

# VISCOSE – a Kanji Dictionary Enriched with VISual, COmpositional, and SEMantic Information

**Werner Winiwarter**  
University of Vienna  
Faculty of Computer Science  
Währingerstraße 29  
1090 Vienna, Austria  
werner.winiwarter  
@univie.ac.at

**Bartholomäus Wloka**  
University of Vienna  
Department for Translation Studies  
Gymnasiumstraße 50  
1190 Vienna, Austria  
bartholomaeus.wloka  
@univie.ac.at

## Abstract

In this paper, we present a novel approach for building kanji dictionaries by enriching the lexical data of 3,500 kanji with images, structural decompositions, and semantically based cross-media mappings from the textual to the visual dimension. Our kanji dictionary is part of a Web-based contextual language learning environment based on augmented browsing technology. We display our multimodal kanji information as kanji cards in the Web browser, offering a versatile representation that can be integrated into other advanced creative language learning applications, such as memorization puzzles, creative storytelling assignments, or educational games.

## 1 Introduction

Learning a foreign language can be interesting and exciting. However, when we begin to feel overwhelmed by difficulties, or are faced with uninteresting learning material, it can become tedious and frustrating (Doughty and Long, 2003; VanPatton et al., 2020). Learning Japanese as an English speaker poses a particular challenge (Matsumoto, 2007). It requires extensive memorization due to the drastically different and complicated writing system (Paxton, 2019). The logographic characters called *kanji* make up its core and are supplemented by two syllabic scripts: *hiragana* and *katakana*. Kanji pose a significant challenge to students who are not aware of this concept (Mori, 2014). There are thousands of these characters and each of them has several possible meanings and pronunciations depending on the usage context (Hermalin, 2015). People born and educated in Japan learn 80-200 kanji per school year, and more advanced characters after high school. Therefore acquiring kanji is a lifelong process. Someone who decides to learn Japanese as a foreign language cannot fall back on this incremental and steady acquisition process, but has to memorize these characters quickly.

## 2 Related Work

In order to build effective methods for the study of kanji, extensive high quality digital resources are needed. The most predominant, freely available kanji dictionary is *KANJIDIC2* (Breen, 2004), which contains detailed information about 13,108 characters. *Wiktionary* data is even more comprehensive and accessible as LLOD (Linguistic Linked Open Data) via *Dbnary* (Sérasset and Tchechmedjiev, 2014; Sérasset, 2015).

Recently, lexical resources have been increasingly enhanced with **visual** representations. Prominent examples are *Wikipedia* thumbnails and other illustrations, also accessible via *DBpedia* (Lehmann et al., 2014). However, the number of images provided varies widely across language versions. *Babelfy* (Moro et al., 2014a,b) is another good example of such efforts, whereas Wiktionary contains comparatively few images so far.

On the other hand, Wiktionary displays *Ideographic Description Sequences* (IDS) from the *IDS data set*, which is derived from the CHISE project (Morioka, 2008) and is freely available on github<sup>1</sup>. We are aware of only one application that uses this **compositional** data for educational purposes: the *KanjiBuilder* component included in *Kanshudo*<sup>2</sup>. However, the entire content is proprietary, hence it is not available for academic use.

At the **semantic** level, efforts are equally limited. So far, to the best of our knowledge, there exists no approach that maps kanji to *WordNet* (Miller, 1995) *synsets*. However, there are ongoing efforts at the word level in the Japanese *WordNet* (Isahara et al., 2008). Regarding the mapping of images to *WordNet* synsets, there is the well-known *ImageNet* collection, which maps about 1,000 images to each synset (Deng et al., 2009). While this is undoubtedly an excellent resource for deep learn-

<sup>1</sup><https://github.com/cjkvi/cjkvi-ids>

<sup>2</sup><https://www.kanshudo.com/>



Figure 1: Example of decomposition of a kanji.

ing applications, it is not ideal for educational use, where we often need one well-chosen, representative image. Another effort to assign cliparts from *Openclipart*<sup>3</sup> to synsets was discontinued after illustrating only 581 synsets (Bond et al., 2009).

The use of flashcards has a long tradition in studying Japanese kanji (Diner and Prasetyani, 2015), e.g. available in *Anki*<sup>4</sup>. We integrate the display of our kanji data as kanji cards into our contextual language learning environment by using augmented browsing technology, as opposed to the traditionally isolated presentation. This way, we can offer advanced *creative learning* (Watts and Blessinger, 2017; Davies et al., 2013) solutions, such as storytelling (Windhaber, 2018) or educational games (Cornillie et al., 2012; Peterson, 2010). As stated very recently in (ELM Learning, 2021), creative learning is vital for several reasons:

- it stimulates **problem solving**, which can be further enhanced by *gamification* techniques;
- it develops **critical thinking** by leaving the

study path up to the learners and enabling to change and shape the material to fit their patterns of thinking;

- it **promotes risk-taking** by leaving the difficulty level up to the student;
- the choice of the learning context encourages a **curious mindset** for the subject matter, fusing the acquisition of new, exciting information with acquisition of language;
- the study of more natural, context-oriented material **increases confidence levels** in everyday usage of the study material.

We included these insightful considerations and combine them with our experience from our long-lasting and ongoing research efforts in refining the structure and presentation of enriched kanji cards (Winiwarter, 2017; Wloka and Winiwarter, 2021b,c). We considered the feedback, critique, and comments we received in the course of this research to develop the novel design of kanji cards presented in this paper.

<sup>3</sup><https://openclipart.org/>

<sup>4</sup><https://apps.ankiweb.net/>

Our enriched kanji dictionary *VISCOSE* lays the foundation for a novel and innovative method that contributes a vital stimulus for second language acquisition of Japanese. We believe that this will greatly alleviate the difficulty of memorizing kanji for beginners (Kubota, 2017) and keep advanced students motivated.

### 3 Building an Enhanced Kanji Dictionary

We have implemented our kanji dictionary in *SWI-Prolog* (Wielemaker et al., 2012) because it is an optimal choice for natural language processing tasks as well as the management and retrieval of linguistic data. It is suitable for efficient processing of large XML and RDF files and provides a scalable Web server solution (Wielemaker et al., 2008). We use the latter to generate dynamic Web content for creative language learning scenarios via augmented browsing. We chose to render the kanji information in the Web browser as *kanji cards* because this is an aesthetically pleasing representation, which can be flexibly adapted to many language learning applications, including quizzes and educational games.

The kanji cards in Fig. 1 contain the following information: the radical number, variant forms, on’yomi and kun’yomi readings (described below), glosses, an image, and the ideographic description sequence. The *radical* is the main component of the kanji used for lookup in a paper kanji dictionary. There are 214 radicals in total.

The *on’yomi* readings are displayed in uppercase, they descend from approximations of original Chinese pronunciations. In contrast, *kun’yomi* readings are based on pronunciations of native words approximating the meaning of the kanji when it was introduced. Some kanji do not have on’yomi, they are so-called *kokuji*, having been newly created in Japan. We extracted all this lexical data from KANJIDIC2. So far, we performed 460 corrections and additions using mainly Wiktionary as supplementary resource for the 3,500 kanji in our dictionary.

The images displayed on the kanji cards add essential **visual information**. They were all collected manually and exclusively from Wikipedia pages due to licensing reasons and to guarantee access to valuable contextual and ontological data via DBpedia datasets.

We have also added **compositional information** to the kanji cards, represented as an ideographic

description sequence (IDS). We spent extensive editorial work to meticulously check the IDS data resulting in 581 corrections. One reason for this high number was our goal of creating consistent and complete decompositions of all kanji as shown in Fig. 1. This means that we recursively follow the IDS data down to the level of radicals and some additional individual strokes. All the intermediary components have to be valid characters, i.e. they are included in our set of 3,500 kanji. In our visual representation, the kanji cards for radicals are red, same as the radical of the kanji if it occurs in the IDS. Additional radical kanji in the IDS are highlighted in orange.

During the arduous process of gathering suitable images for kanji cards, we soon identified successful strategies for finding visual representations of abstract concepts. We also observed that we often covered several aspects of the lexical data in one image, which sometimes happened even subconsciously. Often these hidden associations were discovered in a review process by a second person. These experiences were the main motivation to start annotating this mapping process to be able to preserve a formalized representation of the image acquisition task. This **semantic information** is a valuable resource for many more advanced language learning applications. However, to reap its full benefit we also had to address the issue of *word sense disambiguation* by assigning each mapping to the correct WordNet synset.

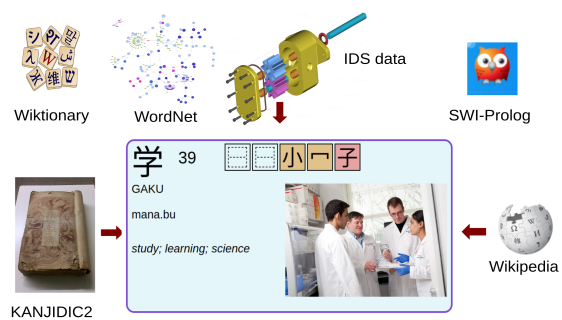


Figure 2: Resources used for the information on a kanji card.

A graphical representation of the integrated resources and an example depiction of a kanji card are shown in Fig. 2.

Figure 3 shows an example of three mappings for a kanji card with verbal descriptions and WordNet synset definitions. We have converted this representation into a more formal annotation format as

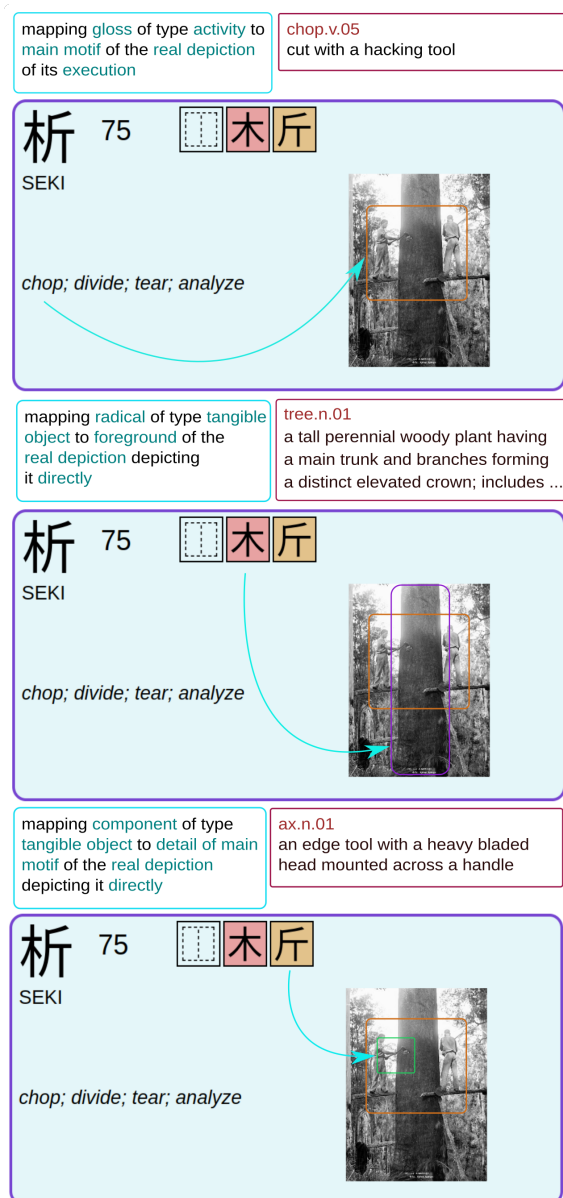


Figure 3: Example of mappings.

a set of septuples:

```
{(LexicalData,SourceType,InformationType,
TargetRegion,DepictionType,MappingType,Synset)}
```

For instance, the mappings in Fig. 3 would be translated into:

```
{(chop,gloss,activity,main motif,
real depiction,execution,chop.v.05),
(tree,radical,tangible object,foreground,
real depiction,direct,tree.n.01),
(axe,component,tangible object,detail of main motif,
real depiction,direct,ax.n.01)}.
```

Of course, we actually use one-letter codes for the values of the five features to guarantee the effi-

cient storage and processing of the annotation data. The features are explained in detail in Sect. 4.

We have created annotations for all 3,500 kanji in our dictionary resulting in a total number of 4,282 annotated mappings. We used altogether 45 different feature values, which are introduced in the next section and summarized later in Table 1.

## 4 Annotation Examples

In the following subsections, we present detailed examples of annotations for all values of the five features that are used to represent the mappings from the textual kanji information to its visual representation.

### 4.1 Source Type

The first example in Fig. 4 shows the mapping of the *gloss* ( $G$ ) “time”, an *intangible object* ( $I$ ), to the *real depiction* ( $R$ ) of a sundial, which is the *main motif* ( $M$ ) of the image. The connection between the two concepts is established through the *association* ( $A$ ) that a sundial is used to measure the time of day. If we look at the *radical* ( $R$ ) 日 (sun), we can see an association because the sunlight produces the shadow that indicates the time. Similarly, we can find an association with the *indirect component* ( $C$ ) 寸 (measurement):

```
{(time,G,I,M,R,A,clock_time.n.01),
(sun,R,I,M,R,A,sunlight.n.01),
(measurement,C,I,M,R,A,measurement.n.01)}.
```



Figure 4: Example of source types  $G$ ,  $R$ , and  $C$ .

The kanji card in Fig. 5 is an example of mapping a *partial gloss* ( $P$ ) “tea kettle”, a *tangible object* ( $T$ ), *directly* ( $D$ ) to its visual representation as *detail of the main motif* ( $D$ ). Partial glosses mainly concern radicals and a few more exotic cases:

```
{(kettle lid radical (no. 8),P,T,D,R,D,lid.n.02)}.
```

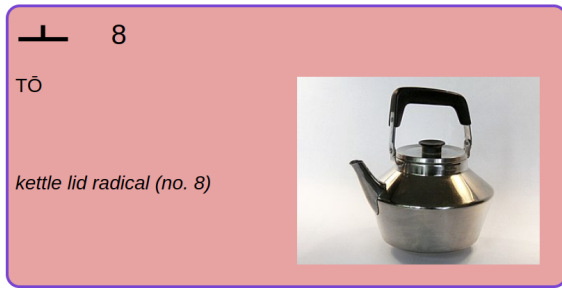


Figure 5: Example of source type *P*.

There are numerous Japanese words that have become English loanwords over the years. In such cases we usually have a mapping from the *kun'yomi* (*K*) reading to the image as in the example in Fig. 6. We can also detect a *component* (*C*) or part meronym relation from the radical 木 (tree) to the fruit as well as an association with the component 市 (market) where the fruit is sold:

{(persimmon,*G,T,M,R,D*,persimmon.n.02),  
 (kaki,*K,T,M,R,D*,japanese\_persimmon.n.01),  
 (tree,*R,T,M,R,C*,tree.n.01),  
 (market,*C,T,M,R,A*,marketplace.n.02)}.



Figure 6: Example of source type *K*.

Similarly, there exist some mappings of *on'yomi* (*O*) readings, like in the example in Fig. 7. Conveniently, the string “SEN” is also printed on the coin, therefore, we have a *literal* (*L*) mapping:

{(.01 yen,*G,I,M,R,A*,sen.n.01),  
 (coin,*G,T,M,R,D*,coin.n.01),  
 (money,*G,I,M,R,A*,money.n.03),  
 (SEN,*O,I,D,R,L*,sen.n.01)}.

Finally, for some kanji we can match the *glyph* (*G*) of its *logogram* (*L*) with shapes, lines, or curves in the image. Figure 8 illustrates such an example for the kanji 交. The image shows a famous *film scene* (*F*) from the “The Great Dictator” in which the “double cross” symbol can be seen on



Figure 7: Example of source type *O*.

Charlie Chaplin’s cap. Therefore, in this case, we have a *full match* (*F*):

{(double X radical (no. 89),*P,I,D,F,L*,x.n.02),  
 (∅,*L,G,D,F,F*,∅)}.

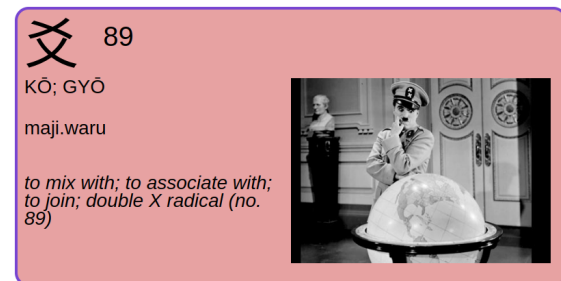


Figure 8: Example of source type *L*.

## 4.2 Information Type

The feature values *I*, *T*, *G* were already introduced in Fig. 4, Fig. 5, and Fig. 8. The two missing information types are *activities* (*A*) and *properties* (*P*). Both can be seen in the annotation for Fig. 9. The image shows a detail from the mural *painting* (*P*) entitled “Labor”. The two men are shown during the *execution* (*E*) of the activity “toil”. From their hard manual work we can infer that they presumably possess the *property* (*P*) “diligent” as well as being “strong” as indicated by the radical 力:

{(toil,*G,A,M,P,E*,labor.v.02),  
 (diligent,*G,P,M,P,P*,diligent.a.02),  
 (strong,*R,P,M,P,P*,strong.a.01)}.

## 4.3 Target Region

So far, we have encountered the feature values *M* in Fig. 4 and *D* in Fig. 5. The missing four target regions, which occur less often, are mappings to the *background* (*B*), the *foreground* (*F*), a *secondary motif* (*S*), and the *whole image* (*W*).

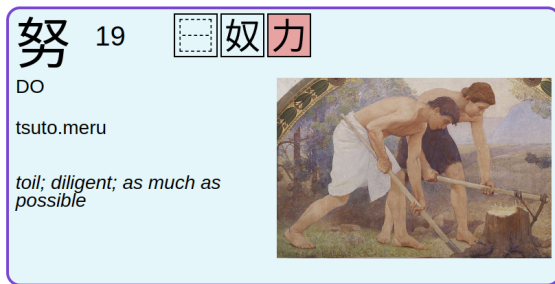


Figure 9: Example of information types *A* and *P*.

In Fig. 10 we map the radical 山 (mountain) to the background of the image:

{(beach,G,T,M,R,D,beach.n.01),  
(mountain,R,T,B,R,D,mountain.n.01)}.



Figure 10: Example of target region *B*.

If you look at the landscape in the foreground of Fig. 11, it gives you the impression of vastness:

{(vast,G,P,F,R,P,huge.s.01)}.

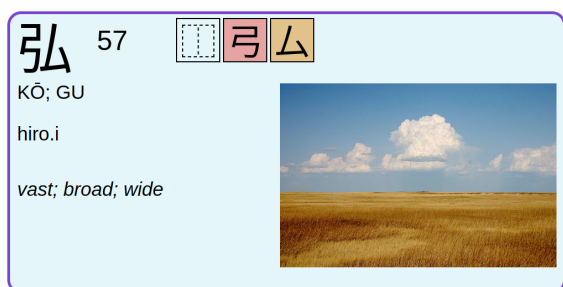


Figure 11: Example of target region *F*.

In Fig. 12, the main motif is the tape measure to represent the intangible objects “measurement” and “tenth of a shaku” because the latter is about 3.03 cm. In addition, there are the two “small” coins as secondary motif:

{(measurement,G,I,M,R,A,measurement.n.01),  
(tenth of a shaku,G,I,M,R,A,unit\_of\_measurement.n.01),  
(small,G,P,S,R,P,minor.s.10)}.

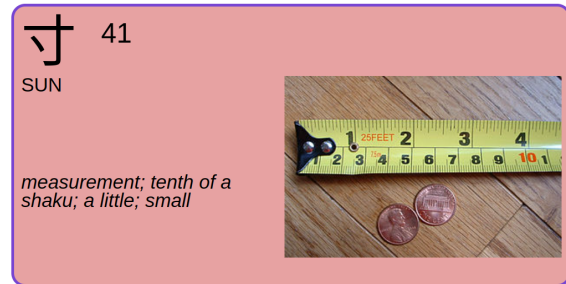


Figure 12: Example of target region *S*.

Finally, Fig. 13 shows a commemorative stamp depicting a *drawing* (*D*) that illustrates the well-known scene from the *narration* (*N*) “Sleeping Beauty”. The *whole image* (*W*) is an excellent visual explanation of the intangible concept “curse”:

{(curse,G,I,W,D,N,hex.n.01)}.



Figure 13: Example of target region *W*.

#### 4.4 Depiction Type

In the previous subsections we have already used the depiction types *R*, *F*, *P*, *D* in Fig. 4, Fig. 8, Fig. 9, and Fig. 13. There are five additional, more specific depiction types. The first one is *bills* (*B*), such as posters or flyers. Figure 14 is a perfume advertisement, which also uses *textual* (*T*) information to make it easier to associate the image with the property “fragrant”:

{(fragrant,G,P,W,B,T,fragrant.a.01)}.

A related category to bills regarding visual design are *covers* (*C*) of magazines, books, etc. Figure 15 shows the cover of the November 1924 issue of “Vanity Fair” magazine, which offers a literal hint towards the correct intangible object:

{(vanity,G,I,S,C,L,amour\_propre.n.01)}.

Another long tradition of transferring immaterial objects to perceivable artifacts are *monumental sculpture* (*M*) and any other form of three-dimensional visual arts. Right from the beginning,

匂 20 𠂇 匂 匕

nio.u; nio.i; nio.waseru

*fragrant; stink; glow; insinuate; (kokuj)*




Figure 14: Example of depiction type B.

賄 154 𠂇 貝 有

WAI

makana.u

*bribe; board; supply; finance*



Figure 17: Example of depiction type S.

徒 60 𠂇 彳 走

TO

itazura; ada

*on foot; junior; emptiness; vanity; futility; uselessness; ephemeral thing; gang; set; party; people*




Figure 15: Example of depiction type C.

勾 20 𠂇 勺 厶

KŌ; KU

kagi; ma.garu

*be bent; slope; capture*




Figure 18: Example of depiction type T.

ancient advanced civilizations used anthropomorphic *metaphors* (*M*), in particular personifications, for this purpose. In many polytheistic religions, abstract concepts were also attributed to deities. Figure 16 is such an example using goddess Justitia with her three symbolic items balance, sword, and blindfold: {(justice,G,I,M,M,M,justice.n.01)}.

The banner in Fig. 17 is an example of a *sign* (*S*), which contains the word “bribe” to demonstrate against bribery: {(bribe,G,I,D,S,L,bribe.n.01)}.

A special type of signs are *traffic signs* (*T*). They often use *icons* (*I*), also called pictograms. Their meaning is interpreted through their resemblance to a real object. Figure 18 is a warning sign from Poland to alert the driver to the danger of a steep upward slope: {(slope,G,I,W,T,I,gradient.n.02)}.

Finally, Fig. 19 shows the *result* (*R*) of the activ-

識 149 𠂇 言 戠

SHIKI

shi.ru; shiru.su

*discriminating; know; write*

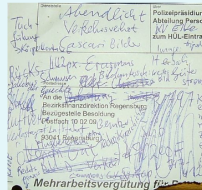


Figure 19: Example of depiction type W.

正 77 𠂇 一 止

SEI; SHŌ

tada.shii; tada.su; masa; masa.ni

*correct; justice; righteous; 10\*\*40*




Figure 16: Example of depiction type M.

汰 85 𠂇 水 太

TA; TAI

ogo.ru; nigo.ru; yona.geru

*washing; sieving; filtering; weeding out; luxury*




Figure 20: Example of mapping type O.

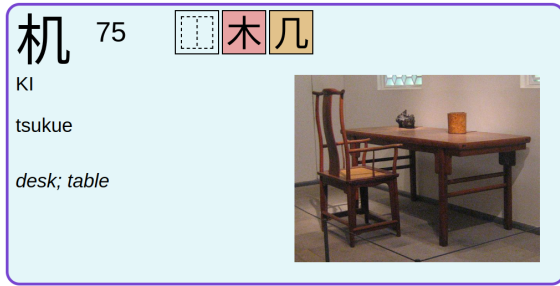


Figure 21: Example of mapping type *S*.



Figure 22: Example of mapping type *V*.

ity “write”, a page filled with scribbled words. The page is an instance of a *written material* (*W*), the words are textual representations of the intangible object “word” referred to by the radical 言 (word):

{(write,*G,A,W,W,R,write.v.02*),  
(word,*R,I,W,W,T,word.n.01*)}.

#### 4.5 Mapping Type

Most of the mapping types have already been discussed in the preceding subsections. There is one remaining feature value specifically for activities in addition to *E* and *R*. In some situations we visualize the *original state* *O* before executing an activity, e.g. in Fig. 20 before literally “weeding out”: {(weeding out,*G,A,W,R,O,weed.v.01*)}.

One important semantic relation is the *substance* (*S*) holonym relation, e.g. in Fig. 21 the radical 木 indicates the material used to manufacture the table (and the chair) in the image:

{(table,*G,T,D,R,D,table.n.02*),  
(wood,*R,T,M,R,S,wood.n.01*)}.

Regarding the mapping of glyphs (see Fig. 8), we not only annotate full matches but also more *vague resemblances* (*V*) as shown in Fig. 22 for the athlete’s legs:

{(legs radical (no. 10),*P,T,D,R,D,leg.n.01*),  
( $\emptyset$ ,*L,G,D,R,V,\emptyset*)}

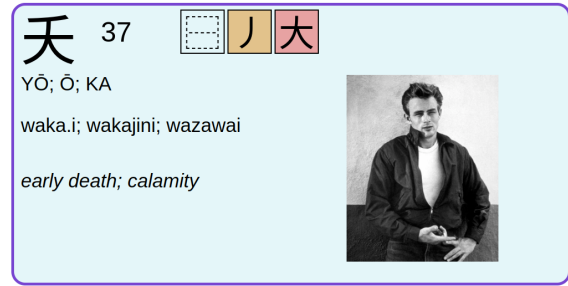


Figure 23: Example of mapping type *W*.

Finally, two very successful strategies to establish associations is to use knowledge and conceptions about *well-known personalities* (*W*) and *zoological subjects* (*Z*), i.e. animals. Figure 23 is a typical example where we can derive the following mapping from some basic biographical information about the life of the actor James Dean:

{(early death,*G,I,M,R,W,death.n.01*)}.

The last image in Fig. 24 is an example of the second strategy. It shows two dogs who seem to be quite happy: {(happiness,*G,I,M,R,Z,happiness.n.01*)}.

For easier reference, we add an overview of all feature values introduced in this section in Table 1.



Figure 24: Example of mapping type *Z*.

## 5 Conclusion

In this paper we presented VISCOSE, an enhanced kanji dictionary with detailed visual, compositional, and semantic annotations. We described our motivation and the steps involved in building this lexical resource. Our main contribution is a formal representation of semantically grounded cross-media mappings from the textual to the visual dimension. We drew upon years of experience and many iterations of designs to optimize the presentation of the many details on the kanji cards.

The current version of the annotation was done by the authors, who both have a higher educational



Source Type	Information Type	Target Region	Depiction Type	Mapping Type
<i>C</i> component	<i>A</i> activity	<i>B</i> background	<i>B</i> bill	<i>A</i> association
<i>G</i> gloss	<i>G</i> glyph	<i>D</i> detail of main motif	<i>C</i> cover	<i>C</i> component
<i>K</i> kun'yomi	<i>I</i> intangible object	<i>F</i> foreground	<i>D</i> drawing	<i>D</i> direct
<i>L</i> logogram	<i>P</i> property	<i>M</i> main motif	<i>F</i> film scene	<i>E</i> execution
<i>O</i> on'yomi	<i>T</i> tangible object	<i>S</i> secondary motif	<i>M</i> monumental sculpture	<i>F</i> full match
<i>P</i> partial gloss		<i>W</i> whole image	<i>P</i> painting	<i>I</i> icon
<i>R</i> radical			<i>R</i> real depiction	<i>L</i> literal
			<i>S</i> sign	<i>M</i> metaphor
			<i>T</i> traffic sign	<i>N</i> narration
			<i>W</i> written material	<i>O</i> original state
				<i>P</i> property
				<i>R</i> result
				<i>S</i> substance
				<i>T</i> textual
				<i>V</i> vague resemblance
				<i>W</i> well-known personality
				<i>Z</i> zoological subject

Table 1: Overview of feature values.

background in computer science, linguistics, and Japanese studies, as well as long research and teaching experience in natural language processing including several projects on lexicographic and terminological topics. Future research will focus on editorial work and writing a comprehensive annotation guide. We will make a preliminary version available as soon as possible, before publishing our resource at LRE Map. We also plan to involve students in the process of refining and extending the annotations as class room assignments, and evaluate the annotation agreement. In this context we plan to measure the improvement regarding language acquisition in comparison with other approaches, as well as get feedback on usability, entertainment factors and the often related engagement level.

We already envision many interesting future use cases. One example is the use of kanji cards to replace thematic cards in strategic games based on feature value agreements and synset similarities. Another idea is to create cross-media analogies for memorization puzzles, such as guessing the correct gloss based on an image and an analogous kanji card. Finally, we also want to put the structural information to good use by applying our decomposition diagrams to creative storytelling to collect mnemonic sentences for improved kanji retention.

Finally, we will continue our ambitious research efforts towards integrating the kanji cards into multifaceted annotations of Japanese sentences at the lexical, syntactic, conceptual, and relational level (Wloka and Winiwarter, 2021a).

All these implementations will be evaluated in graduate courses with students in translation studies. We will follow recent suggestions in evaluation approaches (Heuer and Buschek, 2021) by putting learners in the center of the evaluation process and

giving them an active role in the further development of our environment. We will solicit feedback at the beginning, during, and at the end of the evaluation to incorporate criticism and suggestions into the continued development of VISCOSE.

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