

# Meaning Sort

## — Three examples: dictionary construction, tagged corpus construction, and information presentation system —

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**Abstract.** It is often useful to sort words into an order that reflects relations among their meanings as obtained by using a thesaurus. In this paper, we introduce a method of arranging words semantically by using several types of ‘is-a’ thesauri and a multi-dimensional thesaurus. We also describe three major applications where a meaning sort is useful and show the effectiveness of a meaning sort. Since there is no doubt that a word list in meaning-order is easier to use than a word list in some random order, a meaning sort, which can easily produce a word list in meaning-order, must be useful and effective.

## 1 Using Msort

Arranging words in an order that is based on their meanings is called a meaning sort (Msort). The Msort is a method of arranging words by their meanings rather than alphabetically. The method used to list the meanings is described in the next section.

For example, suppose we obtain the following data in a research project:<sup>1</sup>

an event

a temple, a formal style, an alma mater, to take up one’s post, the Imperial Household, a campus, Japan, the Soviet Union, the whole country, an agricultural village, a prefecture, a school, a festival, the head of a school, an established custom, a government official, a celebration, a Royal family

This is a list of noun phrases (NPs), each followed by the word *gyoji* (an event) in the form NP X *no gyoji* (an event of NP X) in Japanese. To find the most useful way to examine the list, we first arrange the NPs alphabetically:

<sup>1</sup> We actually obtained this data from the EDR co-occurrence dictionary [1].

an agricultural village, an alma mater, a campus, a celebration,  
 an established custom, a festival, a formal style, a government  
 official, the head of a school, the Imperial Household, Japan, a  
 prefecture, a Royal family, a school, the Soviet Union, to take up  
 one's post, a temple, the whole country

This list is not easy to use, so we next arrange the NPs by frequency of appearance:

an established custom, a school, a formal style, Japan, a prefecture,  
 the whole country, a temple, an agricultural village, a Royal  
 family, the Soviet Union, a festival, a campus, to take up one's  
 post, a celebration, an alma mater, the Imperial Household, a  
 government official, the head of a school

Yet, even arranged this way, it is too difficult to use the list.

We then use an Msort to arrange the NPs semantically, by using following categories: Human, Organization, and Action:

(Human)	the Imperial Household, a Royal family, a government official, the head of a school
(Organization)	the whole country, an agricultural village, a prefecture, Japan, the Soviet Union, a temple, a school, a campus, an alma mater
(Action)	a celebration, an established custom, a formal style, to take up one's post, a festival

This list is much easier to use than a listing in alphabetical or frequency order. Note that the words in each line are also arranged in an order that reflects relations among their meanings. For example, *Japan* and *the Soviet Union* are listed side by side, as are *a school*, *a campus*, and *an alma mater*.

Although the list shows a variety of events, we can see at a glance that some are events related to certain special persons, and some are events related to a certain organization, and the others are miscellaneous forms of events.

The Msort is also applicable to other situations as described in later sections. The Msort enables users to more easily and efficiently recognize and examine various types of problems.

## 2 Implementing Msort

To sort words in an order that reflects relations among their meanings, we first need to determine an order for the meanings. The Japanese thesaurus *Bunrui Goi Hyou* [10], an 'is-a' hierarchical thesaurus, is useful for this. We refer to it as *BGH*. In *BGH*, each word has a *category number*. In the electronic version of *BGH*, each word has a 10-digit category number that indicates seven levels of

**Table 1.** Modified BGH category numbers

Semantic marker	Original code	Modified code
Animal	[1-3]56	511
Human	12[0-4]	52[0-4]
Organization	[1-3]2[5-8]	53[5-8]
Products	[1-3]4[0-9]	61[0-9]
Part of a living thing	[1-3]57	621
Plant	[1-3]55	631
Nature	[1-3]52	641
Location	[1-3]17	657
Quantity	[1-3]19	711
Time	[1-3]16	811
Phenomenon	[1-3]5[01]	91[12]
Abstract relation	[1-3]1[0-58]	aa[0-58]
Human activity	[1-3]58,[1-3]3[0-8]	ab[0-9]
Other	4	d

the ‘is-a’ hierarchy. The top five levels are expressed by the first five digits, the sixth level is expressed by the next two digits, and the last level is expressed by the last three digits. (Although we have used BGH, Msort can also be used with other thesauri in other languages.)

The easiest way of implementing Msort is to arrange words in order of their category numbers. However, only arranging words semantically does not produce a convenient result. If the items arranged are numbers, the order is clear, but there is no clear order for words. It is thus convenient to insert a mark, as a kind of bookmark, in certain places. We used semantic markers such as *Human*, *Organization* and *Action* as bookmarks.

These markers were created by combining nominal semantic markers in the IPAL verbal dictionary [2] with the BGH classification system. Table 1 shows the modified category numbers obtained by integrating these new markers with the BGH codes. The first three digits of each category number have been changed. For example, the notation [1-3]56 and 511 in the first line means that when the first three digits of the category number are 156, 256, or 356, those digits will be changed to 511. ([1-3] means 1, 2, or 3.)

The process of using an Msort is explained by applying it to the data set listed in Section 1, obtained by the word *gyoji* (an event), as follows:

1. Firstly, we give each word a new category number according to the transformation shown in Table 1, to obtain the results shown in Table 2(a). *A temple* occurs twice, and *a formal style* occurs four times. This indicates that both *a temple* and *a formal style* have multiple meanings. In the BGH thesaurus, *a temple* is defined as having two meanings, and *a formal style* is defined as having four meanings.

**Table 2.** An example of the Msort process

(a) Examples with BGH category numbers

5363005022	a temple	7118007013	the whole country
5363005021	a temple	5353007012	the whole country
ab18207012	a formal style	5354006033	an agricultural village
ab21509016	a formal style	5355004017	a prefecture
aa11011014	a formal style	5363010012	a school
ab70004013	a formal style	ab46002012	a festival
5363013015	an alma mater	5241023012	the head of a school
ab41201016	to take up one's post	ab18205021	an established custom
5210007021	the Imperial Household	5233004015	a government official
5363010015	a campus	5241101061	a government official
5359001012	Japan	ab14308013	a celebration
5359004192	the Soviet Union	ab46019012	a celebration
continued in the right-hand column		5210007022	a Royal family

2. We then add semantic markers to the set of words in Table 2(a) to get the results shown in Table 2(b).
3. Next, we arrange the items in Table 2(b) in the order of their category numbers to get the results shown in Table 2(c).
4. Finally, we convert the data into a form that is easier to use. For example, when we delete the category numbers, redundant words with the same semantic marker in a line, and semantic markers to which no words correspond, we obtain the data shown in Table 4.

This data is much easier to use than the data shown in the other tables.

### 3 Msort using different dictionaries

#### 3.1 Msort using a different ‘is-a’ thesaurus

In Section 2 we described the implementation of an Msort using the BGH thesaurus. This is the most suitable ‘is-a’ thesaurus for an Msort because each word which contains is assigned a category number. This section examines whether an Msort can be used with an ‘is-a’ hierarchical thesaurus which has no category numbers, such as the EDR dictionary [1].

It is useful to consider the definition sentence of the concept in each node of an is-a thesaurus as the number of the level. If we do this, it is not necessary to create a new number. For example, the definitions of concepts from the top node to the node of the term “an alma mater” are as shown in Table 3.

When we do a meaning sort using the EDR dictionary, we only have to consider the connections of the hierarchy of meanings “concept: agent: autonomous

**Table 2.** Example of the Msort process

(b) Adding semantic markers for divisions		(c) Arranging elements in the order of their category number	
5100000000	(Animal)	5100000000	(Animal)
5200000000	(Human)	5200000000	(Human)
5300000000	(Organization)	5210007021	the Imperial Household
6100000000	(Product)	5210007022	a Royal family
6200000000	(Part of a living thing)	5233004015	a government official
6300000000	(Plant)	5241023012	the head of a school
6400000000	(Nature)	5241101061	a government official
6500000000	(Location)	5300000000	(Organization)
7100000000	(Quantity)	5353007012	the whole country
8100000000	(Time)	5354006033	an agricultural village
9100000000	(Phenomenon)	5355004017	a prefecture
aa00000000	(Abstract relation)	5359001012	Japan
ab00000000	(Human activity)	5359004192	the Soviet Union
d000000000	(Other)	5363005021	a temple
5363005022	a temple	5363005022	a temple
5363005021	a temple	5363010012	a school
ab18207012	a formal style	5363010015	a campus
ab21509016	a formal style	5363013015	an alma mater
aa11011014	a formal style	6100000000	(Product)
ab70004013	a formal style	6200000000	(Part of a living thing)
5363013015	an alma mater	6300000000	(Plant)
ab41201016	to take up one's post	6400000000	(Nature)
5210007021	the Imperial Household	6500000000	(Location)
5363010015	a campus	7100000000	(Quantity)
5359001012	Japan	7118007013	the whole country
5359004192	the Soviet Union	8100000000	(Time)
7118007013	the whole country	9100000000	(Phenomenon)
5353007012	the whole country	aa00000000	(Abstract relation)
5354006033	an agricultural village	aa11011014	a formal style
5355004017	a prefecture	ab00000000	(Human activity)
5363010012	a school	ab14308013	a celebration
ab46002012	a festival	ab18205021	an established custom
5241023012	the head of a school	ab18207012	a formal style
ab18205021	an established custom	ab21509016	a formal style
5233004015	a government official	ab41201016	to take up one's post
5241101061	a government official	ab46002012	a festival
ab14308013	a celebration	ab46019012	a celebration
ab46019012	a celebration	ab70004013	a formal style
5210007022	a Royal family	d000000000	(Other)

**Table 3.** Definitions of concepts from the top node to the node of the term “an alma mater”

concept
agent
autonomous being
organization
educational organization
an organization to provide education, called a school
a school at which a person was or is a student

**Table 4.** Results of an Msort using the BGH thesaurus

(Human)	the Imperial Household, a Royal family, a government official, the head of a school
(Organization)	the whole country, an agricultural village, a prefecture, Japan, the Soviet Union, a temple, a school, a campus, an alma mater
(Quantity)	the whole country
(Relation)	a formal style
(Action)	a celebration, an established custom, a formal style, to take up one’s post, a festival

being: organization: educational organization: an organization to provide education, called a school: a school at which a person was or is a student” as the category number.

Some results of a meaning sort using the EDR dictionary are shown in Table 5<sup>2</sup>. We used the first three definition terms as division markers.

The above analysis demonstrates that a meaning sort can be done using any is-a thesaurus. However, there is a problem in that the order of the branching-point nodes of a hierarchical structure is ambiguous. In the case shown in Table 5, the order is the alphabetical order of the strings in the definition terms. It is better to specify the order manually, but if this is too difficult, it is better to do a meaning sort of the definition terms themselves by using another dictionary or thesaurus, e.g. the BGH thesaurus.

### 3.2 Msort using a dictionary where each word is expressed with a set of multiple features

In some dictionaries, each word is expressed with a set of multiple features [5] [12]. For example, the research of the IPAL Japanese generative dictionary [7]

<sup>2</sup> This table was obtained by using a Japanese dictionary. In the table, “a temple” and “a prefecture” belong to the category “human being.” In Japanese, “a temple” and “a prefecture” have many meanings, including “human being.”

**Table 5.** Results of an Msort using the EDR dictionary

(concept : agent : autonomous being)	a school, a campus, an alma mater, a temple, a prefecture, the Soviet Union, Japan, a Royal family, the Imperial Household, the head of a school, a government official
(concept : agent : human being)	a temple, a prefecture, the head of a school, a government official
(concept : event : action)	a celebration, to take up one's post
(concept : event : phenomenon)	a festival
(concept : matter : event)	a festival, an established custom, a celebration
(concept : matter : thing)	a temple, a school, a prefecture, the head of a school, a government official, a celebration, a formal style
(concept : space : location)	a temple, a school, the whole country, a prefecture, an agricultural village, the Soviet Union, Japan

**Table 6.** Example of a dictionary in which each word is assigned multiple features

Word	Feature				
	Style	Object	Depth	Size	Material
<i>utsuwa</i> (a container)	—	—	—	—	—
<i>wan1</i> (a ceramic bowl)	Oriental	—	deep	—	ceramic
<i>wan2</i> (a wooden bowl)	Oriental	—	deep	—	wooden
<i>yunomi</i> (a Japanese teacup)	Oriental	Japanese tea	deep	—	ceramic
<i>sara</i> (a plate)	—	—	shallow	—	—

gives multiple features to various words having the meaning of the containers in Table 6. In this table, "—" means that the feature value is not specified.

It is possible to do an Msort in the case of such a dictionary. We have only to treat the information as if each feature is equivalent to a level in an imaginary 'is-a' thesaurus. In Table 6, if we assume that the features, from left to right, correspond to the levels, from top to bottom, of an imaginary thesaurus, the levels become *Style*, *Object*, *Depth*, *Size*, and *Material*, and a category number represents *Style:Object:Depth:Size:Material*, which is essentially the same situation as for the EDR data. For example, the category number of *wan2* (a wooden bowl) is *Oriental: —: deep: —: wooden*. (Actually in order to do an Msort of feature values, we may change *Oriental*, *deep*, and *wooden* into the corresponding category numbers in BGH.) We simply do an Msort, assuming that each word has such a category word. The result of this Msort is shown in Table 7.

Table 7 shows the result of an Msort based on the supposition that the leftmost feature is the most important. Which feature is most important is, in

**Table 7.** Result of an Msort, from the leftmost feature

Word	Feature				
	Style	Object	Depth	Size	Material
<i>utsuwa</i> (a container)	—	—	—	—	—
<i>sara</i> (a plate)	—	—	shallow	—	—
<i>wan1</i> (a ceramic bowl)	Oriental	—	deep	—	ceramic
<i>wan2</i> (a wooden bowl)	Oriental	—	deep	—	wooden
<i>yunomi</i> (a Japanese teacup)	Oriental	Japanese tea	deep	—	ceramic

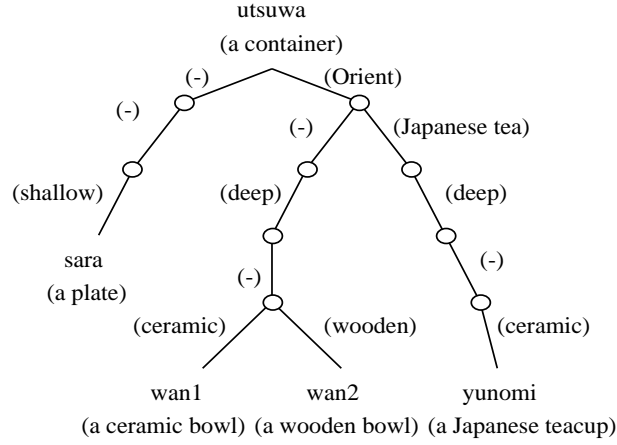
**Table 8.** The result of an Msort, from the rightmost feature

Word	Feature				
	Style	Object	Depth	Size	Material
<i>utsuwa</i> (a container)	—	—	—	—	—
<i>sara</i> (a plate)	—	—	shallow	—	—
<i>wan1</i> (a ceramic bowl)	Oriental	—	deep	—	ceramic
<i>yunomi</i> (a Japanese teacup)	Oriental	Japanese tea	deep	—	ceramic
<i>wan2</i> (a wooden bowl)	Oriental	—	deep	—	wooden

fact, not clear. For example, if we suppose that the rightmost feature is the most important and we do an Msort from that feature, we get a different result, as shown in Table 8. From a dictionary with multiple features, we can get various results of Msorts in this way, by changing the features which are thought to be most important. This means that users can do an Msort in any order of features that they may be interested in. This kind of dictionary, that is, the kind which provides multiple features, is therefore very flexible.

When a hierarchical thesaurus is used to examine this, there are further interesting results. We can assume that each feature corresponds to a level of the hierarchical thesaurus, so we can construct many kinds of hierarchical thesauri by changing the correspondence between levels and features. For example, we can construct the hierarchical thesaurus shown in Figure 1 from the result of an Msort from the leftmost feature as shown in Table 7. We can construct a hierarchical thesaurus shown in Figure 2 from the result of an Msort from the rightmost feature as shown in Table 8. In the thesaurus of Figure 1, we can see the semantic similarity between *wan1* (a ceramic bowl) and *wan2* (a wooden bowl). In the thesaurus of Figure 2, we can understand that *wan1* (a ceramic bowl) and *wan2* (a Japanese teacup) are semantically similar in that they are both ceramic. Such construction of multiple thesauri has led to further research into a multi-dimensional thesaurus. The necessity for a multi-dimensional thesaurus was discussed in Kawamura's paper [3]. Kawamura's paper argued that if we divide *a bird* and *an airplane* into other categories at a relatively higher level of a hierarchy than the level at which entries are divided according to whether





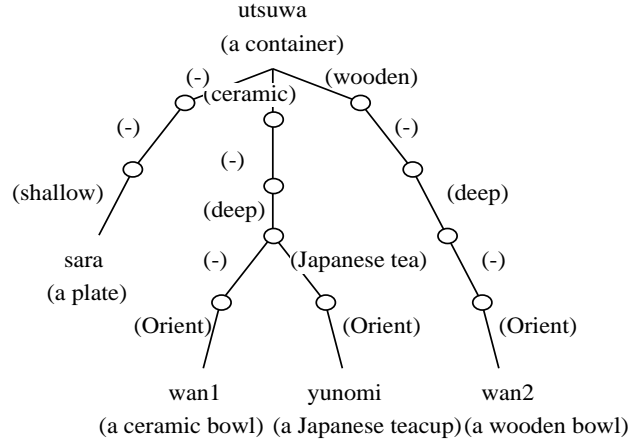
**Fig. 1.** Hierarchical thesaurus of meaning sort from the leftmost feature

the item can fly or not, we will not be able to see that *a bird* and *an airplane* are semantically similar in that they can both fly. Therefore a dictionary with multiple features, which can be flexibly reconfigured into hierarchical thesauri of many kinds, would be very useful, and the construction of such a dictionary is necessary for reasons of practicality. Also, we have our doubts as to whether it is necessary to make a word dictionary in the form of a hierarchical thesaurus. Looking at Table 6, because all the features of *utsuwa (a container)* are “—” representing no specification of feature values, we are able to see that *utsuwa (a container)* is super-ordinate to the other words by looking at the information on the multiple features. We can estimate super-ordinate and subordinate relation from the inclusion relationships of features, so construction of a hierarchical thesaurus as such is not necessary. A dictionary with multiple features is all that is necessary. Furthermore, a dictionary with multiple features has a further advantage in that we can define the similarity of two words in terms of the proportion of features that are the same for both words. Although a high-order predicative logic and a natural language sentence can be thought of as the true semantic descriptions of words, we think that a dictionary using multiple features would be useful in that it can be handled by existing natural language processing techniques, and can handle various multi-dimensional thesauri.

If such a dictionary is constructed, it would be convenient for meaning sort, since it would allow users to do interest-based meaning sort.

#### 4 Three examples of using an Msort

In this section, we describe three major applications for which an Msort is useful.



**Fig. 2.** Hierarchical thesaurus of meaning sort from the rightmost feature

#### 4.1 Dictionary construction

Table 9 shows the construction of a case frame for the verb *eat* according to data in a noun-verb relational dictionary as an example. The table shows the results of an Msort of NPs which may be taken as case elements of *eat*. It is easy to manually construct a case-frame dictionary from such data, as shown in Table 9. The nominative case of *eat* consists of agents, such as animals and people, and the objective case consists of various NPs mainly meaning foods. Regarding the optional case, various phrases such as *by myself*, *in an office*, and *in a meeting* are also included.

The construction of a verbal case-frame dictionary is one example of the potential applications of an Msort. A similar construction process can also be easily applied to copulas and other kinds of relationships among words. An Msort is not only useful for constructing dictionaries, but also for examining data and extracting important information in language investigation. An Msort is also useful for examining data in the process of knowledge acquisition.

#### 4.2 Tagged corpus construction (related to semantic similarity)

Recently, various corpora have been under construction [6,1,4,11], and the investigation of corpus-based learning algorithms is attracting much attention [8]. In this section, we demonstrate how an Msort can be useful in the construction of corpora.

Suppose that we want to disambiguate the meanings of *of* in NP X *of* NP Y by using the example-based method [9]. In this case, we need a tagged corpus

**Table 9.** Example construction of a case frame of the verb *eat*

(a) Results of an Msort of terms in the nominative case

(Animal)	cattle, a calf, fish
(Human)	we, us, all, myself, babies, a parent, a sister, a customer, a Japanese, a nurse, a writer

(b) Results of an Msort of terms in the objective case

(Animal)	an animal, shellfish, plankton
(Product)	prey, a product, a material, food, feed, Japanese food, Japanese-style food, Western food, Chinese food, a rice ball, gruel, sushi, Chinese noodles, macaroni, sandwiches, a pizza, a steak, a barbecued dish, tempura, fried food, cereals, rice, white rice, Japanese rice, barley, kimchi, sugar, jam, a confection, a cake, a cookie, ice cream
(Body part)	the mortal remains, the liver
(Plant)	a gene, a plant, grass, a sweet pepper, chicory, a mulberry, a banana, a matsutake mushroom, kombu
(Phenomenon)	a delicate flavor, snow
(Relation)	the content
(Activity)	breakfast, lunch, dinner, supper

(c) Results of an Msort of terms in the optional cases

(In Japanese, “in”, “on”, and “by” are expressed by the same word, so, we cannot divide data according to “in” or “by”)

(Human)	(by) myself
(Organization)	(in) an office, (in) a restaurant, (in) a hotel
(Product)	(by) soy sauce, (in) a dressing room, (in) bed, (on) a table
(Location)	(on) the spot, (in) the whole area, (on) a train
(Quantity)	(by) two persons, (at) a rate, (by) many people
(Activity)	(at) work, (in) a meeting

**Table 10.** Construction of a manually tagged corpus for the semantic analysis of noun phrases in “NP X of NP Y”

NP X	NP Y	Semantic Relation
an affair	Panama	Location
an affair	a junior high school	Location
an affair	an army	Location
an affair	an album	Indirect-determiner
an affair	a tanker	Indirect-determiner
an affair	the worst	Adjective-feature
an affair	the largest	Adjective-feature
a property	the circumference	Location
items	both countries	Object-agent
items	documentary records	Field-determiner
items	a general meeting	Object-agent
a provision	the Upper House	Field-determiner
a provision	a new law	Field-determiner
a provision	a treaty	Field-determiner
a provision	an agreement	Field-determiner

for semantic analysis of the noun phrases in NP X *of* NP Y. We attach semantic relationships such as *Part-of* and *Location* to each example of the noun phrases. When we do an Msort of these phrases, similar examples are grouped together and the tagging of semantic relationships by hand is made easier.

Table 10 shows part of a manually tagged corpus. In this example we have supposed that NP X in NP X *of* NP Y will be the more important NP, so we first did an Msort of NP X, and then did one of NP Y. Although the technical terms representing the semantic relationships in the table are specialized, it can be seen that the examples which are grouped together by this Msort often have the same relationship. Also, when semantically similar examples are grouped together like this, the cost of tagging is decreased.

In the example-based method, the tag attached to the example that is the most similar to the input phrase is judged to be the result of the analysis. An Msort performs the function of grouping similar examples. The example-based method and the Msort both use word similarity, and this is an advantage of both techniques.

In this section, we noted that using the Msort is an efficient way to construct a noun-phrase corpus. In addition, when a certain corpus uses words, we can also use an Msort for the construct of it.

### 4.3 Information retrieval

Information retrieval activity has increased with the growth of the Internet. An Msort can also easily be applied to this area.

For example, in research conducted by Tsuda and Senda, the features of a document database were displayed to users by using multiple keywords [13].

For example, assume that the document database we want to display has the following set of keywords.

retrieval, a word, a document, construction, candidate, a number, a keyword

Displaying the list of words in a random order is not very convenient for users. However, if we do an Msort of the keywords, we can obtain the following list:

(Quantity)	a number
(Abstract relation)	candidate
(Human activity)	retrieval
	a document, a keyword, a word,
	construction

(Here, we have displayed words with the same first three-digit BGH category number on the same line.) This method provides a more useful perspective for users.

In some cases we may display many keywords and ask the users to select the appropriate ones [13]. In such a case, if we do not have another way of arranging the words in an appropriate order, it is convenient for users if we use an Msort.

## 5 Conclusion

In summary, we have introduced a useful method of arranging words semantically and shown how to implement it by using thesauri. We gave three major examples of the applications of an Msort (dictionary construction, tagged corpus construction, and information presentation).

Since there is no doubt that a word list in a meaning-order is easier to use than a word list in a random-order, the Msort, which can easily produce a word list in a meaning-order, must be useful and effective.

The Msort is a very useful tool for natural language processing, and NLP research can be made more efficient by applying it.

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