Venn diagrams
Technical details and regression checks

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23^{rd} September, 2009

- Try CR for weight=0
- Plot faces for Chow-Ruskey
- General set membership
- implement not showing dark matter eg Fig 1
- AWFE-book like figures
- likesquares argument for triangles
- central dark matter
- Comment on triangles
- Comment on AWFE
- text boxes
- use grob objects/printing properly
- cope with missing data including missing zero intersection;
- discuss Chow-Ruskey zero=nonsimple

1 Venn objects

```
> if ("package:Vennerable" %in% search()) detach("package:Vennerable")
> library(Vennerable)
```

```
> Vcombo <- Venn(SetNames = c("Female", "Visible Minority", "CS Major"),
+     Weight = c(0, 4148, 409, 604, 543, 67, 183, 146))
> setList <- strsplit(month.name, split = "")
> names(setList) <- month.name
> VN3 <- VennFromSets(setList[1:3])
> V2 <- VN3[, c("January", "February"), ]
```

```
> V4 <- VennFromSets(setList[1:4])
> V4f <- V4
> V4f@IndicatorWeight[, ".Weight"] <- 1
```

```
> setList <- strsplit(month.name, split = "")
> names(setList) <- month.name
> VN3 <- VennFromSets(setList[1:3])
> V2 <- VN3[, c("January", "February"), ]
```

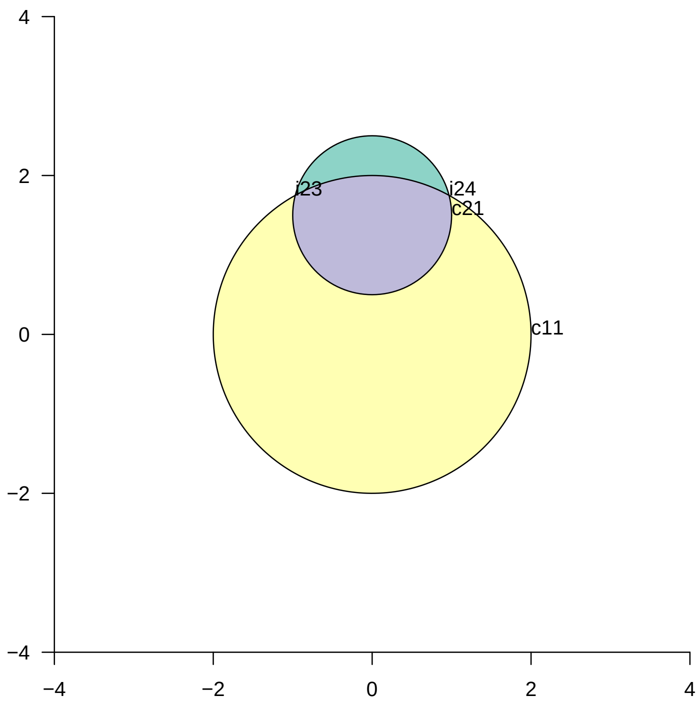
```
> V3.big <- Venn(SetNames = month.name[1:3], Weight = 2^(1:8))
> V2.big <- V3.big[, c(1:2)]
```

```
> Vempty <- VennFromSets(setList[c(4, 5, 7)])
> Vempty2 <- VennFromSets(setList[c(4, 5, 11)])
> Vempty3 <- VennFromSets(setList[c(4, 5, 6)])
```

2 The VennDrawing object

This is created from a `TissueDrawing` object and a `Venn` object

```
> centre.xy <- c(0, 0)
> VDC1 <- newTissueFromCircle(centre.xy, radius = 2, Set = 1)
> VDC2 <- newTissueFromCircle(centre.xy + c(0, 1.5), radius = 1,
+     Set = 2)
> TM <- addSetToDrawing(drawing1 = VDC1, drawing2 = VDC2, set2Name = "Set2")
> VD2 <- new("VennDrawing", TM, V2)
```



3 Two circles

3.1 Two circles

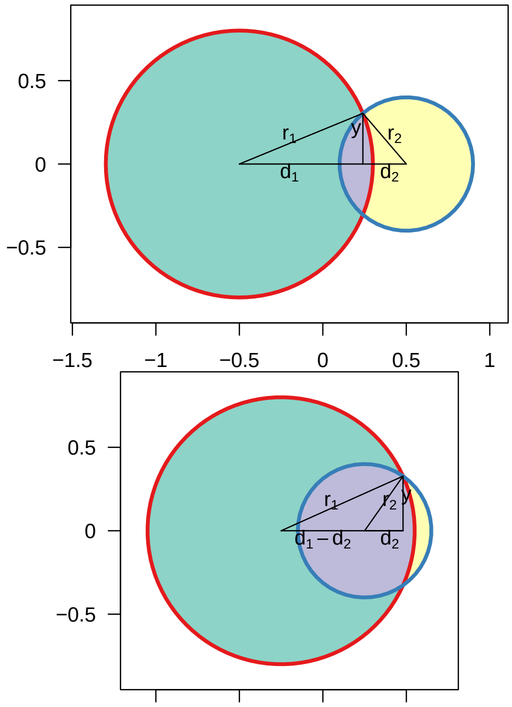


Figure 1: Geometry of two overlapping circles

There is an intersection if $|r_1 - r_2| < d < r_1 + r_2$. If so and $d < \max(r_1, r_2)$ the centre of the smaller circle is in the interior of the larger. Either way we have the relationships

$$\begin{aligned} d_1^2 + y^2 &= r_1^2 \\ d_2^2 + y^2 &= r_2^2 \end{aligned}$$

If $\max(r_1, r_2) < d < r_1 + r_2$ then $d = d_1 + d_2$; if $|r_1 - r_2| < d < \max(r_1, r_2)$ then $d = |d_1 - d_2|$.

We rely on the relationships

$$\begin{aligned} d_1 &= (d^2 - r_2^2 + r_1^2)/(2d) \\ d_2 &= |d - d_1| \\ y &= \frac{1}{2d}\sqrt{4d^2 r_1^2 - (d^2 - r_2^2 + r_1^2)^2} \\ &= \sqrt{r_1^2 - d_1^2} \end{aligned}$$

3.2 Weighted 2-set Venn diagrams for 2 Sets

3.2.1 Circles

It is always possible to get an exactly area-weighted solution for two circles as shown in Figure 2.

```
       00        11        10        01
475.9979 271.9995  67.9992 135.9992
```

```
[1] "Area check passed"
```

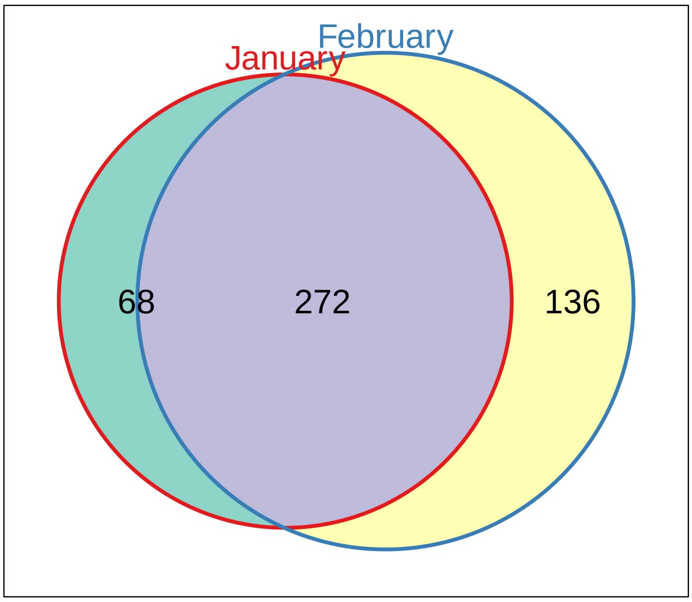


Figure 2: Weighted 2d Venn

3.3 2-set Euler diagrams

3.3.1 Circles

```
       00        11        10        01
7.1339724 3.8633868 0.1352894 3.1352961
```

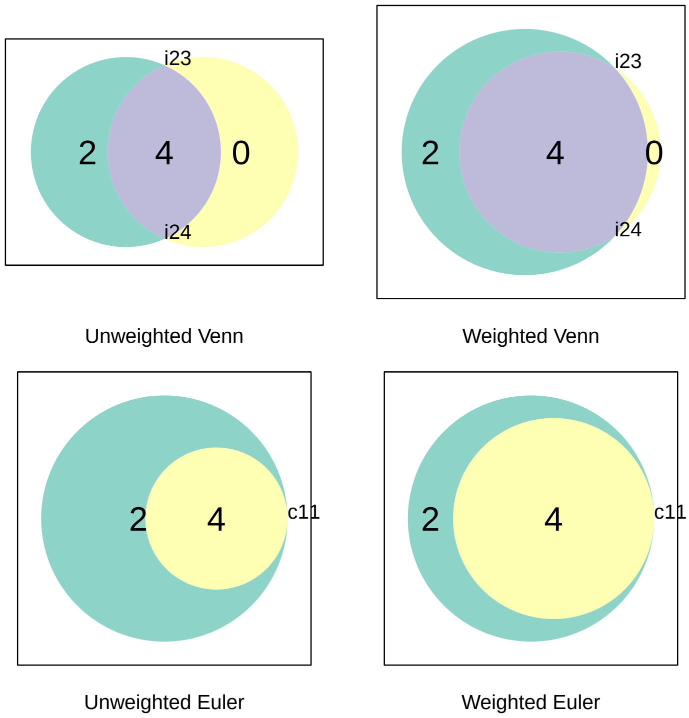
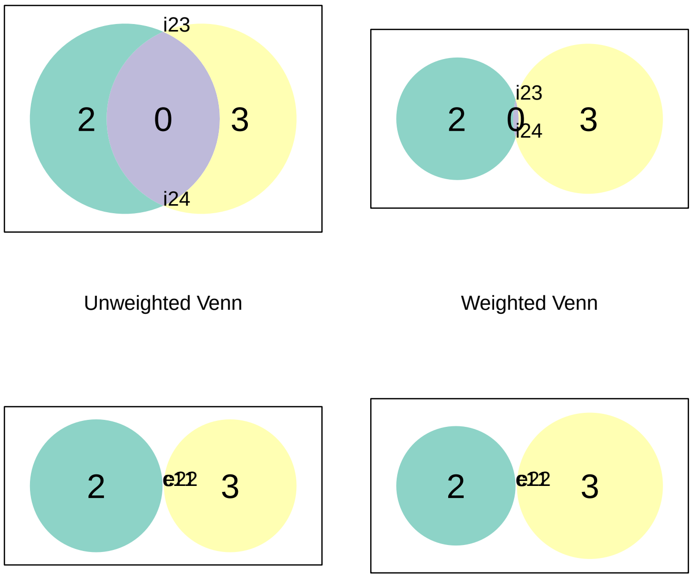


Figure 3: Effect of the Euler and `doWeights` flags.



Unweighted Venn

Weighted Venn

Unweighted Euler

Weighted Euler

Figure 4: As before for a different set of weights

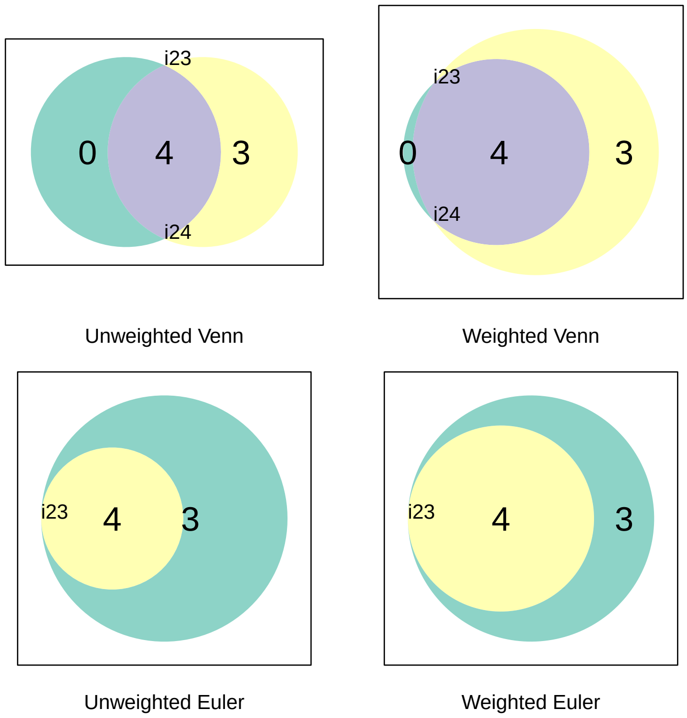
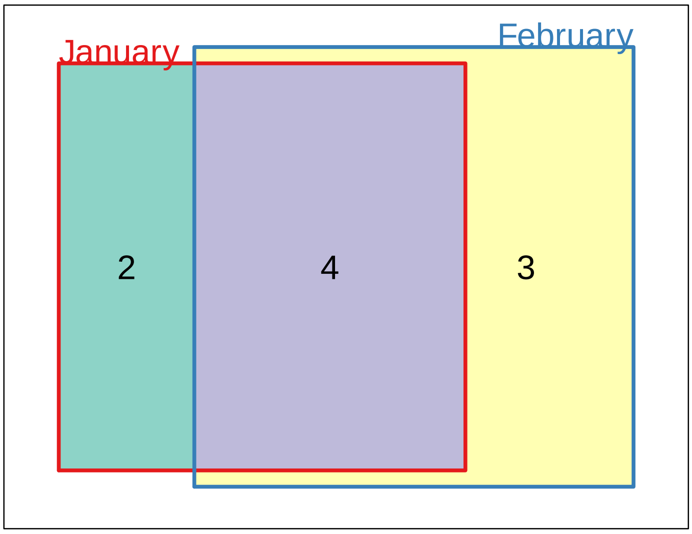


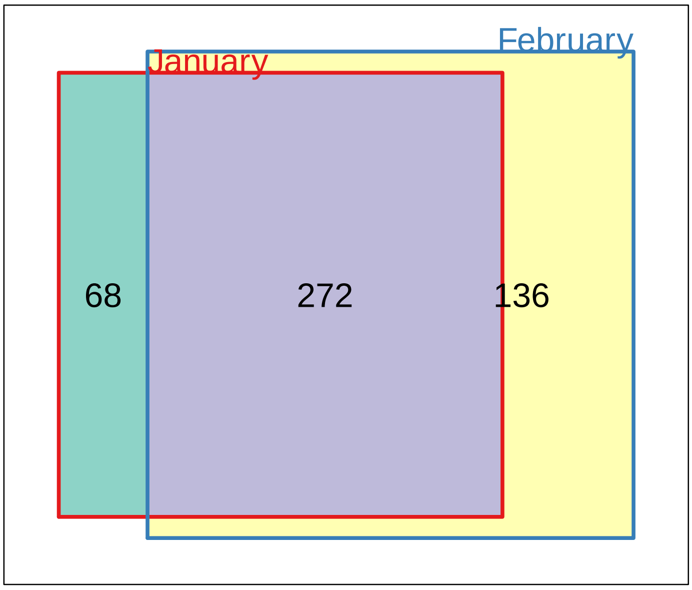
Figure 5: As before for a different set of weights

4 Two squares

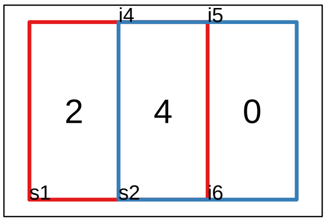


4.0.2 Weights

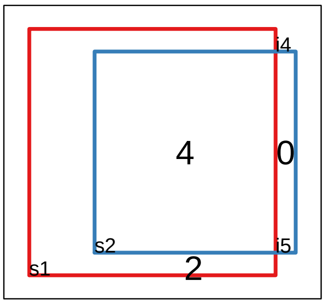
```
 00  11  10  01
476 272  68 136
```



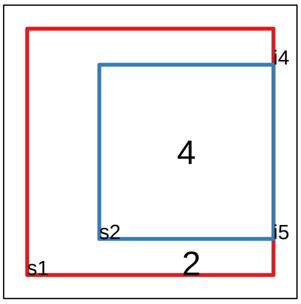
4.0.3 Squares



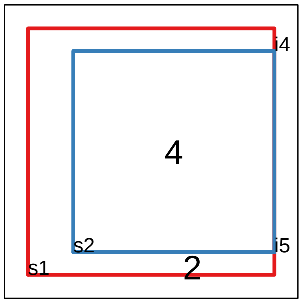
Unweighted Venn



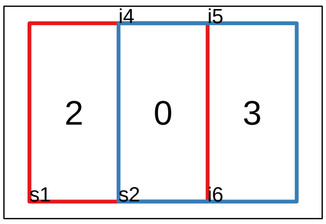
Weighted Venn



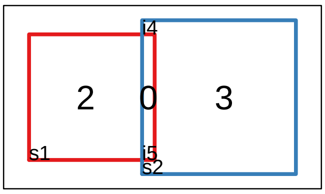
Unweighted Euler



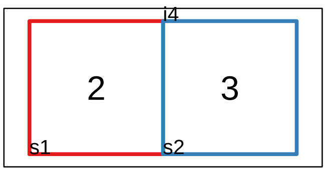
Weighted Euler



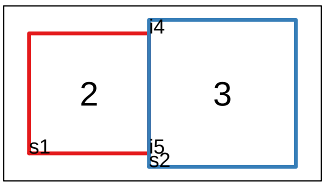
Unweighted Venn



Weighted Venn

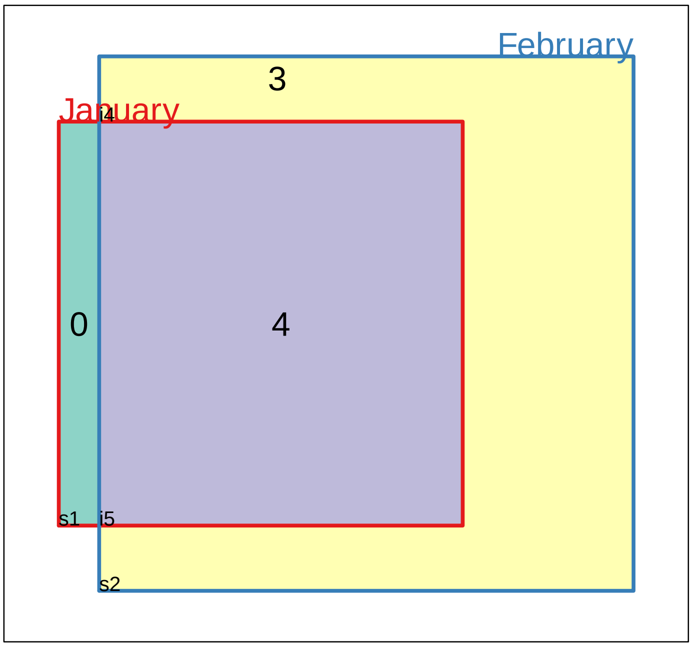


Unweighted Euler



Weighted Euler

```
 00  11  10  01
7.4 3.6 0.4 3.4
```



5 Three circles

```
> plot(Vcombo, doWeights = FALSE, show = list(Faces = TRUE))
```

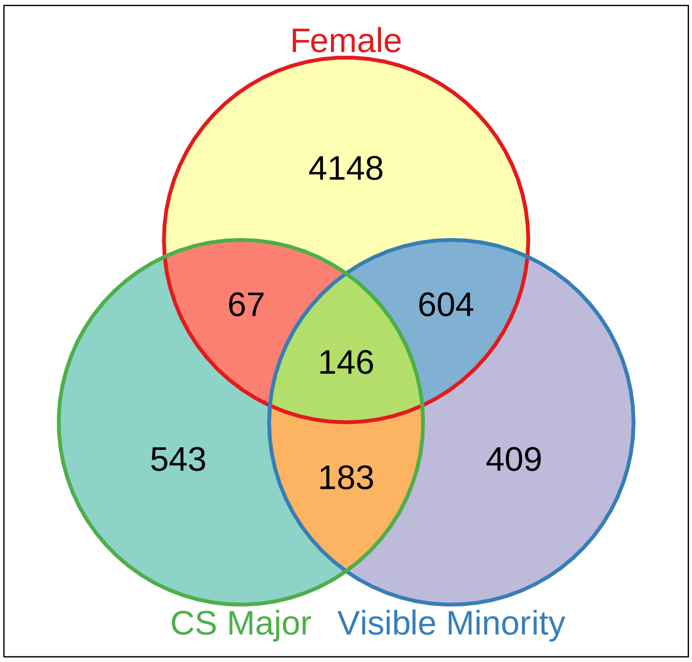


Figure 6: A three-circle Venn diagram

5.0.4 Weights

There is no general way of creating area-proportional 3-circle diagrams. The package makes an attempt to produce approximate ones.

```
       000        001        101        100        111        110        011 
6094.83358  537.83535   72.16413 4142.83542  140.83530  609.16384  188.16391 
       010 
 403.83563 

[1] "Area check passed"
```

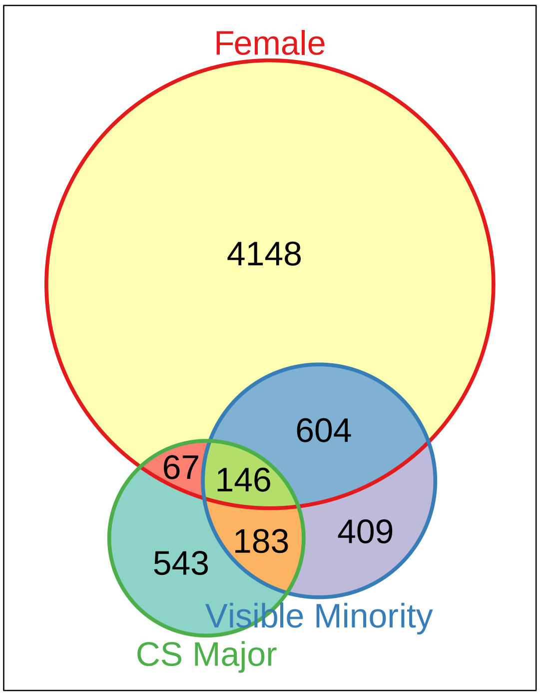


Figure 7: 3D Venn diagram. All of the areas are correct to within 10%

6 Three Triangles

The triangular Venn diagram on 3-sets lends itself nicely to an area-proportional drawing under some contrainsts on the weights

```
[1] "Area check passed"
```

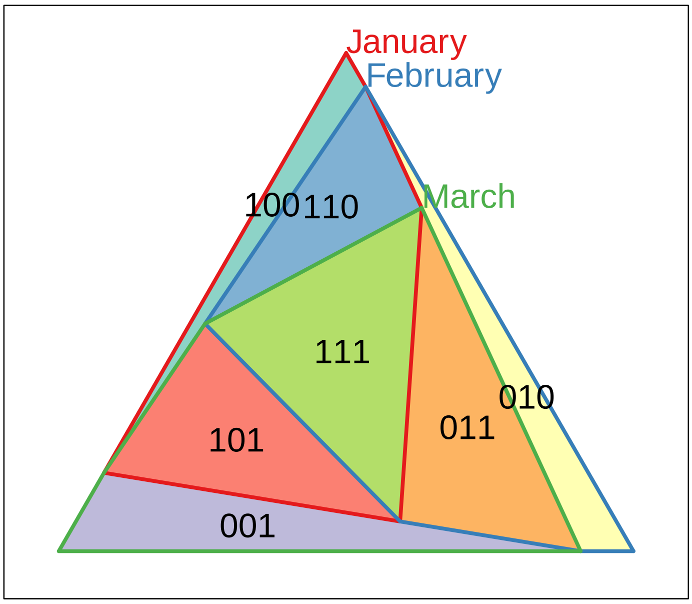


Figure 8: Triangular Venn with external universe

6.1 Triangular Venn diagrams

6.1.1 Triangles

```
000  100  010  111  110  001
 12    2    3    2    2    3
```

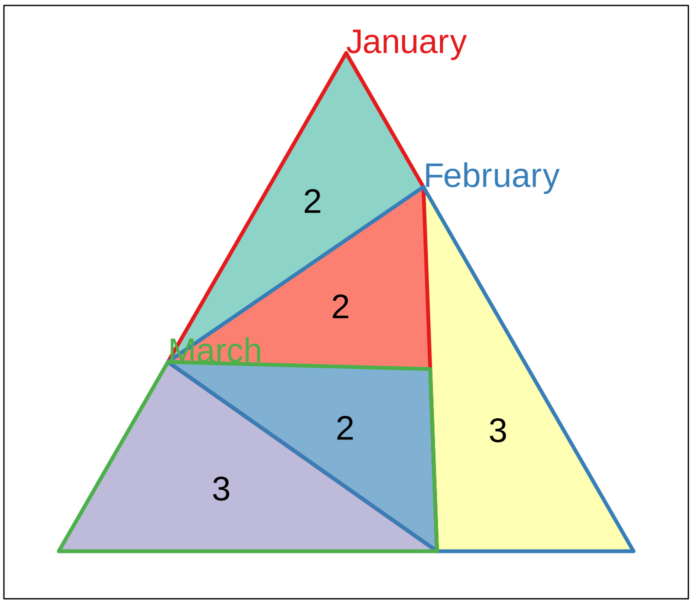


Figure 9: 3d Venn triangular with one empty intersection

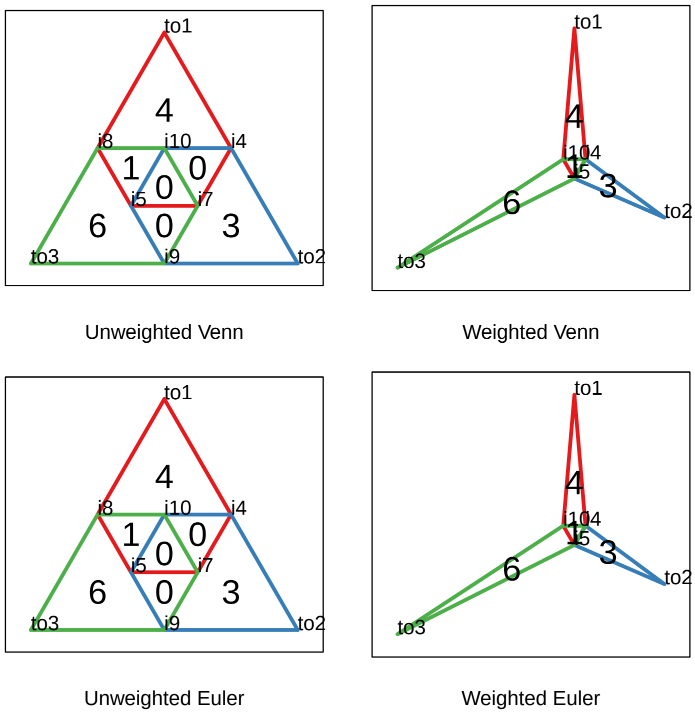
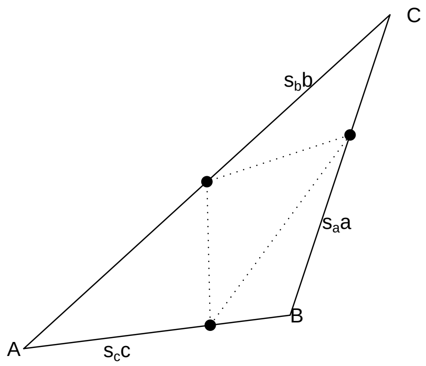


Figure 10: 3d Venn triangular with two empty intersection



Given a triangle ABC of area Δ and some nonnegative weights $w_a + w_b + w_c < 1$ we want to set s_c, s_a and s_b so that the areas of each of the apical triangles are Δ-proportional to w_a, w_b and w_c. This means

$$\begin{aligned} s_c(1-s_b)bc\sin A &= 2w_a\Delta && (1)\\ s_a(1-s_c)ca\sin B &= 2w_b\Delta && (2)\\ s_b(1-s_a)ab\sin C &= 2w_c\Delta && (3) \end{aligned}$$

So

$$\begin{aligned} s_c(1-s_b) &= w_a && (4)\\ s_a(1-s_c) &= w_b && (5)\\ s_b(1-s_a) &= w_c && (6) \end{aligned}$$

$$\begin{aligned} s_b &= 1-w_a/s_c && (7)\\ s_a &= w_b/(1-s_c) && (8)\\ (s_c-w_a)(1-s_c-w_b) &= s_c(1-s_c)w_c && (9) \end{aligned}$$

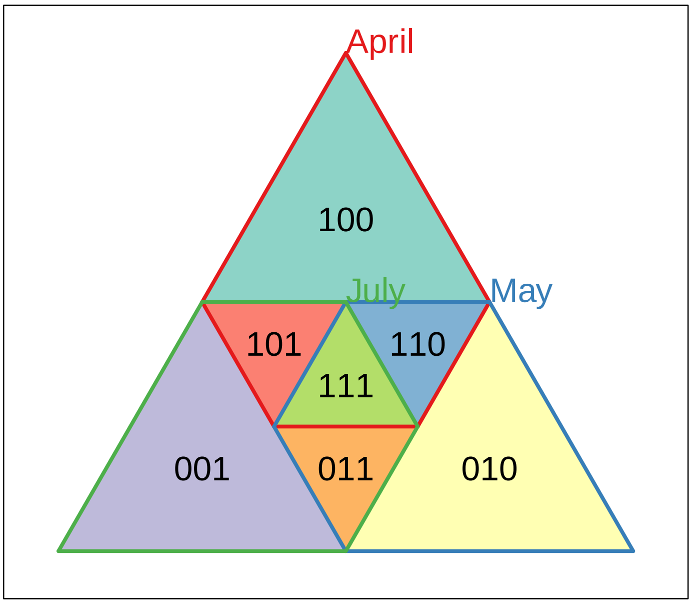
$$s_c^2(1-w_c)+s_c(w_b+w_c-w_a-1)+w_a(1-w_b) = 0 \qquad (10)$$

Iff

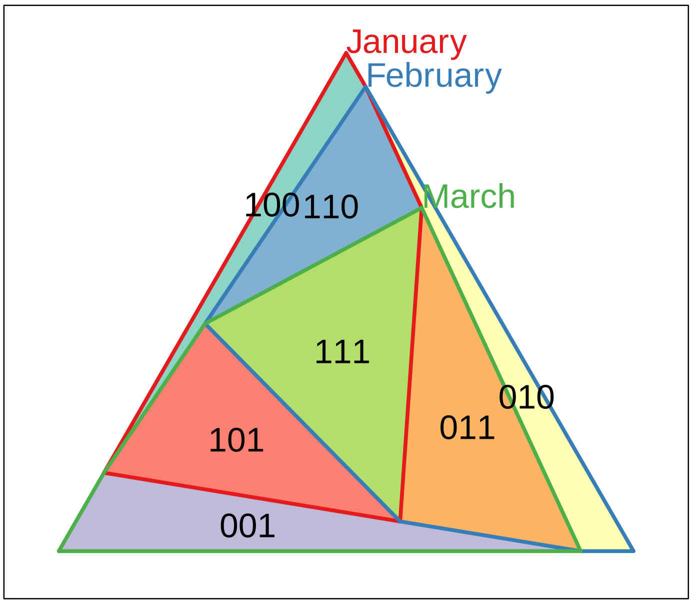
$$4w_aw_bw_c < (1-(w_a+w_b+w_c))^2 \qquad (11)$$

this has two real solutions between w_a and $1-w_b$.

```
[1] TRUE
```



6.2 Three triangles



7 Three Squares

This is a version of the algorithm suggested by Chow Ruskey 2003.

```
[1] "Area check passed"
```

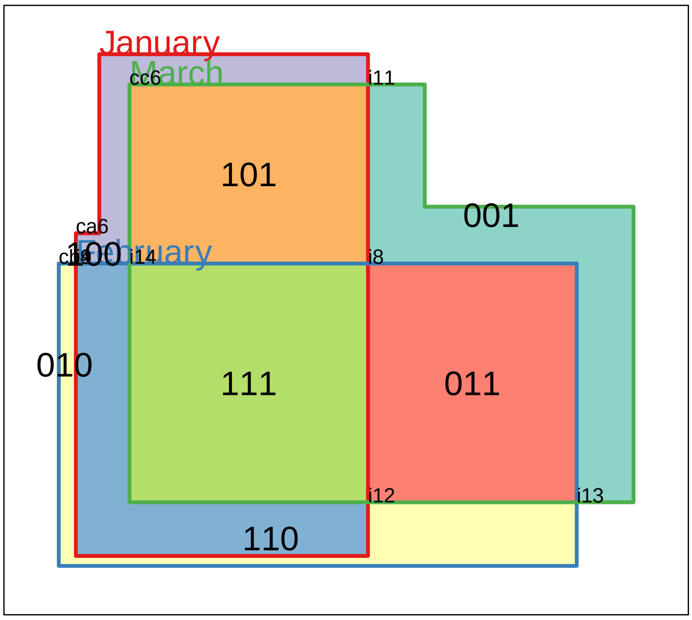
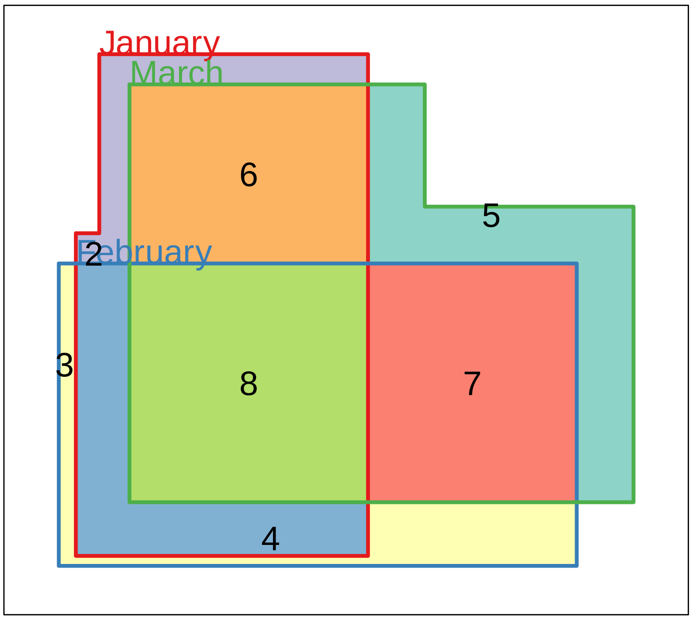


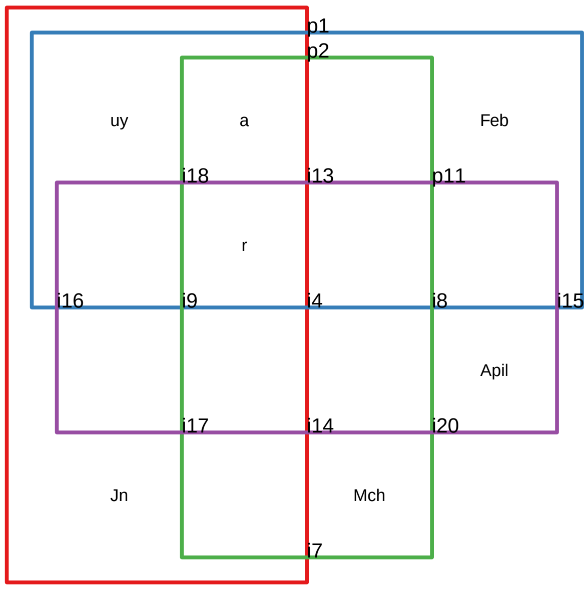
Figure 11: Weighted 3-set Venn diagram based on the algorithm of [1]

7.1 Three squares



8 Four squares

8.1 Unweighted 4-set Venn diagrams

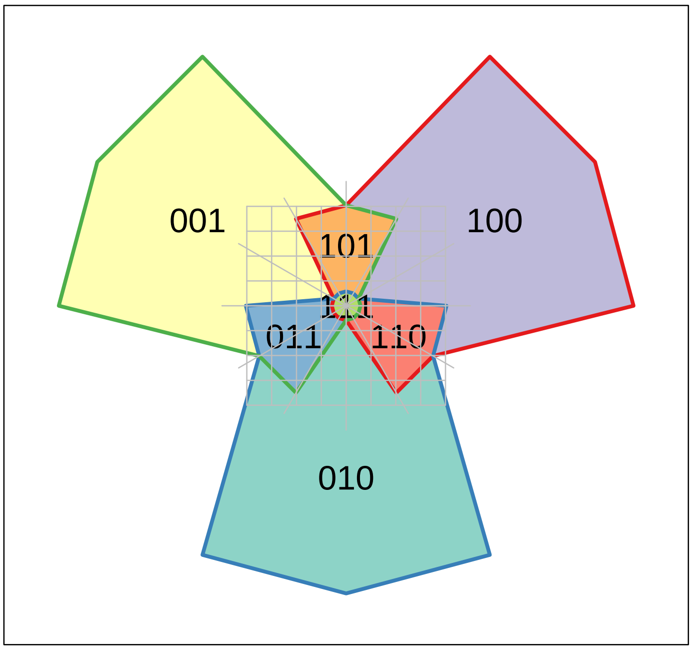


9 Chow-Ruskey

See [2, 1].

9.1 Chow-Ruskey diagrams for 3 sets

```
[1] "Area check passed"
```



```
[1] "Area check passed"
```

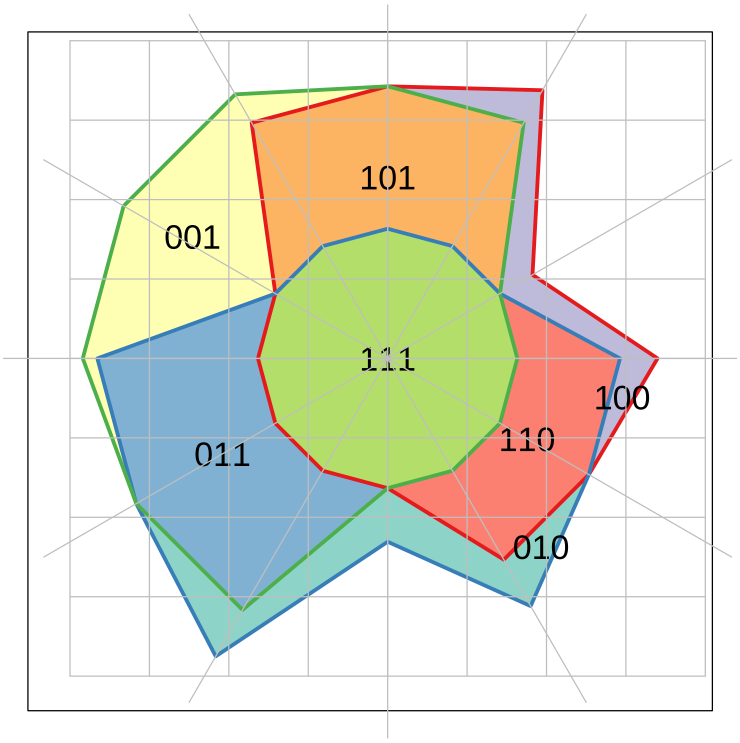


Figure 12: Chow-Ruskey CR3f

```
[1] "Area check passed"
```

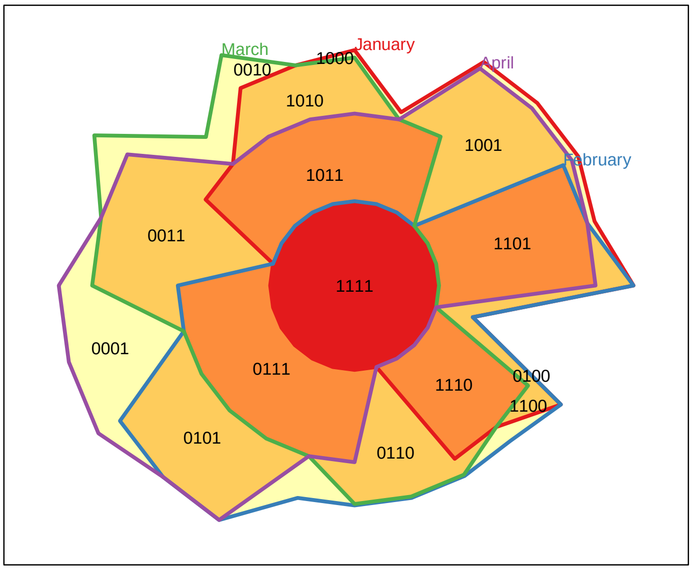


Figure 13: Chow-Ruskey weighted 4-set diagram, produces an error if we try to plot signature face text

```
[1] "Area check passed"
```

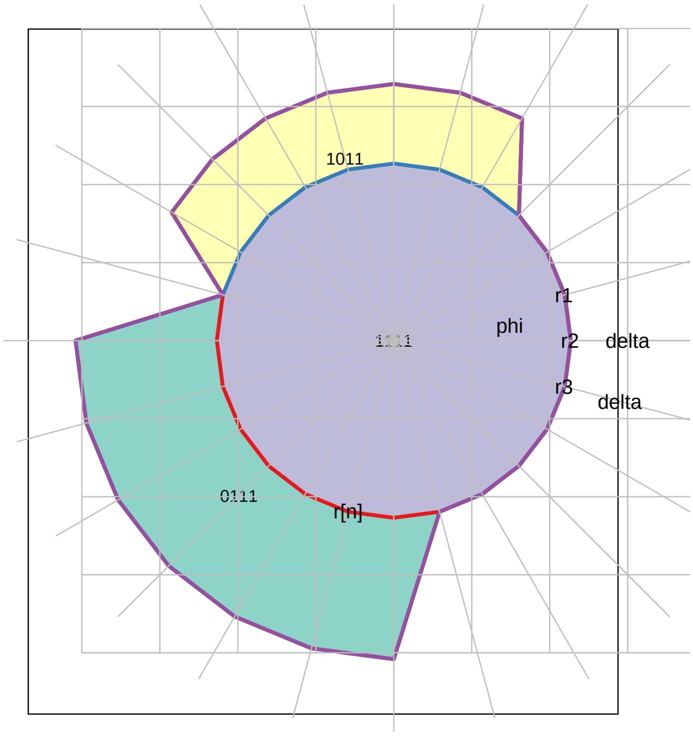


Figure 14: Chow-Ruskey weighted 4-set diagram

The area of the sector $0r_1r_2$ is $\frac{1}{2}r_1r_2\sin\phi$. The area of $0r_1s_2$ is $\frac{1}{2}(r_1(r_2+\delta)\sin\phi)$ and so the area of $r_1r_2s_2$ is $\frac{1}{2}(r_1\delta\sin\phi)$.

The area of $r_2r_2s_2s_3$ is $\frac{1}{2}[(r_3+\delta)(r_2+\delta)-r_3r_2)\sin\phi = \frac{1}{2}[(r_3+r_2)\delta+\delta^2]\sin\phi$.

The total area of the outer shape is

$$A = \frac{1}{2}(\sin\phi)\left[(r_1+r_n)\delta+\sum_{k=2}^{n-2}[(r_{k+1}+r_k)\delta+\delta^2]\right] \tag{12}$$

$$= \frac{1}{2}(\sin\phi)\left[(r_1+r_n)\delta+(n-2)\delta^2+\delta\sum_{k=2}^{n-2}[(r_{k+1}+r_k)]\right] \tag{13}$$

$$= \frac{1}{2}(\sin\phi)\left[(r_1+r_2+2r_3+\ldots+2r_{n-2}+r_{n-1}+r_n)\delta+(n-3)\delta^2\right] \tag{14}$$

so

$$0 = c_a\delta^2+c_b\delta+c_c \tag{15}$$

$$c_a = n-3 \tag{16}$$

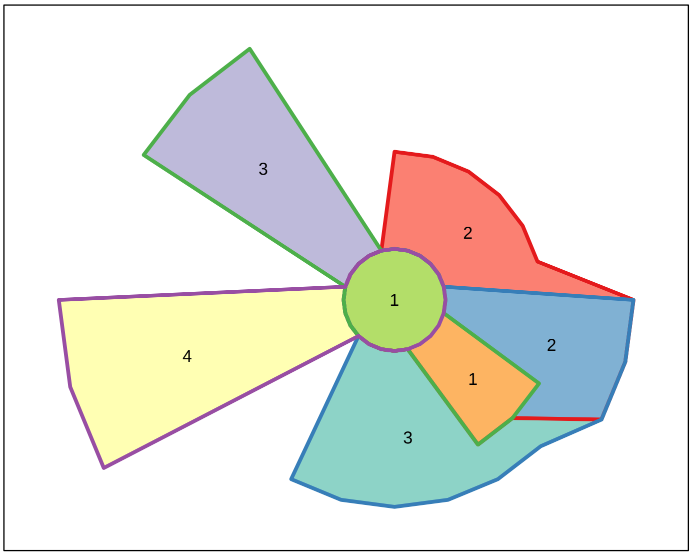
$$c_b = r_1+r_2+2r_3+\ldots+2r_{n-2}+r_{n-1}+r_n \tag{17}$$

$$c_c = -A/\frac{1}{2}\sin\phi \tag{18}$$

This is implemented in the compute.delta function.

If all the rs are the same then $c_b = [2(n-3)+4]r = (2n-2)r$.

```
[1] "Area check passed"
```



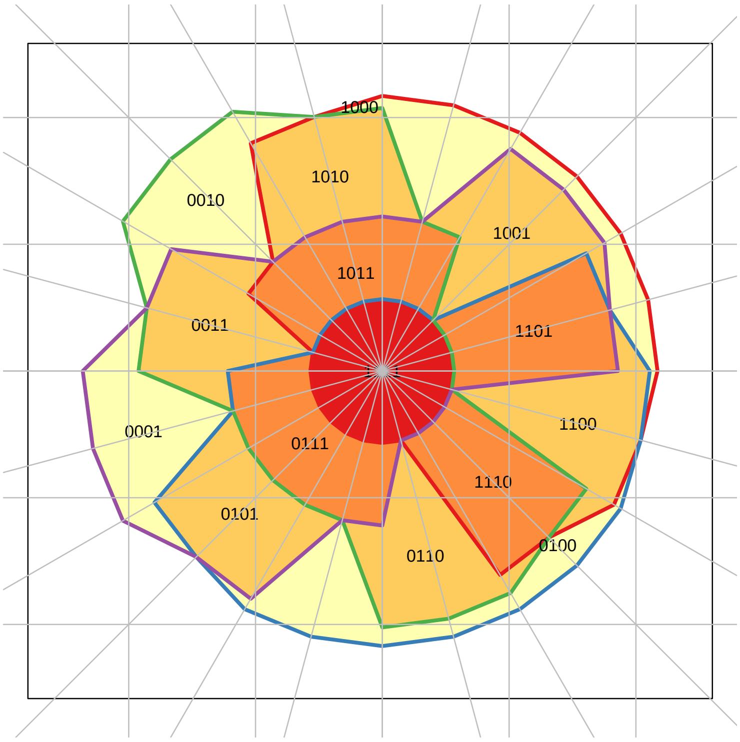


Figure 15: Chow-Ruskey 4

10 Euler diagrams

10.1 3-set Euler diagrams

10.1.1 Other examples of circles

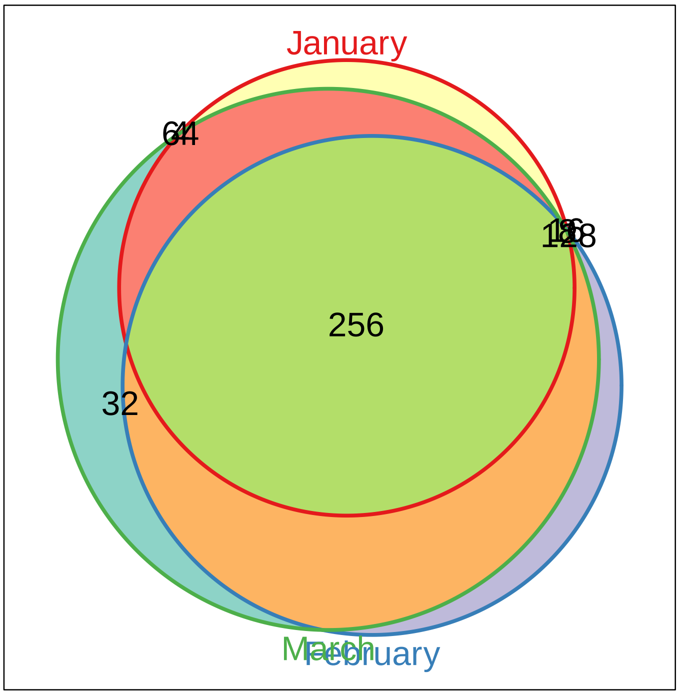


Figure 16: TODO Big weighted 3d Venn fails

11 Error checking

These should fail

```
> print(try(Venn(numberOfSets = 3, Weight = 1:7)))

[1] "Error in Venn(numberOfSets = 3, Weight = 1:7) : \n  Weight length does not match numb
attr(,"class")
[1] "try-error"

> print(try(V3[1, ]))

[1] "Error in V3[1, ] : Can't subset on rows\n"
attr(,"class")
[1] "try-error"
```

Empty objects work

```
> V0 = Venn()
> (Weights(V0))

named numeric(0)

> VennSetNames(V0)

character(0)
```

12 This document

Author	Jonathan Swinton
SVN id of this document	Id: VennDrawingTest.Rnw 57 2009-09-18 17:14:09Z js229 .
Generated on	23$^{\text{rd}}$ September, 2009
R version	R version 2.9.0 (2009-04-17)

References

[1] Stirling Chow and Frank Ruskey. Drawing area-proportional Venn and Euler diagrams. In Giuseppe Liotta, editor, *Graph Drawing*, volume 2912 of *Lecture Notes in Computer Science*, pages 466–477. Springer, 2003.

[2] Stirling Chow and Frank Ruskey. Towards a general solution to drawing area-proportional Euler diagrams. *Electronic Notes in Theoretical Computer Science*, 134:3–18, 2005.