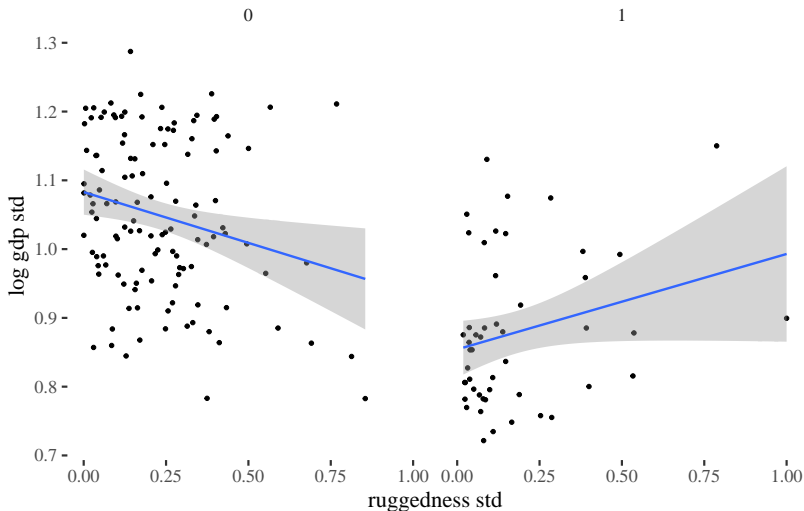# Interactions

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What is interaction/moderation?

The importance of one predictor depends upon another predictor. Interaction is a kind of conditioning, a way of allowing posterior distributions of parameters to be conditional on further aspects of the data.

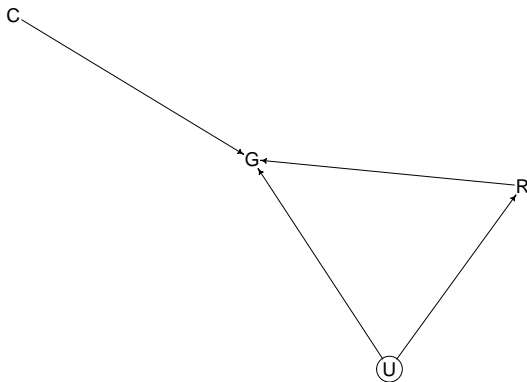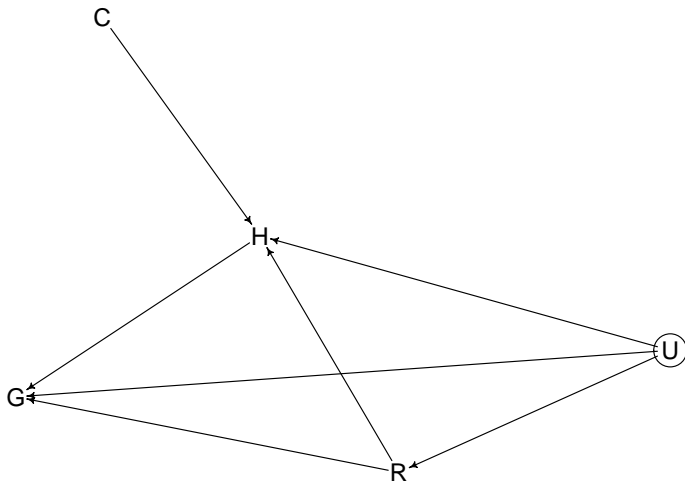# African economy and bad geography

Africa and impact of ruggedness

African economy and bad geography

DAG fails to represent interaction

$G = f(R, C)$

African economy and bad geography

African economy and bad geography

```
africaNoInteraction <- quap(
  alist(
    log_gdp_std ~ dnorm( mu , sigma ) ,
    mu <- a + b*( rugged_std - 0.215 ) ,
    a ~ dnorm( 1 , .1 ) ,
    b ~ dnorm( 0 , .3 ) ,
    sigma ~ dexp( 1 )
  ) , data=dd )
```

African economy and bad geography

```
precis(africaNoInteraction)
```

```
##                mean          sd        5.5%       94.5%
## a      0.999998585 0.010412558  0.98335731 1.01663986
## b      0.001987997 0.054796473 -0.08558735 0.08956334
## sigma  0.136505158 0.007397203  0.12468300 0.14832732
```

African economy and bad geography

```
dd$cid <- ifelse( dd$cont_africa==1 , 1 , 2 )

africaJustIndicator <- quap(
  alist(
    log_gdp_std ~ dnorm( mu , sigma ) ,
    mu <- a[cid] + b*( rugged_std - 0.215 ) ,
    a[cid] ~ dnorm( 1 , 0.1 ) ,
    b ~ dnorm( 0 , 0.3 ) ,
    sigma ~ dexp( 1 )
  ) , data=dd )
```

African economy and bad geography

```
compare(africaNoInteraction, africaJustIndicator)
```

```
##                            WAIC       SE    dWAIC      dSE    pWAIC        weight
## africaJustIndicator   -252.1934 15.30424  0.00000       NA 4.272339 1.000000e+00
## africaNoInteraction   -188.8633 13.24558 63.33009 15.08302 2.642283 1.770299e-14
```
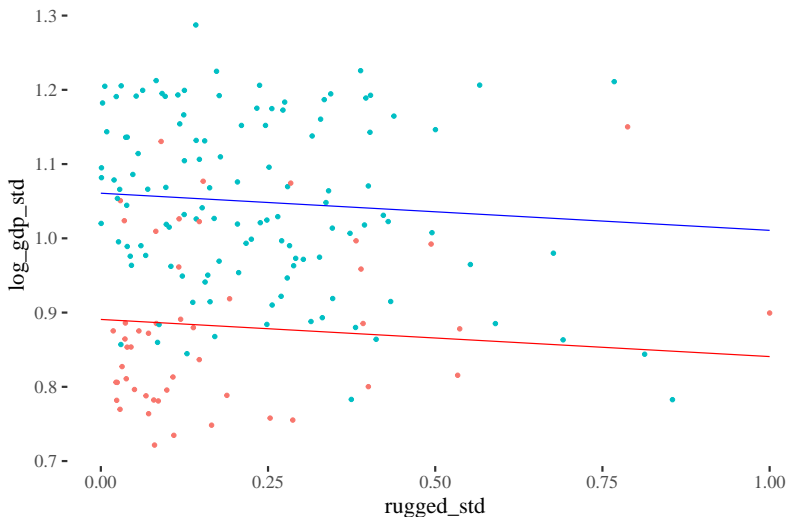
African economy and bad geography

```
precis( africaJustIndicator , depth=2 )
```

```
##                mean           sd        5.5%        94.5%
## a[1]     0.88040635  0.015937612   0.8549350   0.90587773
## a[2]     1.04916045  0.010185961   1.0328813   1.06543958
## b       -0.04649695  0.045688524  -0.1195160   0.02652214
## sigma    0.11239189  0.006091687   0.1026562   0.12212758
```

African economy and bad geography

Model with indicator

African economy and bad geography

```
africaInteraction <- quap(
  alist(
    log_gdp_std ~ dnorm( mu , sigma ) ,
    mu <- a[cid] + b[cid]*( rugged_std - 0.215 ) ,
    a[cid] ~ dnorm( 1 , 0.1 ) ,
    b[cid] ~ dnorm( 0 , 0.3 ) ,
    sigma ~ dexp( 1 )
  ) , data=dd )
```

African economy and bad geography

```
precis( africaInteraction , depth=2 )
```
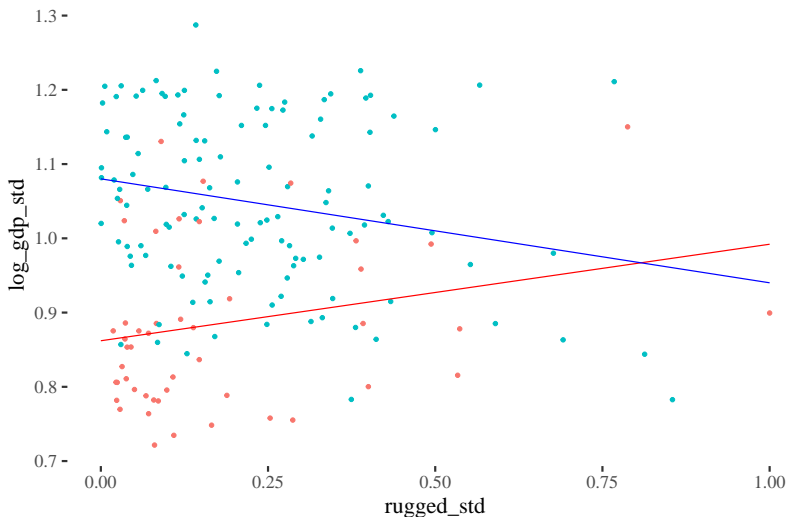
```
##             mean          sd         5.5%        94.5%
## a[1]   0.8865638 0.015675774  0.86151085  0.91161668
## a[2]   1.0505694 0.009936658  1.03468870  1.06645009
## b[1]   0.1325055 0.074204803  0.01391188  0.25109910
## b[2]  -0.1425764 0.054749677 -0.23007697 -0.05507585
## sigma  0.1094947 0.005935376  0.10000881  0.11898056
```

```
compare(africaNoInteraction, africaJustIndicator, africaInteraction)
```

```
##                          WAIC       SE      dWAIC        dSE     pWAIC
## africaInteraction   -259.0097 15.21834   0.000000         NA  5.251338
## africaJustIndicator -252.3183 15.41667   6.691372   6.798868  4.254228
## africaNoInteraction -188.6429 13.26207  70.366785  15.457349  2.725360
##                        weight
## africaInteraction   9.659633e-01
## africaJustIndicator 3.403671e-02
## africaNoInteraction 5.069995e-16
```

African economy and bad geography

Model with interaction

Tulips

```
## 'data.frame':     27 obs. of  4 variables:
##  $ bed   : Factor w/ 3 levels "a","b","c": 1 1 1 1 1 1 1 1 1 2 ...
##  $ water : int  1 1 1 2 2 2 3 3 3 1 ...
##  $ shade : int  1 2 3 1 2 3 1 2 3 1 ...
##  $ blooms: num  0 0 111 183.5 59.2 ...
```

In the absence of light, no amount of water will help

Tulips

```
d$blooms_std <- d$blooms / max(d$blooms)
d$water_cent <- d$water - mean(d$water)
d$shade_cent <- d$shade - mean(d$shade)
```
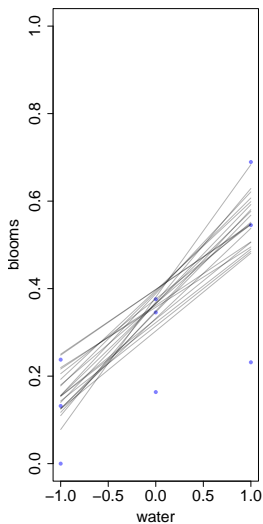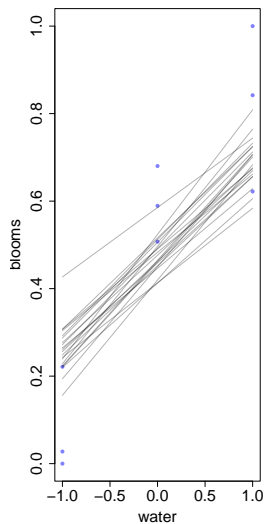
Tulips

```
tulipsNoInteraction <- quap(
  alist(
    blooms_std ~ dnorm( mu , sigma ) ,
    mu <- a + bw*water_cent + bs*shade_cent ,
    a ~ dnorm( 0.5 , 0.25 ) ,
    bw ~ dnorm( 0 , 0.25 ) ,
    bs ~ dnorm( 0 , 0.25 ) ,
    sigma ~ dexp( 1 )
  ) , data=d )
```
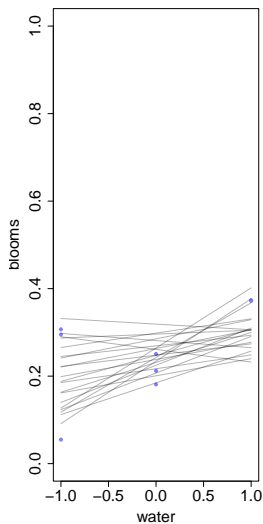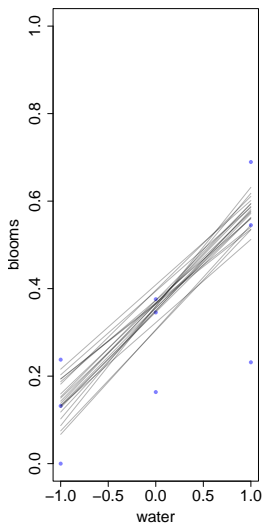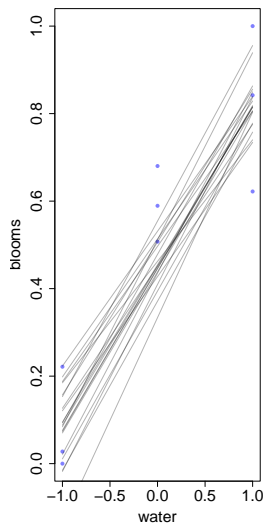
Tulips

```
tulipsInteraction <- quap(
  alist(
    blooms_std ~ dnorm( mu , sigma ) ,
    mu <- a + bw*water_cent + bs*shade_cent +
      bws*water_cent*shade_cent ,
    a ~ dnorm( 0.5 , 0.25 ) ,
    bw ~ dnorm( 0 , 0.25 ) ,
    bs ~ dnorm( 0 , 0.25 ) ,
    bws ~ dnorm( 0 , 0.25 ) ,
    sigma ~ dexp( 1 )
  ) , data=d )
```

Tulips: no interaction

Tulips: with interaction

Tulips

```
compare(tulipsInteraction, tulipsNoInteraction)
```

```
##                       WAIC        SE    dWAIC      dSE    pWAIC     weight
## tulipsInteraction   -20.44760 11.309416 0.000000      NA 7.390437 0.98700314
## tulipsNoInteraction -11.78767  9.052902 8.659931 8.831736 5.491489 0.01299686
```