

Guide for trident v0.28.0

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1 Poseidon package repositories

Trident generally requires Poseidon datasets to work with. Most trident subcommands therefore have a central parameter, called `--baseDir` or simply `-d` to specify one or more base directories to look for Poseidon packages. For example, if all Poseidon packages live inside a repository at `/path/to/poseidon/packages` you would simply say `trident <subcommand> -d /path/to/poseidon/dirs/` and trident would automatically search all subdirectories inside of the repository for valid poseidon packages (as identified by valid `POSEIDON.yml` files).

You can arrange a poseidon repository in a hierarchical way. For example:

```
/path/to/poseidon/packages
  /modern
    /2019_poseidon_package1
    /2019_poseidon_package2
  /ancient
    /...
    /...
  /Reference_Genomes
    /...
    /...
  /Archaic_Humans
```


3 Package creation and manipulation commands

3.1 Init command

`init` creates a new, valid poseidon package from genotype data files. It adds a valid POSEIDON.yml file, a dummy .janno file for context information and an empty .bib file for literature references.

[Click here for command line details](#)

```
Usage: trident init (-r|--inFormat ARG) (-g|--genoFile ARG) (-s|--snpFile ARG)
               (-i|--indFile ARG) [--snpSet ARG] (-o|--outPackagePath ARG)
               [-n|--outPackageName ARG] [--minimal]
Create a new Poseidon package from genotype data
```

Available options:

<code>-h,--help</code>	Show this help text
<code>-r,--inFormat ARG</code>	the format of the input genotype data: EIGENSTRAT or PLINK
<code>-g,--genoFile ARG</code>	the input geno file path
<code>-s,--snpFile ARG</code>	the input snp file path
<code>-i,--indFile ARG</code>	the input ind file path
<code>--snpSet ARG</code>	the snpSet of the new package: 1240K, HumanOrigins or Other. Default: Other
<code>-o,--outPackagePath ARG</code>	the output package directory path
<code>-n,--outPackageName ARG</code>	the output package name - this is optional: If no name is provided, then the package name defaults to the basename of the (mandatory) --outPackagePath argument
<code>--minimal</code>	should only a minimal output package be created?

The command

```
trident init \
  -r EIGENSTRAT/PLINK \
  -g path/to/geno_file \
  -s path/to/snp_file \
  -i path/to/ind_file \
  --snpSet 1240K|HumanOrigins|Other \
  -o path/to/new_package_name
```

requires the format `-r` (`--inFormat`) of your input data (either EIGENSTRAT or PLINK), the paths to the respective files in `-g` (`--genoFile`), `-s` (`--snpFile`), and `-i` (`--indFile`), and optionally the “shape” of these files (`--snpSet`), so if they cover the 1240K, the HumanOrigins or an Other SNP set.

	EIGENSTRAT	PLINK
genoFile	.geno	.bed
snpFile	.snp	.bim
indFile	.ind	.fam

The output package of `init` is created as a new directory `-o`, which should not already exist, and gets the package `title` corresponding to the basename of `-o`. You can also set the title explicitly with `-n`. The `--minimal` flag causes `init` to create a minimal package with a very basic POSEIDON.yml and no .bib and .janno files.

3.2 Fetch command

`fetch` allows to download poseidon packages from a remote poseidon server.

[Click here for command line details](#)

```
Usage: trident fetch (-d|--baseDir DIR) [-f|--fetchString ARG] [--fetchFile ARG]
                  [--remoteURL ARG] [-u|--upgrade] [--downloadAll]
Download data from a remote Poseidon repository
```

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>-f,--fetchString ARG</code>	List of packages to be downloaded from the remote server. Package names should be wrapped in asterisks: <code>*package_title*</code> . You can combine multiple values with comma, so for example: <code>"*package_1*, *package_2*, *package_3*"</code> . <code>fetchString</code> uses the same parser as <code>forgeString</code> , but does not allow excludes. If groups or individuals are specified, then packages which include these groups or individuals are included in the download.
<code>--fetchFile ARG</code>	A file with a list of packages. Works just as <code>-f</code> , but multiple values can also be separated by newline, not just by comma. <code>-f</code> and <code>--fetchFile</code> can be combined.
<code>--remoteURL ARG</code>	URL of the remote Poseidon server (default: <code>"https://c107-224.cloud.gwdg.de"</code>)
<code>-u,--upgrade</code>	overwrite outdated local package versions
<code>--downloadAll</code>	download all packages the server is offering

It works with

```
trident fetch -d ... -d ... \
  -f "*package_title_1*,*package_title_2*,*package_title_3*,group_name,<Individual1>" \
  --fetchFile path/to/forgeFile
```

and the entities you want to download must be listed either in a simple string with comma-separated values (**-f/--fetchString**) or in a text file (**--fetchFile**). Entities are specified using a special syntax: Package titles are wrapped in asterisks: *package_title* (see also the documentation of **forge** below), group names are spelled as is, and individual names are wrapped in angular brackets, like **<Individual1>**. Fetch will figure out which packages need to be downloaded to include all specified entities. **--downloadAll** causes fetch to ignore **-f** and download all packages from the server. The downloaded packages are added in the first (!) **-d** directory, but downloads are only performed if the respective packages are not already present in an up-to-date version in any of the **-d** dirs.

Note that `trident fetch` makes most sense in combination with `trident list --remote`: First one can inspect what is available on the server, then one can create a custom fetch command.

`fetch` also has the optional arguments `--remote https://...` to name an alternative poseidon server. The default points to the [DAG server](#).

To overwrite outdated package versions with `fetch`, the `-u/--upgrade` flag has to be set. Note that many file systems do not offer a way to recover overwritten files. So be careful with this switch.

3.3 Forge command

forge creates new poseidon packages by extracting and merging packages, populations and individuals from your poseidon repositories.

[Click here for command line details](#)

Usage: trident forge [-d|--baseDir DIR]

```

[(-r|--inFormat ARG) (-g|--genoFile ARG) (-s|--snpFile ARG)
 (-i|--indFile ARG) [--snpSet ARG]]
[--forgeFile ARG | (-f|--forgeString ARG)]
[--selectSnps ARG] [--intersect] [--outFormat ARG]
[--minimal] [--onlyGeno] (-o|--outPackagePath ARG)
[-n|--outPackageName ARG] [-w|--warnings] [--no-extract]

```

Select packages, groups or individuals and create a new Poseidon package from them

Available options:

-h,--help	Show this help text
-d,--baseDir DIR	a base directory to search for Poseidon Packages (could be a Poseidon repository)
-r,--inFormat ARG	the format of the input genotype data: EIGENSTRAT or PLINK
-g,--genoFile ARG	the input geno file path
-s,--snpFile ARG	the input snp file path
-i,--indFile ARG	the input ind file path
--snpSet ARG	the snpSet of the new package: 1240K, HumanOrigins or Other. Default: Other
--forgeFile ARG	A file with a list of packages, groups or individual samples. Works just as -f, but multiple values can also be separated by newline, not just by comma. Empty lines are ignored and comments start with "#", so everything after "#" is ignored in one line.
-f,--forgeString ARG	List of packages, groups or individual samples to be combined in the output package. Packages follow the syntax *package_title*, populations/groups are simply group_id and individuals <individual_id>. You can combine multiple values with comma, so for example: "*package_1*, <individual_1>, <individual_2>, group_1". Duplicates are treated as one entry. Negative selection is possible by prepending "-" to the entity you want to exclude (e.g. "*package_1*, -<individual_1>, -group_1"). forge will apply excludes and includes in order. If the first entity is negative, then forge will assume you want to merge all individuals in the packages found in the baseDirs (except the ones explicitly excluded) before the exclude entities are applied. An empty forgeString will therefore merge all available individuals.
--selectSnps ARG	To extract specific SNPs during this forge operation, provide a Snp file. Can be either Eigenstrat (file ending must be '.snp') or Plink (file ending must be '.bim'). When this option is set, the output package will have exactly the SNPs listed in this file. Any SNP not listed in the file will be excluded. If option '--intersect' is also set, only the SNPs overlapping between the SNP file and the forged packages are output.
--intersect	Whether to output the intersection of the genotype files to be forged. The default (if this option is not set) is to output the union of all SNPs, with genotypes defined as missing in those packages which do not have a SNP that is present in another package.

	With this option set, the forged dataset will typically have fewer SNPs, but less missingness.
<code>--outFormat ARG</code>	the format of the output genotype data: EIGENSTRAT or PLINK. Default: PLINK
<code>--minimal</code>	should only a minimal output package be created?
<code>--onlyGeno</code>	should only the resulting genotype data be returned?
	This means the output will not be a Poseidon package
<code>-o,--outPackagePath ARG</code>	the output package directory path
<code>-n,--outPackageName ARG</code>	the output package name - this is optional: If no name is provided, then the package name defaults to the basename of the (mandatory) <code>--outPackagePath</code> argument
<code>-w,--warnings</code>	Show all warnings for merging genotype data
<code>--no-extract</code>	Skip the selection step in forge. This will result in outputting all individuals in the relevant packages, and hence a superset of the requested individuals/groups. It may result in better performance in cases where one wants to forge entire packages or almost entire packages. Note that this will also ignore any ordering in the output groups/individuals. With this option active, individuals from the relevant packages will just be written in the order that they appear in the original packages.

forge can be used with

```
trident forge -d ... -d ... \
  -f "*package_name*, group_id, <individual_id>" \
  --forgeFile path/to/forgeFile \
  -o path/to/new_package_name
```

where the entities (packages, groups/populations, individuals/samples) you want in the output package can be denoted either as a simple string with comma-separated values (`-f/--forgeString`) or in a text file (`--forgeFile`).

Including one or multiple Poseidon packages with `-d` is not the only way to include data for a forge operation. It is also possible to include unpackaged genotype data directly with `-r + -g + -s + -i (+ --snpSet)`. This makes the following example possible, where we merge data from one Poseidon package and two genotype datasets.

```
trident forge \
  -d 2017_GonzalesFortesCurrentBiology \
  -r PLINK -g 2017_HaberAJHG/2017_HaberAJHG.bed -s 2017_HaberAJHG/2017_HaberAJHG.bim -i 2017_HaberAJHG/
  -r PLINK -g 2018_VeeramahPNAS/2018_VeeramahPNAS.bed -i 2018_VeeramahPNAS/2018_VeeramahPNAS.fam -s 201
  -f "<STR241.SG>,<ERS1790729.SG>,Iberia_HG.SG" \
  -o testpackage \
  --onlyGeno
```

3.3.1 The forge selection language

Entities in the `--forgeString` or the `--forgeFile` have to be marked in a certain way:

- Each package is surrounded by `*`, so if you want all individuals of 2019_Jeong_InnerEurasia in the output package you would add `*2019_Jeong_InnerEurasia*` to the list.
- Groups/populations are not specially marked. So to get all individuals of the group `Swiss_Roman_period`, you would simply add `Swiss_Roman_period`.
- Individuals/samples are surrounded by `<` and `>`, so `ALA026` becomes `<ALA026>`.

Do not forget to wrap the `forgeString` in quotes.

You can either use `-f/--forgeString` or `--forgeFile`. In the file each line is treated as a separate `forgeString`, empty lines are ignored and `#`s start comments. So this is a valid `forgeFile`:

```
# Packages
*package1*, *package2*

# Groups and individuals from other packages beyond package1 and package2
group1, <individual1>, group2, <individual2>, <individual3>

# group2 has two outlier individuals that should be ignored
-<bad_individual1> # This one has very low coverage
-<bad_individual2> # This one is from a different time period
```

By prepending `-` to the bad individuals, we can exclude them from the forged package. `forge` figures out the final list of samples to include by executing all `forge`-entities in order. So an entity list `*PackageA*,-<Individual1>,GroupA` may result in a different outcome than `*PackageA*,GroupA,-<Individual1>`, depending on whether `<Individual1>` belongs to `GroupA` or not. If the `forge` entity list starts with a negative entity, or if the entity list is empty, `forge` will implicitly assume you want to include all individuals in all packages found in the `baseDirs` (except the ones explicitly excluded, of course). An empty `forgeString` will therefore merge all available individuals.

3.3.2 Other options

Just as for `init` the output package of `forge` is created as a new directory `-o`. The title can also be explicitly defined with `-n`.

`--minimal` allows for the creation of a minimal output package without `.bib` and `.janno`. This might be especially useful for data analysis pipelines, where only the genotype data is required. Even more basic output comes with `--onlyGeno`, which means that only the genotype data is returned without any Poseidon package.

`forge` has an optional flag `--intersect`, that defines, if the genotype data from different packages should be merged with an **union** or an **intersect** operation. The default (if this option is not set) is to output the union of all SNPs, with genotypes defined as missing in samples from packages which do not have a SNP that is present in another package. With this option set, on the other hand, the forged dataset will typically have fewer SNPs, but less missingness.

`--intersect` also influences the automatic determination of the `snpSet` field in the `POSEIDON.yml` file for the resulting package. If the `snpSets` of all input packages are identical, then the resulting package will just inherit this configuration. Otherwise `forge` applies the following pairwise merging logic:

Input snpSet A	Input snpSet B	<code>--intersect</code>	Output snpSet
Other	*	*	Other
1240K	HumanOrigins	True	HumanOrigins
1240K	HumanOrigins	False	1240K

`--selectSnps` allows to provide `forge` with a SNP file in EIGENSTRAT (`.snp`) or PLINK (`.bim`) format to create a package with a specific selection. When this option is set, the output package will have exactly the SNPs listed in this file. Any SNP not listed in the file will be excluded. If `--intersect` is also set, only the SNPs overlapping between the SNP file and the forged packages are output.

Merging genotype data across different data sources and file formats is tricky. `forge` is more verbose about potential issues, if the `-w/--warnings` flag is set.

3.4 Genoconvert command

genoconvert converts the genotype data in a Poseidon package to a different file format. The respective entries in the POSEIDON.yml file are changed accordingly.

[Click here for command line details](#)

```
Usage: trident genoconvert [-d|--baseDir DIR]
                        [(-r|--inFormat ARG) (-g|--genoFile ARG)
                        (-s|--snpFile ARG) (-i|--indFile ARG)
                        [--snpSet ARG]] --outFormat ARG [--onlyGeno]
                        [--removeOld]

Convert the genotype data in a Poseidon package to a different file format
```

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>-r,--inFormat ARG</code>	the format of the input genotype data: EIGENSTRAT or PLINK
<code>-g,--genoFile ARG</code>	the input geno file path
<code>-s,--snpFile ARG</code>	the input snp file path
<code>-i,--indFile ARG</code>	the input ind file path
<code>--snpSet ARG</code>	the snpSet of the new package: 1240K, HumanOrigins or Other. Default: Other
<code>--outFormat ARG</code>	the format of the output genotype data: EIGENSTRAT or PLINK.
<code>--onlyGeno</code>	should only the resulting genotype data be returned?
<code>--removeOld</code>	This means the output will not be a Poseidon package Remove the old genotype files when creating the new ones

With the default setting

```
trident genoconvert -d ... -d ... --outFormat EIGENSTRAT|PLINK
```

all packages in `-d` will be converted to the desired `--outFormat` (either EIGENSTRAT or PLINK), if the data is not already in this format. This includes updating the respective POSEIDON.yml files.

Instead of `-d` to change Poseidon packages, the combination `-r + -g + -s + -i (+ --snpSet)` allows to directly convert genotype data that is not wrapped in a Poseidon package. See this example:

```
trident genoconvert \
  -r PLINK -g 2018_Mittnik_Baltic/Mittnik_Baltic.bed -s 2018_Mittnik_Baltic/Mittnik_Baltic.bim -i 2018_
  --outFormat EIGENSTRAT
```

The “old” data is not deleted, but kept around. That means conversion will result in a package with both PLINK and EIGENSTRAT data, but only one is linked in the POSEIDON.yml file, and that is what will be used by trident. To delete the old data in the conversion you can add the `--removeOld` flag.

Remember that the POSEIDON.yml file can also be edited by hand if you want to replace the genotype data in a package.

3.5 Update command

update automatically updates POSEIDON.yml files of one or multiple packages if the packages were changed.

[Click here for command line details](#)


```
Usage: trident update (-d|--baseDir DIR) [--poseidonVersion ARG]
      [--ignorePoseidonVersion] [--versionComponent ARG]
      [--noChecksumUpdate] [--newContributors ARG]
      [--logText ARG] [--force]
```

Update POSEIDON.yml files automatically

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>--poseidonVersion ARG</code>	Poseidon version the packages should be updated to: e.g. "2.5.3" (default: Nothing)
<code>--ignorePoseidonVersion</code>	Read packages even if their poseidonVersion is not compatible with the trident version. The assumption is, that the package is already structurally adjusted to the trident version and only the version number is lagging behind.
<code>--versionComponent ARG</code>	Part of the package version number in the POSEIDON.yml file that should be updated: Major, Minor or Patch (see https://semver.org) (default: Patch)
<code>--noChecksumUpdate</code>	Should update of checksums in the POSEIDON.yml file be skipped
<code>--ignoreGeno</code>	ignore SNP and GenoFile
<code>--newContributors ARG</code>	Contributors to add to the POSEIDON.yml file in the form "[Firstname Lastname](Email address);..."
<code>--logText ARG</code>	Log text for this version jump in the CHANGELOG file (default: "not specified")
<code>--force</code>	Normally the POSEIDON.yml files are only changed if the poseidonVersion is adjusted or any of the checksums change. With --force a package version update can be triggered even if this is not the case.

It can be called with a lot of optional arguments

```
trident update -d ... -d ... \
  --poseidonVersion "X.X.X" \
  --versionComponent Major/Minor/Patch \
  --noChecksumUpdate
  --ignoreGeno
  --newContributors "[Firstname Lastname](Email address);..."
  --logText "short description of the update"
  --force
```

By default update will not edit a package's POSEIDON.yml file, even when arguments like `--versionComponent`, `--newContributors` or `--logText` are explicitly set. This default exists to run the function on a large set of packages where only few of them were edited and need an active update. A package will only be modified by update if either

- any of the files with checksums (e.g. the genotype data) in it were modified,
- the `--poseidonVersion` argument differs from the `poseidonVersion` in the package's POSEIDON.yml file
- or the `--force` flag was set in update.

If any of these applies to a package in the search directory (`--baseDir/-d`), it will be updated. This includes the following steps:

- If `--poseidonVersion` is different from the `poseidonVersion` field in the package, then that will

be updated.

- The `packageVersion` will be incremented. If `--versionComponent` is not set, then it falls back to `Patch`, so a change in the last position of the three digit version number. `Minor` increments the middle, and `Major` the first position (see [semantic versioning](#)).
- The `lastModified` field will be updated to the current day (based on your computer's system time).
- The contributors in `--newContributors` will be added to the `contributor` field if they're not there already.
- If any checksums changed, then they will be updated. If certain checksums are not set yet, then they will be added. The checksum update can be skipped with `--noChecksumUpdate` or partially skipped for the genotype data with `--ignoreGeno`.
- The `CHANGELOG.md` file will be updated with a new row for the new version and the text in `--logText` (default: "not specified"), which will be appended as the first line of the file. If no `CHANGELOG.md` file exists, then it will be created and referenced in the `POSEIDON.yml` file.

:heavy_exclamation_mark: As `update` reads and rewrites `POSEIDON.yml` files, it may change their inner order, layout or even content (e.g. if they have fields which are not in the [Poseidon package definition](#)). Create a backup of the `POSEIDON.yml` file before running `update` if you are uncertain.

4 Inspection commands

4.1 List command

`list` lists packages, groups and individuals of the datasets you use, or of the packages available on the server.

[Click here for command line details](#)

```
Usage: trident list ((-d|--baseDir DIR) | --remote [--remoteURL ARG])
                (--packages | --groups | --individuals
                [-j|--jannoColumn JANNO_HEADER]) [--raw]
List packages, groups or individuals from local or remote Poseidon
repositories
```

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>--remote</code>	list packages from a remote server instead the local file system
<code>--remoteURL ARG</code>	URL of the remote Poseidon server (default: "https://c107-224.cloud.gwdg.de")
<code>--packages</code>	list all packages
<code>--groups</code>	list all groups, ignoring any group names after the first as specified in the Janno-file
<code>--individuals</code>	list individuals
<code>-j,--jannoColumn JANNO_HEADER</code>	list additional fields from the janno files, using the Janno column heading name, such as Country, Site, Date_C14_Uncal_BP, Endogenous, ...
<code>--raw</code>	output table as tsv without header. Useful for piping into grep or awk
<code>--ignoreGeno</code>	ignore SNP and GenoFile

To list packages from your local repositories, as seen above you can run

```
trident list -d ... -d ... --packages
```

This will yield a table like this

Title	Date	Nr Individuals
2015_1000Genomes_1240K_haploid_pulldown	2020-08-10	2535
2016_Mallick_SGDP1240K_diploid_pulldown	2020-08-10	280
2018_BostonDatashare_modern_published	2020-08-10	2772
...	...	

so a nicely formatted table of all packages, their last update and the number of individuals in it.

To view packages on the remote server, instead of using directories to specify the locations of repositories on your system, you can use `--remote` to show packages on the remote server. For example

```
trident list --packages --remote
```

will result in a view of all published packages in our public online repository.

You can also list groups, as defined in the third column of EIGENSTRAT `.ind` files (or the first column of a PLINK `.fam` file), and individuals:

```
trident list -d ... -d ... --groups
trident list -d ... -d ... --individuals
```

The `--individuals` flag also provides a way to immediately access information from the `.janno` files on the command line. This works with the `-j/--jannoColumn` option. For example adding `--jannoColumn Country` `--jannoColumn Date_C14_Uncal_BP` to the commands above will add the `Country` and the `Date_C14_Uncal_BP` columns to the respective output tables.

Note that if you want a less fancy table, for example because you want to load this into Excel, or pipe into another command that cannot deal with the neat table layout, you can use the `--raw` option to output that table as a simple tab-delimited stream.

4.2 Summarise command

`summarise` prints some general summary statistics for a given poseidon dataset taken from the `.janno` files.

[Click here for command line details](#)

Usage: `trident summarise (-d|--baseDir DIR) [--raw]`

Get an overview over the content of one or multiple Poseidon packages

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>--raw</code>	output table as tsv without header. Useful for piping into grep or awk

You can run it with

```
trident summarise -d ... -d ...
```

which will show you context information like – among others – the number of individuals in the dataset, their sex distribution, the mean age of the samples (for ancient data) or the mean coverage on the 1240K SNP array in a table. `summarise` depends on complete `.janno` files and will silently ignore missing information for some statistics.

You can use the `--raw` option to output the summary table in a simple, tab-delimited layout.

4.3 Survey command

`survey` tries to indicate package completeness (mostly focused on `.janno` files) for poseidon datasets.

[Click here for command line details](#)

Usage: `trident survey (-d|--baseDir DIR) [--raw]`

Survey the degree of context information completeness for Poseidon packages

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>--raw</code>	output table as tsv without header. Useful for piping into <code>grep</code> or <code>awk</code>

Running

```
trident survey -d ... -d ...
```

will yield a table with one row for each package. See `trident survey -h` for a legend which cell of this table means what.

Again you can use the `--raw` option to output the survey table in a tab-delimited format.

4.4 Validate command

`validate` checks poseidon datasets for structural correctness.

[Click here for command line details](#)

Usage: `trident validate (-d|--baseDir DIR) [--verbose]`

Check one or multiple Poseidon packages for structural correctness

Available options:

<code>-h,--help</code>	Show this help text
<code>-d,--baseDir DIR</code>	a base directory to search for Poseidon Packages (could be a Poseidon repository)
<code>--verbose</code>	print more output to the command line
<code>--ignoreGeno</code>	ignore SNP and GenoFile
<code>--noExitCode</code>	do not produce an explicit exit code

You can run it with

```
trident validate -d ... -d ...
```

and it will either report a success (**Validation passed**) or failure with specific error messages to simplify fixing the issues.

`validate` tries to ensure that each package in the dataset adheres to the [schema definition](#). Here is a list of what is checked:

- Presence of the necessary files
- Full structural correctness of `.bib` and `.janno` file
- Superficial correctness of genotype data files. A full check would be too computationally expensive
- Correspondence of BibTeX keys in `.bib` and `.janno`
- Correspondence of individual and group IDs in `.janno` and genotype data files

In fact much of this validation already runs as part of the general package reading pipeline invoked for many trident subcommands (e.g. `forge`). `validate` is meant to be more thorough, though, and will explicitly fail if even a single package is broken.

5 Analysis commands

All analysis commands (e.g. `trident fstats`) have been moved from `trident` to the analysis tool `xerxes`.