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Collection of age of acquisition ratings for over 5,000 Japanese words

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The age of acquisition (AoA) refers to the age at which an individual learns specific items or words. Research on word recognition has shown that items with lower AoA—those acquired earlier—can be processed more quickly and accurately. In the field of Japanese word recognition, a large-scale database that would enable mega-study approaches has not been well-established. In this study, we developed an AoA norm for over 5,000 Japanese words. A total of 1,345 adults rated the AoA of 5,736 words using a 7-point scale. These ratings demonstrated satisfactory reliability. Furthermore, when examining the correlation with lexical decision task performance, words with lower AoA showed shorter response times and higher accuracy than words with higher AoA. These findings indicate that the AoA rating database collected in this study serves as a valuable resource for research using Japanese words.

KEYWORDS

age of acquisition, Japanese, lexicon, word norms, word recognition

1 Introduction

The age of acquisition (AoA) refers to the age at which an individual learns specific items or words. Previous studies have demonstrated that items acquired early are processed more quickly and accurately than those acquired later. Rochford and Williams (1962) conducted an experiment involving 32 adult patients with speech impairment and 120 children aged 2–11 years. Participants were asked to name the objects in the order in which they were presented. A significant correlation was observed between the correct response rates of children and adult patients. Specifically, the study revealed a negative correlation between the age at which 80% or more children correctly answered each item and adult patients' correct response rate for the task. Consequently, it was found that items acquired early, that is, those with a low AoA, could be named more accurately by participants. This phenomenon applies to various stimuli, including words, phrases, images, and faces (Elsherif et al., 2023).

This study focused on the AoA effect on word recognition. In word recognition research, the AoA effect has been observed in naming (Morrison and Ellis, 1995), lexical decision (Turner et al., 1998), and semantic decision tasks (Brysbaert et al., 2000), suggesting that the AoA effect is not limited to the speech system, which is crucial in naming tasks, and that the semantic system may also be involved.

Until the 2000s, many AoA studies employed an experimental approach to factorially compare items acquired early in life with those acquired later. However, the mega-study approach (Balota et al., 2012) gained prominence in subsequent decades. This approach involves collecting word attributes on a large scale and analyzing the attributes that influence cognitive performance in various tasks. Researchers have estimated the AoA of

more than 40,000 English words (Brysbaert and Biemiller, 2017), while also collecting AoA ratings from Italian (Montefinese et al., 2019), Dutch (Brysbaert et al., 2014), German (Birchenough et al., 2017), Portuguese (Cameirão and Vicente, 2010), Spanish (Alonso et al., 2015), Chinese (Xu et al., 2021), and French (Ferrand et al., 2008). Łuniewska et al. (2016) conducted a comparative analysis of AoA across 25 languages. They demonstrated the reliability of subjective ratings by establishing a correlation between them and both the previously collected AoA and quasi-objective AoA estimated using inventories designed to assess children's language development. In addition to subjective AoA ratings, objective AoA measures have also been collected, such as parental reports of the age at which children begin to use specific words (e.g., Frank et al., 2017) and estimations of AoA based on the age at which characters are designated for learning in school textbooks (Cai et al., 2022).

These AoA ratings also serve as control variables in word recognition research (e.g., Diveica et al., 2023; Pexman et al., 2019). When investigating the impact of a variable of interest on word recognition, excluding the influences of other variables is essential. As AoA is correlated with frequency, imageability, and concreteness (Zevin and Seidenberg, 2004), its impact must be controlled to examine these variables' roles.

The AoA effect has also been observed in Japanese. Havelka and Tomita (2006) demonstrated that reaction times in naming tasks were shorter in low-AoA conditions than in high-AoA conditions. They observed that for Japanese, the AoA effect was greater for words written in kanji (ideographic characters) than those written in hiragana (phonetic characters). Yamazaki et al. (1997) reported similar findings, demonstrating that when naming single kanji characters, both the age at which the word was learned to be spoken and the age at which it was learned to be written predicted naming speed.

The abovementioned studies employed experimental approaches and used specific controlled stimuli. They demonstrated AoA effects using rigorous experimental methods; however, their generalizability is limited owing to the small number of stimuli used. To determine whether similar AoA effects are observed across a broader range of Japanese words, a mega-study approach would be beneficial. However, AoA norms suitable for such an approach do not currently exist for Japanese. Only the Japanese AoA ratings from Nishimoto et al. (2005)—who collected the AoA, familiarity, and name agreements for 359 line drawings—are available publicly. In their study, the AoA ratings pertained to line drawings rather than words; thus, only concrete objects were used. The number of items rated was relatively small (359), which is another limitation for the mega-study approach. To facilitate the mega-study approach in Japanese word recognition research, collecting AoA ratings for significantly larger numbers of words is important. Therefore, this study aimed to develop a norm by collecting AoA ratings for over 5,000 Japanese words. To assess the validity and reliability of the collected data, we also examined the relationships between AoA in other languages, as well as the relationships between lexical and semantic variables in Japanese and performance on cognitive tasks. Based on previous research, we expected that items with lower AoA would show shorter reaction times and higher accuracy rates than items with higher AoA on lexical decision tasks.

2 Method

2.1 Participants

To collect AoA ratings from 40 participants per word, we recruited participants aged 18 years and older through Yahoo! Crowdsourcing (https://crowdsourcing.yahoo.co.jp/). Of the 1,376 respondents who completed the survey, 23 were excluded from the analysis owing to incorrect responses on the Directed Questions Scale (DQS; Maniaci and Rogge, 2014), while eight were excluded because they selected the same option for all rating items. Consequently, 1,345 participants were included in the analysis. All the participants reported that their primary language was Japanese. A total of 320 participants identified themselves as women, 1,012 as men, and 13 did not specify their gender. The average age was 50.70 years ($SD = 12.04$, range: 18–90 years). The participants' levels of education were as follows: 15 respondents had graduated from junior high school, 346 had graduated from high school, 854 had graduated from undergraduate university, 86 had completed a master's degree at a graduate school, 22 had completed a doctoral degree at a graduate school, and 22 did not respond.

2.2 Stimuli

We collected AoA ratings for 5,736 words, for which Ota and Mochizuki (2025) collected data on lexical decision tasks. They adopted a mega-study approach and selected items with ratings or characteristics from wider databases to examine the relationships between lexical and semantic variables and lexical decision performance. By using these items, we can assess the relationship between AoA and various variables, as well as performance on lexical decision tasks on a large scale. The words used by Ota and Mochizuki (2025) can be referred to by the following variables: word familiarity (Asahara, 2020; Fujita and Kobayashi, 2020), word frequency (Amano and Kondo, 2000; University of Tsukuba et al., 2013), word difficulty (Kajiwara et al., 2020), imageability (Sakuma et al., 2005), semantic orientations (valence; Takamura et al., 2005), abstractness (The Social Computing Laboratory and Nara Institute of Science and Technology, 2021), and body-object interaction (Mochizuki and Ota, 2024).

Following the procedure of Ota and Mochizuki (2025), the number of letters and morae (a unit of syllable weight) and the phonological and morphological neighborhood sizes were calculated as variables that can be calculated from the words. Subsequently, 5,736 words were randomly divided into 26 lists. Participants were randomly assigned to one of the 26 lists, and each participant rated the AoA for 220 or 221 words during the survey.

2.3 Procedure

The survey was conducted using Pavlovia Survey (Open Science Tools, Nottingham, UK). The participants accessed the survey from a crowdsourcing platform. Informed consent was obtained from all the participants after they received an explanation at the beginning

TABLE 1 Correlation coefficients between AoA ratings.

Datasets	Language	*N*. of items	*N*. of matched items	*r*	95% *CI*	*p*
Cortese and Khanna (2008)	English	3,000	1,321	0.396	0.350, 0.441	<0.001
Cameirão and Vicente (2010)	Portuguese	1,994	1,255	0.428	0.382, 0.472	<0.001
Montefinese et al. (2019)	Italian	1,957	915	0.453	0.400, 0.503	<0.001
Birchenough et al. (2017)	Germany	3,259	2,082	0.489	0.455, 0.521	<0.001
Kuperman et al. (2012)	English	31,124	4,750	0.506	0.485, 0.527	<0.001
Brysbaert and Biemiller (2017)	English	43,991	4,587	0.514	0.492, 0.535	<0.001
Nishimoto et al. (2005)	Japanese	359	128	0.531	0.394, 0.645	<0.001

In Nishimoto et al. (2005), AoA ratings were collected for pictures and their concept names.

of the survey. The participants were subsequently provided with detailed instructions based on the research of Cortese and Khanna (2008) and Stadthagen-Gonzalez and Davis (2006). We modified the instructions to fit the survey format. Specific instructions and English translations are provided on the Open Science Framework (https://osf.io/fawmq/). In this survey, AoA was evaluated using a seven-point Likert scale. Participants were asked to rate the AoA using the following categories: 0–1 years old (1), 2–3 years old (2), 4–5 years old (3), 6–7 years old (4), 8–9 years old (5), 10–11 years old (6), and 12 years or older (7). For words that the participants did not know their AoA, they were instructed to select (7).[1]

Participants rated 10 practice items (恭しい ["respectful"], ばらつく ["scatter"], 下士官 ["non-commissioned officer"], まさか ["impossible"], 疎ましい ["unwelcome"], みんな ["everyone"], 寝そべる ["sprawl"], チャート ["chart"], 騒ぐ ["be noisy"], 大きい ["large"]) before rating the target items. The practice items included words predicted to have a lower AoA (e.g., "large" and "everyone") and words predicted to have a higher AoA (e.g., "respectful" and "unwelcome"). The participants familiarized themselves with the procedure using practice items and rated the target items. The participants rated 220 or 221 words in random order. In addition to the target items, one item was a DQS, and the participants were instructed to select the "10–11 years old" option.

After the target items were rated, participants were asked to complete the ENDCOREs (Fujimoto and Daibo, 2007)—a scale for measuring social skills—and the Plymouth Sensory Imagery Questionnaire (Fukui and Aoki, 2022)—a scale for measuring sensory imagery—to measure their characteristics.[2] The survey ended after the participants answered questions regarding their age, gender, first language, and highest level of education. After completing the survey, participants were given a reward code and received monetary compensation via the crowdsourcing platform.

1 Note that these categories slightly differ from that used by Cortese and Khanna (2008) and Stadthagen-Gonzalez and Davis (2006).

2 These items were collected in order to analyze them together with data collected in a different study.

3 Results

3.1 Data processing

As explained above, before summarizing the AoA ratings, we first excluded 31 participants who did not respond appropriately to the DQS and selected the same option for all target items. Means and standard deviations were calculated for each item. To calculate the reliability measures described below, we used each participant's individual rating values rather than the ratings' average.

3.2 Reliabilities

The participants' ratings were randomly divided into two groups, and the split-half reliability was calculated for 100 iterations, which resulted in a high reliability coefficient of $M = 0.924$, $SD = 0.001$. The mean absolute z-value, indicating the deviation of each participant's rating from the item-specific mean, was $M_z = 0.805$ and $SD_z = 0.269$. The participant-sample correlation coefficient, which measures the degree of correlation between participants' ratings and the mean of their ratings on the assigned list, was $M_r = 0.682$ and $SD_r = 0.182$, suggesting a satisfactory level of reliability.

3.3 Correlations with AoA ratings in other datasets

To validate our data, we calculated the correlations between the AoA ratings collected in this study and those from large-scale AoA datasets that provide English labels or translations. We first assigned what we considered to be the most representative English translations to the Japanese items. Subsequently, from six AoA datasets (see Table 1) that include English labels or corresponding English translations, we extracted only the items that matched those in the present dataset and calculated correlation coefficients. Additionally, although the number of items was relatively small, correlations were also calculated with AoA ratings collected from Japanese speakers (Nishimoto et al., 2005). As shown in Table 1, all ratings were only moderately positively correlated ($r = 0.396$–0.531). Among these, despite the limited number of items, the

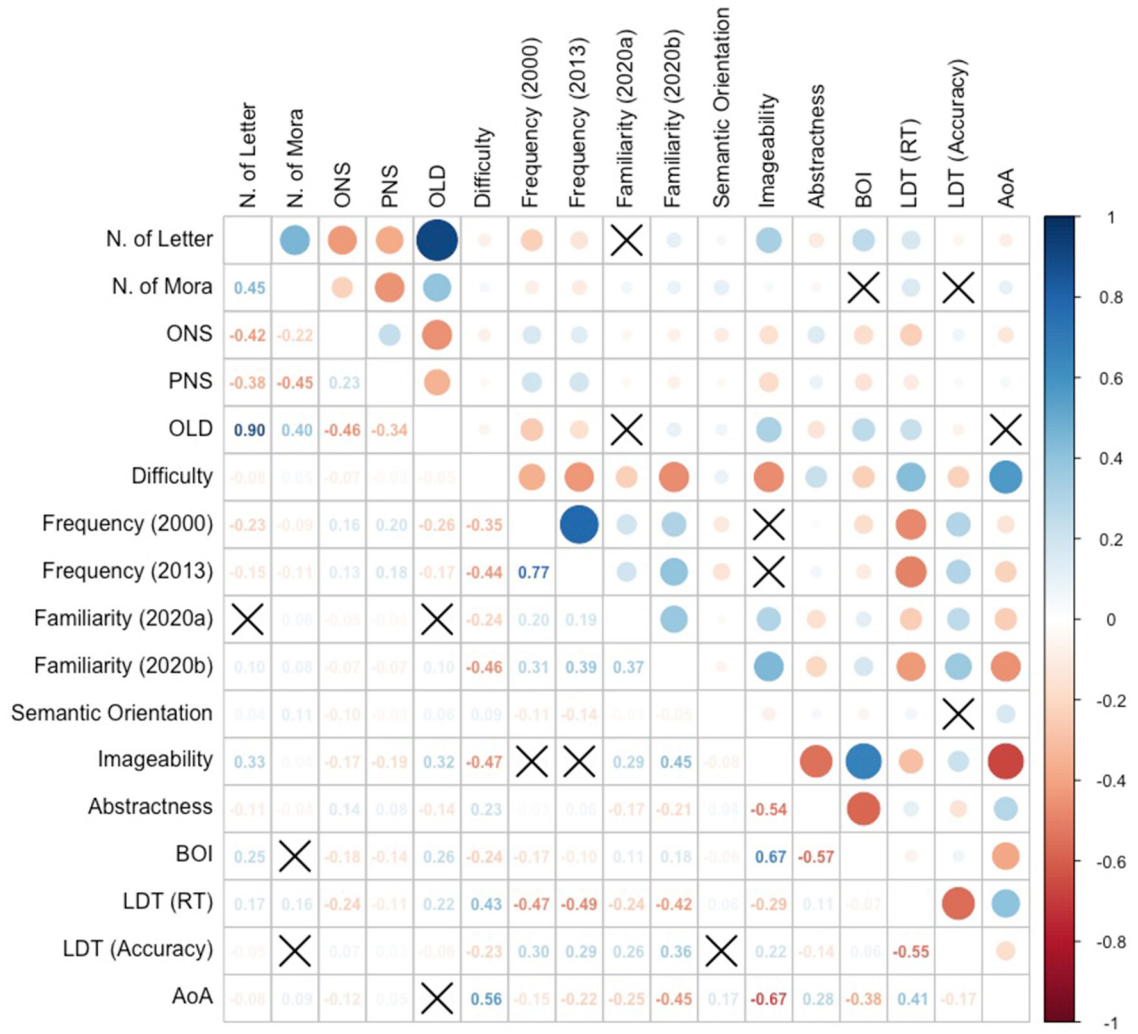

FIGURE 1
Correlations between AoA, lexical and semantic variables, and performance on lexical decision tasks. AoA, age of acquisition; BOI, body-object interaction; LDT, lexical decision task; OLD, orthographic Levenshtein distance (Yarkoni et al., 2008); ONS, orthographic neighborhood size; PNS, phonetic neighborhood size; RT, response time. Each variable was referenced from the following studies: difficulty is from Kajiwara et al. (2020), Frequency (2000) is from Amano and Kondo (2000), Frequency (2013) is from University of Tsukuba et al. (2013), Familiarity (2020a) is from Asahara (2020), Familiarity (2020b) is from Fujita and Kobayashi (2020), Semantic orientation is from Takamura et al. (2005), Imageability is from Sakuma et al. (2005), Abstractness is from The Social Computing Laboratory and Nara Institute of Science and Technology (2021), and BOI is from Mochizuki and Ota (2024). The response time and accuracy data for the LDT for Japanese words were obtained from Ota and Mochizuki (2025). The areas indicated by X show correlations that were not significant.

correlation between the AoA ratings from Nishimoto et al. (2005) and those obtained in the present study was relatively high.

3.4 Relationships among AoA, psycholinguistic variables, and lexical decision task performance

Figure 1 shows the correlations with other lexical and semantic variables in Japanese, as well as with performance on lexical decision tasks (Ota and Mochizuki, 2025). The correlations between AoA and each psycholinguistic variable showed patterns consistent with previous research. To examine the effects of AoA and psycholinguistic variables on performance in the lexical decision task, multiple regression analyses were conducted (Table 2). Following Kuperman et al. (2012), who collected large-scale subjective AoA ratings, a baseline model was constructed including number of characters, number of morae, word frequency (log-transformed; University of Tsukuba et al., 2013), and orthographic Levenshtein distance (Yarkoni et al., 2008). When AoA was added to this model, AoA significantly predicted both response times and accuracy: words with lower AoA ratings were associated with shorter reaction times and higher accuracy (Model 2 in Table 2). Even when additional available psycholinguistic variables were included in the model to rule out their influence, the effect of AoA on response time persisted, such that lower AoA ratings were associated with faster responses. However, for

TABLE 2 Multiple regression analyses predicting lexical decision task performance.

Variable	Response Time						Accuracy					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*	β	*SE*
(Intercept)	0.000	0.011	0.000	0.011	0.000	0.010	0.000***	0.013	0.000***	0.013	0.000***	0.012
N. of letter	−0.182***	0.027	−0.065**	0.025	−0.094***	0.024	0.020	0.030	−0.026	0.030	0.024	0.029
N. of mora	0.083***	0.013	0.036**	0.012	0.060***	0.012	0.042**	0.014	0.061***	0.014	0.032*	0.015
Frequency	−0.466***	0.011	−0.394***	0.011	−0.335***	0.012	0.290***	0.013	0.262***	0.013	0.207***	0.015
OLD	0.274***	0.026	0.208***	0.024	0.259***	0.024	−0.048	0.029	−0.022	0.029	−0.117***	0.028
AoA			0.315***	0.011	0.046**	0.016			−0.123***	0.013	0.139***	0.019
ONS					−0.146***	0.012					0.079***	0.014
PNS					0.010	0.012					0.020	0.014
Difficulty					0.063***	0.014					0.020	0.016
Familiarity					−0.161***	0.013					0.247***	0.015
Imageability					−0.285***	0.019					0.265***	0.023
Semantic orientation					−0.061***	0.010					0.052***	0.012
Abstractness					0.014	0.013					−0.075***	0.015
BOI					0.084***	0.014					−0.077***	0.017
$R^2_{\text{Adj.}}$	0.272		0.362***		0.438***		0.086		0.099***		0.195***	
ΔR^2			0.090		0.077				0.014		0.096	

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

AoA, age of acquisition; BOI, body-object interaction; LDT, lexical decision task; OLD, orthographic Levenshtein distance (Yarkoni et al., 2008); ONS, orthographic neighborhood size; PNS, phonetic neighborhood size; RT, response time. Each variable was referenced from the following studies: difficulty is from Kajiwara et al. (2020), Frequency is from University of Tsukuba et al. (2013), Familiarity is from Fujita and Kobayashi (2020), Semantic orientation is from Takamura et al. (2005), Imageability is from Sakuma et al. (2005), Abstractness is from The Social Computing Laboratory and Nara Institute of Science and Technology (2021), and BOI is from Mochizuki and Ota (2024). The response time and accuracy data for the LDT for Japanese words were obtained from Ota and Mochizuki (2025).

accuracy, an unexpected pattern emerged: lower AoA ratings were associated with lower accuracy, contrary to the traditional AoA effect (Model 3 in Table 2).

4 Discussion

In this study, we collected AoA ratings for 5,736 Japanese words. The results suggest that the AoA ratings have a certain degree of validity and reliability, and that these are a valuable research resource for studies using Japanese words. This is the largest AoA norm available for Japanese. The strength of this dataset is that it enabled us to examine the relationship between the other 13 variables and the two cognitive performances. The AoA is known to be correlated with frequency, imageability, and concreteness. All items in this dataset were cross-referenced with these variables, allowing us to select stimuli based on the characteristics of multiple variables and examine each variable's influence.

Notably, the correlation between the AoA ratings of other languages and the AoA ratings of this study was relatively small. The English translations of the items collected in the present study were assigned by the authors based on what is considered to be the most common or representative meanings. However, word meanings are not necessarily singular, and thus the corresponding items across datasets or languages may not always share identical meanings. This semantic discrepancy could have contributed to the relatively low correlation coefficients. Another potential explanation is that the AoA ratings may have been influenced by the orthographic form of each item. In general, Japanese speakers first learn hiragana and katakana, followed by kanji (Tsukada, 2007). Consequently, words that contain more hiragana and katakana characters may be rated as acquired earlier, whereas words with more kanji characters may be rated as acquired later. To investigate this, we calculated the proportion of kanji, hiragana, and katakana characters in each target item and examined their correlation with the AoA ratings. The results showed that the higher the proportion of kanji, the higher the AoA rating ($r = 0.224$, $p < 0.001$); the higher the proportion of hiragana and katakana, the lower the AoA rating ($r = -0.311$, $p < 0.001$; $r = -0.053$, $p < 0.001$). Although this was a preliminary analysis, the AoA ratings in the present study appeared to be influenced by the orthographic form in which the items were presented. This may partially explain the relatively low correlation between the AoA ratings in this study and those reported in alphabetic cultures.

The multiple regression analyses using models adopted in previous studies revealed the AoA effect: words with lower AoA ratings were associated with shorter response times and higher accuracy, consistent with findings from other languages. This

suggests that AoA plays an important role in word recognition in Japanese as well. It is noteworthy, however, that in the model including multiple available psycholinguistic variables, AoA was a significant predictor of accuracy, but in the opposite direction from the typical AoA effect: higher AoA ratings were associated with higher accuracy (see Model 3 in Table 2). This unexpected finding suggests that, for Japanese words, the effect of AoA on accuracy may be confounded with other variables such as imageability, familiarity, and body–object interaction. Presently, we cannot posit any strong explanation for this result. One possible reason may be the relationship between orthographic forms and AoA. Specifically, as mentioned above, words with higher AoA ratings are more likely to include kanji characters. High AoA words may be more difficult (as shown in Figure 1), leading to greater processing demands; as a result, they may be processed more carefully, yielding longer reaction times but higher accuracy. Because the present study did not include pairs of words that differ only in orthographic form (i.e., no identical-meaning words with different script type), we were unable to directly test this possibility. However, Havelka and Tomita (2006), who demonstrated AoA effects experimentally in Japanese, found that AoA effects on reaction time were larger for words presented in kanji compared to that of the same words presented in kana. The influence of variables such as word length, frequency, and familiarity is known to differ between the processing of kanji and katakana words (Kusunose and Hino, 2017; Kusunose et al., 2014). Future research should further examine how AoA and orthographic forms interactively influence lexical processing, particularly with respect to accuracy.

Additionally, a further examination of the validity and reliability of AoA ratings is crucial. The current study employed a slightly different methodology to collect subjective AoA ratings in distinct categories, compared with the research of Cortese and Khanna (2008) and Stadthagen-Gonzalez and Davis (2006). Therefore, it is important to note that directly comparing the ratings from their respective studies with the average AoA ratings from the present study is not appropriate. It has been pointed out that the AoA should not be rated using the Likert method, but rather by the age at which the target item was acquired (Kuperman et al., 2012). AoA ratings have been shown to differ depending on the individual's relationship with the child (Wikse Barrow et al., 2019) and on how they are asked, such as by rating the age acquired by the respondent themselves vs. the age acquired by the child in general (Łuniewska et al., 2016). Another effective approach is to estimate objective AoA based on materials included in textbooks and examining its relationship with relevant variables (Cai et al., 2022). Future research will not only examine vocabulary and concept acquisition in Japanese speakers using this dataset but also explore the development of more reliable and validated AoA ratings.

Furthermore, investigating the relationship of AoA with tasks such as picture naming and word naming, in which AoA effects have been well-documented, is also necessary. In the context of Japanese, the construction of datasets for psycholinguistic studies has not progressed sufficiently. To validate the subjective ratings of semantic variables, constructing databases related to behavioral outcomes, such as cognitive performance and written language data, will be necessary.

Data availability statement

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found at: https://osf.io/fawmq/.

Ethics statement

The studies involving humans were approved by the Research Ethics Committee of the College of Humanities and Sciences at Nihon University (Approval No.: 06-48). The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

MM: Methodology, Conceptualization, Resources, Writing – review & editing, Project administration, Investigation, Data curation, Software, Funding acquisition, Writing – original draft, Formal analysis, Visualization. NO: Conceptualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

Publisher's note

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