redcapAPI Best Practices

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Introduction

REsearch Data Collection or REDCap puts a lot of power into the hands of folks wishing to collect data, from surveys to running clinical trials. Once the data is collected the task of summarization into reports falls upon the statistician or data scientist. R being a useful tool, the department of Biostatistics at Vanderbilt University Medical Center has provided the community with `redcapAPI` to facilitate using REDCap from R.

`redcapAPI` has grown a lot over time, and recently what once worked inside the code and interface for `redcapAPI` no longer aligned with where the REDCap project was today. To this end, a major refactor based on user feedback was undertaken to better address the challenges of a researcher in todays computing environments. This new interface began with version 2.7.0.

Primarily the means of retrieving records has changed from `exportRecords` to `exportRecordsTyped`. The rename of the function is due to the change of the interface to allow time for systems to switch over to the new function. It is important to read over this document and understand the changes if one is a current user of `exportRecords`. However, the changes go much deeper and this document will outline what is a best practices approach to using the library.

The real goal is that a user make the fewest calls to do accomplish their job and have data ready for analysis. This can't happen without user involvement–if the library doesn't work easily for your needs open an issue on github and we'll do our best to work with you.

If one wishes to reproduce these examples, see '*Reproducing this Vignette*' towards the end of this document.

API_KEY security

The first thing to consider is the API_KEY. This key is what allows for data export from a REDCap project. It is the equivalent of a user name, password and project identifier in a single character string. As such it should be protected as strongly as your password into the systems storing ones data. In the United States, the HIPAA law has a minimum violation of $100 per private health record exposed. In a large clinical trial setting this can easily run into millions of dollars of potential risk.

As such, **the API_KEY should never be stored in a plain text file** unless it's on a tightly monitored and secured production system that cannot work without it.

Logging into REDCap every time one wants to work, and then having to juggle multiple API_KEYs quickly becomes burdensome. Copy and pasting that API_KEY into code (plain text!) and then remembering to delete when finished is too easy to forget. A single git commit and simple push to share code and the API_KEY is exposed to the world. It's a very easy mistake to make. In the United States there is a minimum HIPAA penalty of $100 per medical record exposed. An API_KEY that accesses a large clinical trial, if published could resulting millions of dollars in fines.

What follows is an example helper function using an encrypted local file to store API_KEYS to open connections to REDCap. Using this function greatly reduces the risk of exposure.

Note: *This functionality was originally in the package* `rccola`*, but this library is no longer needed. The functionality is built into* `redcapAPI` *and only requesting connections is supported. This is the preferred long term solution.*

```
library(redcapAPI)
library(Hmisc)
```

```
## Loading required package: lattice
```

```
## Loading required package: survival
```

```
## Loading required package: Formula
```

```
## Loading required package: ggplot2
```

```
##
## Attaching package: 'Hmisc'
```

```
## The following objects are masked from 'package:base':
##
##     format.pval, units
```

```
# Cuts down on password requests on MAC
options(keyring_backend=keyring::backend_file)

unlockREDCap(c(test_conn    = 'TestRedcapAPI', # REDCap project 1
               sandbox_conn = 'SandboxAPI'),   # REDCap project 2
             keyring      = 'API_KEYs',
             envir        = globalenv(),
             url          = 'https://redcap.vanderbilt.edu/api/')
```

```
## Please enter password in TK window (Alt+Tab)
```

The first time this is called, it asks the user for a password that will be used to unlock the crypto locker `API_KEYs`. A keyring can contain multiple API_KEYs and hence the name we've given it here–one is free to use any naming they desire. The first time it is run it will prompt for each API_KEY by the name you've given it, e.g. 'TestRedcapAPI'. If an API_KEY does not connect the call will fail and halt execution in R and it will be deleted from the key_ring to prompt you to enter it again. Subsequent calls will not prompt for an API_KEY, just the password you've given to unlock the remaining keys in the locker. It will stay open in an R session and not prompt again (*caveat: each knitr call creates a new session, so it will prompt each call to knitr*).

Specifying `envir=globalenv()` tells the function to create the connections in the global environment as variables. Without this the function returns a list of the connections.

In summary, the keyring is stored in an encrypted form accessible by a single password. If ones laptop were stolen or compromised it is far more difficult for a hacker to gain further access due to the encryption.

This library also cooperates with our production environments by looking for these things in an plain text file `yml` in the directory above execution. This functionality is *only* recommended for system admins and should **never** be used on a work desktop or laptop.

Also to make sure that R in trying to be helpful doesn't save API_KEYs to files, it is recommended to turn off any saving of workspace data. In RStudio this is under "Tools -> Global Options (General)", set 'Save Workspace to .RData on exit' to *Never*.

For command line users create an `.Rprofile` file in your home directory containing the following base function override:

```
utils::assignInNamespace(
  "q",
  function(save="no", status=0, runLast=TRUE)
  {
    .Internal(quit(save, status, runLast))
  },
  "base"
)
```

If the easiest path is the best path, it will become the common path. We've done our best to make best security practice the easiest path.

The Connection Object (caching)

The connection objects are a much richer object. During a lot of REDCap interaction the meta data is necessary to properly interpret the data and guides data transformation. Instead of calling multiple times with each call for this data, the meta data is now cached in the connection object.

Caching saves a lot of round trip calls, but brings with it the burden that sometimes it needs to be refreshed. For example, one is developing in a REDCap object and has an R environment interacting with it. After a call, it's noted that something needs changed in the project proper. Using the REDCap GUI the project's definition is changed. This requires flushing the cache so the next call will retrieve and cached the new data.

```
head(test_conn$fieldnames())
```

```
##   original_field_name choice_value export_field_name
## 1           record_id         <NA>         record_id
## 2            date_dmy         <NA>          date_dmy
## 3            date_mdy         <NA>          date_mdy
## 4            date_ymd         <NA>          date_ymd
## 5    datetime_dmy_hm         <NA>   datetime_dmy_hm
## 6    datetime_mdy_hm         <NA>   datetime_mdy_hm
```

```
test_conn$flush_fieldnames()

head(test_conn$metadata())
```

```
##        field_name            form_name section_header field_type
## 1       record_id fieldtovar_datetimes           <NA>       text
## 2        date_dmy fieldtovar_datetimes           <NA>       text
## 3        date_mdy fieldtovar_datetimes           <NA>       text
## 4        date_ymd fieldtovar_datetimes           <NA>       text
## 5 datetime_dmy_hm fieldtovar_datetimes           <NA>       text
## 6 datetime_mdy_hm fieldtovar_datetimes           <NA>       text
##            field_label select_choices_or_calculations field_note
```

```
## 1            Record ID                            <NA>         NA
## 2         Date (D-M-Y)                            <NA>         NA
## 3         Date (M-D-Y)                            <NA>         NA
## 4         Date (Y-M-D)                            <NA>         NA
## 5 Datetime (D-M-Y H:M)                            <NA>         NA
## 6 Datetime (M-D-Y H:M)                            <NA>         NA
##   text_validation_type_or_show_slider_number text_validation_min
## 1                                       <NA>                  NA
## 2                                  date_dmy                   NA
## 3                                  date_mdy                   NA
## 4                                  date_ymd                   NA
## 5                              datetime_dmy                   NA
## 6                              datetime_mdy                   NA
##   text_validation_max identifier branching_logic required_field
## 1                  NA         NA            <NA>             NA
## 2                  NA         NA            <NA>             NA
## 3                  NA         NA            <NA>             NA
## 4                  NA         NA            <NA>             NA
## 5                  NA         NA            <NA>             NA
## 6                  NA         NA            <NA>             NA
##   custom_alignment question_number matrix_group_name matrix_ranking
## 1             <NA>              NA                NA             NA
## 2             <NA>              NA                NA             NA
## 3             <NA>              NA                NA             NA
## 4             <NA>              NA                NA             NA
## 5             <NA>              NA                NA             NA
## 6             <NA>              NA                NA             NA
##   field_annotation
## 1             <NA>
## 2   units={"time"}
## 3             <NA>
## 4             <NA>
## 5             <NA>
## 6             <NA>
```

```
test_conn$flush_metadata()

test_conn$flush_all()
```

Tip: Remember to flush cache after updating project meta data in the GUI.

Another benefit the new connection object brings is the idea of retry. When developing, it's okay if the network hiccups, one can simple rerun the report or command and try again. In a production environment, a report that makes a lot of API calls is assuming that all of those calls are successful to be successful. This is not that case 100% of the time, so a mitigation strategy is needed on the connection object. This is implemented via the `retries`, `retry_interval` and `retry_quietly` parameters when calling to build the connection objects. These are passed to `redcapAPI::redcapConnection` as additional parameters. The default is to quietly make 5 retries on a call, with an interval of 2, 4, 8, 16, and 32 seconds between retries. This greatly improves the odds of building a complex report involving a lot of REDCap calls. The user of the package gets this for **free**.

exportRecordsTyped

`exportRecords`, `redcapFactor` and `redcapFlipFactor` still exist in the library but are deprecated. `exportRecordsTyped` is the preferred way forward.

Now armed with a connection from a secured API_KEY in one's R session, the usual goal is to get the data into R, properly typed for use in an R model. Dates and Factors need to be converted into a usable format that makes statistical modelling easy. Type theory is a very deep theoretical topic in mathematics and computer science and thus this topic is a complex. `redcapAPI` has made a lot of default choices which we felt will satisfy 80% of use cases.

However, these choices are not a limitation. Care has been taken to allow each of these choices a user defined override and be extensible to handle just about anything the user would prefer. The strategy chosen is called *inversion of control*.

Understanding the type 'casting' algorithm is important if the default choices are not satisfactory. Casting refering to the transformation of one data class in R to another (aka type casting).

The algorithm

REDCap stores all data as character strings. A validation on input may be specified as a `field_type` in the REDCap project. However, these might be added later, changed or raw data from a different system pushed up. The declared `field_type` from the REDCap meta data has no guarantee to describe the data format of the actual data. This divergence can be a source of frustration and difficulty, thus we've designed the following steps of the process to cast a column of data from a project:

1. Detect fields that are NA. This defaults to `""` or `"NA"`.
2. Fields that are not NA, are passed through a validation for the `field_type`.
3. Fields that are not NA, that pass validation are then cast to the desired class.

The choice of which routine to call is a defined by `field_type`. The current version of REDCap as of this writing is: `date_`, `datetime_`, `datetime_seconds_`, `time_mm_ss`, `time_hh_mm_ss`, `time`, `float`, `number`, `calc`, `int`, `integer`, `yesno`, `truefalse`, `checkbox`, `form_complete`, `select`, `radio`, `dropdown`, and `sql`.

The field_type for `date_`, `datetime_` and `datetime_seconds` are all truncated from the original as all of these are reported in the API as ymd.

NA

The definition of NA may vary. An example is someone uploaded external data that says "-5" is an NA due to a code book. These values are not desired to be treated as anything but NA. In this case the user needs to specify an override.

The expected function signature is `function(x, field_name, coding)`. The following demonstrates some test data. It follows with a declaration that date "2023-03-24" is to be treated as NA. Then, "2023-03-24" is only to be treated as NA for the field `date_mdy`. Coding is only provided if there is a defined code book for the variable.

```
head(exportRecordsTyped(test_conn)[,1:10])
```

```
##   record_id redcap_event_name redcap_repeat_instrument redcap_repeat_instance
## 1         1     event_1_arm_1                      <NA>                   <NA>
## 2         1     event_1_arm_1     repeating_instrument                      1
## 3         1     event_1_arm_1     repeating_instrument                      2
```

```
## 4         2     event_1_arm_1                     <NA>                     <NA>
## 5         3     event_1_arm_1                     <NA>                     <NA>
## 6        10     event_1_arm_1                     <NA>                     <NA>
##     date_dmy   date_mdy   date_ymd     datetime_dmy_hm     datetime_mdy_hm
## 1 2023-02-24 2023-02-24 2023-02-24 2023-02-24 12:04:00 2023-02-24 12:04:00
## 2       <NA>       <NA>       <NA>                <NA>                <NA>
## 3       <NA>       <NA>       <NA>                <NA>                <NA>
## 4       <NA>       <NA>       <NA>                <NA>                <NA>
## 5       <NA>       <NA>       <NA>                <NA>                <NA>
## 6       <NA>       <NA>       <NA>                <NA>                <NA>
##       datetime_ymd_hm
## 1 2023-02-24 12:04:00
## 2                <NA>
## 3                <NA>
## 4                <NA>
## 5                <NA>
## 6                <NA>
```

```
my_na_detector <- function(x, field_name, coding) is.na(x) | x=="" | x == "2023-02-24"

head(exportRecordsTyped(test_conn, na=list(date_=my_na_detector))[,1:10])
```

```
##   record_id redcap_event_name redcap_repeat_instrument redcap_repeat_instance
## 1         1     event_1_arm_1                     <NA>                     <NA>
## 2         1     event_1_arm_1     repeating_instrument                        1
## 3         1     event_1_arm_1     repeating_instrument                        2
## 4         2     event_1_arm_1                     <NA>                     <NA>
## 5         3     event_1_arm_1                     <NA>                     <NA>
## 6        10     event_1_arm_1                     <NA>                     <NA>
##   date_dmy date_mdy date_ymd     datetime_dmy_hm     datetime_mdy_hm
## 1     <NA>     <NA>     <NA> 2023-02-24 12:04:00 2023-02-24 12:04:00
## 2     <NA>     <NA>     <NA>                <NA>                <NA>
## 3     <NA>     <NA>     <NA>                <NA>                <NA>
## 4     <NA>     <NA>     <NA>                <NA>                <NA>
## 5     <NA>     <NA>     <NA>                <NA>                <NA>
## 6     <NA>     <NA>     <NA>                <NA>                <NA>
##       datetime_ymd_hm
## 1 2023-02-24 12:04:00
## 2                <NA>
## 3                <NA>
## 4                <NA>
## 5                <NA>
## 6                <NA>
```

```
my_limited_na_detector <- function(x, field_name, coding)
  is.na(x) |
  x==""    |
  field_name=='date_mdy'

head(exportRecordsTyped(test_conn, na=list(date_=my_limited_na_detector))[,1:10])
```

```
##   record_id redcap_event_name redcap_repeat_instrument redcap_repeat_instance
## 1         1     event_1_arm_1                     <NA>                     <NA>
```

```
## 2         1     event_1_arm_1     repeating_instrument                    1
## 3         1     event_1_arm_1     repeating_instrument                    2
## 4         2     event_1_arm_1                     <NA>                 <NA>
## 5         3     event_1_arm_1                     <NA>                 <NA>
## 6        10     event_1_arm_1                     <NA>                 <NA>
##     date_dmy date_mdy   date_ymd     datetime_dmy_hm     datetime_mdy_hm
## 1 2023-02-24     <NA> 2023-02-24 2023-02-24 12:04:00 2023-02-24 12:04:00
## 2       <NA>     <NA>       <NA>                <NA>                <NA>
## 3       <NA>     <NA>       <NA>                <NA>                <NA>
## 4       <NA>     <NA>       <NA>                <NA>                <NA>
## 5       <NA>     <NA>       <NA>                <NA>                <NA>
## 6       <NA>     <NA>       <NA>                <NA>                <NA>
##       datetime_ymd_hm
## 1 2023-02-24 12:04:00
## 2                <NA>
## 3                <NA>
## 4                <NA>
## 5                <NA>
## 6                <NA>
```

It is hopefully a rare case when this is needed. The next step, validation, has an available report that will hopefully make it clear when it is.

Validation

This step based on `field_type` calls a function that returns a vector of logical specifying what is valid or not. The simplest of these is via a regular expression or regex. Detailing construction of a regex for validation of a field is outside the scope of this document, good tutorials are available online such as https://regextutorial.org/. It's helpful to have an interactive environment to develop one, we used https://regex101.com/ frequently in developing the regexs provided by default.

The function signature once again is `function(x, field_name, coding)`.

The default set of validations is:

```
list(
  date_              = valRx("^[0-9]{1,4}-(0?[1-9]|1[012])-(0?[1-9]|[12][0-9]|3[01])$"),
  datetime_          = valRx("^[0-9]{1,4}-(0?[1-9]|1[012])-(0?[1-9]|[12][0-9]|3[01])\\s([0-9]|0[0-9]|1[
  datetime_seconds_  = valRx("^[0-9]{1,4}-(0?[1-9]|1[012])-(0?[1-9]|[12][0-9]|3[01])\\s([0-9]|0[0-9]|1[
  time_mm_ss         = valRx("^[0-5][0-9]:[0-5][0-9]$"),
  time_hh_mm_ss      = valRx("^([0-9]|0[0-9]|1[0-9]|2[0-3]):[0-5][0-9]:[0-5][0-9]$"),
  time               = valRx("^([0-9]|0[0-9]|1[0-9]|2[0-3]):[0-5][0-9]$"),
  float              = valRx("^[-+]?(([0-9]+\\.?[0-9]*)|(\\.[0-9]+))([Ee][+-]?[0-9]+)?$"),
  number             = valRx("^[-+]?(([0-9]+\\.?[0-9]*)|(\\.[0-9]+))([Ee][+-]?[0-9]+)?$"),
  calc               = valRx("^[-+]?(([0-9]+\\.?[0-9]*)|(\\.[0-9]+))([Ee][+-]?[0-9]+)?$"),
  int                = valRx("^[-+]?[0-9]+(|\\.|\\.[0]+)$"),
  integer            = valRx("^[-+]?[0-9]+$"),
  yesno              = valRx("^(?i)(0|1|yes|no)$"),
  truefalse          = valRx("^(0|1|true|false)$"),
  checkbox           = valRx("^(?i)(0|1|yes|no)$"),
  form_complete      = valRx("^[012]$"),
  select             = valChoice,
  radio              = valChoice,
  dropdown           = valChoice,
```

```
  sql                = NA # Incomplete at present
)
```

Ignore the complex regular expressions above if you're not familiar. Let's look at a building a simple validation for `form_complete`: `valRx("^[012]$")`. The regex here starts with "^" for beginning of string, it's followed by a set in square brakets meaning to match one of those characters, then the "$" meaning end of string. Thus, it asks to build a validation function of the right signature that will return a vector that is TRUE for input that is a single character "0", "1" or "2" and FALSE otherwise.

All characters that fail a validation are returned as an attribute "invalid" on the resulting data.frame. The default print method will format this into Markdown, and all records that are not NA that fail validation will be called out.

We will use a RegEx to make a lot of numbers fail in this example, and use the [1:10,] selector to limit the output for this example.

```
Records <- exportRecordsTyped(test_conn,
             validation=list(number=valRx("^5$|^-100$")))
```

```
## Warning in .castRecords_attachInvalid(rcon = rcon, Records = Records, Raw =
## Raw, : Some records failed validation. See 'invalid' attr.
```

```
summary(Records$prereq_number)
```

```
##    Min. 1st Qu.  Median    Mean 3rd Qu.    Max.    NA's
##  -100.0  -100.0   -47.5   -47.5     5.0     5.0      23
```

```
knitr::asis_output(format(attr(Records, "invalid")[1:10,]))
```

Failed Validations from REDCap project 'TestRedcapAPI (Experimental)'

Sun 07 May 2023 12:00:00 AM CST
Package redcapAPI version 2.7.0
REDCap version 13.4.13

- Field[number] 'prereq_number' has 10 failures
  - Row 6, Record Id '10', Value '1'
  - Row 7, Record Id '11', Value '1'
  - Row 8, Record Id '12', Value '1'
  - Row 9, Record Id '13', Value '1'
  - Row 10, Record Id '14', Value '1'
  - Row 11, Record Id '15', Value '1'
  - Row 12, Record Id '16', Value '1'
  - Row 13, Record Id '17', Value '1'
  - Row 14, Record Id '18', Value '1'
  - Row 15, Record Id '19', Value '1'

This shows that the number records containing "1" did not pass the regex validation and these will become NA in the final output. The field name, type, row number and record id all help the user to quickly diagnose what is not validating.

Once again, overriding the default is expected to be a rare need, but the option is available should it arise. Casting variables to the desired class is up next.

Casting

The na and validation callback list serve to exclude what should not be attempted to cast into a class. This prevents the library from crashing when the input does not match the expected format. This is particularly troublesome with date and time casting, and excluding these failed validations ensures the cast will be successful.

The function signature for these callbacks is the familiar `function(x, field_name, coding)`.

```
list(
  date_              = function(x, ...) as.POSIXct(x, format = "%Y-%m-%d"),
  datetime_          = function(x, ...) as.POSIXct(x, format = "%Y-%m-%d %H:%M"),
  datetime_seconds_  = function(x, ...) as.POSIXct(x, format = "%Y-%m-%d %H:%M:%S"),
  time_mm_ss         = function(x, ...) chron::times(ifelse(is.na(x),NA,paste0("00:",x)), format=c(times
  time_hh_mm_ss      = function(x, ...) chron::times(x, format=c(times="h:m:s")),
  time               = function(x, ...) chron::times(gsub("(^\\d{2}:\\d{2}$)", "\\1:00", x),
                                                     format=c(times="h:m:s")),
  float              = as.numeric,
  number             = as.numeric,
  calc               = as.numeric,
  int                = as.integer,
  integer            = as.numeric,
  yesno              = castLabel,
  truefalse          = function(x, ...) x=='1' | tolower(x) =='true',
  checkbox           = castChecked,
  form_complete      = castLabel,
  select             = castLabel,
  radio              = castLabel,
  dropdown           = castLabel,
  sql                = NA
)
```

A common request is instead of using POSIXct for the dates, to use the internal as.Date function.

NOTE: An exported object `cast_raw` consists of NA for each of these keys. If one desires raw data the cast function is NA.

```
head(exportRecordsTyped(test_conn, cast=list(date_=as.Date))[,1:10])
```

```
##   record_id redcap_event_name redcap_repeat_instrument redcap_repeat_instance
## 1         1     event_1_arm_1                     <NA>                   <NA>
## 2         1     event_1_arm_1     repeating_instrument                      1
## 3         1     event_1_arm_1     repeating_instrument                      2
## 4         2     event_1_arm_1                     <NA>                   <NA>
## 5         3     event_1_arm_1                     <NA>                   <NA>
## 6        10     event_1_arm_1                     <NA>                   <NA>
##     date_dmy   date_mdy   date_ymd     datetime_dmy_hm     datetime_mdy_hm
## 1 2023-02-24 2023-02-24 2023-02-24 2023-02-24 12:04:00 2023-02-24 12:04:00
## 2       <NA>       <NA>       <NA>                <NA>                <NA>
## 3       <NA>       <NA>       <NA>                <NA>                <NA>
## 4       <NA>       <NA>       <NA>                <NA>                <NA>
## 5       <NA>       <NA>       <NA>                <NA>                <NA>
## 6       <NA>       <NA>       <NA>                <NA>                <NA>
##       datetime_ymd_hm
```

```
## 1 2023-02-24 12:04:00
## 2                 <NA>
## 3                 <NA>
## 4                 <NA>
## 5                 <NA>
## 6                 <NA>
```

The date columns are now of the internal base R `date` class. Various helper routines are available on the `?fieldValidationAndCasting` help page. One of note is `castCode` which when used instead of `castLabel` it will cast to the coded value and not the labelled value.

With na, validation and cast covered a large amount of new functionality and control is in the hands of the user.

Labels and Units

Inversion of control is available for the assignment of attributes to columns as well. There exists an assignment argument which will is a list of functions that will assign their output to the attribute using the name of the list key.

The defaults add labels and units.

```
assignment=list(label=stripHTMLandUnicode, units=unitsFieldAnnotation)
```

The function signature for these is `function(field_name, field_label, field_annotation)`.

The label for a column is created by stripping HTML and Unicode characters from the REDCap field label. The units are done by searching the field annotation for something of the following form: `units={"meters"}` (using a regex).

If one desired custom attributes on columns based on this information it can be done with an override.

Post Processing

The scope and purpose of `exportRecordsTyped` was to extract the data frame in the desired classes for analysis. Sometimes post processing of the frame for further cleanup is desired and casting cannot do all that is required. Several useful helper routines for post processing are provided. The first we'll cover is `recastRecords`.

recastRecords

User have reported that `redcapFactorFlip` has been very useful for them to switch the way the data was cast in a back and forth manner. The current library has deprecated `redcapFactorFlip` and the new method to replace it is `recastRecords`.

```
exportRecordsTyped(test_conn,
  fields=c("record_id", "date_dmy",
           "date_mdy", "prereq_yesno")) |>
  recastRecords(test_conn,
                fields = c("date_dmy", "date_mdy", "prereq_yesno"),
                cast   = list(date_  = as.Date,
                              yesno = castRaw)) |>
head()
```

```
##   record_id redcap_event_name redcap_repeat_instrument redcap_repeat_instance
## 1         1     event_1_arm_1                     <NA>                   <NA>
## 2         2     event_1_arm_1                     <NA>                   <NA>
## 3         3     event_1_arm_1                     <NA>                   <NA>
## 4        10     event_1_arm_1                     <NA>                   <NA>
## 5        11     event_1_arm_1                     <NA>                   <NA>
## 6        12     event_1_arm_1                     <NA>                   <NA>
##     date_dmy   date_mdy prereq_yesno
## 1 2023-02-24 2023-02-24           NA
## 2       <NA>       <NA>           NA
## 3       <NA>       <NA>           NA
## 4       <NA>       <NA>            0
## 5       <NA>       <NA>            0
## 6       <NA>       <NA>            0
```

Recasting may be performed using a character vector of field names; a numeric vector of field indices; or a logical vector (the logical vector must be the same length as the number of columns in the data frame).

mChoice

Users of `Hmisc` or `rms` might want multiple choice class fields added to their resulting Record data.frame.

```
x <- exportRecordsTyped(test_conn) |> mChoiceCast(test_conn)
x$checkbox_test
```

```
##  [1]
##  [5]                  Guitar                           Mandolin
##  [9] Ukulele          Mandolin         Ukulele;Mandolin Guitar;Mandolin
## [13] Ukulele          Guitar;Ukulele   Guitar;Mandolin  Guitar
## [17] Ukulele          Mandolin         Guitar           Guitar;Mandolin
## [21] Ukulele          Guitar;Ukulele   Ukulele          Ukulele
## [25] Guitar;Ukulele
## attr(,"label")
## [1] checkbox_test
## Levels: Guitar Ukulele Mandolin
```

guessCast

What if validations were never added to the project and one would like to take a guess at casting, i.e. not rely on the meta data? Any field that remains character can be subject to a guess based on passing validation.

This is kept as a separate function to ensure that the user makes a clear choice in using guesswork.

```
exportRecordsTyped(test_conn, fields="date_dmy", cast=raw_cast) |>
  guessCast(
    test_conn,
    validation=valRx("^[0-9]{1,4}-(0?[1-9]|1[012])-(0?[1-9]|[12][0-9]|3[01])$"),
    cast=as.Date,
    threshold=0.1)
```

```
## guessCast triggered on date_dmy for 2 of 2 records.
```

```
##     date_dmy
## 1 2023-02-24
## 2 2023-02-24
```

Since dates are common, a helper specifically for this guess is provided.

```
exportRecordsTyped(test_conn, fields="date_dmy", cast=raw_cast) |>
  guessDate(test_conn, threshold=0.1)
```

```
## guessCast triggered on date_dmy for 2 of 2 records.
```

```
##     date_dmy
## 1 2023-02-24
## 2 2023-02-24
```

Widen / Shorten a Repeating Instrument

FIXME: Savannah–need a good writeup here.

castForImport

While it is true that `importRecords` will convert most data types into a format that can be imported, it has proven to be overly rigid with blind spots that cannot be easily overcome. In order to provide better support for importing data, we have provided the stand alone function `castForImport`.

`castForImport` follows the same strategy of validation and casting used in `exportRecordsTyped`. It returns a data frame where the fields are cast in a format (usually character) that can be passed into `importRecords`.

```
Records <- exportRecordsTyped(test_conn,
                              records = 10:29,
                              forms = "data_import_export")

Records$checkbox_test___x
```

```
##  [1] Checked   Unchecked Unchecked Unchecked Unchecked Unchecked Checked
##  [8] Unchecked Checked   Checked   Checked   Unchecked Unchecked Checked
## [15] Checked   Unchecked Checked   Unchecked Unchecked Checked
## attr(,"label")
## [1] Checkbox Example
## Levels: Unchecked Checked
```

```
Records$dropdown_test
```

```
##  [1] Lavender Blue     Lavender Green    Lavender Blue     Blue     Lavender
##  [9] Green    Green    Green    Blue     Blue     Green    Lavender Lavender
## [17] Lavender Lavender Green    Blue
## attr(,"label")
## [1] Drop Down Field
## Levels: Green Blue Lavender
```

The default settings of `castForImport` are arranged so that most cases of data will be recast for import as desired.

```
ForImport <- castForImport(Records,
                           test_conn)

ForImport$checkbox_test___x
```

```
##  [1] 1 0 0 0 0 0 1 0 1 1 1 0 0 1 1 0 1 0 0 1
```

```
ForImport$dropdown_test
```

```
##  [1] 3 2 3 1 3 2 2 3 1 1 1 2 2 1 3 3 3 3 1 2
```

The actual default casting list for `castForImport` is

```
list(
  date_                   = as.character,
  datetime_               = as.character,
  datetime_seconds_       = as.character,
  time_mm_ss              = castTimeMMSS,
  time_hh_mm_ss           = as.character,
  time                    = castTimeHHMM,
  alpha_only              = as.character,
  float                   = as.character,
  number                  = as.character,
  number_1dp              = castDpCharacter(1, dec_symbol = "."),
  number_1dp_comma_decimal = castDpCharacter(1),
  number_2dp              = castDpCharacter(2, dec_symbol = "."),
  number_2dp_comma_decimal = castDpCharacter(2),
  calc                    = as.character,
  int                     = function(x, ...) as.character(as.integer(x)),
  integer                 = function(x, ...) as.character(as.integer(x)),
  yesno                   = castRaw,
  truefalse               = function(x, ...) (x=='1' | tolower(x) =='true') + 0L,
  checkbox                = castRaw,
  form_complete           = castRaw,
  select                  = castRaw,
  radio                   = castRaw,
  dropdown                = castRaw,
  email                   = as.character,
  phone                   = as.character,
  zipcode                 = as.character,
  slider                  = as.numeric,
  sql                     = NA
)
```

At this time, we have not changed anything within `importRecords`. Doing so would require making a breaking change and we aren't prepared to do that on short notice. However, we are considering this change in the future. For that reason, we advise changing your processes to utilize `castForImport` prior to importing data.

Customizing Checkbox Casting We have encountered a special case of a checkbox function that `importRecords` is entirely incapable of handling. In this case, the checkbox variable was defined with the options

```
0, 0
1, 1
2, 2
```

In this case, the field `checkbox_example___0` could actually be cast in a way that "0" indicates the checkbox was "checked". This is a scenario that is problematic, as the API would determine that any value of "0" is unchecked.

In order to handle this scenario, we have provided a special casting function, `castCheckForImport`, that allows the user to designate what values are to represent a checked value.

```
Records <- data.frame(checkbox_test___x = c("0", "", "", "0"),
                      checkbox_test___y = c("y", "y", "", "y"))

ForImport <- castForImport(Records,
                           test_conn,
                           fields = "checkbox_test___x",
                           cast = list(checkbox = castCheckForImport(checked = "0")))
ForImport
```

```
##   checkbox_test___x checkbox_test___y
## 1                 1                 y
## 2                 0                 y
## 3                 0
## 4                 1                 y
```

To complete an import in this scenario may require two passes with `castForImport` before calling `importRecords`.

```
ForImport <-
  castForImport(Records,
                test_cond,
                fields = "checkbox_test___x",
                cast = list(checkbox = castCheckForImport(checked = "0"))) |>
  castForImport(test_conn)

importRecords(test_conn,
              data = ForImport)
```

Even More

Bulk Records Pull

A helper function is provided that will pull a set of projects and/or forms from projects into memory and apply a post processor set in bulk.

```
exportBulkRecords(
 rcon  = list(test = test_conn,
              sand = sandbox_conn),
 forms = list(test = c('form1', 'form2'),
 envir = globalenv(),
 post  = function(Records, rcon)
         {
           Records              |>
           mChoiceCast(rcon)    |>
           guessDat(rcon)       |>
           widerRepeating(rcon)
         }
)
```

This references the connections we opened in the `unlockREDCap` section at the beginning and provides the names we want for the resulting records. The environment post execution contains the data.frames: `test.form1`, `test.form2`, `sand`. Each of these were retrieved, possibly using the forms argument and all were post processed in the same manner as specified by `post`. Any additional arguments are passed on to the `exportRecordsTyped` call.

Branching Logic NA detection

The `missingSummary` function provides a utility to look for missing values within a dataset. The results account for branching logic in the instrument; fields that are missing because branching logic did not expose them do not get counted as missing. One may restrict the summary to fields, forms, and/or records as well.

```
missingSummary(test_conn,
               exportRecordsArgs = list(records = 10:29,
                                        fields = "record_id",
                                        forms = "branching_logic")) |>
  head()
```

```
## Please use exportRecordsTyped instead. exportRecords is DEPRECATED.

## Registered S3 methods overwritten by 'labelVector':
##   method         from
##   [.labelled     Hmisc
##   print.labelled Hmisc

##   record_id redcap_event_name redcap_repeat_instrument redcap_repeat_instance
## 1        10     event_1_arm_1                       NA                     NA
## 2        11     event_1_arm_1                       NA                     NA
## 3        12     event_1_arm_1                       NA                     NA
## 4        13     event_1_arm_1                       NA                     NA
## 5        14     event_1_arm_1                       NA                     NA
## 6        15     event_1_arm_1                       NA                     NA
##   n_missing                missing
## 1         1        no_prereq_number
## 2         0
## 3         0
## 4         0
## 5         1 one_prereq_non_checkbox
## 6         0
```

One limitation of `missingSummary`, however, is that the summary operates exclusively within each row of the data. Thus, if your branching logic utilizes values from previous events, this summary will not correctly identify non-missing values.

Design your own API Calls

`redcapAPI` are very specific in how they access the REDCap API and leave very little flexibility to the user in the choice of arguments to pass to the API. This lack of flexibility is deliberate, as it helps limit the potential for errors and frustration to the typical user. Advanced users may, at times, find our decisions limiting. Of there may be a need to use an API method that `redcapAPI` does not yet offer.

Users wishing to customize their API calls may use `makeApiCall`. This is a flexible function that utilizes the `redcapConnection` object, permitting customized calls within the same code style of the rest of the package. It has an added benefit of the retry strategy for API call failures as mentioned in the '*Connection*' section above.

For example, using `makeApiCall`, we can get User-Roles, even though `redcapAPI` does not have a dedicated method to retrieve those.

```
response <- makeApiCall(sandbox_conn,
                        body = list(content = 'userRole',
                                    format = 'csv',
                                    returnFormat = 'csv'))
read.csv(text = as.character(response),
         na.strings = '')
```

```
##   unique_role_name          role_label design user_rights data_access_groups
## 1     U-646TTM48XJ redcapApiTestEditor      1           1                  0
##   reports stats_and_charts manage_survey_participants calendar data_import_tool
## 1       1               1                          1        1                1
##   data_comparison_tool logging file_repository data_quality_create
## 1                    0       0               1                  0
##   data_quality_execute api_export api_import mobile_app
## 1                    0          0          0          0
##   mobile_app_download_data record_create record_rename record_delete
## 1                        0             1             0             0
##   lock_records_customization lock_records lock_records_all_forms
## 1                          0            0                      0
##   mycap_participants
## 1                  1
##                                                                                forms
## 1 date_time_tests:1,multiple_choice_tests:1,numeric_import_tests:1,import_meta_data:1
##
## 1 date_time_tests:1,multiple_choice_tests:1,numeric_import_tests:1,import_meta_data:1,date_time_tests
```

Cornacopia of Functions to explore

The functions offered by `redcapAPI` have expanded significantly in recent versions. The table below names all of the methods provided by the REDCap API and indicates which are supported by `redcapAPI`.

System	Export	Import	Delete	Other Method
Arms	Yes	Yes	Yes	N/A

System	Export	Import	Delete	Other Method
DAGs	No	No	No	SwitchDag (No) exportDagAssigment (No) importDagAssigment (No)
Events	Yes	Yes	Yes	N/A
Field Names	Yes	N/A	N/A	N/A
Files	Yes	Yes	Yes	N/A
File Repository	Yes	Yes	Yes	createFileRepositoryFolder (Yes) exportFileRepositoryListing (Yes)
Instruments	Yes	N/A	N/A	exportMappings (Yes) importMappings (Yes)
Logging	Yes	N/A	N/A	N/A
Meta Data	Yes	Yes	N/A	N/A
Project Info	Yes	Yes	N/A	createProject (No) exportProjectXML (No)
Records	Yes	Yes	Yes	renameRecord (No) exportNextRecordName (Yes)
Reports	Yes	N/A	N/A	N/A
Version	Yes	N/A	N/A	N/A
Surveys	N/A	N/A	N/A	exportSurveyLink (No) exportSurveyParticipants (Yes) exportSurveyQueueLink (No) exportSurveyReturnCode (No)
Users	Yes	No	No	N/A
UserRoles	No	No	No	exportUserRoleAssigments (No) importUserRoleAssigments (No)

Reproducing this Vignette

This requires building one's own test database. Functions to build a REDCap project and load with data are included, as well as the test database this was built from

FIXME: Thomas Dupont - Example building test database here. Pull from existing tests.

Thanks

Thanks to all those that have made this effort possible for `redcapAPI` as an R package, and striven to make it better.

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