# Package 'JoF'

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**Type** Package

**Title** Modelling and Simulating Judgments of Frequency

**Version** 0.1.0

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**Description** In a typical experiment for the intuitive judgment of frequencies (JoF) different stimuli with different frequencies are presented. The participants consider these stimuli with a constant duration and give a judgment of frequency. These judgments can be simulated by formal models: PASS 1 and PASS 2 based on Sedlmeier (2002, ISBN:978-0198508632), MINERVA 2 baesd on Hintzman (1984) <doi:10.3758/BF03202365> and TODAM 2 based on Murdock, Smith & Bai (2001) <doi:10.1006/jmps.2000.1339>. The package provides an assessment of the frequency by determining the core aspects of these four models (attention, decay, and presented frequency) that can be compared to empirical results.

**Depends** R (>= 3.1.0)

**License** GPL-3

**Encoding** UTF-8

**LazyData** true

**RoxygenNote** 7.0.2

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**VignetteBuilder** knitr

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## R topics documented:

MINERVA2 *Modeling Judgments of Frequency with MINERVA 2*

## Description

Modeling Judgments of Frequency with MINERVA 2

## Usage

```
MINERVA2(x, y, ..., sqc, L, dec = NULL)
```

## Arguments

| | |
|---|---|
| `x` | input handled by MINERVA 2. Values -1, 0 and 1 are allowed. -1 represents the absence of a feature, 0 the irrelevance of a feature and 1 the presence of a feature. |
| `y` | another input handled by MINERVA 2. At least two inputs are needed for the simulation. |
| `...` | other inputs for modeling. |
| `sqc` | sequence of the different objects. Each input gets an ascending number. `x` gets the value `1`, `y` gets the value `2`, `...` gets the value `3` and so on. The argument `sqc = c(1,2,3,2)` means: first input `x` is processed, second input `y` is processed followed by processing input number three and fourth, th input `y` is used again. So `sqc` contains the frequency information too. In `c(1,2,3,2)`, `x` and the third input are presented once. The input `y` is presented twice. |
| `L` | learning parameter. This is the proportion of a correctly stored vector. `L = 1` means 100 % of the input is processed correctly. If `L` is a vector, each input could be handled differently. So `L = c(.5,.6,.9)` means, input `x` is correctly stored to 50 %, input `y` is stored to 60 % and the third input (inserted in `...`) is stored with 90 % probability. |
| `dec` | decay is not part of the original version of MINERVA 2. This is just implemented for a better comparison with the other models of JoF. In `dec = NULL`, decay has no effect. For `dec = 'curve'` decay uses a forgetting curve. If dec is a numeric Vector e. g. `dec = c(.8,.9,1)` the memory traces are weighted. The first represented trace is weighted by .8 the second by .9 and the youngest trace by 1. The value `dec = 1` corresponds with the original model. |

## Details

Calculations of MINERVA 2 contain four steps.

$$S_i = \frac{\sum_{j=1}^{N} P_j T_{ij}}{N_i}$$

$$A_i = S_i^3$$

$$I = \sum_{i=1}^{M} A_i$$

$$relativeJoF = \frac{I_j}{\sum_j^K I_j}$$

### Value

MINERVA2 returns the relative judgment of frequency

### References

Dougherty, M. R., Gettys, C. F., & Ogden, E. E. (1999). MINERVA-DM: A memory processes model for judgments of likelihood. *Psychological Review, 106*(1), 180.

Hintzman, D. L. (1984). MINERVA 2: A simulation model of human memory. *Behavior Research Methods, Instruments, and Computers, 16,* 96–101.

### Examples

```
#This example is presented in Dougherty,
#Gettys, & Ogden, 1999 (p. 185)
H1 <- c(-1, 1, 0, 1, 0, -1, 1, -1, 0)
H2 <- c(-1, 0, 0, 1, 0, 0, 1, 0, 0)
x <- MINERVA2(H1, H2, sqc = c(2, 1), L = 1)
```

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## PASS1 *Modeling Judgments of Frequency with PASS 1*

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### Description

Modeling Judgments of Frequency with PASS 1

### Usage

```
PASS1(x, y, ..., sqc, att, dec, ifc, rdm_weights = TRUE, noise = 0)
```

### Arguments

| | |
|---|---|
| `x` | input handled by PASS 1. Only binary input is allowed. |
| `y` | a second binary input handled by PASS 1. At least two inputs are needed for the simulation. |
| `...` | other binary inputs for modeling. |
| `sqc` | sequence of the different objects. Each input gets an ascending number. `x` gets the value `1`, `y` gets the value `2`, `...` gets the value `3` and so on. The argument `sqc = c(1,2,3,2)` means: first input `x` is processed, second input `y` is processed followed by processing input number three and fourth, th input `y` is used again. So `sqc` contains the frequency information too. In `c(1,2,3,2)`, `x` and the third input are presented once. The input `y` is presented twice. |

`att` attention is a vector with numeric values between 0 and 1. `att` has the same length like `sqc`, so each input processing have its own value and PASS 1 can modulate attention by time or input. If `att` is exact one numeric value (e.g. `att = .1`), all inputs get the same parameter of attention.

`dec` decay is a vector with numeric values between -1 and 0. `dec` has the same length as `sqc`, so each input processing have its own value and PASS 1 can modulate decay by time. If `dec` is exact one numeric value (e.g. `dec = -.1`), all inputs get the same parameter of decay.

`ifc` interference is a vector with numeric values between -1 and 0. `ifc` must have the same length as `sqc`. So each inputprocessing have its own value and PASS 1 can modulate inference by time. If `ifc` is exact one numeric value (e.g. `ifc = -.1`), all inputs get the same parameter of inference.

`rdm_weights` a logical value indicating whether random weights in the neural network are used or not. If `rdm_weights = FALSE` all network connections are zero at the beginning.

`noise` a proportion between 0 and 1 which determine the number of randome activiated inputunits (hihger numbers indicate higher noise).

### Details

PASS 1 is a simple neural pattern associator learning by delta rule.

Learning:

$$ifU_iandU_jareactivated, then\Delta w_{ij} = \Theta_1(1 - w_{ij})$$

Interference:

$$ifeitherU_iorU_jisactivated, then\Delta w_{ij} = \Theta_2 * w_{ij}$$

Decay:

$$ifneitherU_inorU_jisactivated, then\Delta w_{ij} = \Theta_3 * w_{ij}$$

### Value

`PASS1` returns the relative judgment of frequency for each input.

### References

Sedlmeier, P. (2002). Associative learning and frequency judgements: The PASS model. In P. Sedlmeier, T. Betsch (Eds.), *Etc.: Frequency processing and cognition* (pp. 137-152). New York: Oxford University Press.

### Examples

```
o1 <- c(1, 0, 0, 0)
o2 <- c(0, 1, 0, 0)
o3 <- c(0, 0, 1, 0)
o4 <- c(0, 0, 0, 1)
PASS1(o1, o2, o3, o4,
      sqc = rep(1:4, 4:1), att = .1, dec = -.05,
      ifc = -.025, rdm_weights = FALSE, noise = 0)
```

PASS2 *Modelling Judgments of Frequency with PASS 2*

## Description

Modelling Judgments of Frequency with PASS 2

## Usage

```
PASS2(x, y, ..., sqc, att, n_output_units = "half", rdm_weights = F, noise = 0)
```

## Arguments

| | |
|---|---|
| `x` | input handled by PASS 2. Only binary input is allowed. |
| `y` | a second binary input handled by PASS 1. At least two inputs are needed for the simulation. |
| `...` | other binary inputs for modeling. |
| `sqc` | sequence of the different objects. Each input gets an ascending number. `x` gets the value `1`, `y` gets the value `2`, `...` gets the value `3` and so on. The argument `sqc = c(1,2,3,2)` means: first input `x` is processed, second input `y` is processed followed by processing input number three and fourth, th input `y` is used again. So `sqc` contains the frequency information too. In `c(1,2,3,2)`, `x` and the third input are presented once. The input `y` is presented twice. |
| `att` | attention is a vector with numeric values between 0 and 1. `att` has the same length like `sqc`, so each input processing have its own value and PASS 1 can modulate attention by time or input. If `att` is exact one numeric value (e.g. `att = .1`), all inputs get the same parameter of attention. |
| `n_output_units` | number of output units as numeric value. This must be between 1 and the maximum number of input units. `n_output_units = 'half'` determines the half of the input units. |
| `rdm_weights` | a logical value indicating whether random weights in the neural network are used or not. If `rdm_weights = FALSE` all network connections are zero at the beginning. |
| `noise` | a proportion between 0 and 1 which determines the number of random activated input units (higher numbers indicate higher noise). |

## Details

PASS 2 uses a competitive learning algorithm, which usually clusters the input as side effect. If weights are equal, the winning unit is chosen randomly, because of this, each simulation is slightly different.

$$if an output uni O_i losses : \Delta w_{ij} = 0$$

$$if an output uni O_i wins : \Delta w_{ij} = g_w \frac{a_i}{\sum_i^n a_i} - g_w w_{ij}$$

## Value

`PASS2` returns the relative judgment of frequency for each input.

## References

Sedlmeier, P. (2002). Associative learning and frequency judgements: The PASS model. In P. Sedlmeier, T. Betsch (Eds.), *Etc.: Frequency processing and cognition* (pp. 137-152). New York: Oxford University Press.

## Examples

```
o1 <- c(1, 0, 0, 0)
o2 <- c(0, 1, 0, 0)
o3 <- c(0, 0, 1, 0)
o4 <- c(0, 0, 0, 1)
PASS2(o1, o2, o3, o4,
      sqc = rep(1:4, 4:1), att = .1, n_output_units = 2,
      rdm_weights = FALSE, noise = 0)
```

---

# `plot.JoF` *plot progress of judgment of frequency simulation*

---

## Description

plot progress of judgment of frequency simulation

## Usage

```
## S3 method for class 'JoF'
plot(x, type = "l", ...)
```

## Arguments

| | |
|---|---|
| `x` | output of JoF simulation |
| `type` | "l" for lines, "p" for points, "b" for both |
| `...` | further arguments |

## Value

Displays the judgment of frequency as proportion of all inputs

## print.JoF *Output of judgment of frequecny simulation*

### Description

Output of judgment of frequecny simulation

### Usage

```
## S3 method for class 'JoF'
print(x, ...)
```

### Arguments

| | |
|---|---|
| x | output of JoF simulation |
| ... | further arguments |

### Value

Displays the judgment of frequency as proportion of all inputs

## TODAM2 *Modeling Judgments of Frequency with TODAM 2*

### Description

Modeling Judgments of Frequency with TODAM 2

### Usage

```
TODAM2(x, y, ..., sqc, gamma = 1, alpha = 1)
```

### Arguments

| | |
|---|---|
| x | input handled by TODAM 2. Normal distributed inputs with mean = 0 and sd = 1 / n are allowed. This representation enables discrimination and similarity between different items. See vignette for details. |
| y | another input handled by TODAM 2. At least two inputs are needed for the simulation. |
| ... | other inputs handled by TODAM 2. |
| sqc | sequence of the different objects. Each input gets an ascending number. `x` gets the value `1`, `y` gets the value `2`, `...` gets the value `3` and so on. The argument `sqc = c(1,2,3,2)` means: first input `x` is processed, second input `y` is processed followed by processing input number three and fourth, th input `y` is used again. So `sqc` contains the frequency information too. In `c(1,2,3,2)`, `x` and the third input are presented once. The input `y` is presented twice. |

gamma — is the atttention- or learningparameter. Values between 0 and 1 are allowed. 1 represents perfect learning. If `gamma` iis a vector, each input could be handled differently. So `gamma = c(.5,.6,1)` means, the third input is stored correctly and betther than the `y` better than first input `x`).

alpha — represents the decay. If `alpha = 1`, the complete memory vector is used (and no forgetting takes place). If `alpha` is an numeric Vector e. g. `alpha = c(.8,.9,1)`, the memory vector is weighted. The memory for the first input is weaker than the second than the third.

## Details

In the original publication TODAM 2 is more complex and has more parameters. Especially the design for the input is a concatenation between item and context. The normal distributed input has a *mean = 0* and *sd = 1/n*. A pragmatic solution to make the models input comparable is to use a binary input like in PASS. There is no explicit argument for noise.

Convolution:

$$F_i^2 = \sum_{i=1} f_i * f_{m-i+1} and m = 2n - 1$$

Memory:

$$M_t = \alpha M_{t-1} + \gamma F_t^2$$

Correlation

$$R_m = \sum_{(i;j) \in S(m)} F_t^2 there S(m)(i;j)| - (n-1)/2 \leq i, j \leq (n-1)/2 and i - j = m$$

## References

Murdock, B. B., Smith, D., & Bai, J. (2001). Judgments of frequency and recency in a distributed memory model. *Journal of Mathematical Psychology, 45,* 564–602. https://doi.org/10.1006/jmps.2000.1339

## Examples

```
o1 <- c(-0.27, -0.24, -0.24, 0.75)
o2 <- c(-0.06, -0.55,  0.66, -0.06)
o3 <- c(0.04,  0.57, -0.65,  0.04)
o4 <- c(0.73, -0.39, -0.20, -0.14)
TODAM2(o1, o2, o3, o4, gamma = rep(c(0.7, 0.8), 5),
alpha = 0.95, sqc = rep(1:4, 4:1))
```

# Index