# Estimation & Troubleshooting Errors

```
library(lavaan)
```

```
## This is lavaan 0.6-9
## lavaan is FREE software! Please report any bugs.
```

```
library(dplyr)
```

```
##
## Attaching package: 'dplyr'
```

```
## The following objects are masked from 'package:stats':
##
##     filter, lag
```

```
## The following objects are masked from 'package:base':
##
##     intersect, setdiff, setequal, union
```

```
habit <- read.table("sem_categorical.dat", header = FALSE)
```

This is a longer dataset, so we'll add column names to the variables. Because we're using the same dataset as the one for Mplus, missing values are still "." At last line of code in this chunk tells R to turn all variables into numeric, which means that the "." (which are character) will be turned into NAs - and that's what we want.

```
colnames(habit) <- c("age", "sex", "white", "child", "init",
    "inhib", "cont", "bfi", "psyeffect", "sched", "insec", "prehabit",
    "sl", "exer", "dt", "screen", "sm", "subs", "fri", "work",
    "hobby", "fam")

habit <- data.frame(lapply(habit, function(x) as.numeric(as.character(x))))
```

```
## Warning in FUN(X[[i]], ...): NAs introduced by coercion

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```

We'll first specify the model with categorical variables as continuous.

```
habit.sem <- "disrupt =~ psyeffect + sched + insec
          sreg =~ init + inhib + cont + bfi

          sl + exer + dt + subs ~ disrupt + sreg + prehabit + age + sex + white + child

          sreg ~~ disrupt + prehabit + age + sex + white + child
          disrupt ~~ prehabit + age + sex + white + child
          prehabit ~~ age + sex + white + child
          age ~~ sex + white + child
          sex ~~ white + child
          white ~~ child
          "
```

Then we estimate the model as we did before

```
cont.fit <- sem(model = habit.sem, data = habit, missing = "ml",
    estimator = "mlr")

summary(cont.fit, fit.measures = TRUE, standardized = TRUE)
```

```
## lavaan 0.6-9 ended normally after 141 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        94
##
##   Number of observations                           432
##   Number of missing patterns                         8
##
## Model Test User Model:
##                                                   Standard      Robust
##   Test Statistic                                   164.661     166.366
##   Degrees of freedom                                    58          58
##   P-value (Chi-square)                               0.000       0.000
##   Scaling correction factor                                      0.990
##         Yuan-Bentler correction (Mplus variant)
##
## Model Test Baseline Model:
##
##   Test statistic                                1223.810    1182.152
##   Degrees of freedom                                 120         120
##   P-value                                            0.000       0.000
##   Scaling correction factor                                      1.035
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                       0.903       0.898
##   Tucker-Lewis Index (TLI)                          0.800       0.789
##
##   Robust Comparative Fit Index (CFI)                            0.902
##   Robust Tucker-Lewis Index (TLI)                               0.798
```

```
##
## Loglikelihood and Information Criteria:
##
##   Loglikelihood user model (H0)              -8314.432   -8314.432
##   Scaling correction factor                                  0.984
##       for the MLR correction
##   Loglikelihood unrestricted model (H1)      -8232.102   -8232.102
##   Scaling correction factor                                  0.986
##       for the MLR correction
##
##   Akaike (AIC)                               16816.865   16816.865
##   Bayesian (BIC)                             17199.297   17199.297
##   Sample-size adjusted Bayesian (BIC)        16900.994   16900.994
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.065       0.066
##   90 Percent confidence interval - lower         0.054       0.054
##   90 Percent confidence interval - upper         0.077       0.078
##   P-value RMSEA <= 0.05                          0.016       0.014
##
##   Robust RMSEA                                               0.065
##   90 Percent confidence interval - lower                     0.054
##   90 Percent confidence interval - upper                     0.077
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.036       0.036
##
## Parameter Estimates:
##
##   Standard errors                             Sandwich
##   Information bread                           Observed
##   Observed information based on                Hessian
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   disrupt =~
##     psyeffect         1.000                               0.680    0.724
##     sched             1.070    0.184    5.811    0.000    0.728    0.749
##     insec             1.022    0.145    7.029    0.000    0.695    0.538
##   sreg =~
##     init              1.000                               0.792    0.818
##     inhib             0.425    0.046    9.258    0.000    0.336    0.483
##     cont              0.616    0.047   13.146    0.000    0.488    0.654
##     bfi               0.781    0.043   18.342    0.000    0.619    0.879
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   sl ~
##     disrupt          -0.318    0.074   -4.271    0.000   -0.216   -0.269
##     sreg             -0.026    0.060   -0.433    0.665   -0.020   -0.025
##     prehabit         -0.028    0.061   -0.449    0.654   -0.028   -0.023
##     age              -0.001    0.004   -0.398    0.690   -0.001   -0.021
```

```
##     sex              -0.016    0.079   -0.209    0.834   -0.016   -0.010
##     white            -0.061    0.082   -0.745    0.456   -0.061   -0.036
##     child             0.136    0.083    1.646    0.100    0.136    0.083
##   exer ~
##     disrupt          -0.319    0.075   -4.235    0.000   -0.217   -0.254
##     sreg              0.028    0.061    0.464    0.643    0.022    0.026
##     prehabit          0.054    0.064    0.845    0.398    0.054    0.043
##     age              -0.001    0.004   -0.148    0.882   -0.001   -0.008
##     sex              -0.001    0.083   -0.016    0.987   -0.001   -0.001
##     white            -0.130    0.088   -1.474    0.141   -0.130   -0.071
##     child             0.093    0.089    1.051    0.293    0.093    0.054
##   dt ~
##     disrupt          -0.096    0.062   -1.562    0.118   -0.066   -0.107
##     sreg             -0.028    0.046   -0.604    0.546   -0.022   -0.036
##     prehabit          0.022    0.047    0.464    0.643    0.022    0.024
##     age               0.003    0.003    1.036    0.300    0.003    0.059
##     sex              -0.024    0.060   -0.395    0.693   -0.024   -0.019
##     white            -0.011    0.063   -0.167    0.868   -0.011   -0.008
##     child             0.096    0.065    1.472    0.141    0.096    0.077
##   subs ~
##     disrupt          -0.267    0.071   -3.781    0.000   -0.182   -0.236
##     sreg              0.019    0.058    0.332    0.740    0.015    0.020
##     prehabit          0.078    0.063    1.235    0.217    0.078    0.068
##     age               0.003    0.003    0.934    0.350    0.003    0.047
##     sex              -0.021    0.076   -0.276    0.783   -0.021   -0.013
##     white             0.162    0.081    2.008    0.045    0.162    0.099
##     child             0.028    0.082    0.344    0.731    0.028    0.018
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   disrupt ~~
##     sreg             -0.072    0.039   -1.837    0.066   -0.134   -0.134
##   sreg ~~
##     prehabit          0.119    0.030    4.002    0.000    0.150    0.223
##     age               1.731    0.501    3.458    0.001    2.185    0.190
##     sex              -0.046    0.020   -2.305    0.021   -0.059   -0.119
##     white             0.024    0.019    1.251    0.211    0.030    0.064
##     child             0.057    0.021    2.777    0.005    0.072    0.147
##   disrupt ~~
##     prehabit          0.074    0.028    2.653    0.008    0.108    0.161
##     age              -0.689    0.462   -1.490    0.136   -1.013   -0.088
##     sex              -0.021    0.022   -0.945    0.345   -0.030   -0.061
##     white            -0.028    0.019   -1.527    0.127   -0.042   -0.089
##     child             0.058    0.023    2.523    0.012    0.086    0.174
##   prehabit ~~
##     age               1.003    0.371    2.703    0.007    1.003    0.130
##     sex              -0.024    0.016   -1.503    0.133   -0.024   -0.072
##     white            -0.020    0.015   -1.342    0.180   -0.020   -0.064
##     child             0.025    0.016    1.571    0.116    0.025    0.075
##   age ~~
##     sex              -0.342    0.266   -1.287    0.198   -0.342   -0.061
##     white             0.746    0.244    3.054    0.002    0.746    0.138
##     child             1.072    0.260    4.123    0.000    1.072    0.190
##   sex ~~
```

```
##     white            -0.018    0.011   -1.632    0.103   -0.018   -0.080
##     child            -0.000    0.012   -0.033    0.973   -0.000   -0.002
##   white ~~
##     child            -0.011    0.011   -0.945    0.345   -0.011   -0.046
##  .sl ~~
##    .exer              0.017    0.034    0.515    0.607    0.017    0.027
##    .dt               -0.010    0.023   -0.433    0.665   -0.010   -0.021
##    .subs              0.059    0.028    2.101    0.036    0.059    0.103
##  .exer ~~
##    .dt                0.011    0.024    0.441    0.659    0.011    0.021
##    .subs             -0.033    0.030   -1.086    0.278   -0.033   -0.054
##  .dt ~~
##    .subs              0.011    0.023    0.454    0.650    0.011    0.024
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .psyeffect        3.251    0.045   71.940    0.000    3.251    3.461
##    .sched            3.641    0.047   77.870    0.000    3.641    3.747
##    .insec            2.661    0.062   42.751    0.000    2.661    2.060
##    .init             3.270    0.047   70.144    0.000    3.270    3.375
##    .inhib            3.826    0.033  114.233    0.000    3.826    5.496
##    .cont             3.448    0.036   96.077    0.000    3.448    4.623
##    .bfi              3.861    0.034  113.981    0.000    3.861    5.484
##    .sl               2.083    0.275    7.570    0.000    2.083    2.593
##    .exer             1.734    0.286    6.065    0.000    1.734    2.027
##    .dt               1.730    0.229    7.561    0.000    1.730    2.817
##    .subs             1.746    0.287    6.086    0.000    1.746    2.273
##     prehabit         4.056    0.032  125.295    0.000    4.056    6.035
##     age             34.647    0.557   62.200    0.000   34.647    3.017
##     sex              0.406    0.024   17.163    0.000    0.406    0.827
##     white            0.669    0.023   29.394    0.000    0.669    1.423
##     child            0.406    0.024   17.159    0.000    0.406    0.826
##     disrupt          0.000                              0.000    0.000
##     sreg             0.000                              0.000    0.000
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .psyeffect        0.420    0.077    5.435    0.000    0.420    0.476
##    .sched            0.415    0.093    4.458    0.000    0.415    0.439
##    .insec            1.186    0.096   12.299    0.000    1.186    0.711
##    .init             0.311    0.034    9.053    0.000    0.311    0.331
##    .inhib            0.371    0.025   14.936    0.000    0.371    0.766
##    .cont             0.318    0.029   11.123    0.000    0.318    0.572
##    .bfi              0.113    0.020    5.710    0.000    0.113    0.227
##    .sl               0.599    0.027   21.976    0.000    0.599    0.929
##    .exer             0.683    0.030   22.816    0.000    0.683    0.934
##    .dt               0.370    0.023   16.029    0.000    0.370    0.981
##    .subs             0.545    0.029   18.762    0.000    0.545    0.923
##     prehabit         0.452    0.032   13.991    0.000    0.452    1.000
##     age            131.838   10.579   12.462    0.000  131.838    1.000
##     sex              0.241    0.004   54.251    0.000    0.241    1.000
##     white            0.221    0.008   28.625    0.000    0.221    1.000
##     child            0.241    0.004   54.240    0.000    0.241    1.000
##     disrupt          0.463    0.091    5.095    0.000    1.000    1.000
```

```
##     sreg              0.628    0.058   10.808    0.000    1.000    1.000
```

Note that we're not getting any estimation errors here, as we did in Mplus. If you check the output, you'll see that the variance and SE of age are really high in comparison to the other variables in the model. This will yield the error that we saw earlier in Mplus. One way to fix this is to bring age to a smaller range of scores.

To estimate the model with categorical endogenous variables, we only need to make changes to the estimation part by adding "ordered" to the sem() command. But note that lavaan isn't set up to estimate models with observed categorical outcomes. Errors you'll get: 1. If you try to use MLR as the estimator, lavaan will tell you that you need WLSMV 2. If you try to use FIML in missing, lavaan will tell you it's not supported in categorical models 3. If you try to use WLSMV, lavaan will tell you there's an error and the model isn't identified

```
cont.fit <- sem(model = habit.sem, data = habit, estimator = "WLSMV",
    ordered = c("sl", "dt", "exer", "subs"))
```

```
## Warning in muthen1984(Data = X[[g]], wt = WT[[g]], ov.names = ov.names[[g]], :
## lavaan WARNING: trouble constructing W matrix; used generalized inverse for A11
## submatrix
```

```
## Warning in lav_model_vcov(lavmodel = lavmodel, lavsamplestats = lavsamplestats, : lavaan WARNING:
##     The variance-covariance matrix of the estimated parameters (vcov)
##     does not appear to be positive definite! The smallest eigenvalue
##     (= -3.751027e-19) is smaller than zero. This may be a symptom that
##     the model is not identified.
```

```
summary(cont.fit, fit.measures = TRUE, standardized = TRUE)
```

```
## lavaan 0.6-9 ended normally after 155 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of model parameters                        94
##
##                                                   Used       Total
##   Number of observations                           416         432
##
## Model Test User Model:
##                                               Standard      Robust
##   Test Statistic                                78.231     137.889
##   Degrees of freedom                                58          58
##   P-value (Chi-square)                           0.040       0.000
##   Scaling correction factor                                  0.621
##   Shift parameter                                           11.824
##        simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                              1057.606     729.399
##   Degrees of freedom                               120         120
##   P-value                                        0.000       0.000
##   Scaling correction factor                                  1.539
```

```
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                    0.978       0.869
##   Tucker-Lewis Index (TLI)                       0.955       0.729
##
##   Robust Comparative Fit Index (CFI)                            NA
##   Robust Tucker-Lewis Index (TLI)                               NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                          0.029       0.058
##   90 Percent confidence interval - lower         0.007       0.045
##   90 Percent confidence interval - upper         0.044       0.070
##   P-value RMSEA <= 0.05                          0.990       0.149
##
##   Robust RMSEA                                                  NA
##   90 Percent confidence interval - lower                        NA
##   90 Percent confidence interval - upper                        NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                           0.038       0.038
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   disrupt =~
##     psyeffect         1.000                               0.723    0.768
##     sched             0.957    0.113    8.456    0.000    0.692    0.709
##     insec             0.969    0.142    6.804    0.000    0.700    0.544
##   sreg =~
##     init              1.000                               0.778    0.795
##     inhib             0.471    0.055    8.632    0.000    0.367    0.527
##     cont              0.667    0.060   11.142    0.000    0.519    0.690
##     bfi               0.761    0.053   14.355    0.000    0.593    0.840
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   sl ~
##     disrupt          -0.445    0.094   -4.748    0.000   -0.322   -0.322
##     sreg             -0.040    0.081   -0.491    0.624   -0.031   -0.031
##     prehabit         -0.041    0.082   -0.502    0.616   -0.041   -0.028
##     age              -0.002    0.005   -0.347    0.729   -0.002   -0.020
##     sex              -0.074    0.108   -0.688    0.492   -0.074   -0.036
##     white            -0.104    0.118   -0.887    0.375   -0.104   -0.049
##     child             0.210    0.117    1.795    0.073    0.210    0.103
##   exer ~
##     disrupt          -0.391    0.094   -4.149    0.000   -0.283   -0.283
```

```
##     sreg              0.020    0.084    0.241    0.810    0.016    0.016
##     prehabit          0.069    0.085    0.818    0.413    0.069    0.047
##     age              -0.001    0.005   -0.114    0.909   -0.001   -0.007
##     sex               0.009    0.114    0.083    0.934    0.009    0.005
##     white            -0.213    0.116   -1.827    0.068   -0.213   -0.100
##     child             0.121    0.120    1.013    0.311    0.121    0.060
##   dt ~
##     disrupt          -0.166    0.093   -1.780    0.075   -0.120   -0.120
##     sreg             -0.086    0.087   -0.986    0.324   -0.067   -0.067
##     prehabit          0.017    0.091    0.184    0.854    0.017    0.011
##     age               0.007    0.004    1.504    0.133    0.007    0.077
##     sex              -0.066    0.112   -0.585    0.559   -0.066   -0.032
##     white            -0.052    0.124   -0.420    0.674   -0.052   -0.025
##     child             0.204    0.124    1.641    0.101    0.204    0.100
##   subs ~
##     disrupt          -0.385    0.097   -3.973    0.000   -0.278   -0.278
##     sreg              0.035    0.082    0.421    0.674    0.027    0.027
##     prehabit          0.111    0.080    1.400    0.161    0.111    0.075
##     age               0.005    0.005    1.113    0.266    0.005    0.059
##     sex              -0.037    0.114   -0.325    0.745   -0.037   -0.018
##     white             0.209    0.117    1.790    0.073    0.209    0.098
##     child             0.052    0.121    0.428    0.669    0.052    0.026
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   disrupt ~~
##     sreg             -0.094    0.035   -2.672    0.008   -0.166   -0.166
##   sreg ~~
##     prehabit          0.113    0.028    3.967    0.000    0.145    0.216
##     age               1.991    0.539    3.695    0.000    2.557    0.222
##     sex              -0.037    0.020   -1.850    0.064   -0.048   -0.098
##     white             0.023    0.020    1.177    0.239    0.030    0.063
##     child             0.060    0.021    2.834    0.005    0.077    0.156
##   disrupt ~~
##     prehabit          0.071    0.027    2.646    0.008    0.099    0.147
##     age              -0.774    0.479   -1.617    0.106   -1.071   -0.093
##     sex              -0.024    0.021   -1.150    0.250   -0.033   -0.067
##     white            -0.031    0.019   -1.640    0.101   -0.043   -0.091
##     child             0.054    0.020    2.710    0.007    0.075    0.152
##   prehabit ~~
##     age               1.010    0.392    2.575    0.010    1.010    0.131
##     sex              -0.025    0.016   -1.567    0.117   -0.025   -0.076
##     white            -0.022    0.015   -1.446    0.148   -0.022   -0.071
##     child             0.024    0.016    1.463    0.143    0.024    0.071
##   age ~~
##     sex              -0.320    0.286   -1.120    0.263   -0.320   -0.057
##     white             0.782    0.291    2.687    0.007    0.782    0.144
##     child             1.043    0.219    4.768    0.000    1.043    0.185
##   sex ~~
##     white            -0.021    0.011   -1.844    0.065   -0.021   -0.089
##     child             0.001    0.012    0.070    0.944    0.001    0.003
##   white ~~
##     child            -0.011    0.011   -0.967    0.334   -0.011   -0.047
##  .sl ~~
```

```
##    .exer              0.030    0.059    0.505    0.613    0.030    0.033
##    .dt               -0.027    0.056   -0.477    0.633   -0.027   -0.029
##    .subs              0.104    0.059    1.754    0.079    0.104    0.116
##  .exer ~~
##    .dt                0.010    0.058    0.171    0.864    0.010    0.011
##    .subs             -0.086    0.061   -1.427    0.154   -0.086   -0.096
##  .dt ~~
##    .subs              0.023    0.056    0.404    0.686    0.023    0.024
##
## Intercepts:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .psyeffect         3.259    0.047   69.457    0.000    3.259    3.463
##    .sched             3.631    0.054   66.813    0.000    3.631    3.719
##    .insec             2.637    0.067   39.451    0.000    2.637    2.047
##    .init              3.270    0.048   67.603    0.000    3.270    3.340
##    .inhib             3.823    0.035  109.730    0.000    3.823    5.484
##    .cont              3.454    0.037   93.374    0.000    3.454    4.592
##    .bfi               3.858    0.035  108.774    0.000    3.858    5.469
##    .sl                0.000                              0.000    0.000
##    .exer              0.000                              0.000    0.000
##    .dt                0.000                              0.000    0.000
##    .subs              0.000                              0.000    0.000
##     prehabit          4.055    0.039  104.497    0.000    4.055    6.044
##     age              34.599    0.734   47.162    0.000   34.599    3.010
##     sex               0.406    0.021   19.396    0.000    0.406    0.827
##     white             0.666    0.015   44.741    0.000    0.666    1.412
##     child             0.406    0.021   19.396    0.000    0.406    0.827
##     disrupt           0.000                              0.000    0.000
##     sreg              0.000                              0.000    0.000
##
## Thresholds:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     sl|t1            -0.593    0.371   -1.598    0.110   -0.593   -0.593
##     sl|t2             0.316    0.374    0.845    0.398    0.316    0.316
##     exer|t1           0.021    0.388    0.054    0.957    0.021    0.021
##     exer|t2           0.668    0.386    1.730    0.084    0.668    0.668
##     dt|t1            -0.448    0.427   -1.050    0.294   -0.448   -0.448
##     dt|t2             1.301    0.427    3.042    0.002    1.301    1.301
##     subs|t1          -0.068    0.369   -0.186    0.853   -0.068   -0.068
##     subs|t2           0.853    0.366    2.334    0.020    0.853    0.853
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .psyeffect         0.363    0.051    7.138    0.000    0.363    0.410
##    .sched             0.474    0.054    8.777    0.000    0.474    0.498
##    .insec             1.170    0.119    9.853    0.000    1.170    0.705
##    .init              0.352    0.039    9.081    0.000    0.352    0.368
##    .inhib             0.351    0.028   12.529    0.000    0.351    0.723
##    .cont              0.296    0.026   11.382    0.000    0.296    0.524
##    .bfi               0.146    0.019    7.643    0.000    0.146    0.294
##    .sl                0.898                              0.898    0.898
##    .exer              0.915                              0.915    0.915
##    .dt                0.971                              0.971    0.971
##    .subs              0.895                              0.895    0.895
```

```
##     prehabit          0.450    0.035   12.749    0.000    0.450    1.000
##     age             132.115   10.172   12.989    0.000  132.115    1.000
##     sex               0.241    0.008   29.631    0.000    0.241    1.000
##     white             0.222    0.011   20.053    0.000    0.222    1.000
##     child             0.241    0.008   29.631    0.000    0.241    1.000
##     disrupt           0.523    0.087    6.030    0.000    1.000    1.000
##     sreg              0.606    0.085    7.121    0.000    1.000    1.000
##
## Scales y*:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     sl                1.000                               1.000    1.000
##     exer              1.000                               1.000    1.000
##     dt                1.000                               1.000    1.000
##     subs              1.000                               1.000    1.000
```

An alternative is to make behavior into a latent variable.

```
habit.sem.lv <- "disrupt =~ psyeffect + sched + insec
          sreg =~ init + inhib + cont + bfi
          beh =~ sl + exer + dt + subs

          beh ~ disrupt + sreg + prehabit + age + sex + white + child

          sreg ~~ disrupt + prehabit + age + sex + white + child
          disrupt ~~ prehabit + age + sex + white + child
          prehabit ~~ age + sex + white + child
          age ~~ sex + white + child
          sex ~~ white + child
          white ~~ child
          "
```

To use categorical, you can either specify in R that these are categorical variables.

```
is.factor(habit$dt)
```

```
## [1] FALSE
```

```
is.factor(habit$sl)
```

```
## [1] FALSE
```

```
is.factor(habit$exer)
```

```
## [1] FALSE
```

```
is.factor(habit$subs)
```

```
## [1] FALSE
```

You can see from these lines that the outcome variables are not being read as categorical.

```
habit[, c("sl", "dt", "exer", "subs")] <- lapply(habit[, c("sl",
    "dt", "exer", "subs")], ordered)
```

Try again to see if it worked... And it did.

```
is.factor(habit$dt)
```

```
## [1] TRUE
```

```
is.factor(habit$sl)
```

```
## [1] TRUE
```

```
is.factor(habit$exer)
```

```
## [1] TRUE
```

```
is.factor(habit$subs)
```

```
## [1] TRUE
```

Like before, you can also tell lavaan that these variables are ordered with the line 'ordered = c("sl", "dt", "exer", "subs")'. There are still several limitations to using lavaan for categorical variables, including the fact that you can't use FIML or unordered (nominal) categorical variables.

```
cont.fit.lv <- sem(model = habit.sem.lv, data = habit, estimator = "WLSMV",
    ordered = c("sl", "dt", "exer", "subs"))
```

```
## Warning in muthen1984(Data = X[[g]], wt = WT[[g]], ov.names = ov.names[[g]], :
## lavaan WARNING: trouble constructing W matrix; used generalized inverse for A11
## submatrix
```

```
## Warning in lav_model_vcov(lavmodel = lavmodel, lavsamplestats = lavsamplestats, : lavaan WARNING:
##     The variance-covariance matrix of the estimated parameters (vcov)
##     does not appear to be positive definite! The smallest eigenvalue
##     (= -1.558889e-19) is smaller than zero. This may be a symptom that
##     the model is not identified.
```

```
summary(cont.fit.lv, fit.measures = TRUE, standardized = TRUE)
```

```
## lavaan 0.6-9 ended normally after 110 iterations
##
##   Estimator                                         DWLS
##   Optimization method                           NLMINB
##   Number of model parameters                        71
##
##                                                   Used       Total
##   Number of observations                           416         432
##
```

```
## Model Test User Model:
##                                                   Standard      Robust
##   Test Statistic                                   104.082     137.353
##   Degrees of freedom                                    81          81
##   P-value (Chi-square)                               0.043       0.000
##   Scaling correction factor                                      0.889
##   Shift parameter                                               20.300
##        simple second-order correction
##
## Model Test Baseline Model:
##
##   Test statistic                                  1057.606     729.399
##   Degrees of freedom                                   120         120
##   P-value                                            0.000       0.000
##   Scaling correction factor                                      1.539
##
## User Model versus Baseline Model:
##
##   Comparative Fit Index (CFI)                        0.975       0.908
##   Tucker-Lewis Index (TLI)                           0.964       0.863
##
##   Robust Comparative Fit Index (CFI)                                NA
##   Robust Tucker-Lewis Index (TLI)                                   NA
##
## Root Mean Square Error of Approximation:
##
##   RMSEA                                              0.026       0.041
##   90 Percent confidence interval - lower             0.005       0.029
##   90 Percent confidence interval - upper             0.040       0.053
##   P-value RMSEA <= 0.05                              0.999       0.897
##
##   Robust RMSEA                                                      NA
##   90 Percent confidence interval - lower                            NA
##   90 Percent confidence interval - upper                            NA
##
## Standardized Root Mean Square Residual:
##
##   SRMR                                               0.045       0.045
##
## Parameter Estimates:
##
##   Standard errors                             Robust.sem
##   Information                                   Expected
##   Information saturated (h1) model        Unstructured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   disrupt =~
##     psyeffect         1.000                               0.719    0.764
##     sched             0.965    0.114    8.472    0.000    0.694    0.711
##     insec             0.979    0.143    6.830    0.000    0.704    0.546
##   sreg =~
##     init              1.000                               0.781    0.798
##     inhib             0.470    0.054    8.640    0.000    0.367    0.526
```

```
##     cont              0.661    0.060   11.078    0.000    0.516    0.686
##     bfi               0.761    0.053   14.230    0.000    0.594    0.842
##   beh =~
##     sl                1.000                              0.330    0.330
##     exer              0.827    0.237    3.485    0.000    0.273    0.273
##     dt                0.352    0.209    1.681    0.093    0.116    0.116
##     subs              1.054    0.262    4.019    0.000    0.348    0.348
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   beh ~
##     disrupt          -0.424    0.089   -4.745    0.000   -0.924   -0.924
##     sreg             -0.008    0.052   -0.160    0.873   -0.020   -0.020
##     prehabit          0.050    0.051    0.978    0.328    0.151    0.101
##     age               0.002    0.003    0.752    0.452    0.007    0.076
##     sex              -0.044    0.068   -0.645    0.519   -0.133   -0.065
##     white            -0.025    0.073   -0.341    0.733   -0.075   -0.036
##     child             0.150    0.075    2.004    0.045    0.453    0.222
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##   disrupt ~~
##     sreg             -0.093    0.035   -2.670    0.008   -0.166   -0.166
##   sreg ~~
##     prehabit          0.113    0.029    3.970    0.000    0.145    0.216
##     age               1.995    0.540    3.694    0.000    2.555    0.222
##     sex              -0.038    0.020   -1.853    0.064   -0.048   -0.098
##     white             0.023    0.020    1.176    0.239    0.030    0.063
##     child             0.060    0.021    2.833    0.005    0.077    0.156
##   disrupt ~~
##     prehabit          0.071    0.027    2.640    0.008    0.099    0.147
##     age              -0.771    0.476   -1.618    0.106   -1.072   -0.093
##     sex              -0.024    0.021   -1.144    0.253   -0.033   -0.067
##     white            -0.031    0.019   -1.648    0.099   -0.043   -0.091
##     child             0.054    0.020    2.715    0.007    0.075    0.152
##   prehabit ~~
##     age               1.010    0.392    2.575    0.010    1.010    0.131
##     sex              -0.025    0.016   -1.567    0.117   -0.025   -0.076
##     white            -0.022    0.015   -1.446    0.148   -0.022   -0.071
##     child             0.024    0.016    1.463    0.143    0.024    0.071
##   age ~~
##     sex              -0.320    0.286   -1.121    0.262   -0.320   -0.057
##     white             0.782    0.291    2.687    0.007    0.782    0.144
##     child             1.043    0.219    4.768    0.000    1.043    0.185
##   sex ~~
##     white            -0.021    0.011   -1.844    0.065   -0.021   -0.089
##     child             0.001    0.012    0.070    0.944    0.001    0.003
##   white ~~
##     child            -0.011    0.011   -0.967    0.334   -0.011   -0.047
##
## Intercepts:
##                    Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .psyeffect         3.259    0.047   69.457    0.000    3.259    3.463
##    .sched             3.631    0.054   66.813    0.000    3.631    3.719
```

```
##    .insec             2.637    0.067   39.451    0.000    2.637    2.047
##    .init              3.270    0.048   67.603    0.000    3.270    3.340
##    .inhib             3.823    0.035  109.730    0.000    3.823    5.484
##    .cont              3.454    0.037   93.374    0.000    3.454    4.592
##    .bfi               3.858    0.035  108.774    0.000    3.858    5.469
##    .sl                0.000                              0.000    0.000
##    .exer              0.000                              0.000    0.000
##    .dt                0.000                              0.000    0.000
##    .subs              0.000                              0.000    0.000
##     prehabit          4.055    0.039  104.497    0.000    4.055    6.044
##     age              34.599    0.734   47.162    0.000   34.599    3.010
##     sex               0.406    0.021   19.396    0.000    0.406    0.827
##     white             0.666    0.015   44.741    0.000    0.666    1.412
##     child             0.406    0.021   19.396    0.000    0.406    0.827
##     disrupt           0.000                              0.000    0.000
##     sreg              0.000                              0.000    0.000
##    .beh               0.000                              0.000    0.000
##
## Thresholds:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     sl|t1           -0.045    0.242   -0.187    0.851   -0.045   -0.045
##     sl|t2            0.863    0.247    3.487    0.000    0.863    0.863
##     exer|t1          0.101    0.205    0.494    0.621    0.101    0.101
##     exer|t2          0.748    0.203    3.685    0.000    0.748    0.748
##     dt|t1           -0.661    0.120   -5.502    0.000   -0.661   -0.661
##     dt|t2            1.088    0.122    8.949    0.000    1.088    1.088
##     subs|t1         -0.522    0.262   -1.989    0.047   -0.522   -0.522
##     subs|t2          0.400    0.257    1.557    0.120    0.400    0.400
##
## Variances:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##    .psyeffect         0.369    0.051    7.276    0.000    0.369    0.416
##    .sched             0.471    0.054    8.728    0.000    0.471    0.495
##    .insec             1.165    0.118    9.838    0.000    1.165    0.702
##    .init              0.349    0.039    8.957    0.000    0.349    0.364
##    .inhib             0.351    0.028   12.553    0.000    0.351    0.723
##    .cont              0.300    0.026   11.430    0.000    0.300    0.530
##    .bfi               0.145    0.019    7.572    0.000    0.145    0.291
##    .sl                0.891                              0.891    0.891
##    .exer              0.925                              0.925    0.925
##    .dt                0.987                              0.987    0.987
##    .subs              0.879                              0.879    0.879
##     prehabit          0.450    0.035   12.749    0.000    0.450    1.000
##     age             132.115   10.172   12.989    0.000  132.115    1.000
##     sex               0.241    0.008   29.631    0.000    0.241    1.000
##     white             0.222    0.011   20.053    0.000    0.222    1.000
##     child             0.241    0.008   29.631    0.000    0.241    1.000
##     disrupt           0.517    0.086    6.019    0.000    1.000    1.000
##     sreg              0.610    0.086    7.124    0.000    1.000    1.000
##    .beh               0.018    0.037    0.482    0.630    0.162    0.162
##
## Scales y*:
##                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
##     sl                1.000                              1.000    1.000
```

```
##     exer              1.000                                1.000    1.000
##     dt                1.000                                1.000    1.000
##     subs              1.000                                1.000    1.000
```

There are lots of errors in this output and you'll notice that the number of estimated parameters is not the same as in Mplus. That's because lavaan isn't computing the loadings for each of the level-combinations of the categorical variable (so the behavior latent variable as only 4 loadings instead of 8).