

# Package ‘LSAfun’

March 29, 2018

**Type** Package

**Title** Applied Latent Semantic Analysis (LSA) Functions

**Description** Provides functions that allow for convenient working with latent semantic analysis (LSA). For actually building an LSA space, use the package ‘lsa’ or other specialized software. A description of the LSA algorithm can be found in Landauer and Dumais (1997) <doi:10.1037/0033-295X.104.2.211> .

**Version** 0.5.2

**Date** 2018-03-28

**Depends** R (>= 3.1.0), lsa, rgl

**License** GPL (>= 2)

**LazyData** true

**Author** Fritz Guenther [aut, cre]

**Maintainer** Fritz Guenther <fritz.guenther@uni-tuebingen.de>

**RoxygenNote** 6.0.1

**NeedsCompilation** no

**Repository** CRAN

**Date/Publication** 2018-03-29 15:52:53 UTC

## R topics documented:

LSAfun-package . . . . .	2
asym . . . . .	3
breakdown . . . . .	5
choose.target . . . . .	6
coherence . . . . .	7
compose . . . . .	9
conSIM . . . . .	11
Cosine . . . . .	12
costring . . . . .	13
distance . . . . .	15
genericSummary . . . . .	16

multicos . . . . .	17
multicostring . . . . .	18
MultipleChoice . . . . .	20
neighbors . . . . .	21
normalize . . . . .	22
oldbooks . . . . .	23
pairwise . . . . .	24
plausibility . . . . .	25
plot_neighbors . . . . .	27
plot_wordlist . . . . .	29
Predication . . . . .	31
priming . . . . .	32
syntest . . . . .	33
wonderland . . . . .	34
<b>Index</b>	<b>35</b>

---

 LSAfun-package

*Computations based on Latent Semantic Analysis*


---

## Description

Offers methods and functions for working with Vector Space Models of semantics, such as Latent Semantic Analysis (LSA). Such models are created by algorithms working on a corpus of text documents. Those algorithms achieve a high-dimensional vector representation for word (and document) meanings. The exact LSA algorithm is described in Martin & Berry (2007).

Such a representation allows for the computation of word (and document) similarities, for example by computing cosine values of angles between two vectors.

## The focus of this package

This package is not designed to create LSA semantic spaces. In R, this functionality is provided by the package [lsa](#). The focus of the package *LSAfun* is to provide functions to be applied on existing LSA (or other) semantic spaces, such as

1. Similarity Computations
2. Neighborhood Computations
3. Applied Functions
4. Composition Methods

## How to obtain a semantic space

*LSAfun* comes with one example LSA space, the [wonderland](#) space.

This package can also directly use LSA semantic spaces created with the [lsa](#)-package. Thus, it allows the user to use own LSA spaces. (Note that the function [lsa](#) gives a list of three matrices. Of those, the term matrix  $U$  should be used.)

The `lsa` package works with (very) small corpora, but gets difficulties in scaling up to larger corpora. In this case, it is recommended to use specialized software for creating semantic spaces, such as

- S-Space (Jurgens & Stevens, 2010), available [here](#)
- SemanticVectors (Widdows & Ferraro, 2008), available [here](#)
- gensim (Rehurek & Sojka, 2010), available [here](#)
- DISSECT (Dinu, Pham, & Baroni, 2013), available [here](#)

Another possibility is to use one of the LSA spaces provided at <http://www.lingexp.uni-tuebingen.de/z2/LSAspaces>. These are stored in the `.rda` format. To load one of these spaces into the R workspace, save them into a directory, set the working directory to that directory, and load the space using `load()`.

### Author(s)

Fritz Günther

---

asym

*Asymmetric Similarity functions*

---

### Description

Compute various asymmetric similarities between words

### Usage

```
asym(x, y, method, t=0, tvecs, breakdown=FALSE)
```

### Arguments

<code>x</code>	A single word, given as a character of <code>length(x) = 1</code>
<code>y</code>	A single word, given as a character of <code>length(y) = 1</code>
<code>method</code>	Specifying the formula to use for asymmetric similarity computation
<code>t</code>	A numeric threshold a dimension value of the vectors has to exceed so that the dimension is considered <i>active</i> ; not needed for the <code>kintsch</code> method
<code>tvecs</code>	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
<code>breakdown</code>	if TRUE, the function <code>breakdown</code> is applied to the input

## Details

Asymmetric (or directional) similarities can be useful e.g. for examining *hyponymy* (category inclusion), for example the relation between *dog* and *animal* should be asymmetrical. The general idea is that, if one word is a hypernym of another (i.e. it is semantically narrower), then a significant number of dimensions that are salient in this word should also be salient in the semantically broader term (Lenci & Benotto, 2012).

In the formulas below,  $w_x(f)$  denotes the value of vector  $x$  on dimension  $f$ . Furthermore,  $F_x$  is the set of *active* dimensions of vector  $x$ . A dimension  $f$  is considered active if  $w_x(f) > t$ , with  $t$  being a pre-defined, free parameter.

The options for method are defined as follows (see Kotlerman et al., 2010) (1)):

- method = "weedsprec"

$$weedsprec(u, v) = \frac{\sum_{f \in F_u \cap F_v} w_u(f)}{\sum_{f \in F_u} w_u(f)}$$

- method = "cosweeds"

$$cosweeds(u, v) = \sqrt{weedsprec(u, v) \times cosine(u, v)}$$

- method = "clarkede"

$$clarkede(u, v) = \frac{\sum_{f \in F_u \cap F_v} \min(w_u(f), w_v(f))}{\sum_{f \in F_u} w_u(f)}$$

- method = "invcl"

$$invcl(u, v) = \sqrt{clarkede(u, v) \times (1 - clarkede(u, v))}$$

- method = "kintsch"

Unlike the other methods, this one is not derived from the logic of hypernymy, but rather from asymmetrical similarities between words due to different amounts of knowledge about them. Here, asymmetric similarities between two words are computed by taking into account the vector length (i.e. the amount of information about those words). This is done by projecting one vector onto the other, and normalizing this resulting vector by dividing its length by the length of the longer of the two vectors (Details in Kintsch, 2014, see References).

## Value

A numeric giving the asymmetric similarity between  $x$  and  $y$

## Author(s)

Fritz Günther

## References

- Kintsch, W. (2015). Similarity as a Function of Semantic Distance and Amount of Knowledge. *Psychological Review*, 121, 559-561.
- Kotlerman, L., Dagan, I., Szpektor, I., & Zhitomirsky-Geffet, M (2010). Directional distributional similarity for lexical inference. *Natural Language Engineering*, 16, 359-389.
- Lenci, A., & Benotto, G. (2012). Identifying hypernyms in distributional semantic spaces. In *Proceedings of \*SEM* (pp. 75-79), Montreal, Canada.

## See Also

[Cosine conSIM](#)

## Examples

```
data(wonderland)

asym("alice", "girl", method="cosweeds", t=0, tvectors=wonderland)
asym("alice", "rabbit", method="cosweeds", tvectors=wonderland)
```

---

breakdown

*Clean up special characters*

---

## Description

Replaces special characters in character vectors

## Usage

```
breakdown(x)
```

## Arguments

x                    a character vector

## Details

Applies the following functions to a character vector

- sets all letters to lower case
- replaces umlauts (for example ä replaced by ae)
- removes accents from letters (for example é replaced by e)
- replaces ß by ss

Also removes other special characters, like punctuation signs, numbers and breaks

## Value

A character vector

**Author(s)**

Fritz Günther

**See Also**[gsub](#)**Examples**

```
breakdown("Märchen")
```

```
breakdown("I was visiting Orléans last week.  
It was nice, though!")
```

---

 choose.target

*Random Target Selection*


---

**Description**

Randomly samples words within a given similarity range to the input

**Usage**

```
choose.target(x, lower, upper, n, tvecs=tvecs, breakdown=FALSE)
```

**Arguments**

x	a character vector of length(x) = 1 specifying a word or a sentence/document
lower	the lower bound of the similarity range; a numeric
upper	the upper bound of the similarity range; a numeric
n	an integer giving the number of target words to be sampled
tvecs	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

Computes cosine values between the input x and all the word vectors in tvecs. Then only selects words with a cosine similarity between lower and upper to the input, and randomly samples n of these words.

This function is designed for randomly selecting target words with a predefined similarity towards a given prime word (or sentence/document).

**Value**

A named numeric vector. The names of the vector give the target words, the entries their respective cosine similarity to the input.

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

**See Also**[cosine](#), [Cosine](#), [neighbors](#)**Examples**

```
data(wonderland)

choose.target("mad hatter", lower=.2, upper=.3,
             n=20, tectors=wonderland)
```

---

`coherence`*Coherence of a text*

---

**Description**

Computes coherence of a given paragraph/document

**Usage**

```
coherence(x, split=c(".", "!", "?"), tectors=tectors, breakdown=FALSE)
```

**Arguments**

<code>x</code>	a character vector of length(x) = 1 containing the document
<code>split</code>	a vector of expressions that determine where to split sentences
<code>tectors</code>	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
<code>breakdown</code>	if TRUE, the function <a href="#">breakdown</a> is applied to the input

## Details

This function applies the method described in Landauer & Dumais (1997): The *local coherence* is the cosine between two adjacent sentences. The *global coherence* is then computed as the mean value of these local coherences.

The format of `x` (or `y`) should be of the kind `x <- "sentence1. sentence2. sentence3"` Every sentence can also just consist of one single word.

To import a document `Document.txt` to from a directory for coherence computation, set your working directory to this directory using `setwd()`. Then use the following command lines:

```
fileName1 <- "Alice_in_Wonderland.txt"
x <- readChar(fileName1, file.info(fileName1)$size)
```

## Value

A list of two elements; the first element (`$local`) contains the local coherences as a numeric vector, the second element (`$global`) contains the global coherence as a numeric.

## Author(s)

Fritz Günther

## References

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

## See Also

[cosine](#), [Cosine](#), [costring](#)

## Examples

```
data(wonderland)
```

```
coherence ("There was certainly too much of it in the air. Even the Duchess
sneezed occasionally; and as for the baby, it was sneezing and howling
alternately without a moment's pause. The only things in the kitchen
that did not sneeze, were the cook, and a large cat which was sitting on
the hearth and grinning from ear to ear.",
tvectors=wonderland)
```



---

compose	<i>Two-Word Composition</i>
---------	-----------------------------

---

**Description**

Computes the vector of a complex expression  $p$  consisting of two single words  $u$  and  $v$ , following the methods examined in Mitchell & Lapata (2008) (see *Details*).

**Usage**

```
## Default
compose(x,y,method="Add", a=1,b=1,c=1,m,k,lambda=2,
        tvectors=tvectors,breakdown=FALSE, norm="none")
```

**Arguments**

$x$	a single word (character vector with $\text{length}(x) = 1$ )
$y$	a single word (character vector with $\text{length}(y) = 1$ )
$a, b, c$	weighting parameters, see <i>Details</i>
$m$	number of nearest words to the Predicate that are initially activated (see <a href="#">Predication</a> )
$k$	size of the $k$ -neighborhood; $k \leq m$ (see <a href="#">Predication</a> )
$\lambda$	dilation parameter for method = "Dilation"
method	the composition method to be used (see <i>Details</i> )
norm	whether to <a href="#">normalize</a> the single word vectors before applying a composition function. Setting norm = "none" will not perform any normalizations, setting norm = "all" will normalize every involved word vector. Setting norm = "block" is only valid for the <a href="#">Predication</a> method
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

Let  $p$  be the vector with entries  $p_i$  for the two-word phrase consisting of  $u$  with entries  $u_i$  and  $v$  with entries  $v_i$ . The different composition methods as described by Mitchell & Lapata (2008, 2010) are as follows:

- Additive Model (method = "Add")

$$p_i = u_i + v_i$$

- Weighted Additive Model (method = "WeightAdd")

$$p_i = a * u_i + b * v_i$$

- Multiplicative Model (method = "Multiply")

$$p_i = u_i * v_i$$

- Combined Model (method = "Combined")

$$p_i = a * u_i + b * v_i + c * u_i * v_i$$

- Predication (method = "Predication")

(see [Predication](#))

If method="Predication" is used, x will be taken as Predicate and y will be taken as Argument of the phrase (see *Examples*)

- Circular Convolution (method = "CConv")

$$p_i = \sum_j u_j * v_{i-j}$$

, where the subscripts of  $v$  are interpreted modulo  $n$  with  $n = \text{length}(x)(= \text{length}(y))$

- Dilation (method = "Dilation")

$$p = (u * u) * v + (\lambda - 1) * (u * v) * u$$

, with  $(u * u)$  being the dot product of  $u$  and  $u$  (and  $(u * v)$  being the dot product of  $u$  and  $v$ ).

The Add, Multiply, and CConv methods are *symmetrical* composition methods, i.e. `compose(x="word1", y="word2")` will give the same results as `compose(x="word2", y="word1")`. On the other hand, WeightAdd, Combined, Predication and Dilation are *asymmetrical*, i.e. `compose(x="word1", y="word2")` will give different results than `compose(x="word2", y="word1")`

## Value

The phrase vector as a numeric vector

## Author(s)

Fritz Günther

## References

- Kintsch, W. (2001). Predication. *Cognitive science*, 25, 173-202.
- Mitchell, J., & Lapata, M. (2008). Vector-based Models of Semantic Composition. In *Proceedings of ACL-08: HLT* (pp. 236-244). Columbus, Ohio.
- Mitchell, J., & Lapata, M. (2010). Composition in Distributional Models of Semantics. *Cognitive Science*, 34, 1388-1429.

## See Also

[Predication](#)

## Examples

```

data(wonderland)

compose(x="mad",y="hatter",method="Add",tvectors=wonderland)

compose(x="mad",y="hatter",method="Combined",a=1,b=2,c=3,
tvectors=wonderland)

compose(x="mad",y="hatter",method="Predication",m=20,k=3,
tvectors=wonderland)

compose(x="mad",y="hatter",method="Dilation",lambda=3,
tvectors=wonderland)

```

---

conSIM

*Similarity in Context*


---

## Description

Compute Similarity of a word with a set of two other test words, given a third context word

## Usage

```
conSIM(x,y,z,c,tvectors=tvectors,breakdown=FALSE)
```

## Arguments

x	The relevant word, given as a character of length(x) = 1
y, z	The two test words, given each as a character of length(y) = 1
c	The context word in respect to which the similarity of x to y and z is to be computed (a character of length(y) = 1)
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

## Details

Following the example from Kintsch (2014): If one has to judge the similarity between *France* on the one hand and the test words *Germany* and *Spain* on the other hand, this similarity judgement varies as a function of a fourth context word. If *Portugal* is given as a context word, *France* is considered to be more similar to *Germany* than to *Spain*, and vice versa for the context word *Poland*. Kintsch (2014) proposed a context sensitive, asymmetrical similarity measure for cases like this, which is implemented here

**Value**

A list of two similarity values:

SIM\_XY\_zc: Similarity of x and y, given the alternative z and the context c

SIM\_XZ\_yc: Similarity of x and z, given the alternative y and the context c

**Author(s)**

Fritz Günther

**References**

Kintsch, W. (2015). Similarity as a Function of Semantic Distance and Amount of Knowledge. *Psychological Review*, 121, 559-561.

Tversky, A. (1977). Features of similarity. *Psychological Review*, 84, 327-352.

**See Also**

[Cosine asym](#)

**Examples**

```
data(wonderland)
```

```
conSIM(x="rabbit",y="alice",z="hatter",c="dormouse",tvectors=wonderland)
```

---

Cosine

*Compute cosine similarity*

---

**Description**

Computes the cosine similarity for two single words

**Usage**

```
Cosine(x,y,tvectors=tvectors,breakdown=FALSE)
```

**Arguments**

x	A single word, given as a character of length(x) = 1
y	A single word, given as a character of length(y) = 1
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

Instead of using numeric vectors, as the `cosine()` function from the `lsa` package does, this function allows for the direct computation of the cosine between two single words (i.e. Characters). which are automatically searched for in the LSA space given in `tvectors`.

**Value**

The cosine similarity as a numeric

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, *104*, 211-240.

Dennis, S. (2007). How to use the LSA Web Site. In T. K. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of Latent Semantic Analysis* (pp. 35-56). Mahwah, NJ: Erlbaum.

<http://lsa.colorado.edu/>

**See Also**

[distance asym](#)

**Examples**

```
data(wonderland)
```

```
Cosine("alice","rabbit",tvectors=wonderland)
```

---

costring

*Sentence Comparison*

---

**Description**

Computes cosine values between sentences and/or documents

**Usage**

```
costring(x,y,tvectors=tvectors,breakdown=FALSE)
```

**Arguments**

x	a character vector
y	a character vector
tectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <code>breakdown</code> is applied to the input

**Details**

In the traditional LSA approach, the vector  $D$  for a document (or a sentence) consisting of the words  $(t_1, \dots, t_n)$  is computed as

$$D = \sum_{i=1}^n t_n$$

This function computes the cosine between two documents (or sentences) or the cosine between a single word and a document (or sentence).

The format of  $x$  (or  $y$ ) can be of the kind `x <- "word1 word2 word3"`, but also of the kind `x <- c("word1", "word2", "word3")`. This allows for simple copy&paste-inserting of text, but also for using character vectors, e.g. the output of `neighbors()`.

To import a document *Document.txt* to from a directory for comparisons, set your working directory to this directory using `setwd()`. Then use the following command lines:

```
fileName1 <- "Alice_in_Wonderland.txt"
x <- readChar(fileName1, file.info(fileName1)$size)
```

**Value**

A numeric giving the cosine between the input sentences/documents

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

Dennis, S. (2007). How to use the LSA Web Site. In T. K. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of Latent Semantic Analysis* (pp. 35-56). Mahwah, NJ: Erlbaum.

<http://lsa.colorado.edu/>

**See Also**

[cosine](#), [Cosine](#), [multicos](#), [multicostring](#)

**Examples**

```
data(wonderland)
costring("Alice was beginning to get very tired.",
        "A white rabbit with a clock ran close to her.",
        tvectors=wonderland)
```

---

distance	<i>Compute distance</i>
----------	-------------------------

---

**Description**

Computes distance metrics for two single words

**Usage**

```
distance(x,y,method="euclidean",tvectors=tvectors,breakdown=FALSE)
```

**Arguments**

x	A single word, given as a character of length(x) = 1
y	A single word, given as a character of length(y) = 1
method	Specifies whether to compute euclidean or cityblock metric
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

Computes Minkowski metrics, i.e. geometric distances between the vectors for two given words. Possible options are `euclidean` for the Euclidean Distance,  $d(x, y) = \sqrt{\sum (x - y)^2}$ , and `cityblock` for the City Block metric,  $d(x, y) = \sum |x - y|$

**Value**

The distance value as a numeric

**Author(s)**

Fritz Günther

**See Also**

[Cosine asym](#)

**Examples**

```
data(wonderland)

distance("alice", "rabbit", method="euclidean", tvecs=wonderland)
```

---

genericSummary	<i>Summarize a text</i>
----------------	-------------------------

---

**Description**

Selects sentences from a text that best describe its topic

**Usage**

```
genericSummary(text, k, split=c(".", "!", "?"), min=5, breakdown=FALSE, ...)
```

**Arguments**

text	A character vector of <code>length(text) = 1</code> specifying the text to be summarized
k	The number of sentences to be used in the summary
split	A character vector specifying which symbols determine the end of a sentence in the document
min	The minimum amount of words a sentence must have to be included in the computations
breakdown	If TRUE, the function <code>breakdown</code> is applied to the input
...	Further arguments to be passed on to <code>textmatrix</code>

**Details**

Applies the method of Gong & Liu (2001) for generic text summarization of text document  $D$  via Latent Semantic Analysis:

1. Decompose the document  $D$  into individual sentences, and use these sentences to form the candidate sentence set  $S$ , and set  $k = 1$ .
2. Construct the terms by sentences matrix  $A$  for the document  $D$ .
3. Perform the SVD on  $A$  to obtain the singular value matrix  $\Sigma$ , and the right singular vector matrix  $V^t$ . In the singular vector space, each sentence  $i$  is represented by the column vector  $\psi_i = [v_{i1}, v_{i2}, \dots, v_{ir}]^t$  of  $V^t$ .
4. Select the  $k$ 'th right singular vector from matrix  $V^t$ .
5. Select the sentence which has the largest index value with the  $k$ 'th right singular vector, and include it in the summary.
6. If  $k$  reaches the predefined number, terminate the operation; otherwise, increment  $k$  by one, and go to Step 4.

(Cited directly from Gong & Liu, 2001, p. 21)



**Value**

A character vector of the length  $k$

**Author(s)**

Fritz Günther

**See Also**

[textmatrix](#), [lsa](#), [svd](#)

**Examples**

```
D <- "This is just a test document. It is set up just to throw some random
sentences in this example. So do not expect it to make much sense. Probably, even
the summary won't be very meaningful. But this is mainly due to the document not being
meaningful at all. For test purposes, I will also include a sentence in this
example that is not at all related to the rest of the document. Lions are larger than cats."
```

```
genericSummary(D,k=1)
```

---

multicos

*Vector x Vector Comparison*

---

**Description**

Computes a cosine matrix from given word vectors

**Usage**

```
multicos(x,y=x,tvectors=tvectors,breakdown=FALSE)
```

**Arguments**

x	a character vector or numeric of length=ncol(tvectors) (vector with same dimensionality as LSA space)
y	a character vector; y = x by default
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

Submit a character vector consisting of  $n$  words to get a  $n \times n$  cosine matrix of all their pairwise cosines.

Alternatively, submit two different character vectors to get their pairwise cosines. Single words are also possible arguments.

Also allows for computation of cosines between a given numeric vector with the same dimensionality as the LSA space and a vector consisting of  $n$  words.

**Value**

A matrix containing the pairwise cosines of  $x$  and  $y$

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, *104*, 211-240.

Dennis, S. (2007). How to use the LSA Web Site. In T. K. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of Latent Semantic Analysis* (pp. 35-56). Mahwah, NJ: Erlbaum.

<http://lsa.colorado.edu/>

**See Also**

[cosine](#), [Cosine](#), [costring](#), [multicostring](#)

**Examples**

```
data(wonderland)
multicos("mouse rabbit cat", "king queen",
         tvectors=wonderland)
```

---

multicostring	<i>Sentence x Vector Comparison</i>
---------------	-------------------------------------

---

**Description**

Computes cosines between a sentence/ document and multiple words

**Usage**

```
multicostring(x,y,tvectors=tvectors,breakdown=FALSE)
```

**Arguments**

$x$	a character vector specifying a sentence/ document (or also a single word)
$y$	a character vector specifying multiple single words
$tvectors$	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
$breakdown$	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

The format of `x` (or `y`) can be of the kind `x <- "word1 word2 word3"`, but also of the kind `x <- c("word1", "word2", "word3")`. This allows for simple copy&paste-inserting of text, but also for using character vectors, e.g. the output of [neighbors](#).

Both `x` and `y` can also just consist of one single word. For computing the vector for the document/sentence specified in `x`, the simple Addition model is used (see [costring](#)).

**Value**

A numeric giving the cosine between the input sentences/documents

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, *104*, 211-240.

Dennis, S. (2007). How to use the LSA Web Site. In T. K. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of Latent Semantic Analysis* (pp. 35-56). Mahwah, NJ: Erlbaum.

<http://lsa.colorado.edu/>

**See Also**

[cosine](#), [Cosine](#), [multicos](#), [multicostring](#)

**Examples**

```
data(wonderland)

multicostring("Alice was beginning to get very tired.",
              "A white rabbit with a clock ran close to her.",
              tvectors=wonderland)

multicostring("Suddenly, a cat appeared in the woods",
              names(neighbors("cheshire",n=20,tvectors=wonderland)),
              tvectors=wonderland)
```

---

MultipleChoice

*Answers Multiple Choice Questions*

---

### Description

Selects the nearest word to an input out of a set of options

### Usage

```
MultipleChoice(x,y,tvectors=tvectors,breakdown=FALSE)
```

### Arguments

x	a character vector of length(x) = 1 specifying a sentence/ document (or also a single word)
y	a character vector specifying multiple answer options
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

### Details

Computes all the cosines between a given sentence/document or word and multiple answer options. Then selects the nearest option to the input (the option with the highest cosine). This function relies entirely on the [costring](#) function.

A warning message will be displayed if all words of one answer alternative are not found in the semantic space.

### Value

The nearest option to x as a character

### Author(s)

Fritz Günther

### References

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

### See Also

[cosine](#), [Cosine](#), [costring](#)

**Examples**

```
data(wonderland)

LSAfun::MultipleChoice("Who does the march hare celebrate his unbrithday with?",
  c("Mad Hatter", "Red Queen", "Caterpillar", "Cheshire Cat"),
  tectors=wonderland)
```

---

neighbors	<i>Find nearest neighbors</i>
-----------	-------------------------------

---

**Description**

Returns the n nearest words to a given word or sentence/document

**Usage**

```
neighbors(x,n,tectors=tectors,breakdown=FALSE)
```

**Arguments**

x	a character vector of length(x) = 1 or a numeric of length=ncol(tectors) vector with same dimensionality as LSA space
n	the number of neighbors to be computed
tectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

The format of x should be of the kind `x <- "word1 word2 word3"` instead of `x <- c("word1", "word2", "word3")` if sentences/documents are used as input. This allows for simple copy&paste-inserting of text.

To import a document *Document.txt* to from a directory for comparisons, set your working directory to this directory using `setwd()`. Then use the following command lines:

```
fileName1 <- "Alice_in_Wonderland.txt"
x <- readChar(fileName1, file.info(fileName1)$size).
```

Since x can also be chosen to be any vector of the active LSA Space, this function can be combined with `compose()` to compute neighbors of complex expressions (see examples)

**Value**

A named numeric vector. The neighbors are given as names of the vector, and their respective cosines to the input as vector entries.

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, *104*, 211-240.

Dennis, S. (2007). How to use the LSA Web Site. In T. K. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of Latent Semantic Analysis* (pp. 35-56). Mahwah, NJ: Erlbaum.

<http://lsa.colorado.edu/>

**See Also**

[cosine](#), [plot\\_neighbors](#), [compose](#)

**Examples**

```
data(wonderland)

neighbors("cheshire",n=20,tvectors=wonderland)

neighbors(compose("mad","hatter",method="Add",tvectors=wonderland),
n=20,tvectors=wonderland)
```

---

normalize

*Normalize a vector*

---

**Description**

Normalizes a character vector to a unit vector

**Usage**

```
normalize(x)
```

**Arguments**

x                    a numeric or integer vector

**Details**

The (euclidean) norm of a vector  $x$  is defined as

$$\|x\| = \sqrt{\sum(x^2)}$$

To normalize a vector to a unit vector  $u$  with  $\|u\| = 1$ , the following equation is applied:

$$x' = x/\|x\|$$

**Value**

The normalized vector as a numeric

**Author(s)**

Fritz Günther

**Examples**

```
normalize(1:2)

## check vector norms:

x <- 1:2

sqrt(sum(x^2))          ## vector norm
sqrt(sum(normalize(x)^2)) ## norm = 1
```

---

oldbooks

*A collection of five classic books*

---

**Description**

This object is a list containing five classical books:

- *Around the World in Eighty Days* by Jules Verne
- *The Three Musketeers* by Alexandre Dumas
- *Frankenstein* by Mary Shelley
- *Dracula* by Bram Stoker
- *The Strange Case of Dr Jekyll and Mr Hyde* by Robert Stevenson

as single-element character vectors. All five books were taken from the [Project Gutenberg home-page](#) and contain formatting symbols, such as `\n` for breaks.

**Usage**

```
data(oldbooks)
```

**Format**

A named list containing five character vectors as elements

**Source**

[Project Gutenberg](#)

**References**

Dumas, A. (1844). *The Three Musketeers*. Retrieved from <http://www.gutenberg.org/ebooks/1257>

Shelley, M. W. (1818). *Frankenstein; Or, The Modern Prometheus*. Retrieved from <http://www.gutenberg.org/ebooks/84>

Stevenson, R. L. (1886). *The Strange Case of Dr. Jekyll and Mr. Hyde*. Retrieved from <http://www.gutenberg.org/ebooks/42>

Stoker, B. (1897). *Dracula*. Retrieved from <http://www.gutenberg.org/ebooks/345>

Verne, J.(1873). *Around the World in Eighty Days*. Retrieved from <http://www.gutenberg.org/ebooks/103>

---

pairwise

*Pairwise cosine computation*

---

**Description**

Computes pairwise cosine similarities

**Usage**

```
pairwise(x,y,tvectors=tvectors,breakdown=FALSE)
```

**Arguments**

x	a character vector
y	a character vector
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input



**Details**

Computes pairwise cosine similarities for two vectors of words. These vectors need to have the same length.

**Value**

A vector of the same length as x and y containing the pairwise cosine similarities. Returns NA if at least one word in a pair is not found in the semantic space.

**Author(s)**

Fritz Günther

**References**

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

Dennis, S. (2007). How to use the LSA Web Site. In T. K. Landauer, D. S. McNamara, S. Dennis, & W. Kintsch (Eds.), *Handbook of Latent Semantic Analysis* (pp. 35-56). Mahwah, NJ: Erlbaum.

<http://lsa.colorado.edu/>

**See Also**

[cosine](#), [Cosine](#), [multicos](#),

**Examples**

```
data(wonderland)
pairwise("mouse rabbit cat", "king queen hearts",
         tvectors=wonderland)
```

---

plausibility

*Compute word (or compound) plausibility*

---

**Description**

Gives measures of semantic transparency (plausibility) for words or compounds

**Usage**

```
plausibility(x, method, n=10, stem, tvectors=tvectors, breakdown=FALSE)
```

**Arguments**

x	a character vector of length(x) = 1 or a numeric of length=ncol(tvectors) vector with same dimensionality as LSA space
method	the measure of semantic transparency, can be one of n_density,length,proximity, or entropy (see <i>Details</i> )
n	the number of neighbors for the n_density method
stem	the stem (or word) of comparison for the proximity method
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input

**Details**

The format of x should be of the kind `x <- "word1 word2 word3"` instead of `x <- c("word1", "word2", "word3")` if phrases of more than one word are used as input. Simple vector addition of the constituent vectors is then used to compute the phrase vector. Since x can also be chosen to be any vector of the active LSA Space, this function can be combined with `compose()` to compute semantic transparency measures of complex expressions (see examples). Since semantic transparency methods were developed as measures for composed vectors, applying them makes most sense for those.

The methods are defined as follows:

- method = "n\_density" The average cosine between a (word or phrase) vector and its n nearest neighbors (see [neighbors](#))
- method = "length" The length of a vector (as computed by the standard Euclidean norm)
- method = "proximity" The cosine similarity between a compound vector and its stem word (for example between *mad hatter* and *hatter* or between *objectify* and *object*)
- method = "entropy" The entropy of the K-dimensional vector with the vector components  $t_1, \dots, t_K$ , as computed by

$$entropy = \log K - \sum t_i * \log t_i$$

**Value**

The semantic transparency as a numeric

**Author(s)**

Fritz Günther

**References**

Lazaridou, A., Vecchi, E., & Baroni, M. (2013). Fish transporters and miracle homes: How compositional distributional semantics can help NP parsing. In *Proceedings of EMNLP 2013* (pp. 1908 - 1913). Seattle, WA.

Marelli, M., & Baroni, M. (in press). Affixation in semantic space: Modeling morpheme meanings with compositional distributional semantics. *Psychological Review*.

Vecchi, E. M., Baroni, M., & Zamparelli, R. (2011). (Linear) maps of the impossible: Capturing semantic anomalies in distributional space. In *Proceedings of the ACL Workshop on Distributional Semantics and Compositionality* (pp. 1-9). Portland, OR.

### See Also

[Cosine](#), [neighbors](#), [compose](#)

### Examples

```
data(wonderland)
```

```
plausibility("cheshire cat",method="n_density",n=10,tvectors=wonderland)
```

```
plausibility(compose("mad","hatter",method="Multiply",tvectors=wonderland),
method="proximity",stem="hatter",tvectors=wonderland)
```

---

plot_neighbors	<i>2D- or 3D-Plot of neighbors</i>
----------------	------------------------------------

---

### Description

2D- or 3D-Approximation of the neighborhood of a given word/sentence

### Usage

```
plot_neighbors(x,n,connect.lines=0,start.lines=T,
method="PCA",dims=3,axes=F,box=F,cex=1,alpha=0.5,
col="black",tvectors=tvectors,breakdown=FALSE,...)
```

### Arguments

x	a character vector of length(x) = 1 or a numeric of length=ncol(tvectors) vector with same dimensionality as LSA space
n	the number of neighbors to be computed
dims	the dimensionality of the plot; set either dims = 2 or dims = 3
method	the method to be applied; either a Principal Component Analysis (method="PCA") or a Multidimensional Scaling (method="MDS")
connect.lines	(3d plot only) the number of closest associate words each word is connected with via line. Setting connect.lines="all" will draw all connecting lines and will automatically apply alpha="shade"; it will furthermore override the start.lines argument
start.lines	(3d plot only) whether lines shall be drawn between x and all the neighbors
axes	(3d plot only) whether axes shall be included in the plot

box	(3d plot only) whether a box shall be drawn around the plot
cex	(2d Plot only) A numerical value giving the amount by which plotting text should be magnified relative to the default.
tectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <code>breakdown</code> is applied to the input
alpha	(3d plot only) a vector of one or two numerics between 0 and 1 specifying the luminance of <code>start.lines</code> (first entry) and <code>connect.lines</code> (second entry). Specifying only one numeric will pass this value to both kinds of lines. With setting <code>alpha="shade"</code> , the luminance of every line will be adjusted to the cosine between the two words it connects.
col	(3d plot only) a vector of one or two characters specifying the color of <code>start.lines</code> (first entry) and <code>connect.lines</code> (second entry). Specifying only one colour will pass this colour to both kinds of lines. With setting <code>col="rainbow"</code> , the colour of every line will be adjusted to the cosine between the two words it connects. Setting <code>col="rainbow"</code> will also apply <code>alpha="shade"</code>
...	additional arguments which will be passed to <code>plot3d</code> (in a three-dimensional plot only)

### Details

Attempts to create an image of the semantic neighborhood (based on cosine similarity) to a given word, sentence/ document, or vector. An attempt is made to depict this subpart of the LSA space in a two- or three-dimensional plot.

To achieve this, either a Principal Component Analysis (PCA) or a Multidimensional Scaling (MDS) is computed to preserve the interconnections between all the words in this neighborhood as good as possible. Therefore, it is important to note that the image created from this function is only the best two- or three-dimensional approximation to the true LSA space subpart.

For creating pretty plots showing the similarity structure within this neighborhood best, set `connect.lines="all"` and `col="rainbow"`

### Value

For three-dimensional plots: see `plot3d`: this function is called for the side effect of drawing the plot; a vector of object IDs is returned  
`plot_neighbors` also gives the coordinate vectors of the words in the plot as a data frame

### Author(s)

Fritz Günther

### References

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

Mardia, K.V., Kent, J.T., & Bibby, J.M. (1979). *Multivariate Analysis*, London: Academic Press.

### See Also

[cosine](#), [neighbors](#), [multicos](#), [plot\\_wordlist](#), [plot3d](#), [princomp](#)

### Examples

```
data(wonderland)

## Standard Plot
plot_neighbors("cheshire",n=20,tvectors=wonderland)

## Pretty Plot
plot_neighbors("cheshire",n=20,tvectors=wonderland,
              connect.lines="all",col="rainbow")

plot_neighbors(compose("mad","hatter",tvectors=wonderland),
              n=20, connect.lines=2,tvectors=wonderland)
```

---

plot_wordlist	<i>2D- or 3D-Plot of a list of words</i>
---------------	--

---

### Description

2D or 3D-Plot of mutual word similarities to a given list of words

### Usage

```
plot_wordlist(x,connect.lines=0,method="PCA",dims=3,
             axes=F,box=F,cex=1,alpha=0.5,col="black",
             tvectors=tvectors,breakdown=FALSE,...)
```

### Arguments

x	a character vector of length(x) > 1 that contains multiple words
dims	the dimensionality of the plot; set either dims = 2 or dims = 3
method	the method to be applied; either a Principal Component Analysis (method="PCA") or a Multidimensional Scaling (method="MDS")
connect.lines	(3d plot only) the number of closest associate words each word is connected with via line. Setting connect.lines="all" will draw all connecting lines and will automatically apply alpha="shade"; it will furthermore override the start.lines argument

axes	(3d plot only) whether axes shall be included in the plot
box	(3d plot only) whether a box shall be drawn around the plot
cex	(2d Plot only) A numerical value giving the amount by which plotting text should be magnified relative to the default.
tectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <code>breakdown</code> is applied to the input
alpha	(3d plot only) a vector of one or two numerics between 0 and 1 specifying the luminance of <code>start.lines</code> (first entry) and <code>connect.lines</code> (second entry). Specifying only one numeric will pass this value to both kinds of lines. With setting <code>alpha="shade"</code> , the luminance of every line will be adjusted to the cosine between the two words it connects.
col	(3d plot only) a vector of one or two characters specifying the color of <code>start.lines</code> (first entry) and <code>connect.lines</code> (second entry). Specifying only one colour will pass this colour to both kinds of lines. With setting <code>col="rainbow"</code> , the colour of every line will be adjusted to the cosine between the two words it connects. Setting <code>col="rainbow"</code> will also apply <code>alpha="shade"</code>
...	additional arguments which will be passed to <code>plot3d</code> (in a three-dimensional plot only)

### Details

Computes all pairwise similarities within a given list of words. On this similarity matrix, a Principal Component Analysis (PCA) or a Multidimensional Scaling (MDS) is applied to get a two- or three-dimensional solution that best captures the similarity structure. This solution is then plotted. For creating pretty plots showing the similarity structure within this list of words best, set `connect.lines="all"` and `col="rainbow"`

### Value

see `plot3d`: this function is called for the side effect of drawing the plot; a vector of object IDs is returned.  
`plot_neighbors` also gives the coordinate vectors of the words in the plot as a data frame

### Author(s)

Fritz Günther

### References

Landauer, T.K., & Dumais, S.T. (1997). A solution to Plato's problem: The Latent Semantic Analysis theory of acquisition, induction and representation of knowledge. *Psychological Review*, 104, 211-240.

Mardia, K.V., Kent, J.T., & Bibby, J.M. (1979). *Multivariate Analysis*, London: Academic Press.

**See Also**

[cosine](#), [neighbors](#), [multicos](#), [plot\\_neighbors](#), [plot3d](#), [princomp](#)

**Examples**

```
data(wonderland)

## Standard Plot

words <- c("alice", "hatter", "queen", "knight", "hare", "cheshire")

plot_wordlist(words, tvectors=wonderland, method="MDS", dims=2)
```

---

 Predication

*Compute Vector for Predicate-Argument-Expressions*


---

**Description**

Computes vectors for complex expressions of type PREDICATE[ARGUMENT] by applying the method of Kintsch (2001) (see *Details*).

**Usage**

```
Predication(P,A,m,k,tvectors=tvectors,breakdown=FALSE,norm="none")
```

**Arguments**

P	Predicate of the expression, a single word (character vector)
A	Argument of the expression, a single word (character vector)
m	number of nearest words to the Predicate that are initially activated
k	size of the k-neighborhood; $k \leq m$
tvectors	the semantic space in which the computation is to be done (a numeric matrix where every row is a word vector)
breakdown	if TRUE, the function <a href="#">breakdown</a> is applied to the input
norm	whether to <a href="#">normalize</a> the single word vectors before applying a composition function. Setting <code>norm = "none"</code> will not perform any normalizations, setting <code>norm = "all"</code> will normalize every involved word vector (Predicate, Argument, and every single activated neighbor). Setting <code>norm = "block"</code> will normalize the Argument vector and will normalize the [Predicate + neighbors] vector, to weight the Argument and the "Predicate in context" equally.

**Details**

The vector for the expression is computed following the Predication Process by Kintsch (2001): The  $m$  nearest neighbors to the Predicate are computed. Of those, the  $k$  nearest neighbors to the Argument are selected. The vector for the expression is then computed as the sum of Predicate vector, Argument vector, and the vectors of those  $k$  neighbors (the  $k$ -neighborhood).

**Value**

An object of class Pred: This object is a list consisting of:

\$PA	The vector for the complex expression as described above
\$P.Pred	The vector for Predicate plus the $k$ -neighborhoodvectors without the Argument vector
\$neighbors	The words in the $k$ -neighborhood.
\$P	The Predicate given as input
\$A	The Argument given as input

**Author(s)**

Fritz Günther

**References**

Kintsch, W. (2001). Predication. *Cognitive science*, 25, 173-202.

**See Also**

[cosine](#), [neighbors](#), [multicos](#), [compose](#)

**Examples**

```
data(wonderland)
```

```
Predication(P="mad",A="hatter",m=20,k=3,tvectors=wonderland)
```

---

priming

*Simulated data for a Semantic Priming Experiment*

---

**Description**

A data frame containing simulated data for a Semantic Priming Experiment. This data contains 514 prime-target pairs, which are taken from the Hutchison, Balota, Cortese and Watson (2008) study. These pairs are generated by pairing each of 257 target words with one semantically related and one semantically unrelated prime.

The data frame contains four columns:

- First column: Prime Words
- Second column: Target Words
- Third column: **Simulated** Reaction Times
- Fourth column: Specifies whether a prime-target pair is considered semantically related or unrelated



**Usage**

```
data(priming)
```

**Format**

A data frame with 514 rows and 4 columns

**References**

Hutchison, K. A., Balota, D. A., Cortese, M. & Watson, J. M. (2008). Predicting semantic priming at the item level. *Quarterly Journal of Experimental Psychology*, *61*, 1036-1066.

---

syntest

*A multiple choice test for synonyms and antonyms*

---

**Description**

This object multiple choice test for synonyms and antonyms, consisting of seven columns.

1. The first column defines the question, i.e. the word a synonym or an antonym has to be found for.
2. The second up to the fifth column show the possible answer alternatives.
3. The sixth column defines the correct answer.
4. The seventh column indicates whether a synonym or an antonym has to be found for the word in question.

The test consists of twenty questions, which are given in the twenty rows of the data frame.

**Usage**

```
data(syntest)
```

**Format**

A data frame with 20 rows and 7 columns

---

wonderland

*LSA Space: Alice's Adventures in Wonderland*

---

### Description

This data set is a 50-dimensional LSA space derived from Lewis Carroll's book "Alice's Adventures in Wonderland". The book was split into 791 paragraphs which served as documents for the LSA algorithm (Landauer, Foltz & Laham, 1998). Only words that appeared in at least two documents were used for building the LSA space.

This LSA space contains 1123 different terms, all in lower case letters, and was created using the [lsa](#)-package. It can be used as `tvector`s for all the functions in the `LSAfun`-package.

### Usage

```
data(wonderland)
```

### Format

A 1123x50 matrix with terms as rownames.

### Source

[Alice in Wonderland from Project Gutenberg](#)

### References

Landauer, T., Foltz, P., and Laham, D. (1998) *Introduction to Latent Semantic Analysis*. In: *Discourse Processes* 25, pp. 259-284.

Carroll, L. (1865). *Alice's Adventures in Wonderland*. New York: MacMillan.

# Index

## \*Topic **Books**

oldbooks, [23](#)

## \*Topic **LSA space**

wonderland, [34](#)

## \*Topic **Synonym Test**

priming, [32](#)

syntest, [33](#)

asym, [3](#), [12](#), [13](#), [15](#)

breakdown, [3](#), [5](#), [6](#), [7](#), [9](#), [11](#), [12](#), [14–18](#), [20](#), [21](#),  
[24](#), [26](#), [28](#), [30](#), [31](#)

choose.target, [6](#)

coherence, [7](#)

compose, [9](#), [22](#), [27](#), [32](#)

conSIM, [5](#), [11](#)

Cosine, [5](#), [7](#), [8](#), [12](#), [12](#), [15](#), [18–20](#), [25](#), [27](#)

cosine, [7](#), [8](#), [15](#), [18–20](#), [22](#), [25](#), [29](#), [31](#), [32](#)

costring, [8](#), [13](#), [18–20](#)

distance, [13](#), [15](#)

genericSummary, [16](#)

gsub, [6](#)

lsa, [2](#), [3](#), [17](#), [34](#)

LSAfun-package, [2](#)

multicos, [15](#), [17](#), [19](#), [25](#), [29](#), [31](#), [32](#)

multicostring, [15](#), [18](#), [18](#), [19](#)

MultipleChoice, [20](#)

neighbors, [7](#), [19](#), [21](#), [26](#), [27](#), [29](#), [31](#), [32](#)

normalize, [9](#), [22](#), [31](#)

oldbooks, [23](#)

pairwise, [24](#)

plausibility, [25](#)

plot3d, [28–31](#)

plot\_neighbors, [22](#), [27](#), [31](#)

plot\_wordlist, [29](#), [29](#)

Predication, [9](#), [10](#), [31](#)

priming, [32](#)

princomp, [29](#), [31](#)

svd, [17](#)

syntest, [33](#)

textmatrix, [16](#), [17](#)

wonderland, [2](#), [34](#)