Package 'reflectR'

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Type Package

Title Automatic Scoring of the Cognitive Reflection Test

Version 2.1.4

Description Automatic coding of open-ended responses to the Cognitive Reflection Test (CRT), a widely used class of tests in cognitive science and psychology that assess the tendency to override an initial intuitive (but incorrect) answer and engage in reflection to reach a correct solution. The package standardizes CRT response coding across datasets in cognitive psychology, decision-making, and related fields. Automated coding reduces manual effort and improves reproducibility by limiting variability from subjective interpretation of open-ended responses. The package supports automatic coding and machine scoring for the original English-language CRT (Frederick, 2005) <doi:10.1257/089533005775196732>, CRT4 and CRT7 (Toplak et al., 2014) <doi:10.1080/13546783.2013.8447long (Primi et al., 2016) <doi:10.1002/bdm.1883>, and CRT-2 (Thomson & Oppenheimer, 2016) <doi:10.1017/s1930297500007622>.

URL https://github.com/g-corbelli/reflectR

BugReports https://github.com/g-corbelli/reflectR/issues

License GPL-3

Encoding UTF-8

RoxygenNote 7.3.2

Imports stringr

Suggests spelling

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NeedsCompilation no

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Contents

`CRT` *Automatic coding for Cognitive Reflection Test (Frederick, 2005) open-ended responses*

Description

Applies coding logic to any number of provided CRT question responses and supports multiple coding schemes. This function can output original coded responses, binary-coded responses, and aggregate scores based on these binary codings.

Usage

```
CRT(
  item1 = NULL,
  item2 = NULL,
  item3 = NULL,
  codingscheme = "categ",
  na.rm = TRUE
)
```

Arguments

`item1`	Vector of responses to the first CRT question, or NULL if not provided.
`item2`	Vector of responses to the second CRT question, or NULL if not provided.
`item3`	Vector of responses to the third CRT question, or NULL if not provided.
`codingscheme`	A character string indicating the desired coding scheme. Options are "categ" for the original 1, 2, 3 coding, "sum" for a sum of binary-coded correct answers, or "mean" for an average of binary-coded correct answers. The default is "categ".
`na.rm`	Logical, indicating whether to treat missing values as empty responses or preserve them as missing information. When TRUE, NAs are coded as "other" incorrect responses; when FALSE, NAs are preserved. Default is TRUE.

Value

A list containing the coded and, if applicable, binary-coded responses for each provided CRT question. For "sum" or "mean" coding schemes, additional vectors representing these aggregate scores are included.

Note

Developed by Giuseppe Corbelli, email: giuseppe.corbelli@uninettunouniversity.net, giuseppe.corbelli@uniroma1.it

Examples

```
# Automated scoring for CRT responses using the categorical coding scheme:
reflectR::CRT(
item1 = c("meh", "five", "10", "ten"),
item2 = c("5", "one hundred", NA, "five"),
item3 = c("47", "24", "forty-sevenn", "who knows"),
codingscheme = "categ",
na.rm = TRUE)

# Compute the sum score for CRT responses based on binary-coded correctness:
reflectR::CRT(
item1 = c("meh", "five", "10", "ten"),
item2 = c("5", "one hundred", NA, "five"),
item3 = c("47", "24", "forty-sevenn", "who knows"),
codingscheme = "sum",
na.rm = FALSE)$crt_sum
```

CRT4 *Automatic coding for Cognitive Reflection Test 4-item version (Toplak et al., 2014) open-ended responses*

Description

Applies coding logic to any number of provided CRT question responses and supports multiple coding schemes. This function can output original coded responses, binary-coded responses, and aggregate scores based on these binary codings.

Usage

```
CRT4(
  item1 = NULL,
  item2 = NULL,
  item3 = NULL,
  item4 = NULL,
  codingscheme = "categ",
  na.rm = TRUE
)
```

Arguments

item1	Vector of responses to the first CRT question, or NULL if not provided.
item2	Vector of responses to the second CRT question, or NULL if not provided.
item3	Vector of responses to the third CRT question, or NULL if not provided.

item4	Vector of responses to the fourth CRT question, or NULL if not provided.
codingscheme	A character string indicating the desired coding scheme. Options are "categ" for the original 1, 2, 3 coding, "sum" for a sum of binary-coded correct answers, or "mean" for an average of binary-coded correct answers. The default is "categ".
na.rm	Logical, indicating whether to treat missing values as empty responses or preserve them as missing information. When TRUE, NAs are coded as "other" incorrect responses; when FALSE, NAs are preserved. Default is TRUE.

Value

A list containing the coded and, if applicable, binary-coded responses for each provided CRT question. For "sum" or "mean" coding schemes, additional vectors representing these aggregate scores are included.

Note

Developed by Giuseppe Corbelli, email: giuseppe.corbelli@uninettunouniversity.net, giuseppe.corbelli@uniroma1.it

Examples

```
# Automated scoring for CRT4 responses using the categorical coding scheme:
reflectR::CRT4(
item1 = c("four", "nineeee", "maybe 4?"),
item2 = c("29", "thirty", "30"),
item3 = c("twentyyyy", "ten I think", "dunno"),
item4 = c("your behind", NA, "richer"),
codingscheme = "categ",
na.rm = TRUE)

# Compute the sum score for CRT4 responses based on binary-coded correctness:
reflectR::CRT4(
item1 = c("four", "nineeee", "maybe 4?"),
item2 = c("29", "thirty", "30"),
item3 = c("twentyyyy", "ten I think", "dunno"),
item4 = c("your behind", NA, "richer"),
codingscheme = "sum",
na.rm = FALSE)$crt_sum
```

CRT7 *Automatic coding for Cognitive Reflection Test 7-item expanded version (Toplak et al., 2014) open-ended responses*

Description

Applies coding logic to any number of provided CRT question responses and supports multiple coding schemes. This function can output original coded responses, binary-coded responses, and aggregate scores based on these binary codings.

Usage

```
CRT7(
  item1 = NULL,
  item2 = NULL,
  item3 = NULL,
  item4 = NULL,
  item5 = NULL,
  item6 = NULL,
  item7 = NULL,
  codingscheme = "categ",
  na.rm = TRUE
)
```

Arguments

item1	Vector of responses to the first CRT question, or NULL if not provided.
item2	Vector of responses to the second CRT question, or NULL if not provided.
item3	Vector of responses to the third CRT question, or NULL if not provided.
item4	Vector of responses to the fourth CRT question, or NULL if not provided.
item5	Vector of responses to the fifth CRT question, or NULL if not provided.
item6	Vector of responses to the sixth CRT question, or NULL if not provided.
item7	Vector of responses to the seventh CRT question, or NULL if not provided.
codingscheme	A character string indicating the desired coding scheme. Options are "categ" for the original 1, 2, 3 coding, "sum" for a sum of binary-coded correct answers, or "mean" for an average of binary-coded correct answers. The default is "categ".
na.rm	Logical, indicating whether to treat missing values as empty responses or preserve them as missing information. When TRUE, NAs are coded as "other" incorrect responses; when FALSE, NAs are preserved. Default is TRUE.

Value

A list containing the coded and, if applicable, binary-coded responses for each provided CRT question. For "sum" or "mean" coding schemes, additional vectors representing these aggregate scores are included.

Note

Developed by Giuseppe Corbelli, email: giuseppe.corbelli@uninettunouniversity.net, giuseppe.corbelli@uniroma1.it

Examples

```
# Automated scoring for CRT7 responses using the categorical coding scheme:
reflectR::CRT7(
item1 = c("five", "5 cents", "10"),
item2 = c("5", "one hundred", "100"),
item3 = c("47", "24", "forty seven"),
item4 = c("four", "nineeee", "maybe 4?"),
```

```
item5 = c("29", "thirty", "30"),
item6 = c("twentyyyy", "ten I think", NA),
item7 = c("your behind", "poorer", "richer"),
codingscheme = "categ",
na.rm = TRUE)

# Compute the sum score for CRT7 responses based on binary-coded correctness:
reflectR::CRT7(
item1 = c("five", "5 cents", "10"),
item2 = c("5", "one hundred", "100"),
item3 = c("47", "24", "forty seven"),
item4 = c("four", "nineeee", "maybe 4?"),
item5 = c("29", "thirty", "30"),
item6 = c("twentyyyy", "ten I think", NA),
item7 = c("your behind", "poorer", "richer"),
codingscheme = "sum",
na.rm = FALSE)$crt_sum
```

`CRTlong` *Automatic coding for Cognitive Reflection Test LONG (Primi et al., 2016) open-ended responses*

Description

Applies coding logic to any number of provided CRT question responses and supports multiple coding schemes. This function can output original coded responses, binary-coded responses, and aggregate scores based on these binary codings.

Usage

```
CRTlong(
  item1 = NULL,
  item2 = NULL,
  item3 = NULL,
  item4 = NULL,
  item5 = NULL,
  item6 = NULL,
  codingscheme = "categ",
  na.rm = TRUE
)
```

Arguments

`item1`	Vector of responses to the first CRT question, or NULL if not provided.
`item2`	Vector of responses to the second CRT question, or NULL if not provided.
`item3`	Vector of responses to the third CRT question, or NULL if not provided.
`item4`	Vector of responses to the fourth CRT question, or NULL if not provided.

item5	Vector of responses to the fifth CRT question, or NULL if not provided.
item6	Vector of responses to the sixth CRT question, or NULL if not provided.
codingscheme	A character string indicating the desired coding scheme. Options are "categ" for the original 1, 2, 3 coding, "sum" for a sum of binary-coded correct answers, or "mean" for an average of binary-coded correct answers. The default is "categ".
na.rm	Logical, indicating whether to treat missing values as empty responses or preserve them as missing information. When TRUE, NAs are coded as "other" incorrect responses; when FALSE, NAs are preserved. Default is TRUE.

Value

A list containing the coded and, if applicable, binary-coded responses for each provided CRT question. For "sum" or "mean" coding schemes, additional vectors representing these aggregate scores are included.

Note

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Examples

```
# Automated scoring for CRTlong responses using the categorical coding scheme:
reflectR::CRTlong(
item1 = c("five", "5 cents", "10"),
item2 = c("5", "one hundred", "100"),
item3 = c("47", "24", "forty seven"),
item4 = c("3 elves", "dunno", "six"),
item5 = c(NA, "thirty", "30"),
item6 = c("15", "fifteen", "0"),
codingscheme = "categ",
na.rm = TRUE)

# Compute the sum score for CRTlong responses based on binary-coded correctness:
reflectR::CRTlong(
item1 = c("five", "5 cents", "10"),
item2 = c("5", "one hundred", "100"),
item3 = c("47", "24", "forty seven"),
item4 = c("3 elves", "dunno", "six"),
item5 = c(NA, "thirty", "30"),
item6 = c("15", "fifteen", "0"),
codingscheme = "sum",
na.rm = FALSE)$crt_sum
```

CRTtwo *Automatic coding for Cognitive Reflection Test 2 (Thomson & Oppenheimer, 2016) open-ended responses*

Description

Applies coding logic to any number of provided CRT question responses and supports multiple coding schemes. This function can output original coded responses, binary-coded responses, and aggregate scores based on these binary codings.

Usage

```
CRTtwo(
  item1 = NULL,
  item2 = NULL,
  item3 = NULL,
  item4 = NULL,
  codingscheme = "categ",
  na.rm = TRUE
)
```

Arguments

item1	Vector of responses to the first CRT question, or NULL if not provided.
item2	Vector of responses to the second CRT question, or NULL if not provided.
item3	Vector of responses to the third CRT question, or NULL if not provided.
item4	Vector of responses to the fourth CRT question, or NULL if not provided.
codingscheme	A character string indicating the desired coding scheme. Options are "categ" for the original 1, 2, 3 coding, "sum" for a sum of binary-coded correct answers, or "mean" for an average of binary-coded correct answers. The default is "categ".
na.rm	Logical, indicating whether to treat missing values as empty responses or preserve them as missing information. When TRUE, NAs are coded as "other" incorrect responses; when FALSE, NAs are preserved. Default is TRUE.

Value

A list containing the coded and, if applicable, binary-coded responses for each provided CRT question. For "sum" or "mean" coding schemes, additional vectors representing these aggregate scores are included.

Note

Developed by Giuseppe Corbelli, email: giuseppe.corbelli@uninettunouniversity.net, giuseppe.corbelli@uniroma1.it

Examples

```
# Automated scoring for CRTtwo responses using the categorical coding scheme:
reflectR::CRTtwo(
item1 = c("first place", "second place", "1", "seconddd", "meh"),
item2 = c("7", "eightt", "seven", NA, "8"),
item3 = c("emily", "i think emily", "JUNEE", "maybe june", "the name is emily"),
item4 = c("nothing", "27 sqmt", "0", "it's empty", "i suck at math"),
codingscheme = "categ",
```

```
na.rm = TRUE)

# Compute the sum score for CRTtwo responses based on binary-coded correctness:
reflectR::CRTtwo(
item1 = c("first place", "second place", "1", "seconddd", "meh"),
item2 = c("7", "eightt", "seven", NA, "8"),
item3 = c("emily", "i think emily", "JUNEE", "maybe june", "the name is emily"),
item4 = c("nothing", "27 sqmt", "0", "it's empty", "i suck at math"),
codingscheme = "sum",
na.rm = FALSE)$crt_sum
```

`itaCRTtwo` *Automatic coding for Cognitive Reflection Test 2 (Thomson & Oppenheimer, 2016) open-ended responses (Italian language)*

Description

Applies coding logic to any number of provided CRT question responses and supports multiple coding schemes. This function can output original coded responses, binary-coded responses, and aggregate scores based on these binary codings.

Usage

```
itaCRTtwo(
  item1 = NULL,
  item2 = NULL,
  item3 = NULL,
  item4 = NULL,
  codingscheme = "categ",
  na.rm = TRUE
)
```

Arguments

`item1`	Vector of responses to the first CRT question, or NULL if not provided.
`item2`	Vector of responses to the second CRT question, or NULL if not provided.
`item3`	Vector of responses to the third CRT question, or NULL if not provided.
`item4`	Vector of responses to the fourth CRT question, or NULL if not provided.
`codingscheme`	A character string indicating the desired coding scheme. Options are "categ" for the original 1, 2, 3 coding, "sum" for a sum of binary-coded correct answers, or "mean" for an average of binary-coded correct answers. The default is "categ".
`na.rm`	Logical, indicating whether to treat missing values as empty responses or preserve them as missing information. When TRUE, NAs are coded as "other" incorrect responses; when FALSE, NAs are preserved. Default is TRUE.

Value

A list containing the coded and, if applicable, binary-coded responses for each provided CRT question. For "sum" or "mean" coding schemes, additional vectors representing these aggregate scores are included.

Note

Developed by Giuseppe Corbelli, email: giuseppe.corbelli@uninettunouniversity.net, giuseppe.corbelli@uniroma1.it

Examples

```
# Automated scoring for itaCRTtwo responses using the categorical coding scheme:
reflectR::itaCRTtwo(
item1 = c("al primo", "secondo", "1", NA),
item2 = c("7", "non so", "sette", "otto"),
item3 = c("pprimo", "carlo", "CARLOO", "si chiama boh"),
item4 = c("nulla", "27 metri cubi", "mille", "zero"),
codingscheme = "categ",
na.rm = TRUE)

# Compute the sum score for itaCRTtwo responses based on binary-coded correctness:
reflectR::itaCRTtwo(
item1 = c("al primo", "secondo", "1", NA),
item2 = c("7", "non so", "sette", "otto"),
item3 = c("pprimo", "carlo", "CARLOO", "si chiama boh"),
item4 = c("nulla", "27 metri cubi", "mille", "zero"),
codingscheme = "sum",
na.rm = FALSE)$crt_sum
```

`reflectR` *Automatic Scoring of the Cognitive Reflection Test*

Description

The reflectR package provides functions for automatic coding of open-ended responses to several forms of the Cognitive Reflection Test (CRT). The CRT is widely used in cognitive psychology, decision-making research, and related fields to assess the tendency to override an initial intuitive (but incorrect) answer and engage in reflection to reach a correct solution. The package standardizes CRT response coding across datasets and supports different coding schemes. Automated coding reduces manual effort and improves reproducibility by limiting variability from subjective interpretation of open-ended responses.

Details

The package includes functions to code responses from:

- `CRT`: Original CRT version by Frederick (2005)
- `CRT4`: 4-item CRT version by Toplak et al. (2014)

- `CRT7`: 7-item expanded CRT version by Toplak et al. (2014)
- `CRTlong`: CRT LONG version by Primi et al. (2016)
- `CRTtwo`: CRT version 2 by Thomson & Oppenheimer (2016)
- `itaCRTtwo`: Italian version of CRT version 2 by Thomson & Oppenheimer (2016)

Note

While reflectR draws inspiration from the scientific literature on the CRT, it has been independently developed and does not hold any affiliation with the original authors of these tests. This software is provided "as is", without any express or implied warranties of accuracy or reliability.

Acknowledgments

The development of this package benefited significantly from the kind insight and suggestion provided by Dr. Keela Thomson, whose contribution is gratefully acknowledged. Special thanks are also due to Dr. Paolo Giovanni Cicirelli, Prof. Marinella Paciello, Dr. Carmela Sportelli, and Prof. Francesca D'Errico. Acknowledgment is also due to the European project STERHEOTYPES for funding the data collection that produced the datasets initially used for manual multi-rater coding of CRT-2 items.

Author(s)

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References

Frederick, S. (2005). Cognitive Reflection and Decision Making. *Journal of Economic Perspectives*, 19(4), 25-42. doi:10.1257/089533005775196732

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Thomson, K. S., & Oppenheimer, D. M. (2016). Investigating an alternate form of the cognitive reflection test. *Judgment and Decision Making*, 11(1), 99-113. doi:10.1017/s1930297500007622

See Also

Useful links:

- https://github.com/g-corbelli/reflectR
- Report bugs at https://github.com/g-corbelli/reflectR/issues

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