Package 'beezdiscounting'

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Title Behavioral Economic Easy Discounting

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Description Facilitates some of the analyses performed in studies of behavioral economic discounting. The package supports scoring of the 27-Item Monetary Choice Questionnaire (see Kaplan et al., 2016; <doi:10.1007/s40614-016-0070-9>), calculating k values (Mazur's simple hyperbolic and exponential) using nonlinear regression, calculating various Area Under the Curve (AUC) measures, plotting regression curves for both fit-to-group and two-stage approaches, checking for unsystematic discounting (Johnson & Bickel, 2008; <doi:10.1037/1064-1297.16.3.264>) and scoring of the minute discounting task (see Koffarnus & Bickel, 2014; <doi:10.1037/a0035973>) using the Qualtrics 5-trial discounting template (see the Qualtrics Minute Discounting User Guide; <doi:10.13140/RG.2.2.26495.79527>), which is also available as a .qsf file in this package.

License GPL (>= 2)

URL https://github.com/brentkaplan/beezdiscounting

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`ans_dd` *Converts answers from 5.5 trial delay discounting from Qualtrics template*

Description

Converts answers from 5.5 trial delay discounting from Qualtrics template

Usage

```
ans_dd(df)
```

Arguments

df	A dataframe containing all the columns

Value

A dataframe with the ResponseId, index, and response (ss or ll).

Examples

```
ans_dd(five.fivetrial_dd)
```

---

ans_pd *Converts answers from 5.5 trial probability discounting from Qualtrics template*

Description

Converts answers from 5.5 trial probability discounting from Qualtrics template

Usage

```
ans_pd(df)
```

Arguments

df	A dataframe containing all the columns

Value

A dataframe with the ResponseId, index, and response (sc or lu).

Examples

```
ans_pd(five.fivetrial_pd)
```

`calc_aucs` *Calculate Area-Under-the-Curve (AUC) Metrics for Delay Discounting Data*

Description

This function calculates three types of Area-Under-the-Curve (AUC) metrics for delay discounting data: regular AUC (using raw delays), log10 AUC (using logarithmically scaled delays), and ordinal AUC (using ordinally scaled delays). These metrics provide different perspectives on the rate of delay discounting.

Usage

```
calc_aucs(dat)
```

Arguments

`dat`	A data frame containing delay discounting data. It must include the following columns: • `id`: Participant or group identifier. • `x`: Delay values (e.g., in days). • `y`: Indifference point values (e.g., subjective value of the delayed reward).

Value

A tibble with the following columns:

- `id`: The participant or group identifier.
- `auc_regular`: The regular AUC, calculated using the raw delay values.
- `auc_log10`: The log10 AUC, calculated using logarithmically transformed delay values.
- `auc_rank`: The rank AUC, calculated using ordinally scaled delay values.

Examples

```
# Example data
data <- data.frame(
  id = rep("P1", 6),
  x = c(1, 7, 30, 90, 180, 365),
  y = c(0.8, 0.5, 0.3, 0.2, 0.1, 0.05)
)

# Calculate AUC metrics for a single participant
calc_aucs(data)
```

calc_conf_int *Calculate Confidence Intervals for a Parameter*

Description

This function computes the lower and upper bounds of the confidence interval for a parameter estimate, given its standard error, a specified significance level, and the degrees of freedom from the model.

Usage

```
calc_conf_int(estimate, std_error, model, alpha = 0.05)
```

Arguments

estimate	A numeric value representing the parameter estimate.
std_error	A numeric value representing the standard error of the parameter estimate.
model	A fitted model object that provides the residual degrees of freedom via `df.residual()`.
alpha	A numeric value representing the significance level. Default is 0.05 (95% confidence interval).

Value

A numeric vector of length two:

- First element: Lower bound of the confidence interval.
- Second element: Upper bound of the confidence interval.

Examples

```
# Example using a linear model
data <- data.frame(x = 1:10, y = c(2.3, 2.1, 3.7, 4.5, 5.1, 6.8, 7.3, 7.9, 9.2, 10.1))
lm_model <- lm(y ~ x, data = data)
calc_conf_int(estimate = 0.5, std_error = 0.1, model = lm_model, alpha = 0.05)
```

calc_dd *Calculate scores, answers, and timing for 5.5 trial delay discounting from Qualtrics template*

Description

Calculate scores, answers, and timing for 5.5 trial delay discounting from Qualtrics template

Usage

```
calc_dd(df)
```

Arguments

df	A dataframe containing all the columns from the template.

Value

A dataframe with k/ed50 values, answers, timing

Examples

```
calc_dd(five.fivetrial_dd)
```

---

calc_pd *Calculate scores, answers, and timing for 5.5 trial probability discounting from Qualtrics template*

Description

Calculate scores, answers, and timing for 5.5 trial probability discounting from Qualtrics template

Usage

```
calc_pd(df)
```

Arguments

df	A dataframe containing all the columns from the template.

Value

A dataframe with h/ep50 values, answers, timing

Examples

```
calc_pd(five.fivetrial_pd)
```

calc_r2 *Calculate R-Squared for a Model*

Description

This function calculates the coefficient of determination (R^2) for a given model by comparing the sum of squared errors (SSE) to the total sum of squares (SST).

Usage

```
calc_r2(model)
```

Arguments

model	A fitted model object. The model must have `resid()` and `fitted()` methods to extract residuals and fitted values.

Value

A numeric value representing the R^2 value of the model. Returns `NA` if the model is `NULL`.

Examples

```
# Example using a simple linear model
data <- data.frame(x = 1:10, y = c(1, 2, 3, 4, 5, 6, 7, 9, 10, 11))
lm_model <- lm(y ~ x, data = data)
calc_r2(lm_model)
```

check_unsystematic *Check for Unsystematic Data Violations*

Description

This function checks a dataset for violations of two criteria commonly used to identify unsystematic delay-discounting data:

- Criterion 1: Any subsequent value of `y` exceeds the previous value by more than a specified proportion of the larger later reward (`ll`).
- Criterion 2: The last value of `y` is not at least a specified proportion less than the first value of `y`.

Usage

```
check_unsystematic(dat, ll = 1, c1 = 0.2, c2 = 0.1)
```

Arguments

dat	A data frame containing the delay-discounting data. It must have at least two columns: • id: A unique identifier for the data set. • y: The indifference points to be analyzed.
ll	A numeric value representing the larger later reward. Default is 1.
c1	A numeric value for the threshold proportion for Criterion 1. Default is 0.2.
c2	A numeric value for the threshold proportion for Criterion 2. Default is 0.1.

Value

A tibble with the following columns:

- id: The unique identifier for the data set.
- c1_pass: Logical value indicating whether Criterion 1 was passed.
- c2_pass: Logical value indicating whether Criterion 2 was passed.

Examples

```
data <- tibble::tibble(
  id = c(rep("P1", 6)),
  x = c(1, 7, 30, 90, 180, 365), # delays
  y = c(0.9, 0.5, 0.3, 0.2, 0.1, 0.05) # indifference points
)
check_unsystematic(data, ll = 1, c1 = 0.2, c2 = 0.1)
```

---

dd_ip *Delay Discounting Data*

Description

A dataset containing a set of fake delay discounting responses

Usage

```
dd_ip
```

Format

A data frame with delay discounting responses

`fit_dd` *Fit Delay-Discounting Model*

Description

This function fits a delay-discounting model to the given dataset using the specified equation and method.

Usage

```
fit_dd(dat, equation, method)
```

Arguments

`dat`	A data frame containing delay (`x`) and indifference point (`y`) data. For "two stage" methods, the data must include an `id` column to identify participants.
`equation`	A character string specifying the delay-discounting equation to use. Options include: • `"mazur"` or `"hyperbolic"`: Hyperbolic delay-discounting model ($y = 1/(1 + k \cdot x)$). • `"exponential"`: Exponential delay-discounting model ($y = \exp(-k \cdot x)$).
`method`	A character string specifying the method for fitting the model. Options include: • `"pooled"` or `"agg"`: Fits the model using pooled data. • `"mean"`: Fits the model using the mean of indifference points at each delay. • `"ts"` or `"two stage"`: Fits the model separately for each participant (requires an `id` column in `dat`).

Value

A list object of class `"fit_dd"`, containing:

- The fitted model(s).
- The original dataset (`dat`).
- The specified method (`method`).

Examples

```
data <- data.frame(
  id = rep(1:2, each = 6),
  x = rep(c(1, 7, 30, 90, 180, 365), 2),
  y = c(0.9, 0.5, 0.3, 0.2, 0.1, 0.05, 0.85, 0.55, 0.35, 0.15, 0.1, 0.05)
)
fit_dd(data, equation = "mazur", method = "two stage")
```

five.fivetrial_dd — *Example Qualtrics output from the 5.5 trial delay discounting template.*

Description

An example dataset containing four participants' data (two typical discounting patterns and two patterns suggesting potential misattention to the task).

Usage

```
five.fivetrial_dd
```

Format

Example Qualtrics output

five.fivetrial_pd — *Example Qualtrics output from the 5.5 trial probability discounting template.*

Description

An example dataset containing four participants' data.

Usage

```
five.fivetrial_pd
```

Format

Example Qualtrics output

generate_data_mcq *Generate fake MCQ data*

Description

Generate fake MCQ data

Usage

```
generate_data_mcq(n_ids = 100, n_items = 27, seed = 1234, prop_na = 0)
```

Arguments

n_ids	Number of subjectids
n_items	Number of trials
seed	Random seed
prop_na	Proportion of NAs in the entire data set

Value

Dataframe of subjectid, questionid, and response

Examples

```
generate_data_mcq(n_ids = 2, n_items = 27, prop_na = .01)
```

get_lookup_table *Get internal lookup table for the 27-item MCQ*

Description

Get internal lookup table for the 27-item MCQ

Usage

```
get_lookup_table()
```

Value

Dataframe with questionid, magnitude, and kindiff

Examples

```
get_lookup_table()
```

inn — *Calculates item nearest neighbor imputation approach discussed by Yeh et al. (2023)*

Description

Calculates item nearest neighbor imputation approach discussed by Yeh et al. (2023)

Usage

```
inn(dat, random, verbose)
```

Arguments

dat	A single subject's 27-item MCQ data in long form
random	Boolean whether to insert a random draw (0 or 1) for NAs
verbose	Boolean whether to print subject and question ids pertaining to missing data

Value

An imputed data set to be scored

long_to_wide_mcq — *Reshape MCQ data long to wide*

Description

Reshape MCQ data long to wide

Usage

```
long_to_wide_mcq(dat, q_col = "questionid", ans_col = "response")
```

Arguments

dat	Long format MCQ
q_col	Name of the question column (default is "questionid")
ans_col	Name of the answer column (defualt is "response")

Value

Wide format data frame

long_to_wide_mcq_excel

Reshape MCQ data from long to wide (as used in the 21- and 27-Item Monetary Choice Questionnaire Automated Scorer)

Description

Reshape MCQ data from long to wide (as used in the 21- and 27-Item Monetary Choice Questionnaire Automated Scorer)

Usage

```
long_to_wide_mcq_excel(dat, subj_col = "subjectid", ans_col = "response")
```

Arguments

dat	Long format MCQ data
subj_col	Character column name of subject ids
ans_col	Character column name of responses

Value

Wide format MCQ data that can be used in the Excel Automated Scorers

Examples

```
long_to_wide_mcq_excel(generate_data_mcq(2))
```

mcq27

Example 27-item MCQ data

Description

A dataset containing two participants' data (same data as in the paper by Kaplan et al., 2016)

Usage

```
mcq27
```

Format

Long-form data.frame with columns: subjectid, questionid, response.

`plot.prop_ss_output` *Plot Proportion of SIR/SS Choices by k Value*

Description

This function creates a plot of the proportion of SIR/SS choices by k value using the output of the `prop_ss` function.

Usage

```
## S3 method for class 'prop_ss_output'
plot(
  x,
  ...,
  pt_shape = 21,
  pt_fill = "white",
  pt_size = 3,
  title = "Proportion of SIR/SS choices by k value",
  xlab = "k value rank",
  ylab = "Proportion of SS choices"
)
```

Arguments

`x`	Output from the `prop_ss` function
`...`	Additional arguments passed to `ggplot2::geom_point()`
`pt_shape`	Shape of the points in the plot. Default is 21.
`pt_fill`	Fill color of the points in the plot. Default is "white".
`pt_size`	Size of the points in the plot. Default is 3.
`title`	Title of the plot. Default is "Proportion of SIR/SS choices by k value".
`xlab`	Label for the x-axis. Default is "k value rank".
`ylab`	Label for the y-axis. Default is "Proportion of SS choices".

Value

A ggplot object.

Examples

```
plot(prop_ss(mcq27))
```

plot.score_mcq27_output *Plot MCQ-27 Scores*

Description

This function creates a plot of the MCQ-27 scores for different metrics (small_k, medium_k, large_k, geomean_k, overall_k). The function handles different logarithmic transformations of the k-values and adjusts the y-axis label accordingly.

Usage

```
## S3 method for class 'score_mcq27_output'
plot(x, ..., xlab = "Metric", alpha = 0.3)
```

Arguments

x	A data frame returned by the score_mcq27 function.
...	Additional arguments passed to methods.
xlab	Label for the x-axis. Default is "Metric".
alpha	Transparency of the points in the plot. Default is 0.3.

Value

A ggplot object showing the boxplot of MCQ-27 scores.

Examples

```
plot(score_mcq27(mcq27))
```

plot_dd *Plot Delay-Discounting Model*

Description

This function generates a plot of the delay-discounting data and the fitted model.

Usage

```
plot_dd(
  fit_dd_object,
  xlabel = "Delay",
  ylabel = "Indifference Point",
  title = "",
  logx = TRUE
)
```

Arguments

fit_dd_object	A fitted delay-discounting model object of class "fit_dd", created by the fit_dd() function.
xlabel	A character string specifying the label for the x-axis. Default is "Delay".
ylabel	A character string specifying the label for the y-axis. Default is "Indifference Point".
title	A character string specifying the plot title. Default is "".
logx	Logical. If TRUE, the x-axis is log-transformed. Default is TRUE.

Value

A ggplot object representing the fitted model and data.

Examples

```
data <- data.frame(
  id = rep(1:2, each = 6),
  x = rep(c(1, 7, 30, 90, 180, 365), 2),
  y = c(0.9, 0.5, 0.3, 0.2, 0.1, 0.05, 0.85, 0.55, 0.35, 0.15, 0.1, 0.05)
)
fit <- fit_dd(data, equation = "mazur", method = "mean")
plot_dd(fit)
```

---

prop_ss *Calculate proportion of SIR/SS responses at each k value*

Description

Calculate proportion of SIR/SS responses at each k value

Usage

```
prop_ss(dat)
```

Arguments

dat	Dataframe (longform) with subjectid, questionid, and response (0 for SIR/SS and 1 for LDR/LL)

Value

Dataframe with proportion of SIR/SS responses at each k rank

Examples

```
prop_ss(mcq27)
```

`results_dd` *Extract Results from Delay-Discounting Model*

Description

This function extracts model parameter estimates, fit statistics, and confidence intervals from a fitted delay-discounting model.

Usage

```
results_dd(fit_dd_object)
```

Arguments

`fit_dd_object`	A fitted delay-discounting model object of class `"fit_dd"`, created by the `fit_dd()` function.

Value

A tibble containing the following columns:

- `id`: The participant or group ID (if applicable).
- `term`: The model parameter (e.g., k).
- `estimate`: The estimated value of the parameter.
- `std.error`: The standard error of the parameter estimate.
- `statistic`: The t-statistic for the parameter estimate.
- `p.value`: The p-value for the parameter estimate.
- `conf_low`: The lower bound of the 95% confidence interval.
- `conf_high`: The upper bound of the 95% confidence interval.
- `R2`: The coefficient of determination (R^2).

Examples

```
data <- data.frame(
  id = rep(1:2, each = 6),
  x = rep(c(1, 7, 30, 90, 180, 365), 2),
  y = c(0.9, 0.5, 0.3, 0.2, 0.1, 0.05, 0.85, 0.55, 0.35, 0.15, 0.1, 0.05)
)
fit <- fit_dd(data, equation = "mazur", method = "two stage")
results_dd(fit)
```

score_dd *Score 5.5 trial delay discounting from Qualtrics template*

Description

Score 5.5 trial delay discounting from Qualtrics template

Usage

```
score_dd(df)
```

Arguments

df	A dataframe containing all the columns

Details

Currently assumes the attending questions are present and labeled "Attend-LL" and "Attend-SS"

Value

A dataframe with id, indexes, response, k value, and effective delay 50.

Examples

```
score_dd(five.fivetrial_dd)
```

score_mcq27 *Score 27-item MCQ*

Description

Score 27-item MCQ

Usage

```
score_mcq27(
  dat = dat,
  impute_method = "none",
  round = 6,
  random = FALSE,
  trans = "none",
  return_data = FALSE,
  verbose = FALSE
)
```

Arguments

dat	Dataframe (longform) with subjectid, questionid, and response (0 for SIR/SS and 1 for LDR/LL)
impute_method	One of: "none", "ggm", "GGM", "inn", "INN"
round	Numeric specifying number of decimal places (passed to base::round())
random	Boolean whether to insert a random draw (0 or 1) for NAs. Default is FALSE
trans	Transformation to apply to k values: "none", "log", or "ln". Default is "none"
return_data	Boolean whether to return the original data and new imputed responses. Default is FALSE.
verbose	Boolean whether to print subject and question ids pertaining to missing data. Default is FALSE.

Value

Summary dataframe

Examples

```
score_mcq27(mcq27)
```

---

score_one_mcq27 *Score one subject's 27-item MCQ*

Description

Score one subject's 27-item MCQ

Usage

```
score_one_mcq27(dat, impute_method = "none", round = 6)
```

Arguments

dat	One subject's 27 items from the MCQ
impute_method	One of: "none", "ggm", "GGM", "inn", "INN"
round	Numeric specifying number of decimal places (passed to base::round())

Value

Vector with scored 27-item MCQ metrics

Examples

```
beezdiscounting:::score_one_mcq27(mcq27[mcq27$subjectid %in% 1, ])
```

score_pd *Score 5.5 trial probability discounting from Qualtrics template*

Description

Score 5.5 trial probability discounting from Qualtrics template

Usage

```
score_pd(df)
```

Arguments

df	A dataframe containing all the columns

Details

Currently assumes the attending questions are present and labeled "Attend-LL" and "Attend-SS"

Value

A dataframe with id, indexes, response, h value, and effective probability 50.

Examples

```
score_pd(five.fivetrial_pd)
```

summarize_mcq *Provide a summary of the results from the MCQ ouutput table.*

Description

Provide a summary of the results from the MCQ ouutput table.

Usage

```
summarize_mcq(res, na.rm = TRUE)
```

Arguments

res	Dataframe with MCQ results (output from the calc_mcq function)
na.rm	Boolean whether to remove NAs from the calculation

Value

Dataframe with summary statistics

Examples

```
summarize_mcq(score_mcq27(mcq27))
```

`timing_dd` *Extract timing metrics from 5.5 trial delay discounting from Qualtrics template*

Description

Extract timing metrics from 5.5 trial delay discounting from Qualtrics template

Usage

```
timing_dd(df)
```

Arguments

`df`	A dataframe containing all the columns

Details

Currently assumes the attending questions are present and labeled "Attend-LL" and "Attend-SS"

Value

A dataframe with ResponseId, indexes, values and timing

Examples

```
timing_dd(five.fivetrial_dd)
```

`timing_pd` *Extract timing metrics from 5.5 trial probability discounting from Qualtrics template*

Description

Extract timing metrics from 5.5 trial probability discounting from Qualtrics template

Usage

```
timing_pd(df)
```

Arguments

`df`	A dataframe containing all the columns

Details

Currently assumes the attending questions are present and labeled "Attend-LL" and "Attend-SS"

Value

A dataframe with ResponseId, indexes, values and timing

Examples

```
timing_pd(five.fivetrial_pd)
```

`wide_to_long_mcq` *Reshape MCQ data wide to long*

Description

Reshape MCQ data wide to long

Usage

```
wide_to_long_mcq(dat, items = 27)
```

Arguments

`dat`	Wide format MCQ assuming subject id is in column 1
`items`	Number of MCQ questions

Value

Long format data frame

`wide_to_long_mcq_excel` *Reshape MCQ data from wide (as used in the 21- and 27-Item Monetary Choice Questionnaire Automated Scorer) to long*

Description

Reshape MCQ data from wide (as used in the 21- and 27-Item Monetary Choice Questionnaire Automated Scorer) to long

Usage

```
wide_to_long_mcq_excel(dat)
```

Arguments

dat	Wide format MCQ data as used in the Excel Automated Scorers

Value

Long format data frame

Examples

```
wide_to_long_mcq_excel(long_to_wide_mcq_excel(generate_data_mcq(2)))
```

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