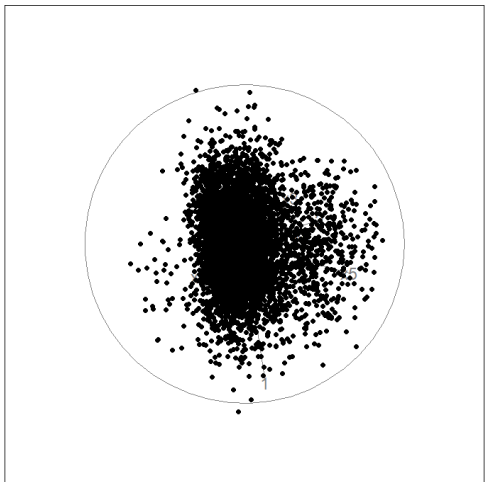
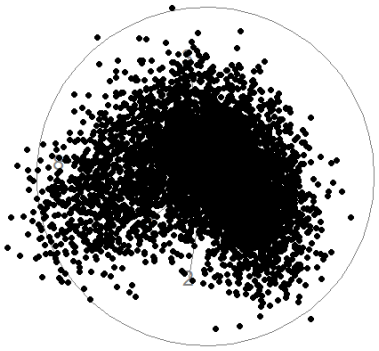
**ANIMATE MYSTERY9, INTERESTING PLOTS:**



**Plot appears squished/narrow, like an oval rather than circular (unlike usual)**

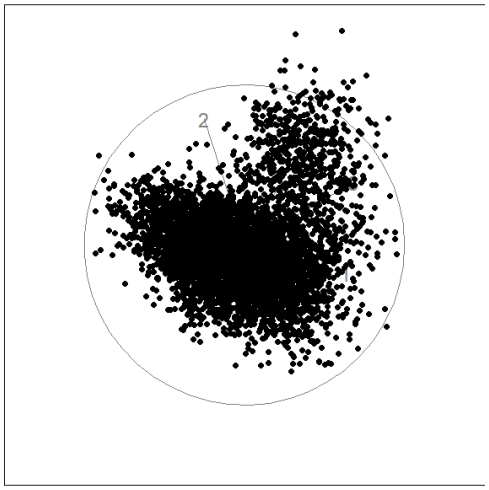
**Mostly condensed except for the less populated group (coming off the "oval") on the right**

---



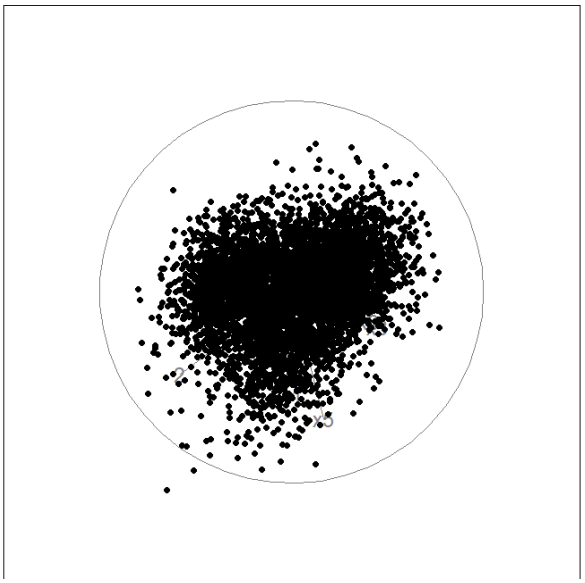
**Plot takes a shape similar to a heart or butterfly**
**One side (left) is less populated/filled in than the other**

---

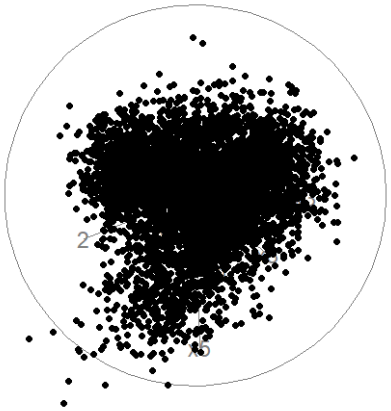


**Similar to plot above, except rotated**
**Right side is also less dense than the left**

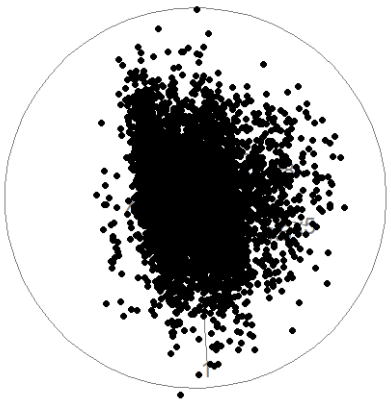
**ANIMATE MYSTERY2, INTERESTING PLOTS:**



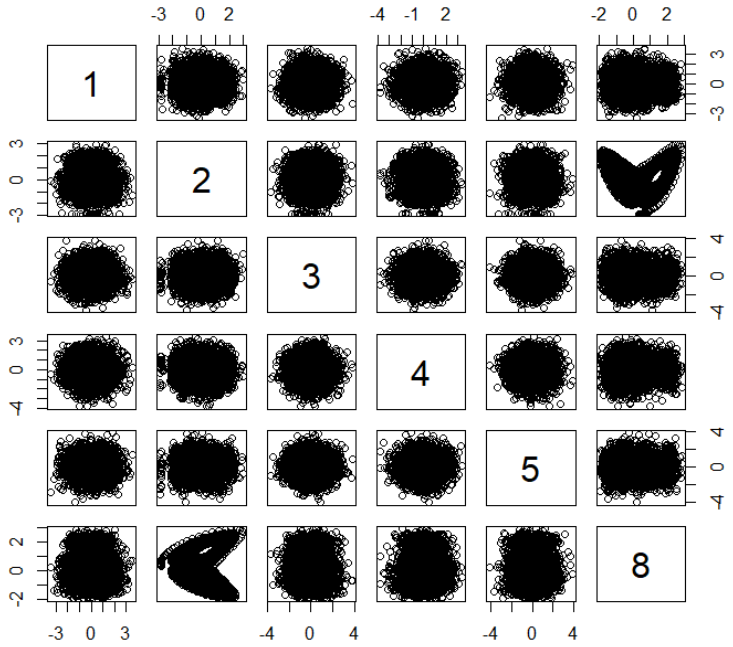
**Plot appears triangular, rather than circular**



**Similar to above plot except there appears to be a dip in the plot's left side, making it more similar to the heart/butterfly shape seen with animate(mystery9)**



**Plot is narrow and almost has straight sides, to the point of being rectangular**
**Mostly condensed except for the less populated area (coming off the "rectangle") on the right, similar to the first plot screenshotted for animate(mystery9)**

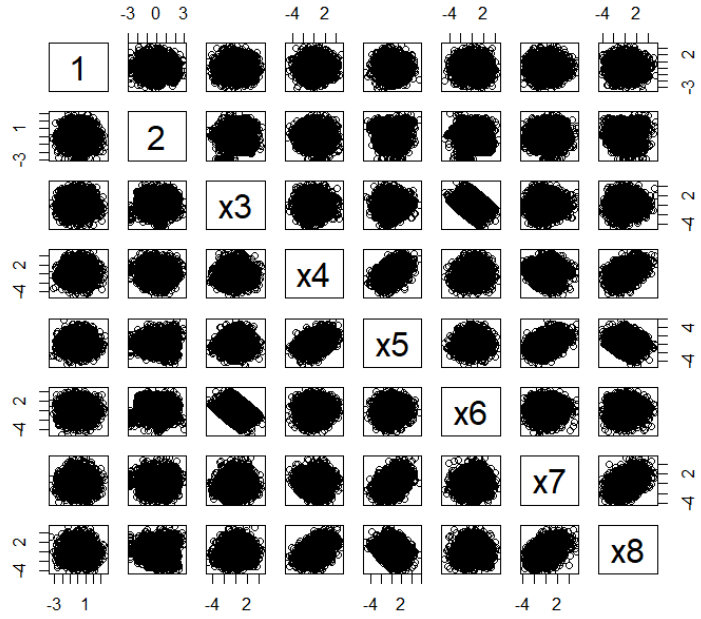



**PAIRS MYSTERY9:**

**interesting plots: (2, 6), (6, 2)**

**Plots are shaped like butterflies**

**Note: we describe the butterfly effect at the end of page 2**




**PAIRS MYSTERY2:**

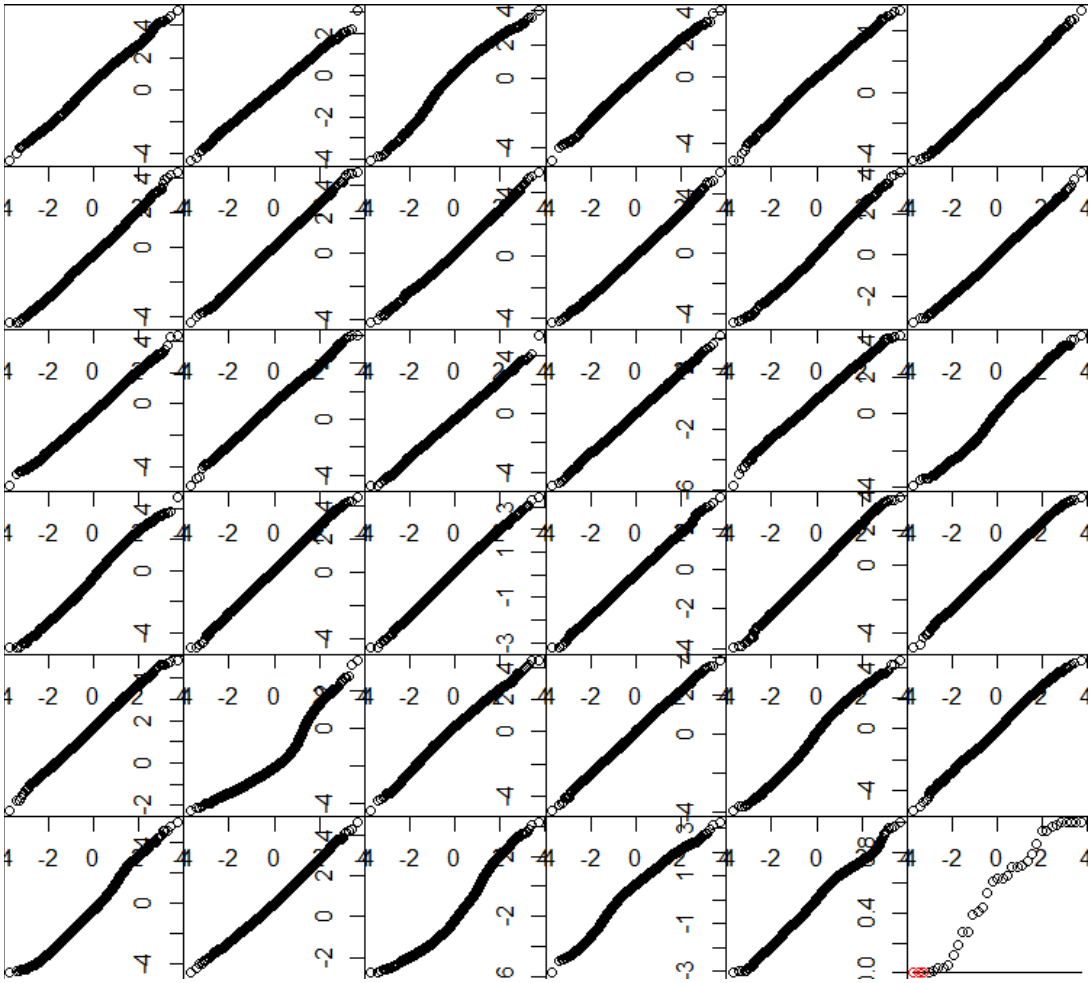
**interesting plots: (3, 6), (6, 3)**

**Plots appear rectangular, unlike the more circular plots surrounding them**
**(8, 5) and (5, 8) are also vaguely rectangular, although their sides appear less straight/defined**

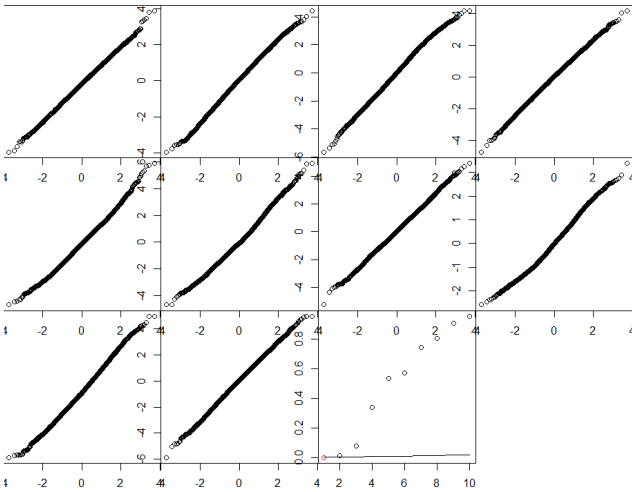
If we look at the mystery9 pairs graphs, we notice that two of the graphs follow butterfly effect trends. The butterfly effect, as mentioned above in the document, is when an action occurs and a rapid process of larger and larger actions happen because of it. This is not visible in the mystery2 pairs data as that has a lot more noise, so it's harder to see definitive shapes.

## MVNTEST ON MYSTERY2 DATA

```
> Multivariate.normal.test(mystery2, 35)
$Interesting.directions
          [,1]       [,2]        [,3]       [,4]       [,5]        [,6]        [,7]
u1 -0.1278779  0.3991551  0.17085251 -0.1549844 0.46399746 -0.20386283 -0.18828536
u1  0.1050744  0.1236882  0.27363828 -0.1866246 0.58775779 -0.08583574  0.04233545
u1  0.3385767 -0.5628584 -0.07990759  0.5525457 0.05927245 -0.05570119  0.48393710
          [,8]
u1 0.6919585
u1 0.7136769
u1 0.1267016

$rejectingplots
[1] 26 33 31

$pvals
 [1] 0.9975 0.1904 1.0000 0.9460 0.9815 0.6465 0.3910 0.6996 0.1212 0.6239 0.0291
[12] 0.6033 0.0482 0.9414 0.7174 0.5333 0.7413 0.9711 0.2706 0.0345 0.7932 0.4112
[23] 0.2753 0.6278 0.4339 0.0000 0.9999 0.7028 0.9985 0.0128 0.0001 0.0016 0.0000
[34] 1.0000 0.8558
```



```
> gui.mvntest()
[1] "mystery2" "10"       ".05"
$Interesting.directions
[1]  0.10005193 -0.17899805 -0.03051417  0.20663077  0.30326321
[6] -0.29337609  0.85538098 -0.06787637

$rejectingplots
[1] 6

$pvals
 [1] 0.8035 0.9059 0.5353 0.9529 0.5708 0.0000 0.3370 0.0799 0.0122 0.7446
```



**Similar plots of a line going from bottom left to top right; while the line is fairly straight, some of the plots have a dip in the lower half or a bump in the upper half/middle**

**INTERESTING DIRECTION MATRIX**
**(directions taken from mvntest)**

**directions = c(0.10005193, -0.17899805, -0.03051417, 0.20663077, 0.30326321, -0.29337609, 0.85538098, -0.06787637)**
**directions = c(directions, as.matrix(c(-0.1278779, 0.3991551, 0.17085251, -0.1549844, 0.46399746, -0.20386283, -0.18828536, 0.6919585, 0.1050744, 0.1236882, 0.27363828, -0.1866246, 0.58775779, -0.08583574, 0.04233545, 0.7136769, 0.3385767, -0.5628584, -0.07990759, 0.5525457, 0.05927245, -0.05570119, 0.48393710, 0.1267016)))**
**directions = matrix(directions, 8, 4)**
**directions = t(directions)**

```
> directions
           [,1]       [,2]        [,3]       [,4]       [,5]        [,6]
[1,]  0.1000519 -0.1789980 -0.03051417  0.2066308 0.30326321 -0.29337609
[2,] -0.1278779  0.3991551  0.17085251 -0.1549844 0.46399746 -0.20386283
[3,]  0.1050744  0.1236882  0.27363828 -0.1866246 0.58775779 -0.08583574
[4,]  0.3385767 -0.5628584 -0.07990759  0.5525457 0.05927245 -0.05570119
            [,7]        [,8]
[1,]  0.85538098 -0.06787637
[2,] -0.18828536  0.69195850
[3,]  0.04233545  0.71367690
[4,]  0.48393710  0.12670160
```

## ORTHOGONALIZE MYSTERY2:

```
> orthogonalize(mystery2)
             1          2         x3        x4         x5         x6          x7
[1,] 0.4296331 -0.5149734 -0.2003239 0.1902949 -0.3204298 -0.4258319 -0.04901055
            x8
[1,] 0.4329733
```

| | 1 | 2 | x3 | x4 | x5 | x6 |
|---|---|---|---|---|---|---|
| [1,] | 0.4296330754 | -0.51497341 | -0.2003239 | 0.19029489 | -0.3204298 | -0.42583191 |
| [2,] | -0.4839322794 | -0.44044313 | -0.6786419 | 0.15551375 | 0.2237785 | 0.14420640 |
| [3,] | 0.0858550079 | -0.25432661 | 0.2679039 | 0.09452947 | 0.5390926 | -0.57515442 |
| [4,] | 0.7072496109 | 0.09866441 | -0.2784294 | 0.23386000 | 0.2989446 | 0.42548588 |
| [5,] | 0.2576173879 | -0.14705042 | -0.1991832 | -0.60898676 | 0.1550408 | 0.04379119 |
| [6,] | 0.0774206873 | 0.03050791 | -0.1811894 | 0.03078715 | -0.6536852 | -0.10626728 |
| [7,] | -0.0359315766 | 0.12639694 | 0.0811292 | 0.70977787 | 0.0313174 | 0.04688244 |
| [8,] | 0.0003397716 | 0.65411375 | -0.5205138 | -0.01948482 | 0.1222146 | -0.52021390 |
| [9,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [10,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [11,] | 0.0023221877 | 0.65475750 | -0.5254535 | -0.01781054 | 0.1031847 | -0.52318107 |
| [12,] | 0.0023221876 | 0.65475750 | -0.5254535 | -0.01781054 | 0.1031847 | -0.52318107 |
| [13,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [14,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [15,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [16,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [17,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [18,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [19,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [20,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [21,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [22,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [23,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [24,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [25,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [26,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [27,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [28,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [29,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [30,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [31,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [32,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [33,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [34,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [35,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [36,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [37,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [38,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [39,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [40,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [41,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [42,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [43,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [44,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [45,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [46,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [47,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [48,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [49,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [50,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [51,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [52,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [53,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [54,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [55,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [56,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [57,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [58,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [59,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [60,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [61,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [62,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [63,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [64,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |
| [65,] | -0.0023221877 | -0.65475750 | 0.5254535 | 0.01781054 | -0.1031847 | 0.52318107 |

```
  [66,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
  [67,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
  [68,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
  [69,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
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  [74,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
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  [81,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
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  [93,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
  [94,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
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 [106,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [107,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [108,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [109,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [110,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [111,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [112,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [113,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [114,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [115,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [116,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [117,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [118,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [119,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [120,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [121,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [122,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [123,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [124,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
 [125,] -0.0023221877 -0.65475750  0.5254535  0.01781054 -0.1031847  0.52318107
              x7          x8
  [1,] -0.04901055  0.43297330
  [2,] -0.03471186 -0.12248578
  [3,] -0.02334647 -0.47462622
  [4,] -0.21698479 -0.20090154
  [5,]  0.68930897 -0.01919587
  [6,]  0.08624494 -0.71642348
  [7,]  0.68250277  0.05811530
  [8,] -0.01924883  0.12203031
  [9,]  0.01568009 -0.10127792
 [10,]  0.01568009 -0.10127792
 [11,] -0.01568009  0.10127792
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[12,] -0.01568009  0.1012779
[13,]  0.01568009 -0.1012779
[14,]  0.01568009 -0.1012779
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[45,]  0.01568009 -0.1012779
[46,]  0.01568009 -0.1012779
[47,]  0.01568009 -0.1012779
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[84,]  0.01568009 -0.10127792
[85,]  0.01568009 -0.10127792
[86,]  0.01568009 -0.10127792
[87,]  0.01568009 -0.10127792
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[114,]  0.01568009 -0.10127792
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[116,]  0.01568009 -0.10127792
[117,]  0.01568009 -0.10127792
[118,]  0.01568009 -0.10127792
[119,]  0.01568009 -0.10127792
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[48,]  0.01568009 -0.10127792
[49,]  0.01568009 -0.10127792
[50,]  0.01568009 -0.10127792
[51,]  0.01568009 -0.10127792
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[69,]  0.01568009 -0.10127792
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[73,]  0.01568009 -0.10127792
[74,]  0.01568009 -0.10127792
[75,]  0.01568009 -0.10127792
[76,]  0.01568009 -0.10127792
[77,]  0.01568009 -0.10127792
[78,]  0.01568009 -0.10127792
[79,]  0.01568009 -0.10127792
[80,]  0.01568009 -0.10127792
[81,]  0.01568009 -0.10127792
[82,]  0.01568009 -0.10127792
[83,]  0.01568009 -0.10127792

[120,]  0.01568009 -0.10127792
[121,]  0.01568009 -0.10127792
[122,]  0.01568009 -0.10127792
[123,]  0.01568009 -0.10127792
[124,]  0.01568009 -0.10127792
[125,]  0.01568009 -0.10127792
[ reached getOption("max.print") -- omitted 4876 rows ]
```

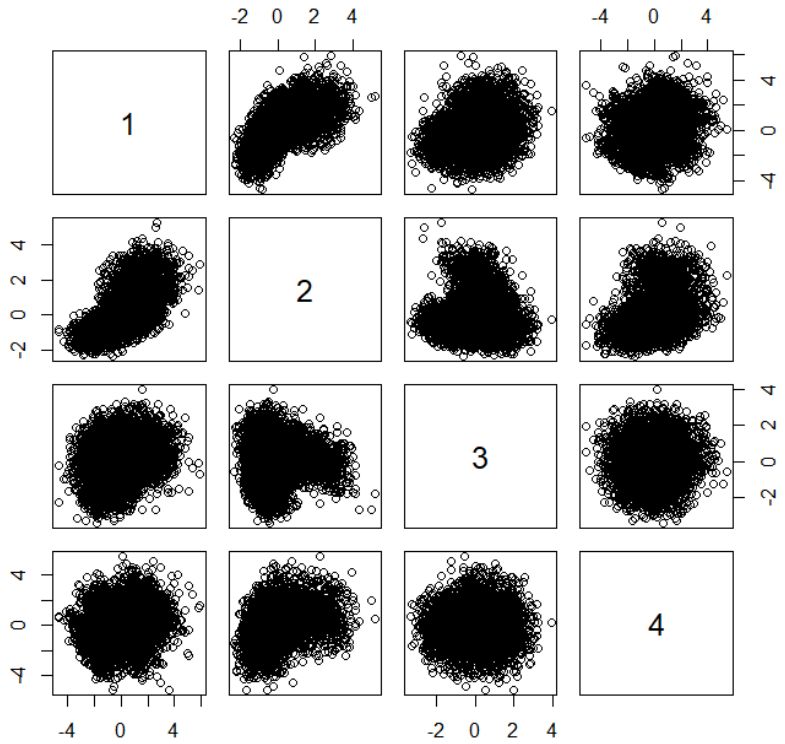
## ORTHOGONALIZE DIRECTIONS MATRIX

```
> odirections = orthogonalize(directions)
          [,1]      [,2]        [,3]      [,4]      [,5]       [,6]     [,7]        [,8]
[1,] 0.1000519 -0.178998 -0.03051417 0.2066308 0.3032632 -0.2933761 0.855381 -0.06787637
> odirections
           [,1]       [,2]        [,3]       [,4]       [,5]        [,6]         [,7]        [,8]
[1,]  0.1000519 -0.1789980 -0.03051417  0.2066308  0.3032632 -0.29337609  0.855380977 -0.06787637
[2,] -0.1159415  0.3792354  0.16832275 -0.1294138  0.5073509 -0.24373901 -0.078613368  0.68895861
[3,]  0.5103657 -0.5129479  0.32055821 -0.2478510  0.2185414  0.45324882  0.001523396  0.24295363
[4,]  0.1308678 -0.3046210 -0.19895077  0.7600294 -0.1590077 -0.09460374 -0.210854464  0.44063659
```

**EXPLORE MYSTERY2 (gui.explore()):**

**gui.explore pairs plot**

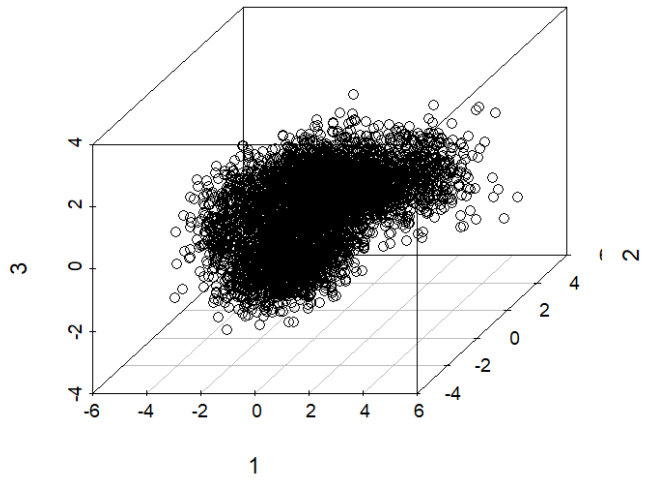
```
> gui.explore()
[1] "odirections" "mystery2"    "T"           "F"           "F"           "c(1,2,3)"
```




**Butterfly shape is now shown, especially in (2, 3) and (3, 2), unlike with pairs(mystery2)**

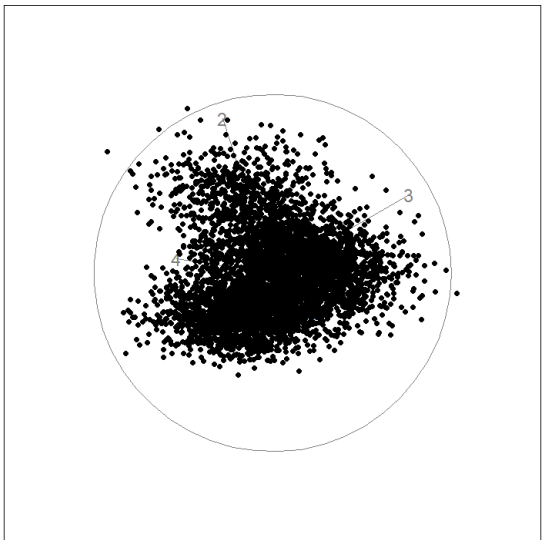
**gui.explore 3d plot**

```
> gui.explore()
[1] "odirections" "mystery2"    "F"           "F"           "T"           "c(1,2,3)"
```

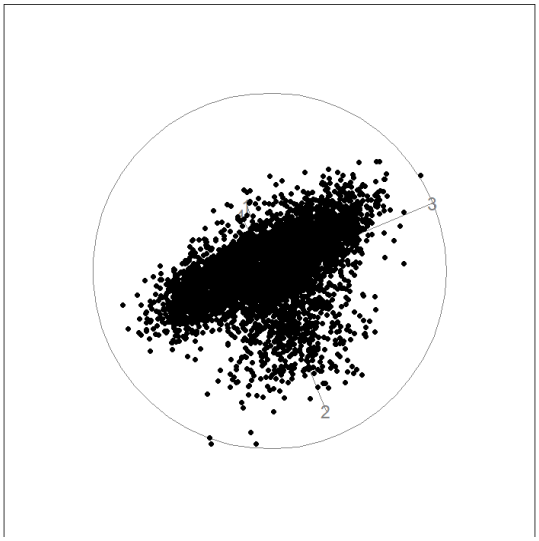


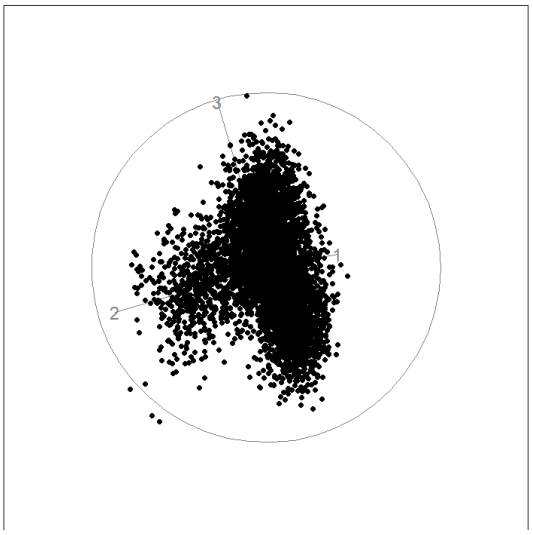

**Shape appears curved and has a dip in one side**
**Could be interpreted as the shape of a butterfly (dip is between two "wings")**

**gui.explore animate: more examples of the butterfly shape**

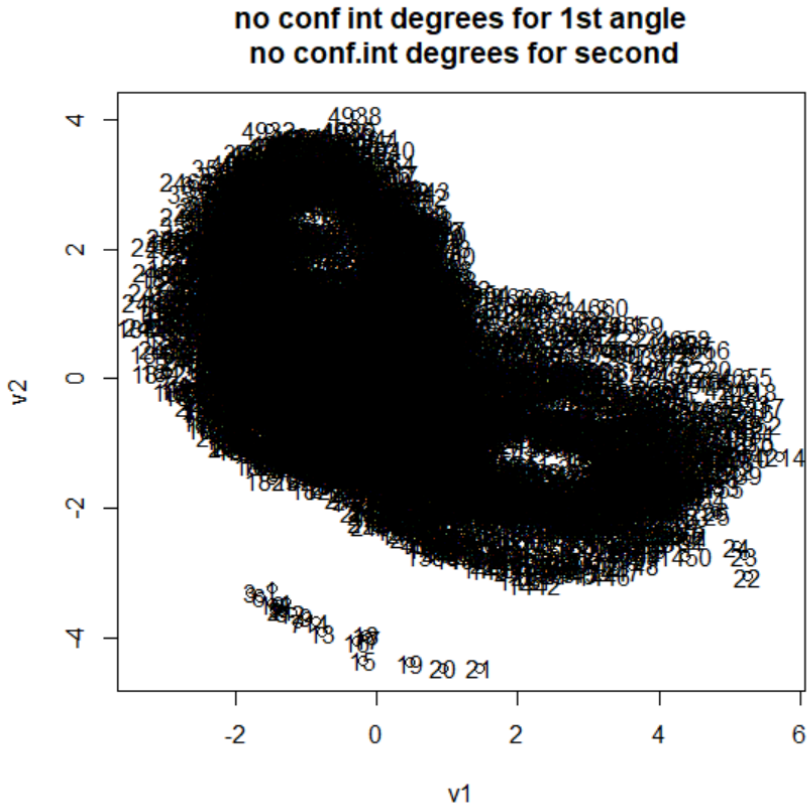



**Due to the curse of dimensionality, shapes look different from different angles. As a result, without using certain directions or starting values, it could take a while for this butterfly shape to be visible (if it becomes visible at all).**



**ASYMMETRY TEST ON MYSTERY2 DATA:**




**Plot is fairly flat on the lower left, but is curved on the top and other sides, with a dip in the middle of the side going from the top left to the middle right**

**Shape could be compared to a B, a rabbit (rotated), etc. Regardless, it also has a vague butterfly effect shape.**

```
[[1]]$new$vector1
         1          2         x3         x4         x5         x6
0.04373604 0.54356502 0.17321542 0.29052929 0.46392029 0.02872508
        x7         x8
0.41582675 0.44637913

[[1]]$new$vector2
         1          2         x3         x4         x5
 0.08057901  0.65739700  0.32121212 -0.16269253 -0.36540765
        x6         x7         x8
 0.40623551 -0.15250333 -0.33148577


$vector1
          1           2          x3          x4          x5
 0.043221478  0.507811472  0.152560303  0.307100220  0.455034934
         x6          x7          x8
-0.006430106  0.444877254  0.466540794

$vector2
         1          2          x3          x4          x5
 0.07142552  0.69790611  0.30721495 -0.14456972 -0.33414627
        x6          x7          x8


[[1]]$new[[1]]$new
[[1]]$new[[1]]$new[[1]]
[[1]]$new[[1]]$new[[1]]$lb1
[1] "no conf int"

[[1]]$new[[1]]$new[[1]]$lb2
[1] "no conf.int"


[[1]]$new[[1]]$new$vector1
         1          2         x3         x4         x5         x6
0.03131996 0.58344126 0.20061554 0.28679734 0.44700213 0.06549721
        x7         x8
0.38041211 0.43278388

[[1]]$new[[1]]$new$vector2
         1          2          x3          x4          x5
 0.07615825  0.61039786  0.32154913 -0.16954084 -0.38539080
        x6          x7          x8
 0.41744283 -0.19534969 -0.35851129
```