

RANDOMIZING AND AUTOMATING ASSESSMENT WITH R exams

THE `exams` PACKAGE

- by [@AchimZeileis](#) and others, Statistics, Universität Innsbruck
- www.r-exams.org
- latest release 2.3-2 (2018-12-08)

OVERVIEW

design

combine

generate

```
```{r data generation, echo=FALSE, results = 'hide', message = FALSE}
edata <- xngen::exams_two_way_popmeans(c(A = FALSE, B = TRUE, AB = TRUE))
```

Question
=====

Consider the population means from a factorially designed experiment below.

```{r showdata, echo = FALSE}
edata$edata
```

Which of the following statements are correct?

```{r questionlist, echo = FALSE, results='asis'}
exams::answerlist(edata$questions, markup = "markdown")
```

Solution
=====

```{r solutionlist, echo = FALSE, results='asis'}
exams::answerlist(ifelse(edata$solutions, "True", "False"), edata$explanations,
markup = "markdown")
```

Meta-information
=====
extype: mchoice
exsolution: `r exams::mchoice2string(edata$solutions)`
exname: main effects and interactions
```

```
library("exams")

myexam <- list(
  "one_way2.Rmd",
  "glm3.Rmd",
  "cat_by_cont2.Rmd",
  "fac_meix3.Rmd",
  "lmer_output2.Rmd",
  "maxrfx_single2.Rmd",
  "logit_sl2.Rmd"
)
```

```
set.seed(172839)
ex1 <- exams2nops(
  myexam, n = 1, dir = ".",
  points = c(rep(2, length(myexam))),
  showpoints = FALSE,
  institution = "University of Glasgow",
  title = "PSYCH 4037 Practice",
  logo = NULL, date = "2018-12-15",
  samepage = TRUE,
  pages = "appendix_critical_f_ratios.pdf",
  blank = c(0, 6),
  replacement = TRUE)
```



schoice : Single-Choice

- Task: Select the only correct item out of a list of alternatives.
- Knowledge quiz: Arbitrary number of shuffled distractors (e.g., [swisscapital](#)).
- Numeric exercises: Distractors are random numbers (from a set/interval) and/or typical arithmetic mistakes (e.g., [deriv2](#), [tstat2](#)).
- Shuffling (or subsampling) can be turned on or off.



mchoice : Multiple-Choice

- Task: Select all correct items out of a list of alternatives.
- Knowledge quiz: Arbitrary number of shuffled true or false statements (e.g., [switzerland](#)).
- Interpretations: Numeric statements that are approximately correct or clearly wrong (e.g., [boxplots](#), [scatterplot](#), [ttest](#)).



num : Numeric

- Task: Compute a single numeric value (within a tolerance interval).
- Numeric exercise: Solving typical arithmetic problems often based on some random numbers (e.g., [deriv](#), [tstat](#)).



string : Character String

- Task: Enter the answer (exactly) as a character string.
- Knowledge quiz: Sample a word/phrase from a given vocabulary or list of question/answer pairs (e.g., [function](#), [countrycodes](#)).

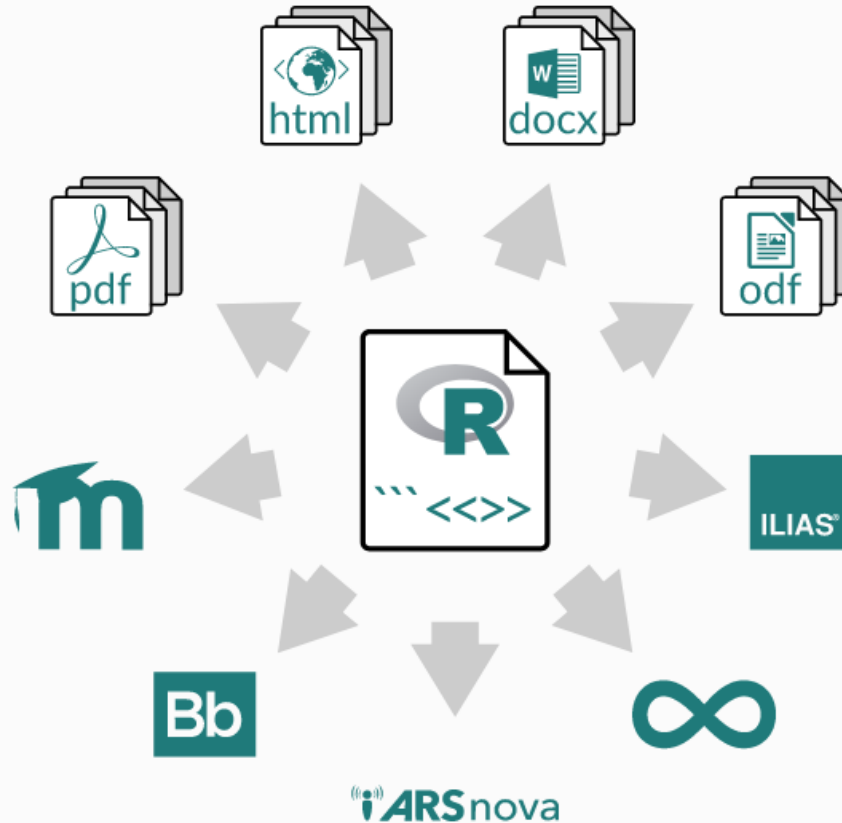


cloze : Cloze (Combinations of the Above)

- Task: Solve a set of sub-exercises combining any of the above types.
- Numeric exercises: Several numeric quantities based on the same problem setting (e.g., [confint2](#), [dist2](#), [fourfold](#)).
- Statistics: Qualitative single-choice questions plus numeric exercises based on randomly-generated data (e.g., [boxhist](#), [lm](#)).

OUTPUT FORMATS

Output formats



- PDFs for written exams (with automatic scanning and evaluation).
- Custom files of various types (PDF, HTML, Docx, ODF, ...), using flexible document templates.
- Imports for learning management systems (like Moodle, Blackboard, OLAT, Ilias, ...).
- ARSnova (live voting software).

DESIGNING MCQS

```
```{r data generation, echo=FALSE, results = 'hide', message = FALSE}
edata <- xngen::exams_two_way_popmeans(c(A = FALSE, B = TRUE, AB = TRUE))
```
```

Question

=====

Consider the population means from a factorially designed experiment below.

```
```{r showdata, echo = FALSE}
edata$data
```
```

Which of the following statements are correct?

```
```{r questionlist, echo = FALSE, results='asis'}
exams::answerlist(edata$questions, markup = "markdown")
```
```

Solution

=====

```
```{r solutionlist, echo = FALSE, results='asis'}
exams::answerlist(ifelse(edata$solutions, "True", "False"),
 edata$explanations, markup = "markdown")
```
```

Meta-information

=====

extype: mchoice

exsolution: `r exams::mchoice2string(edata\$solutions)`

exname: main effects and interactions

OUTPUT

| | | | | |
|--|---|--|--------------------------|--------------------------|
| + | University of Glasgow | + | | |
| PSYCH 4037 Practice 2018-12-15 | | | | |
| Personal Data | | Registration Number | | |
| Family Name:
_____ | | 0 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 0
1 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 1
2 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 2
3 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 3
4 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 4
5 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 5
6 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 6
7 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 7
8 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 8
9 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> 9 | | |
| Given Name:
_____ | | | | |
| Signature:

checked | | | | |
| In this section no changes or modifications must be made! | | Scrambling
0 0 | | |
| Type
<input type="text" value="005"/> | Exam ID
<input type="text" value="18121500001"/> | | | |
| Please mark the boxes carefully: <input checked="" type="checkbox"/> Not marked: <input type="checkbox"/> or <input type="checkbox"/> | | | | |
| This document is scanned automatically. Please keep clean and do not bend or fold. For filling in the document please use a blue or black pen . | | | | |
| Only clearly marked and positionally accurate crosses will be processed! | | | | |
| Answers 1 - 4 | | | | |
| a | b | c | d | e |
| 1 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 2 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 3 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| 4 | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> | <input type="checkbox"/> |
| a | b | c | d | e |

OUTPUT

PSYCH 4037 Practice: 18121500001

1. Consider the population means from a factorially designed experiment below.

```
##      B
## A    B1 B2
## A1  57 93
## A2  51 87
```

Which of the following statements are correct?

- (a) There is not a main effect of A
- (b) There is a main effect of B
- (c) The simple effect of A at B1 equals the simple effect of A at B2
- (d) The simple effect of B at A1 equals the simple effect of B at A2
- (e) All main effects and interactions are present

2. Consider the population means from a factorially designed experiment below.

```
##      B
## A    B1 B2
## A1  56 100
## A2  68 112
```

Which of the following statements are correct?

- (a) There is not a main effect of A
- (b) There is a main effect of B
- (c) The simple effect of A at B1 equals the simple effect of A at B2
- (d) The simple effect of B at A1 equals the simple effect of B at A2
- (e) Not all main effects and interactions are present

SCANNING

- scan in response sheets using Canon copier
 - small batches (~25)
 - tip: sort according to student ID number
- receive PDF via email

PROCESSING

```
library("exams")

res <- nops_scan(images = dir("png", full.names = TRUE),
                 dir = "results")

## results are stored in Daten.txt
## nops_eval() will evaluate results and create html reports
```

PERFORMANCE

- 9/116 (7.8%) did not scan
 - 3 due to students not following instructions
 - 6 for unknown reasons
- ~30% of student ID numbers did not scan and had to be entered manually
- randomly selected 40 response sheets and manually checked the scanning results (1400 boxes)
- 1399/1400 boxes were scanned correctly

PROBLEMS

- `pdftk` was unavailable for Ubuntu 18.04. Consequently, `nops_scan()` did not work with PDF and had to manually break the PDF into separate PNG files
- Also I got this error using `imagemagick`:

```
convert: not authorized `filename.png`
```

and solved it with:

- <https://cromwell-intl.com/open-source/pdf-not-authorized.html>

VERDICT

- great for written exams
- requires a lot of upfront costs designing questions, but randomly generated exams will save time over the long run
- did not work out of the box for Linux, but perhaps Windows/Mac OS is better supported
- scanning was highly reliable, even with low-quality input