Cluster-Based Bouts

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Introduction and Installation

This vignette will show you how to run the cluster-based bout identifier. The first step is making sure you have the `PAutilities` package (version 1.1.0 or greater) installed on your computer. To get the most current code, you can install from GitHub rather than CRAN. Here's how to do that:

```
## remotes is a package that makes it easy to install packages from GitHub, but
## in my experience it sometimes struggles to install the related packages (i.e.,
## dependencies) correctly. So first we'll do a manual workaround. All it's
## doing is looking through a list of required packages, and installing any of
## them that haven't already been installed (they'll be skipped if they have).
## Be aware: Some of these packages have long installation times.

invisible(lapply(
  c(
    "dplyr", "equivalence", "ggplot2", "graphics", "lazyeval",
    "lubridate", "magrittr", "methods", "reshape2", "remotes",
    "rlang", "stats", "utils", "Rcpp"
  ),
  function(x) if (!x %in% installed.packages()) install.packages(x)
))

## Once that's done, we can (hopefully) install from GitHub
remotes::install_github("paulhibbing/PAutilities", dependencies = FALSE)
```

Copy and paste the above into your R console, then hit enter to run it.

Preparation

Once you have the package installed, all you need is some activity data and the `get_bouts` function. For this demonstration, let's use some sample NHANES data.

```
## Find the file online
datafile <- file.path(
  "https://github.com/paulhibbing/PAutilities",
  "raw/master/data-raw/bouts_example.rds"
)

## Tell R where to save it
destination <- file.path(
  tempdir(),
  basename(datafile)
```

```
)

## Now save it
suppressMessages(
  utils::download.file(datafile, destination)
)

## Load the data
ex_data <- readRDS(destination)

## Discard the file now that we've loaded the data
invisible(file.remove(destination))
```

This dataset has activity counts that we can use to look at bouts of moderate-to-vigorous physical activity (MVPA). For illustration, let's say we initially coded our data as sedentary behavior ($PAXINTEN \leq 100$), light physical activity ($PAXINTEN$ $101 - 1951$), or MVPA ($PAXINTEN \geq 1952$).

```
## Determine minute-by-minute intensity
intensity <- cut(
  ex_data$PAXINTEN,
  breaks = c(0, 101, 1952, Inf),
  labels = c("SB", "LPA", "MVPA"),
  right = FALSE
)

## The above command returns a factor variable -- the `get_bouts`
## function will complain about this and tell you it needs a
## character or numeric variable, so let's cast the intensity
## vector to character
intensity <- as.character(intensity)
```

Running the Code

Once we have our data (`intensity` in this case), we can plug it into `get_bouts`. Let's see the code first, then go over what it means.

```
mvpa_bouts <- PAutilities::get_bouts(
  x = intensity,
  method = "cluster-based",
  target = "MVPA",
  target_buffer = 30,
  longest_allowable_interruption = 2,
  required_percent = 80,
  max_n_interruptions = Inf,
  minimum_bout_length = 10
)
```

Here is what each piece means:

- **mvpa_bouts <-** Store the function results in an object called `mvpa_bouts`

- **PAutilities::get_bouts** This tells R to find the `get_bouts` function in the `PAutilities` package. In fact, if you run `PAutilities::get_bouts` in your console, R will print the source code.
- **x = intensity** Here we specify that our input datastream is `intensity`, as defined in the earlier code.
- **method = "cluster-based"** Here we specify that R should run the cluster-based bout identification method. Right now, this is the only option, but in the future it will be possible to add others.
- **target = "MVPA"** Here we specify which behavior we are interested in. The input data (`intensity`) has values in the set `{SB, LPA, MVPA}`, and we would like to look specifically at bouts of `MVPA`, with the other behaviors being lumped together in a single group called `other`.
- **target_buffer = 30** Here we specify how our data should be stratified/partitioned. In this case, `intensity` is a minute-by-minute variable, so our setting of `30` means the data will be stratified/partitioned anytime we see $\geq$ 30 consecutive minutes of `other` behavior. *It is crucial to understand that the meaning of this setting depends on the epoch length of the input data. If `intensity` was a second-by-second variable, we would need to set `target_buffer = 1800` to achieve the same 30-min threshold we are using for this example.*
- **longest_allowable_interruption = 2** Here we specify that a valid bout should not include any single interruption lasting longer than 2 minutes. *(Again, this is dependent on epoch length; a setting of 120 would be needed to achieve the same threshold for a second-by-second input variable)*
- **required_percent = 80** Here we specify that a valid bout should be interrupted for no more than 20% of its full duration.
- **max_n_interruptions = Inf** Here we specify that a valid bout can have unlimited interruptions as long as the criteria for `longest_allowable_interruption` and `required_percent` are met.
- **minimum_bout_length = 10** Here we specify that only bouts lasting $\geq$ 10 min should be included in the output.

The above elements are set up to allow flexible bout criteria depending on the research question and the variable of interest. In our example, we set `max_n_interruptions = Inf` to avoid a restriction in that area – similar approaches can be taken for other settings as well, by setting them to `0` or `Inf` as appropriate. (For `required_percent`, 100 is the upper limit rather than `Inf`.) Notably, `minimum_bout_length` is a filtering criterion. It has no direct affect on how the bouts are defined; it simply affects which ones are retained *after* they have been defined.

Interpreting the Output

Now let's take a look at the output and go over what it means:

```
mvpa_bouts
#>   start_index end_index values n_total_events n_value_events
#> 1        3809      3828   MVPA              3              2
#> 2        8179      8192   MVPA              1              1
#> 3        8318      8334   MVPA              1              1
#>   n_interruption_events length_total length_value length_interruption
#> 1                     1           20           18                   2
#> 2                     0           14           14                   0
#> 3                     0           17           17                   0
#>   longest_interruption_event percent_time_engaged
#> 1                          2                  90
#> 2                          0                 100
#> 3                          0                 100
```

This is a data frame with one row per bout. The variables are:

- **start_index** The starting point of the bout (e.g., `intensity[3809]` for the first bout in this example)

- **end_index** The ending point of the bout (e.g., `intensity[3828]` for the first bout in this example)
- **values** A meaningless constant (equal to the setting of `target`), left over from run length encoding
- **n_total_events** The number of distinct behavior events occurring between `start_index` and `end_index`
- **n_value_events** The number of distinct target behavior events occurring between `start_index` and `end_index` (referred to as `value` events in reference to the `values` column)
- **n_interruption_events** The number of distinct interruption events occurring between `start_index` and `end_index`
- **length_total** The combined duration of all `value` and `interruption` events
- **length_value** The combined duration of all `value` events
- **length_interruption** The combined duration of all `interruption` events
- **longest_interruption_event** The duration of the single longest interruption event
- **percent_time_engaged** Percentage of `length_total` comprised by `length_value`

As before, epoch length influences the interpretation of length variables. Keep that in mind.

Expanding the Output

In some cases we may want to convert our bout information back to the original length of the input (i.e., `intensity`). We can use the `bout_expand` function to accomplish that.

```
expanded <- PAutilities::bout_expand(mvpa_bouts)
str(expanded)
#>  Factor w/ 3 levels "other","MVPA",..: 1 1 1 1 1 1 1 1 1 1 ...
table(expanded)
#> expanded
#>        other         MVPA interruption
#>        10029           49            2
```

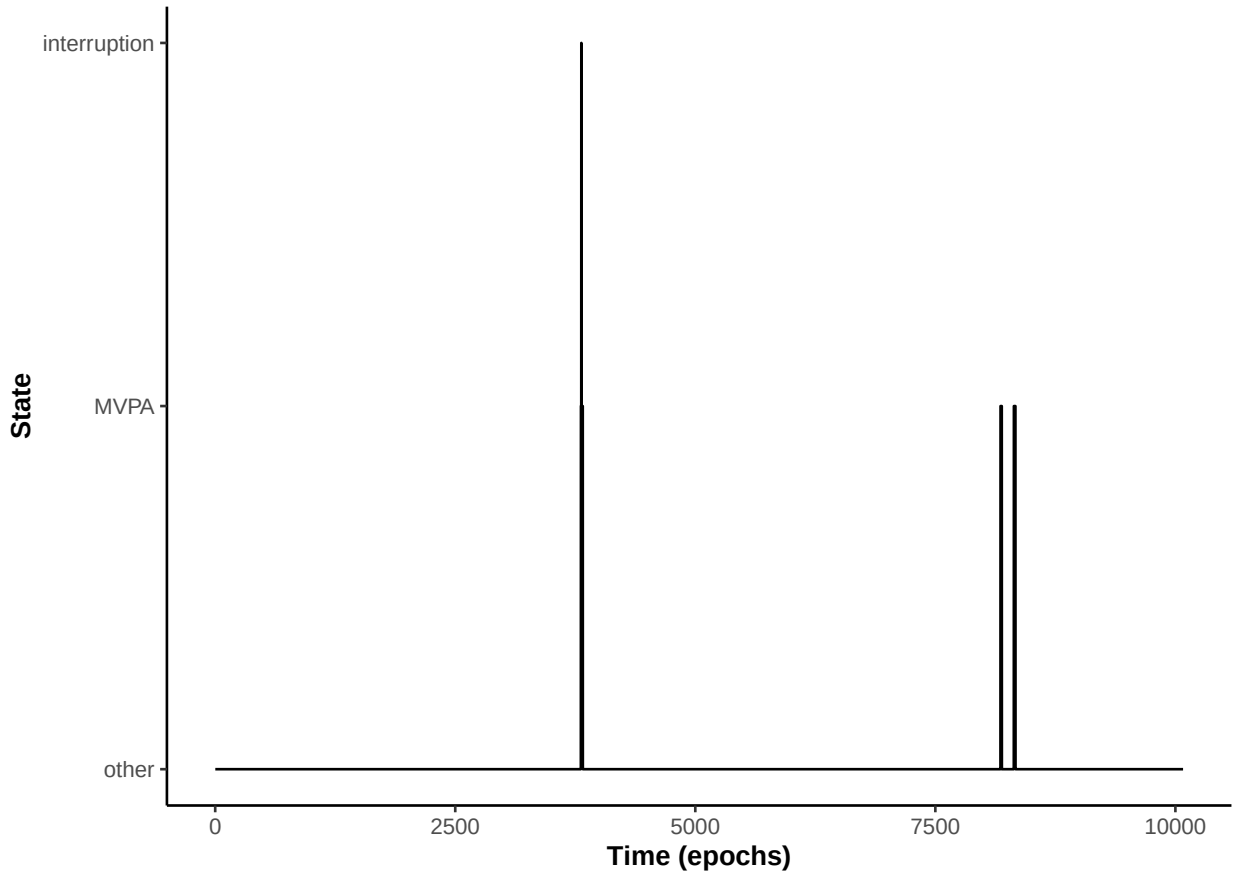
And we can also append that new variable into our original dataset as well.

```
ex_data$intensity <- expanded
head(ex_data)
#>    SEQN PAXSTAT PAXCAL PAXDAY PAXN PAXHOUR PAXMINUT PAXINTEN intensity
#> 1 21137       1      1      1    1       0        0        0     other
#> 2 21137       1      1      1    2       0        1        0     other
#> 3 21137       1      1      1    3       0        2        0     other
#> 4 21137       1      1      1    4       0        3        0     other
#> 5 21137       1      1      1    5       0        4        0     other
#> 6 21137       1      1      1    6       0        5        0     other
```

Plotting the output

If you want to visualize the results of your bout analysis, you can use a basic `plot` function.

```
plot(mvpa_bouts)
```



Conclusion

This should give you a broad sense of how to use the cluster-based bout identification method and what else you can do with it. Feel free to post an issue on the GitHub page if any of the above gives you trouble. Good luck!