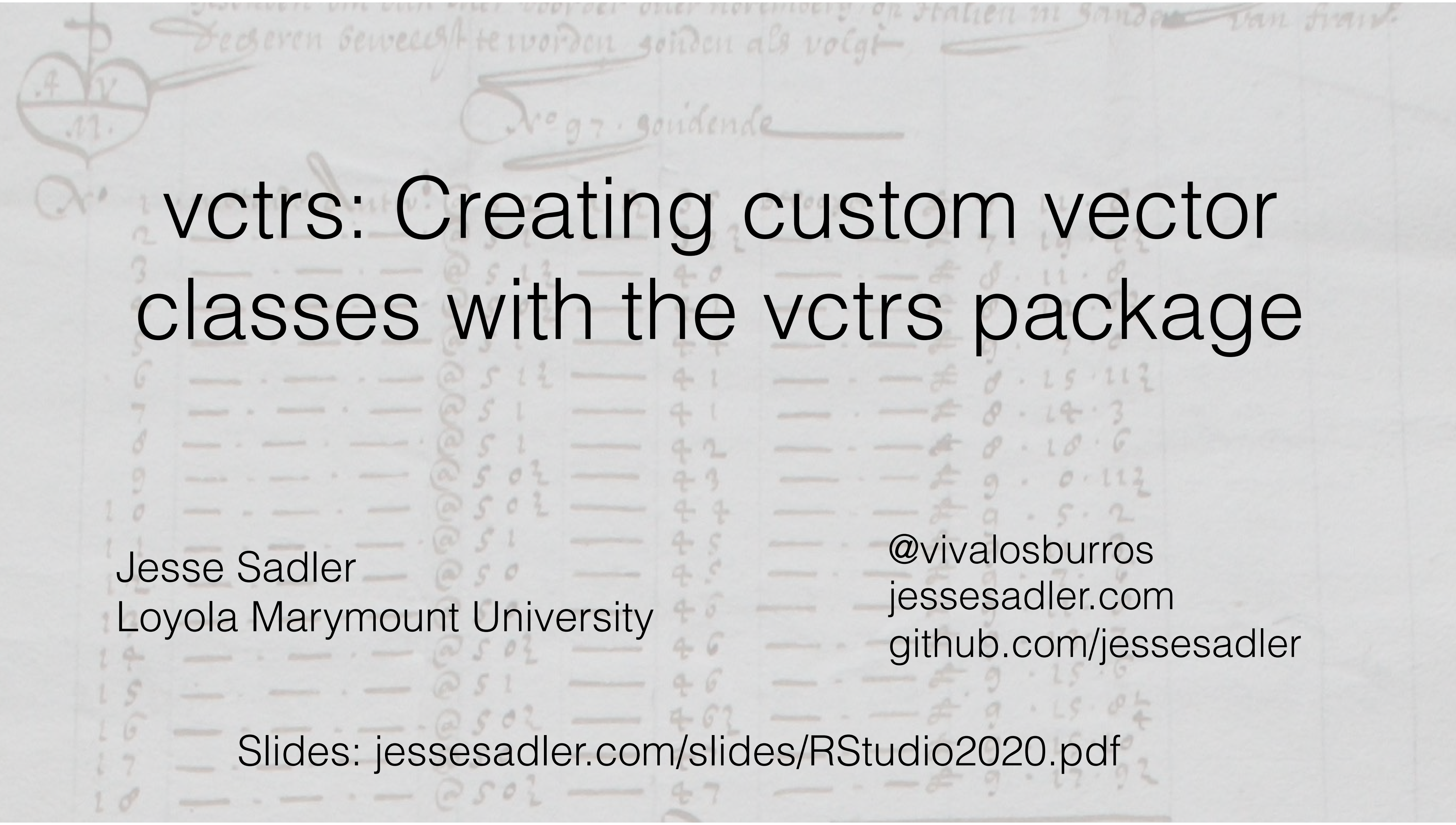

vctrs: Creating custom vector classes with the vctrs package

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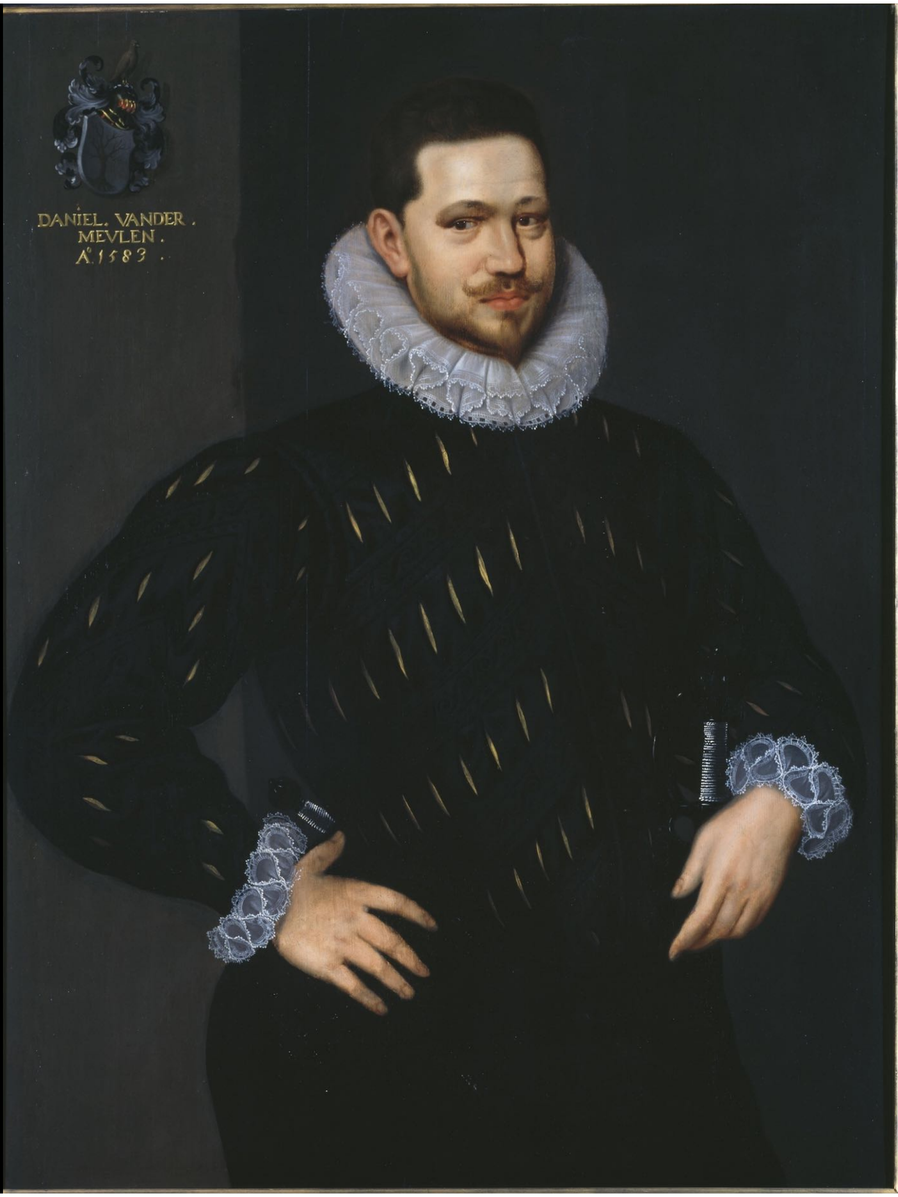
Slides: jessesadler.com/slides/RStudio2020.pdf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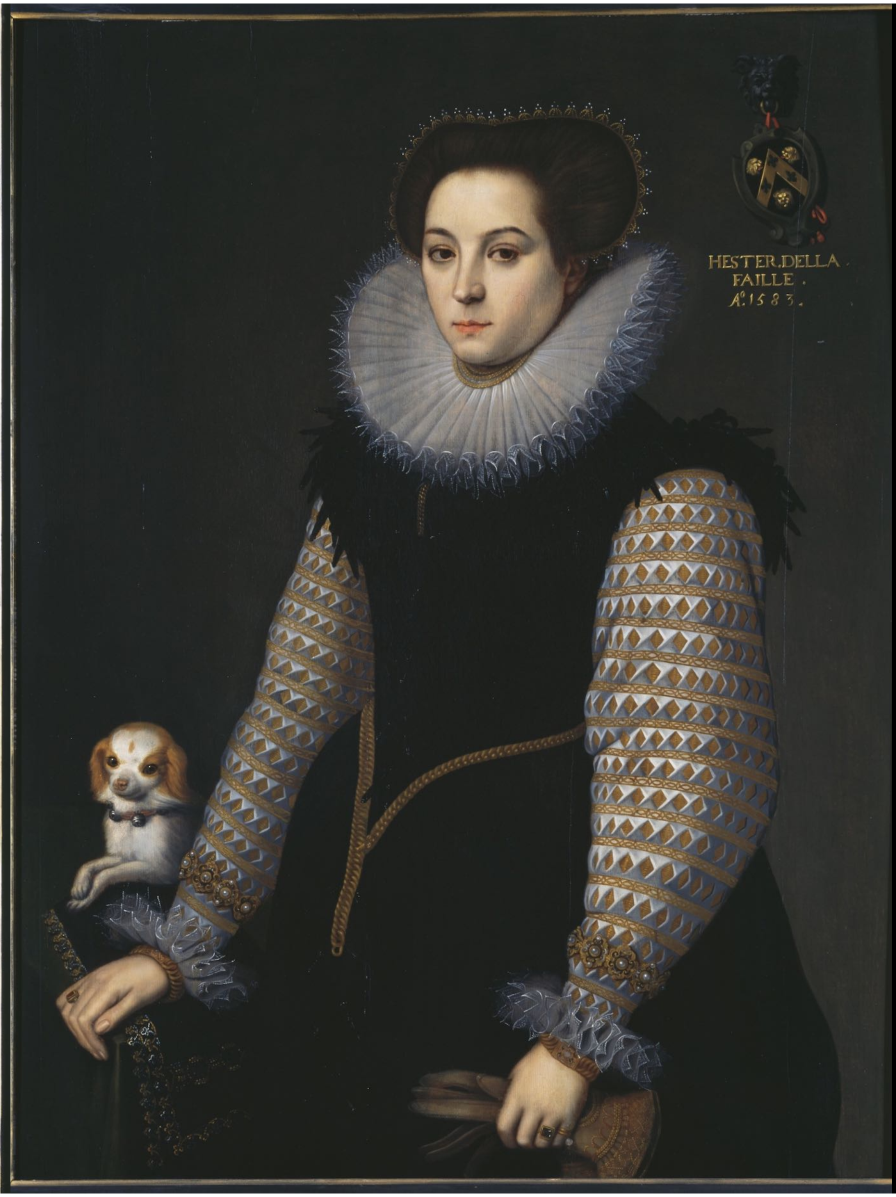
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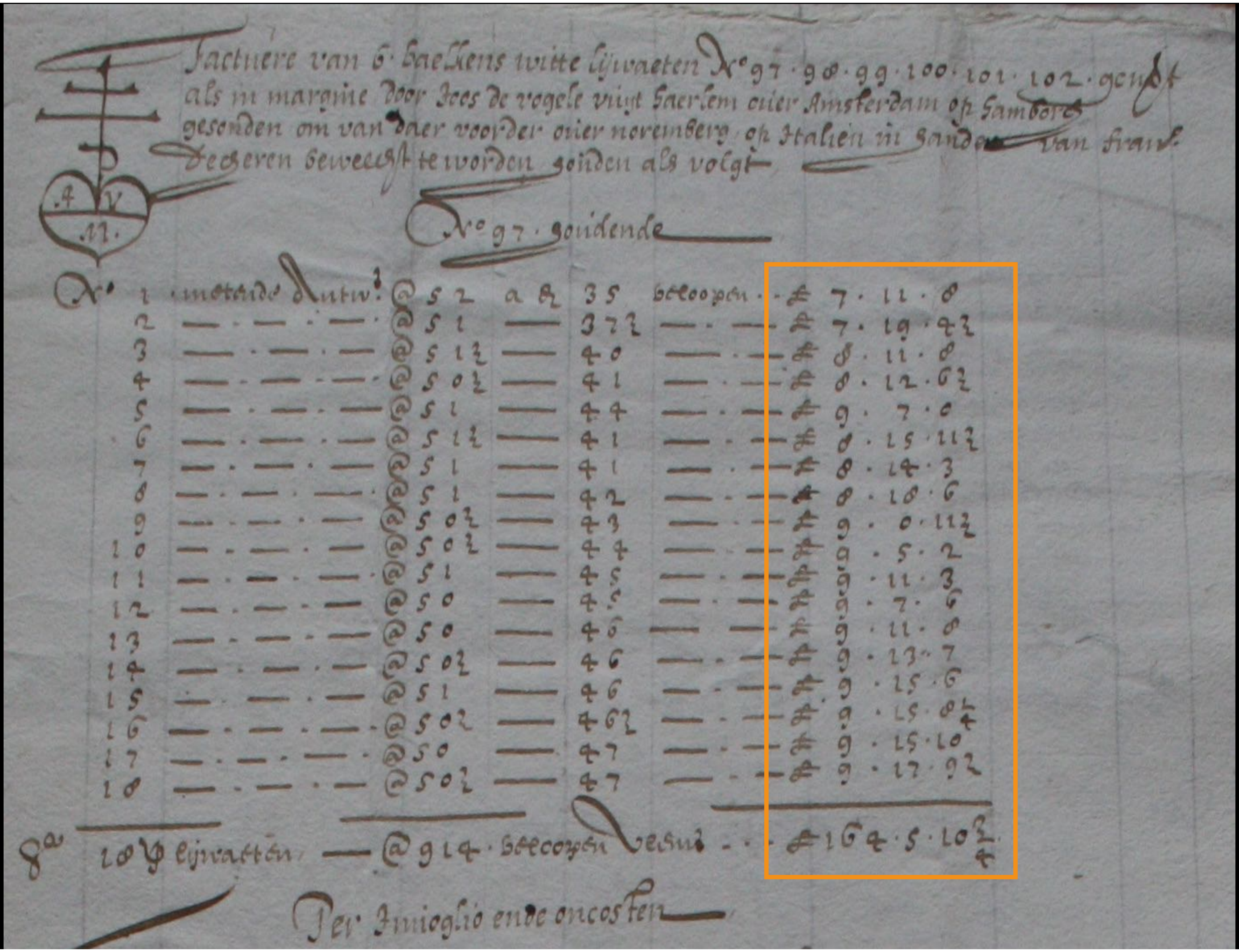

Facture van 6 baelkens witte lijwaeten No 97 · 98 · 99 · 100 · 101 · 102 · gemerct als in margine door Joos de vogele uijt haerlem ouer Amsterdam op hamborch gesonden om van daer voorder ouer noremberg op Italien in handen van Fran. Decheren beweecht te worden houdende als volgt

No 97 · houdende

No 1	metade Antw:t	@ 52	a El	35	beloopen	£ 7 · 11 · 8
2	— · — · —	@ 51	—	37½	— · —	£ 7 · 19 · 4½
3	— · — · —	@ 51½	—	40	— · —	£ 8 · 11 · 8
4	— · — · —	@ 50½	—	41	— · —	£ 8 · 12 · 6½
5	— · — · —	@ 51	—	44	— · —	£ 9 · 7 · 0
6	— · — · —	@ 51½	—	41	— · —	£ 8 · 15 · 11½
7	— · — · —	@ 51	—	41	— · —	£ 8 · 14 · 3
8	— · — · —	@ 51	—	42	— · —	£ 8 · 18 · 6
9	— · — · —	@ 50½	—	43	— · —	£ 9 · 0 · 11½
10	— · — · —	@ 50½	—	44	— · —	£ 9 · 5 · 2
11	— · — · —	@ 51	—	45	— · —	£ 9 · 11 · 3
12	— · — · —	@ 50	—	45	— · —	£ 9 · 7 · 6
13	— · — · —	@ 50	—	46	— · —	£ 9 · 11 · 8
14	— · — · —	@ 50½	—	46	— · —	£ 9 · 13 · 7
15	— · — · —	@ 51	—	46	— · —	£ 9 · 15 · 6
16	— · — · —	@ 50½	—	46½	— · —	£ 9 · 15 · 0¼
17	— · — · —	@ 50	—	47	— · —	£ 9 · 15 · 10
18	— · — · —	@ 50½	—	47	— · —	£ 9 · 17 · 9½
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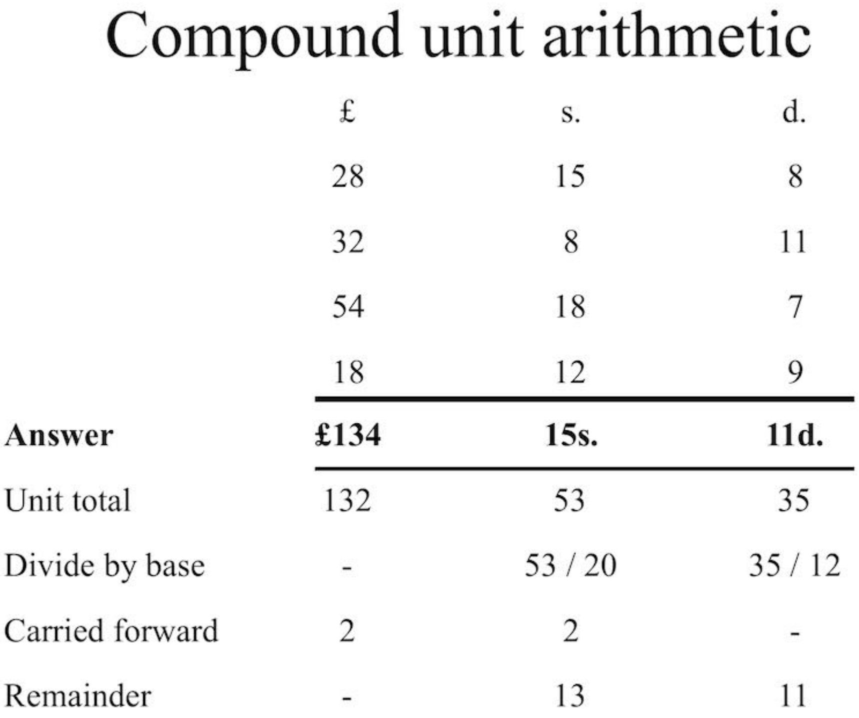
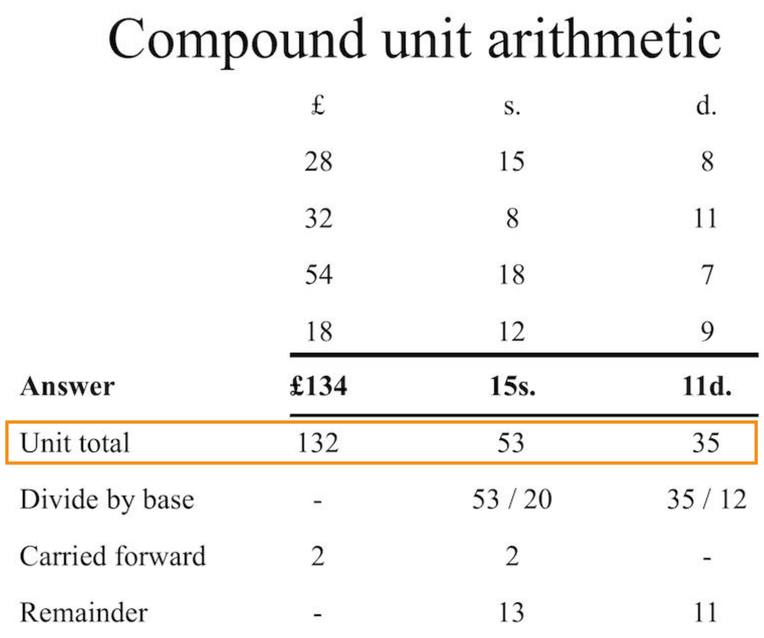


Compound unit arithmetic

	£	s.	d.
	28	15	8
	32	8	11
	54	18	7
	18	12	9
Answer	**£134**	**15s.**	**11d.**
Unit total	132	53	35
Divide by base	-	53 / 20	35 / 12
Carried forward	2	2	-
Remainder	-	13	11

Problem space

- Three separate units make up one value
- The units have non-decimal bases
- Need to use compound-unit arithmetic to normalize values
- The non-decimal bases differed by currency



Compound unit arithmetic

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Divide by base	-	53 / 20	35 / 12
Carried forward	2	2	-
Remainder	-	13	11

Simple normalization function

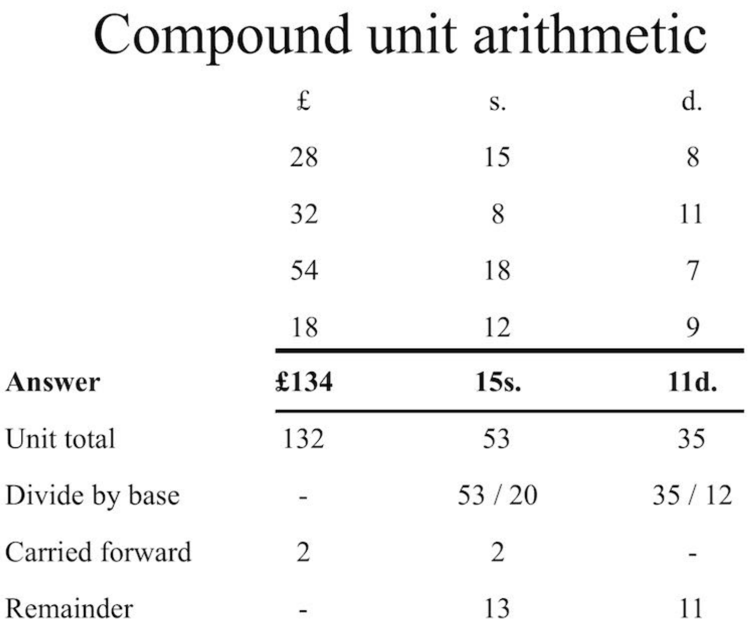
Fixed bases of 20s. and 12d.

```
# Normalize a numeric vector of length 3
normalize <- function(x) {
  pounds <- x[[1]] + ((x[[2]] + x[[3]] %/%
    12) %/% 20)
  shillings <- (x[[2]] + x[[3]] %/% 12) %% 20
  pence <- x[[3]] %% 12

  c(pounds, shillings, pence)
}

normalize(c(132, 53, 35))
#> [1] 134  15  11
```

Create an S3 class for non-decimal currencies



Compound unit arithmetic

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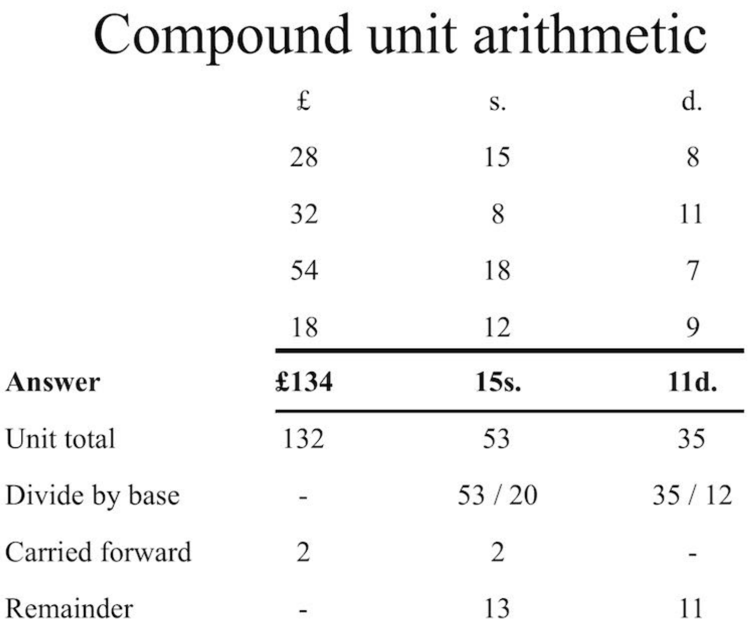
Answer	**£134**	**15s.**	**11d.**
Unit total	132	53	35
Divide by base	-	53 / 20	35 / 12
Carried forward	2	2	-
Remainder	-	13	11

```
lsd <- function(x, bases = c(20, 12)) {
  structure(x,
            class = "lsd",
            bases = bases)
}

lsd(c(134, 15, 11))
#> [1] 134 15 11
#> attr(,"class")
#> [1] "lsd"
#> attr(,"bases")
#> [1] 20 12
```



Compound unit arithmetic

	£	s.	d.
	28	15	8
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Unit total	132	53	35
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Create an S3 class for non-decimal currencies

```
lsd <- function(x, bases = c(20, 12)) {
  structure(x,
            class = "lsd",
            bases = bases)
}

lsd(c(134, 15, 11))
#> [1] 134 15 11
#> attr(,"class")
#> [1] "lsd"
#> attr(,"bases")
#> [1] 20 12
```

Create an S3 class for non-decimal currencies

To-do list

Use lists instead of vectors to have multiple values

Change normalization method

What other methods do we need?

Print

Arithmetic operators

Concatenate

Subset

Mathematical functions

Casting to other classes

Plots

Create an S3 class for non-decimal currencies

To-do list

Use lists instead of vectors to have multiple values

Change normalization method

What other methods do w

Print

etic operators

Concatenat

Subs

Mathematical functions

asting to other classes

Plots

What else do I have to do? 🤯😩

https://vctrs.r-lib.org

Goals of vctrs

- Type stability
- Size stability
- Make it easier to build new S3 classes

What do you get by using vctrs?

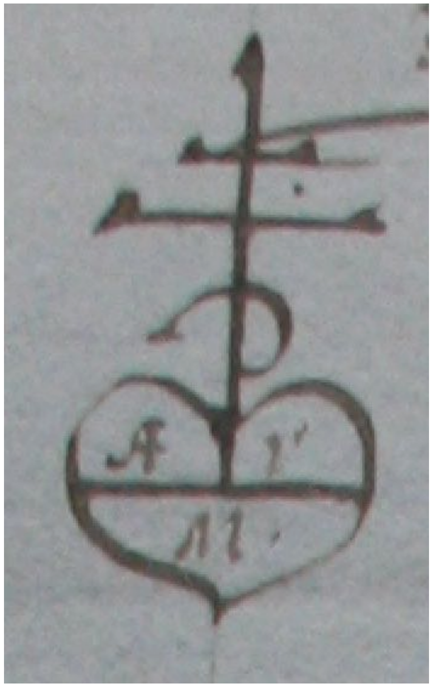
- Clear development path for creating an S3 class
- Consistency with base R functionality
- Integration with the tidyverse

Goals for the talk

- Why you might want to create your own S3 class
- Why you should use vctrs
- Point you to how you can do it

debvctrs

Why and how to use vctrs



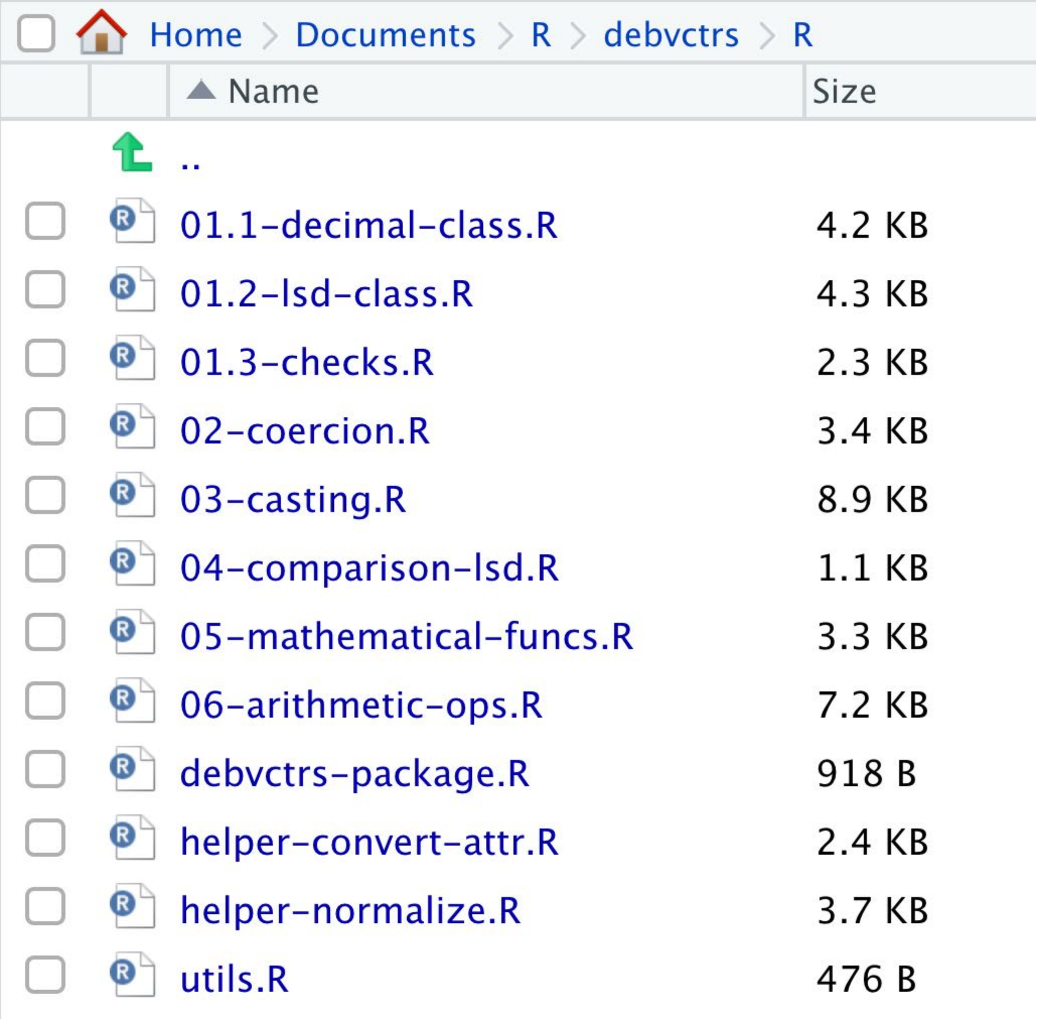
- debvctrs example package on GitHub:
  - github.com/jessesadler/debvctrs
- Simplified version of debkeepr:
  - jessesadler.github.io/debkeepr
- Step-by-step guide to building S3-vector classes with vctrs
  - Use in tandem with vctrs S3 vignette
  - https://vctrs.r-lib.org/articles/s3-vector

Creating S3 classes with vctrs

1. Creation of the class
2. Coercion: implicit transformation of a class: `c()`
3. Casting: explicit transformation of a class: `as.numeric()`
4. Equality and comparison: `>`, `<`, `==`, etc.
5. Mathematical functions: `sum(), mean()`, etc.
6. Arithmetic operations: `+`, `-`, `*`, `/`, etc.

Creating S3 classes with vctrs based on double vector

1. Creation of the class
2. Coercion: implicit transformation of a class: `c()`
3. Casting: explicit transformation of a class: `as.numeric()`
4. ~~Equality and comparison: >, <, ==, etc.~~
5. ~~Mathematical functions: `sum()`, `mean()`, etc.~~
6. Arithmetic operations: `+`, `-`, `*`, `/`, etc.



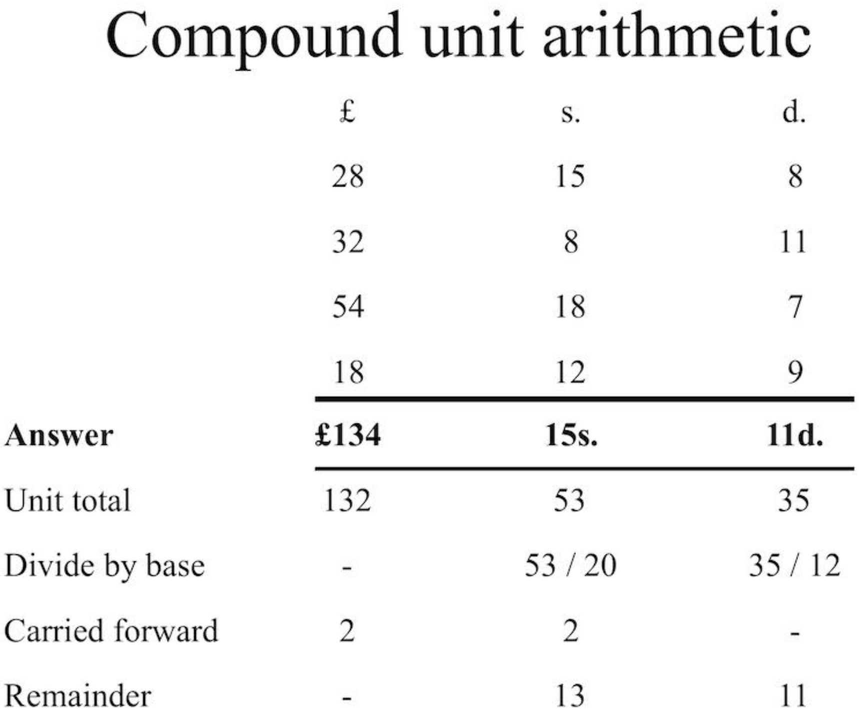
□ Home > Documents > R > debvctrs > R

	▲ Name	Size
	..	
□	01.1-decimal-class.R	4.2 KB
□	01.2-lsd-class.R	4.3 KB
□	01.3-checks.R	2.3 KB
□	02-coercion.R	3.4 KB
□	03-casting.R	8.9 KB
□	04-comparison-lsd.R	1.1 KB
□	05-mathematical-funcs.R	3.3 KB
□	06-arithmetic-ops.R	7.2 KB
□	debvctrs-package.R	918 B
□	helper-convert-attr.R	2.4 KB
□	helper-normalize.R	3.7 KB
□	utils.R	476 B

debvctrs R scripts

github.com/jessesadler/debvctrs

Problem space



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Unit total	132	53	35
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- Three separate units make up one value
- The units have non-decimal bases
- Need to use compound-unit arithmetic to normalize values
- The non-decimal bases differed by currency

Design principles

deb_lsd

- A class that maintains the tripartite structure of non-decimal currencies
- Tracks the bases of shillings and pence units
- Vectors with different bases cannot be combined

deb_decimal

- Decimalized class as fall back
- Tracks the bases of shillings and pence units
- Vectors with different bases cannot be combined
- Choose and track unit represented by decimalized class
- Vectors with different units can be combined but need coercion path

1. Creation

01.1-decimal-class.R, 01.2-lsd-class.r, and 01.3-check.R

1. Constructor: `new_lsd()` and `new_decimal()`
2. Helper: `deb_lsd()` and `deb_decimal()`
3. Formally declare S3 class: `setOldClass()`
4. Attribute access: `deb_bases()` and `deb_unit()`
5. Class check: `deb_is_lsd()` and `deb_is_decimal()`
6. Format method
7. Abbreviated name type

1. Creation

01.1-decimal-class.R, 01.2-lsd-class.r, and 01.3-check.R

deb_lsd()

```
# 1. Constructor
new_lsd <- function(l = double(),
                    s = double(),
                    d = double(),
                    bases = c(20L, 12L)) {

  vctrs::new_rcrd(list(l = l, s = s, d = d),
                  bases = bases,
                  class = "deb_lsd")
}
```

deb_decimal()

```
# 1. Constructor
new_decimal <- function(x = double(),
                        unit = c("l", "s", "d"),
                        bases = c(20L, 12L)) {


  vctrs::new_vctr(.data = x,
                  unit = unit,
                  bases = bases,
                  class = "deb_decimal",
                  inherit_base_type = TRUE)
}
```

1. Creation

01.1-decimal-class.R, 01.2-lsd-class.r, and 01.3-check.R

Arguments

deb_lsd()

```r
# 1. Constructor
new_lsd <- function(l = double(),
                    s = double(),
                    d = double(),
                    bases = c(20L, 12L)) {

  vctrs::new_rcrd(list(l = l, s = s, d = d),
                  bases = bases,
                  class = "deb_lsd")
}
```

deb_decimal()

```r
# 1. Constructor
new_decimal <- function(x = double(),
                        unit = c("l", "s", "d"),
                        bases = c(20L, 12L)) {

  vctrs::new_vctr(.data = x,
                  unit = unit,
                  bases = bases,
                  class = "deb_decimal",
                  inherit_base_type = TRUE)
}
```

Creation of class

Structure of the classes

deb_lsd()

```
deb_lsd(l = c(17, 32, 18),
        s = c(16, 7, 12),
        d = c(6, 9, 3))

#> <deb_lsd[3]>
#> [1] 17:16s:6d 32:7s:9d
#> [3] 18:12s:3d
#> # Bases: 20s 12d
```

deb_decimal()

```
deb_decimal(x = c(17.8250,
                  32.3875,
                  18.6125))

#> <deb_decimal[3]>
#> [1] 17.8250 32.3875
#> [3] 18.6125
#> # Unit: pounds
#> # Bases: 20s 12d
```

Structure of the classes

`deb_lsd()`

record-style vector

```
deb_lsd(l = c(17, 32, 18),
        s = c(16, 7, 12),
        d = c(6, 9, 3))
```

```
#> <deb_lsd[3]>
#> [1] 17:16s:6d 32:7s:9d
#> [3] 18:12s:3d
#> # Bases: 20s 12d
```

Bases attribute

`deb_decimal()`

double vector

```
deb_decimal(x = c(17.8250,
                  32.3875,
                  18.6125))
```

```
#> <deb_decimal[3]>
#> [1] 17.8250 32.3875
#> [3] 18.6125
#> # Unit: pounds
#> # Bases: 20s 12d
```

Unit attribute

Printing methods

Both work natively in a tibble

```
tibble(lsd = deb_lsd(l = c(17, 32, 18),
                     s = c(16, 7, 12),
                     d = c(6, 9, 3)),
       decimal = deb_decimal(x = c(17.8250,
                                   32.3875,
                                   18.6125)))
#> # A tibble: 3 x 2
#>              lsd      decimal
#>   <lsd[20s:12d]> <l[20s:12d]>
#> 1      17:16s:6d      17.8250
#> 2       32:7s:9d      32.3875
#> 3      18:12s:3d      18.6125
```

Coercion and casting with vctrs

1. Creation of the class
2. Coercion: implicit transformation of a class: `c()`
3. Casting: explicit transformation of a class: `as.numeric()`
4. Equality and comparison: `>`, `<`, `==`, etc.
5. Mathematical functions: `sum(), mean()`, etc.
6. Arithmetic operations: `+`, `-`, `*`, `/`, etc.

Coercion and casting workflow

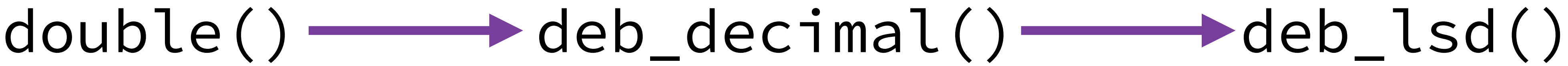
1. Boilerplate
   - Define method for class
   - Default method for class for incompatible inputs
2. Methods within the class
3. Methods with compatible classes

Coercion and casting

- Coercion looks for the common type: `vec_ptype2(x, y)`
- Casting does the actual transformation: `vec_cast(x, to)`
- Casting makes comparison between classes possible

Design choices: coercion hierarchy

Define possibilities and implement hierarchy with `vec_ptype2(x, y)`



`double()` → `deb_decimal()` → `deb_lsd()`

Implementation with casting

Example of `deb_decimal()` to `deb_lsd()`

```r
vec_cast.deb_lsd.deb_decimal <- function(x, to, ...) {
  bases_equal(x, to) # ensure that bases are equal
  # if else depending on the unit
  if (deb_unit(x) == "l") {
    lsd <- deb_lsd(x, 0, 0, bases = deb_bases(x))
  } else if (deb_unit(x) == "s") {
    lsd <- deb_lsd(0, x, 0, bases = deb_bases(x))
  } else if (deb_unit(x) == "d") {
    lsd <- deb_lsd(0, 0, x, bases = deb_bases(x))
  }
  # Normalize the deb_lsd() vector
  deb_normalize(lsd)
}
```

Put it all together

```
# Combine multiple types
c(deb_lsd(134, 15, 11), deb_decimal(14.875), 28.525)
#> <deb_lsd[3]>
#> [1] 134:15s:11d 14:17s:6d   28:10s:6d
#> # Bases: 20s 12d

# Compare different types
deb_decimal(3255, unit = "d") > deb_lsd(15, 13, 4)
#> [1] FALSE

# Arithmetic with different types
deb_decimal(3255, unit = "d") + deb_lsd(15, 13, 4)
#> <deb_lsd[1]>
#> [1] 29:4s:7d
#> # Bases: 20s 12d
```

You can create your own S3 vector

- Extend the capabilities of R to fit your own needs

- vctrs provides a clear development path

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website: jessesadler.com
GitHub: github.com/jessesadler

Resources

- Slides: jessesadler.com/slides/RStudio2020.pdf
- debvctrs: github.com/jessesadler/debvctrs
- debkeepr: jessesadler.github.io/debkeepr
- vctrs websitesite: vctrs.r-lib.org
  - The S3 vignette is particularly helpful
- Hadley Wickham, *Advanced R:* Chapter 13: S3