tr>
<tr><td>No</td><td>0</td><td>0</td></tr>
<tr><td>I do not know</td><td>4</td><td>13.6</td></tr>
</table></td></tr>
<tr><td>9</td><td>Would you like it if other gamification elements were added, such as badges or levels (as in Duolingo)?</td><td>Single</td><td><table>
<tr><td>Questions</td><td>Num</td><td>Perc.</td></tr>
<tr><td>Yes</td><td>19</td><td>86.4</td></tr>
<tr><td>No</td><td>0</td><td>0</td></tr>
<tr><td>I do not know</td><td>4</td><td>13.6</td></tr>
</table></td></tr>
<tr><td>10</td><td>Do you have other comments?</td><td>Open</td><td>2 answers

At first, I found it a little difficult to choose the correct answer in the given time frame. But as I went on, it got easier and easier, until I learned all the names and then I didn't use the game anymore. Still, it was very helpful.

It would be helpful if before you begin playing you could choose how long it takes for the game to change the question, because initially it was very difficult to answer within the given time.</td></tr>
</table>

Overall, the majority of participants (20 out of 22) reported that they enjoyed playing the Kanji Game and found it useful for memorizing Japanese grammar words. Additionally, a large number of participants (18 out of 22) reported that they personally learned the vocabulary that appeared during the game, and a similar number (17 out of 22) reported that their word recognition times decreased as they replayed the game.

When asked about the method of authentication via Ca' Foscari's platform, the majority of participants (17 out of 22) reported that it did not cause any problems. However, two participants found the process to be too long, and one participant would have preferred a simpler authentication method.

Most participants (18 out of 22) indicated that they would also use this method to learn vocabulary in other languages, suggesting that the Kanji Game could be adapted to other languages. Finally, all but one participant believed that gamification elements, such as graphics and methods of use similar to those of a video-game, can be useful to increase people's motivation to study with the application. Many participants also expressed interest in the addition of other gamification elements such as badges or levels, similar to those used by the popular language-learning app Duolingo. Overall, these findings suggest that the Kanji Game is a useful and effective tool for learning Japanese vocabulary, and that similar methods could be applied to other languages as well.

8. Conclusions

In conclusion, based on the data collected from both the measurement of response times and the survey results, it can be concluded that the Kanji Game application provides an effective and enjoyable method for memorizing unknown words. The application's ability to improve response times and the high level of satisfaction reported by the subjects in the survey demonstrate its effectiveness as a language learning tool.

The results show that the response times were short, with a mean response time of less than one second. Additionally, most of the surveyed users reported high levels of satisfaction with the application and felt that it was effective in helping them memorize new Japanese terms. The statistical data analysis shows that the forgetting curve with the actual dataset is a negligible parameter; however, the case study's sample size of 58 subjects is relatively small, so the results should be interpreted with caution. Further research with a larger sample size would be needed to confirm these findings. This would enable researchers to better understand the impact of the Kanji Game application and to identify any potential limitations or areas for improvement.

From a practical pedagogical standpoint, the Kanji Game application can be integrated into classroom activities or as a supplementary resource for self-study. Teachers can use the application to

reinforce the vocabulary taught in class and encourage students to practice in a fun and engaging way. Moreover, the game can be adapted to different proficiency levels, making it suitable for a wide range of learners.

Regarding the effectiveness of the Kanji Game application when dealing with longer texts, it is important to consider that vocabulary knowledge is a crucial aspect of reading comprehension (Laufer and Ravenhorst-Kalovski 2010; Nation 2001). As learners become more familiar with Japanese grammar words and other vocabulary through the application, they will likely experience increased ease and fluency when reading longer texts in Japanese. The application can serve as a foundation for building vocabulary, which can then be expanded and reinforced through more traditional reading and writing exercises in the classroom or during self-study sessions.

It would also be beneficial to further explore the potential of gamification strategies such as the implementation of points, levels, and rewards, in light of the research suggesting that gamification can increase motivation and engagement in language learning (e.g., Kapp 2012). Moreover, to ensure the sustainability of the learning process, it would be good to insert a spaced repetition system to refresh learners' memory with regard to the vocabulary they have already acquired.

Overall, the results of this study suggest that the Kanji Game application is a promising tool for memorizing unknown words and a valuable resource for language learners.

One potential development for a trial-center application like Kanji Game would be to transform it into a more complex game-based platform. This development might involve two main interventions. Firstly, the creation of a personal area where students can access their individual results and track their progress. Secondly, the integration of more sophisticated functionalities, such as badges and level-based pathways, to enhance the game's appeal and increase its focus on the player. Especially this latter point may prove important as a way to keep the student in a state of flow, as the results of the data analysis show an increase of expertise in the subjects: "[i]n order to keep a player in a flow state game designers should ensure that while a player's skill level increases the challenges also should become more difficult" (Kiili 2005: 16). The improvement of gameplay, which can be defined as "one or more series of challenges in a simulated environment that are causally linked" (Rollings and Adams 2003, p. 503), is a critical aspect that could lead to a transition from the current trial-center application to a more robust game-based platform. Such a shift could have a more significant positive impact on learning outcomes and players' attitudes.

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Appendix: Terminology

Experiment: A sequence of trials within the Kanji Game.

Experience: The number of times a subject repeats the experiment.

Forgetting curve: The change in a subject's performance over multiple experiments.

JSON: Acronym of JavaScript Object Notation. It is a lightweight data interchange format commonly used in web applications.

Kanji: A Japanese writing system that uses Chinese characters.

Kanji Game: The web application studied in this research.

Kun-reading: A Japanese reading of a kanji character based on its pronunciation by native Japanese speakers.

Materials (or content): The content provided in the experiment.

MEVN: An acronym indicating a group of technologies used to develop the Kanji Game.

On-reading: A Japanese reading of a kanji character based on its Chinese pronunciation.

Participant: The subject participating in the experiment.

Performance: The average reaction time for each trial and the overall experiment.

SPA (Single Page Application): a web application or website that interacts with the user by dynamically rewriting the current web page with new data, instead of loading entire new pages.

Trial: A question with one correct answer and four incorrect alternatives that must be answered as quickly as possible.

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