Multivariate statistics: Assignment 1

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1 Task 1

1.1 CFA to construct a measurement model for the Attitude items

There are 9 attitude items that are scored on a five-point Likert scale. To conduct CFA on the attitude items using the covariance matrix, we first center the data.

1.1.1 A simple 3-factor model

We first conduct a simple confirmatory factor analysis, assuming each item only has a loading on the concept it aims to measure (organic, packaging, and cruelty free). We will assume the the three latent variables are correlated and the factor loading of the first indicator of each latent variable is fixed to 1. We fit the model on standardized data. The first columns in Table 3 shows several performance measures for the model. It shows that the currently proposed 3-factor model is not a good fit. The chi-squared goodness of fit tests indicate that the constraints imposed by the model are not supported ($p < 0.001$). The cutoff for a good model for CFI and TLI (cutoff > 0.95) and for RMSEA and SRMR (cutoff < 0.08) are also not satisfied. On the other hand, composite reliability measures the reliability of the factor scores. We can see that the composite reliability values are high (Table 1), therefore, the factors are measured in a reliable way. Figure 1 in the appendix shows a graphical representation of the model, including all loadings, correlations and variances.

In the standardized solution, the standardized loadings represent correlations between a variable and a factor (Table 1). All standardized loadings are above 0.7. Therefore, the squared loadings are higher than 0.5. This reflects a sufficient reliability of the indicator variables. Since all the standardized loadings are positive and significant, there is convergent validity.

and the error variances indicate the proportion of the variance in a variable that cannot be explained by the model (Table 1).

```
#We first standardize the variables
cosmetics_std <- scale(cosmetics, center = TRUE, scale = FALSE)
covmat1 <- cov(cosmetics_std[,1:9])
simplemodel1 <-
'organic = ~1*A_organic1 + A_organic2 + A_organic3
  packaging = ~1*A_packaging1 + A_packaging2 + A_packaging3
  crueltyfree = ~1*A_crueltyfree1 + A_crueltyfree2 + A_crueltyfree3
  organic ~~ organic
  packaging ~~ packaging
  crueltyfree ~~ crueltyfree
  organic ~~ packaging
  organic ~~ crueltyfree
  packaging ~~ crueltyfree'
fit1 <- cfa(simplemodel1, sample.cov = covmat1, sample.nobs = nrow(cosmetics))
sum_fit1 <- summary(fit1, fit.measure = T)
sum_fit1_std <- standardizedSolution(fit1)
```

Table 1: The solution of the simple model for the attitudes.

std_loading	value
organic =~ A_organic1	0.87 (0.80, 0.94)***
organic =~ A_organic2	0.73 (0.63, 0.82)***
organic =~ A_organic3	0.72 (0.62, 0.81)***
packaging =~ A_packaging1	0.84 (0.78, 0.91)***
packaging =~ A_packaging2	0.79 (0.72, 0.87)***
packaging =~ A_packaging3	0.80 (0.73, 0.88)***
crueltyfree =~ A_crueltyfree1	0.91 (0.87, 0.96)***
crueltyfree =~ A_crueltyfree2	0.79 (0.72, 0.86)***
crueltyfree =~ A_crueltyfree3	0.86 (0.81, 0.92)***

	std_error.variance	value
10	organic~~organic	1.00 (1.00, 1.00)
11	packaging~~packaging	1.00 (1.00, 1.00)
12	crueltyfree~~crueltyfree	1.00 (1.00, 1.00)
13	organic~~packaging	0.74 (0.63, 0.84)***
14	organic~~crueltyfree	0.60 (0.48, 0.73)***
15	packaging~~crueltyfree	0.72 (0.63, 0.82)***
16	A_organic1~~A_organic1	0.24 (0.12, 0.36)***
17	A_organic2~~A_organic2	0.47 (0.34, 0.61)***
18	A_organic3~~A_organic3	0.48 (0.35, 0.62)***
19	A_packaging1~~A_packaging1	0.29 (0.18, 0.40)***
20	A_packaging2~~A_packaging2	0.37 (0.25, 0.49)***
21	A_packaging3~~A_packaging3	0.35 (0.24, 0.47)***
22	A_crueltyfree1~~A_crueltyfree1	0.17 (0.08, 0.25)***
23	A_crueltyfree2~~A_crueltyfree2	0.38 (0.26, 0.49)***
24	A_crueltyfree3~~A_crueltyfree3	0.25 (0.16, 0.35)***

factor	reliability
organic	0.817
packaging	0.855
crueltyfree	0.892

1.1.2 A 3-factor model with correlated error terms

Since the simple 3-factor model does not seem to perform well, we alter the model by including correlated error terms for all pairs of items that focus on the same aspect. We also impose equal residual correlations for all pairs of items that focus on the same aspect.

```
corrmodel1 <-
'organic = ~1*A_organic1 + A_organic2 + A_organic3
  packaging = ~1*A_packaging1 + A_packaging2 + A_packaging3
  crueltyfree = ~1*A_crueltyfree1 + A_crueltyfree2 + A_crueltyfree3
  A_organic1 ~~c*A_packaging1
  A_organic1 ~~c*A_crueltyfree1
  A_packaging1 ~~c*A_crueltyfree1

  A_organic2 ~~d*A_packaging2
  A_organic2 ~~d*A_crueltyfree2
  A_packaging2 ~~d*A_crueltyfree2

  A_organic3 ~~e*A_packaging3
  A_organic3 ~~e*A_crueltyfree3
  A_packaging3 ~~e*A_crueltyfree3

  organic ~~ organic
  packaging ~~ packaging
  crueltyfree ~~ crueltyfree

  organic ~~ packaging
  organic ~~ crueltyfree
  packaging ~~ crueltyfree
  '
fit1corr <- cfa(corrmodel1, sample.cov = covmat1, sample.nobs = nrow(cosmetics))
sum_fit1corr <- summary(fit1corr, fit.measure = T)
sum_fit1_std_corr <- standardizedSolution(fit1corr)
```

1.1.3 Conclusion

An anova test between the two models shows that the model with correlated error terms is significantly better (p-value < 0.001).

Since, however, the performance measures (second column in Table 3) shows less-than-perfect fit, we look at the residual correlations in the model with correlated error terms for all pairs of attitude items that focus on the same aspect and notice that 7 (19.44%) of all correlations are larger than 0.05 or smaller than -0.05 (this was 27.7% in the simple model). Three of the largest residual correlations involved the correlations between A_organic3, A_packaging3, and A_crueltyfree3 which leads us to believe that the assumption that these correlations are equal does not hold. Indeed, a model that relaxes this assumption has a good TLI (0.967), CFI (0.983), RMSEA (0.073), and SRMR (0.031). The Chi-square goodness of fit test still has a p-value of 0.018.

1.2 CFA to construct a measurement model for the Behavior-Intention items

There are 9 behavior-intention items that are scored on a five-point Likert scale. As with the attitude items, we we fit a CFA on the covariance matrix of the centered dataset.

1.2.1 A simple 3-factor model

Table 3 shows, in the third column) that all performance metrics, except for SRMSR, indicate that this simple model does not fit the data well. Nevertheless, composite reliability (Table 2) is high for all three latent variables.

```
#We first standardize the variables
covmat1 <- cov(cosmetics_std[,10:18])
simplemodel1 <-
'organic = ~1*BI_organic1 + BI_organic2 + BI_organic3
  packaging = ~1*BI_packaging1 + BI_packaging2 + BI_packaging3
  crueltyfree = ~1*BI_crueltyfree1 + BI_crueltyfree2 + BI_crueltyfree3
  organic ~~ organic
  packaging ~~ packaging
  crueltyfree ~~ crueltyfree
  organic ~~ packaging
  organic ~~ crueltyfree
  packaging ~~ crueltyfree'
fit1 <- cfa(simplemodel1, sample.cov = covmat1, sample.nobs = nrow(cosmetics))
sum_fit1 <- summary(fit1, fit.measure = T)
sum_fit1_std <- standardizedSolution(fit1)
```

1.2.2 A 3-factor model with correlated error terms

Since the simple 3-factor model does not seem to perform well, we alter the model by including correlated error terms for all pairs of items that focus on the same aspect. We also impose equal residual residual correlations for all pairs of items that focus on the same aspect.

```
corrmodel1 <-
'organic = ~1*BI_organic1 + BI_organic2 + BI_organic3
  packaging = ~1*BI_packaging1 + BI_packaging2 + BI_packaging3
  crueltyfree = ~1*BI_crueltyfree1 + BI_crueltyfree2 + BI_crueltyfree3

  BI_organic1 ~~c*BI_packaging1
  BI_organic1 ~~c*BI_crueltyfree1
  BI_packaging1 ~~c*BI_crueltyfree1

  BI_organic2 ~~d*BI_packaging2
  BI_organic2 ~~d*BI_crueltyfree2
  BI_packaging2 ~~d*BI_crueltyfree2

  BI_organic3 ~~e*BI_packaging3
  BI_organic3 ~~e*BI_crueltyfree3
  BI_packaging3 ~~e*BI_crueltyfree3

  organic ~~ organic
  packaging ~~ packaging
  crueltyfree ~~ crueltyfree
  organic ~~ packaging
  organic ~~ crueltyfree
  packaging ~~ crueltyfree
  '
fit1corr <- cfa(corrmodel1, sample.cov = covmat1, sample.nobs = nrow(cosmetics))
sum_fit1corr <- summary(fit1corr, fit.measure = T)
```

Table 2: The standardized solution of the simple model for the behavior-intent items.

std_loading	value
organic =~ BI_organic1	0.89 (0.84, 0.93)***
organic =~ BI_organic2	0.90 (0.85, 0.94)***
organic =~ BI_organic3	0.84 (0.79, 0.90)***
packaging =~ BI_packaging1	0.88 (0.83, 0.92)***
packaging =~ BI_packaging2	0.89 (0.85, 0.93)***
packaging =~ BI_packaging3	0.87 (0.82, 0.91)***
crueltyfree =~ BI_crueltyfree1	0.92 (0.88, 0.95)***
crueltyfree =~ BI_crueltyfree2	0.92 (0.89, 0.95)***
crueltyfree =~ BI_crueltyfree3	0.94 (0.91, 0.97)***

	std_error.variance	value
10	organic~~organic	1.00 (1.00, 1.00)
11	packaging~~packaging	1.00 (1.00, 1.00)
12	crueltyfree~~crueltyfree	1.00 (1.00, 1.00)
13	organic~~packaging	0.88 (0.82, 0.93)***
14	organic~~crueltyfree	0.78 (0.71, 0.86)***
15	packaging~~crueltyfree	0.83 (0.77, 0.90)***
16	BI_organic1~~BI_organic1	0.22 (0.14, 0.29)***
17	BI_organic2~~BI_organic2	0.20 (0.12, 0.27)***
18	BI_organic3~~BI_organic3	0.29 (0.20, 0.38)***
19	BI_packaging1~~BI_packaging1	0.23 (0.15, 0.31)***
20	BI_packaging2~~BI_packaging2	0.21 (0.13, 0.28)***
21	BI_packaging3~~BI_packaging3	0.25 (0.17, 0.33)***
22	BI_crueltyfree1~~BI_crueltyfree1	0.16 (0.10, 0.22)***
23	BI_crueltyfree2~~BI_crueltyfree2	0.16 (0.10, 0.22)***
24	BI_crueltyfree3~~BI_crueltyfree3	0.12 (0.07, 0.17)***

factor	reliability
organic	0.908
packaging	0.910
crueltyfree	0.946

Table 3: Performance measure for the different models

parameter	Attitudes: simple model	Attitudes: with correlated error terms	Behavior-intention: simple model	Behavior-intention: with correlated error terms
user model Chisq. (df)	120.89 (24)***	56.74 (21)***	147.81 (24)***	26.78 (21)
baseline model Chisq. (df)	906.01 (36) ***	906.01 (36) ***	1478.43 (36) ***	1478.43 (36) ***
comparative fit index (CFI)	0.889	0.959	0.914	0.996
Tucker-Lewis index (TLI)	0.833	0.93	0.871	0.993
RMSEA (ll,ul)	0.16 (0.14, 0.19)***	0.11 (0.07, 0.14)**	0.19 (0.16, 0.21)***	0.04 (0.00, 0.09)
Standardized root mean square residual	0.057	0.042	0.033	0.02

```
sum_fit1_std_corr <- standardizedSolution(fit1corr)
```

1.2.3 Conclusion

An anova test between the two models shows that the model with correlated error terms for all pairs of Behavior-Intention items that focus on the same aspect is significantly better (p-value < 0.001).

The performance measures (column 3 and 4 in Table 3) show a good fit and all residual correlations are between -0.05 and 0.05 (the simpler model had 0 (0%) residual correlations between -0.05 and 0.05). For the simple model We shall thus keep this model as the final model.

1.3 Structural equation model to evaluate the impact of attitude on behavior intention

With a test statistics of 149.47 with 120 degrees of freedom, the chi-square p-value is 0.0353331 which means we cannot reject the null hypothesis that the model fits well.

```
## lavaan 0.6-12 ended normally after 59 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        63
##   Number of equality constraints                    12
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                               149.465
##   Degrees of freedom                               120
##   P-value (Chi-square)                           0.035
##
## Parameter Estimates:
```

```
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic =~
##     BI_organic1       1.000
##     BI_organic2       0.962    0.062   15.627    0.000
##     BI_organic3       0.905    0.065   13.820    0.000
##   BI_packaging =~
##     BI_packaging1     1.000
##     BI_packaging2     1.003    0.063   15.845    0.000
##     BI_packaging3     0.921    0.067   13.690    0.000
##   BI_crueltyfree =~
##     BI_crueltyfre1    1.000
##     BI_crueltyfre2    0.980    0.050   19.418    0.000
##     BI_crueltyfre3    0.963    0.048   20.064    0.000
##   A_organic =~
##     A_organic1        0.708    0.060   11.836    0.000
##     A_organic2        0.620    0.063    9.909    0.000
##     A_organic3        0.733    0.076    9.646    0.000
##   A_packaging =~
##     A_packaging1      0.758    0.062   12.188    0.000
##     A_packaging2      0.655    0.058   11.281    0.000
##     A_packaging3      0.900    0.075   12.027    0.000
##   A_crueltyfree =~
##     A_crueltyfree1    0.836    0.062   13.472    0.000
##     A_crueltyfree2    0.807    0.070   11.594    0.000
##     A_crueltyfree3    0.985    0.073   13.492    0.000
##
## Regressions:
##                   Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic ~
##     A_organic        0.626    0.068    9.261    0.000
##   BI_packaging ~
##     A_packaging      0.588    0.062    9.524    0.000
##   BI_crueltyfree ~
##     A_crueltyfree    0.695    0.067   10.437    0.000
##
## Covariances:
##                   Estimate  Std.Err  z-value  P(>|z|)
##  .BI_organic1 ~~
##    .BI_pckgng1 (c)   0.055    0.015    3.631    0.000
##    .BI_crltyf1 (c)   0.055    0.015    3.631    0.000
##  .BI_packaging1 ~~
##    .BI_crltyf1 (c)   0.055    0.015    3.631    0.000
##  .BI_organic2 ~~
##    .BI_pckgng2 (d)   0.105    0.017    6.067    0.000
##    .BI_crltyf2 (d)   0.105    0.017    6.067    0.000
```

```
##  .BI_packaging2 ~~
##    .BI_crltyf2 (d)    0.105    0.017    6.067    0.000
##  .BI_organic3 ~~
##    .BI_pckgng3 (e)    0.064    0.020    3.200    0.001
##    .BI_crltyf3 (e)    0.064    0.020    3.200    0.001
##  .BI_packaging3 ~~
##    .BI_crltyf3 (e)    0.064    0.020    3.200    0.001
##  .BI_organic ~~
##    .BI_packgng        0.358    0.060    5.929    0.000
##    .BI_crltyfr        0.330    0.059    5.605    0.000
##  .BI_packaging ~~
##    .BI_crltyfr        0.348    0.057    6.090    0.000
##  .A_organic1 ~~
##    .A_packgng1 (c)    0.055    0.015    3.631    0.000
##    .A_crltyfr1 (c)    0.055    0.015    3.631    0.000
##  .A_packaging1 ~~
##    .A_crltyfr1 (c)    0.055    0.015    3.631    0.000
##  .A_organic2 ~~
##    .A_packgng2 (d)    0.105    0.017    6.067    0.000
##    .A_crltyfr2 (d)    0.105    0.017    6.067    0.000
##  .A_packaging2 ~~
##    .A_crltyfr2 (d)    0.105    0.017    6.067    0.000
##  .A_organic3 ~~
##    .A_packgng3        0.269    0.055    4.854    0.000
##    .A_crltyfr3        0.099    0.044    2.263    0.024
##  .A_packaging3 ~~
##    .A_crltyfr3        0.035    0.039    0.889    0.374
##   A_organic ~~
##     A_packagng       0.733    0.047   15.463    0.000
##     A_crultyfr       0.632    0.059   10.755    0.000
##   A_packaging ~~
##     A_crultyfr       0.708    0.049   14.475    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .BI_organic        0.446    0.078    5.696    0.000
##    .BI_packaging      0.400    0.068    5.896    0.000
##    .BI_crueltyfree    0.454    0.070    6.461    0.000
##     A_organic         1.000
##     A_packaging       1.000
##     A_crueltyfree     1.000
##    .BI_organic1       0.238    0.037    6.433    0.000
##    .BI_organic2       0.217    0.031    6.933    0.000
##    .BI_organic3       0.293    0.041    7.159    0.000
##    .BI_packaging1     0.216    0.033    6.646    0.000
##    .BI_packaging2     0.201    0.029    6.994    0.000
##    .BI_packaging3     0.280    0.038    7.300    0.000
##    .BI_crueltyfre1    0.166    0.027    6.252    0.000
##    .BI_crueltyfre2    0.202    0.027    7.503    0.000
##    .BI_crueltyfre3    0.147    0.026    5.693    0.000
##    .A_organic1        0.222    0.038    5.850    0.000
```

```
##     .A_organic2        0.345    0.043    7.962    0.000
##     .A_organic3        0.550    0.077    7.164    0.000
##     .A_packaging1      0.250    0.037    6.695    0.000
##     .A_packaging2      0.268    0.034    7.853    0.000
##     .A_packaging3      0.402    0.064    6.243    0.000
##     .A_crueltyfree1    0.199    0.033    6.121    0.000
##     .A_crueltyfree2    0.381    0.047    8.108    0.000
##     .A_crueltyfree3    0.269    0.049    5.434    0.000

##               lhs op           rhs label est.std    se      z pvalue
## 1       BI_organic =~    BI_organic1         0.882 0.022 39.818  0.000
## 2       BI_organic =~    BI_organic2         0.884 0.021 42.831  0.000
## 3       BI_organic =~    BI_organic3         0.837 0.028 30.248  0.000
## 4     BI_packaging =~  BI_packaging1         0.881 0.022 40.323  0.000
## 5     BI_packaging =~  BI_packaging2         0.888 0.020 45.112  0.000
## 6     BI_packaging =~  BI_packaging3         0.833 0.028 29.859  0.000
## 7   BI_crueltyfree =~ BI_crueltyfree1         0.922 0.015 61.219  0.000
## 8   BI_crueltyfree =~ BI_crueltyfree2         0.904 0.016 55.989  0.000
## 9   BI_crueltyfree =~ BI_crueltyfree3         0.925 0.015 60.279  0.000
## 10     BI_organic1 ~~  BI_packaging1     c   0.243 0.058  4.208  0.000
## 11     BI_organic1 ~~ BI_crueltyfree1     c   0.277 0.065  4.270  0.000
## 12   BI_packaging1 ~~ BI_crueltyfree1     c   0.290 0.067  4.335  0.000
## 13     BI_organic2 ~~  BI_packaging2     d   0.504 0.060  8.432  0.000
## 14     BI_organic2 ~~ BI_crueltyfree2     d   0.503 0.060  8.369  0.000
## 15   BI_packaging2 ~~ BI_crueltyfree2     d   0.522 0.060  8.704  0.000
## 16     BI_organic3 ~~  BI_packaging3     e   0.224 0.060  3.757  0.000
## 17     BI_organic3 ~~ BI_crueltyfree3     e   0.309 0.078  3.976  0.000
## 18   BI_packaging3 ~~ BI_crueltyfree3     e   0.316 0.079  4.010  0.000
## 19      BI_organic ~~     BI_organic         0.532 0.068  7.791  0.000
## 20    BI_packaging ~~   BI_packaging         0.536 0.064  8.320  0.000
## 21  BI_crueltyfree ~~  BI_crueltyfree         0.484 0.060  8.033  0.000
## 22      BI_organic ~~   BI_packaging         0.847 0.045 18.973  0.000
## 23      BI_organic ~~  BI_crueltyfree         0.733 0.057 12.780  0.000
## 24    BI_packaging ~~  BI_crueltyfree         0.818 0.045 18.069  0.000
## 25       A_organic =~      A_organic1         0.833 0.035 23.997  0.000
## 26       A_organic =~      A_organic2         0.726 0.044 16.433  0.000
## 27       A_organic =~      A_organic3         0.703 0.048 14.581  0.000
## 28     A_packaging =~    A_packaging1         0.835 0.031 27.211  0.000
## 29     A_packaging =~    A_packaging2         0.785 0.035 22.194  0.000
## 30     A_packaging =~    A_packaging3         0.817 0.034 23.774  0.000
## 31   A_crueltyfree =~  A_crueltyfree1         0.882 0.023 37.588  0.000
## 32   A_crueltyfree =~  A_crueltyfree2         0.795 0.033 24.177  0.000
## 33   A_crueltyfree =~  A_crueltyfree3         0.885 0.025 35.710  0.000
## 34      A_organic1 ~~    A_packaging1     c   0.234 0.057  4.136  0.000
## 35      A_organic1 ~~  A_crueltyfree1     c   0.262 0.063  4.142  0.000
## 36    A_packaging1 ~~  A_crueltyfree1     c   0.247 0.060  4.123  0.000
## 37      A_organic2 ~~    A_packaging2     d   0.346 0.049  7.032  0.000
## 38      A_organic2 ~~  A_crueltyfree2     d   0.290 0.043  6.714  0.000
## 39    A_packaging2 ~~  A_crueltyfree2     d   0.329 0.048  6.879  0.000
## 40      A_organic3 ~~    A_packaging3         0.572 0.070  8.188  0.000
## 41      A_organic3 ~~  A_crueltyfree3         0.257 0.100  2.556  0.011
```

```
## 42    A_packaging3 ~~  A_crueltyfree3         0.106 0.114  0.929  0.353
## 43       A_organic ~~       A_organic         1.000 0.000     NA     NA
## 44     A_packaging ~~     A_packaging         1.000 0.000     NA     NA
## 45   A_crueltyfree ~~   A_crueltyfree         1.000 0.000     NA     NA
## 46       A_organic ~~     A_packaging         0.733 0.047 15.463  0.000
## 47       A_organic ~~   A_crueltyfree         0.632 0.059 10.755  0.000
## 48     A_packaging ~~   A_crueltyfree         0.708 0.049 14.475  0.000
## 49      BI_organic  ~       A_organic         0.684 0.050 13.709  0.000
## 50    BI_packaging  ~     A_packaging         0.681 0.047 14.415  0.000
## 51  BI_crueltyfree  ~   A_crueltyfree         0.718 0.042 17.103  0.000
## 52     BI_organic1 ~~     BI_organic1         0.221 0.039  5.662  0.000
## 53     BI_organic2 ~~     BI_organic2         0.218 0.036  5.984  0.000
## 54     BI_organic3 ~~     BI_organic3         0.299 0.046  6.445  0.000
## 55   BI_packaging1 ~~   BI_packaging1         0.225 0.038  5.841  0.000
## 56   BI_packaging2 ~~   BI_packaging2         0.211 0.035  6.045  0.000
## 57   BI_packaging3 ~~   BI_packaging3         0.306 0.046  6.597  0.000
## 58 BI_crueltyfree1 ~~ BI_crueltyfree1         0.151 0.028  5.437  0.000
## 59 BI_crueltyfree2 ~~ BI_crueltyfree2         0.183 0.029  6.291  0.000
## 60 BI_crueltyfree3 ~~ BI_crueltyfree3         0.145 0.028  5.107  0.000
## 61      A_organic1 ~~      A_organic1         0.307 0.058  5.308  0.000
## 62      A_organic2 ~~      A_organic2         0.473 0.064  7.375  0.000
## 63      A_organic3 ~~      A_organic3         0.506 0.068  7.457  0.000
## 64    A_packaging1 ~~    A_packaging1         0.303 0.051  5.918  0.000
## 65    A_packaging2 ~~    A_packaging2         0.384 0.055  6.927  0.000
## 66    A_packaging3 ~~    A_packaging3         0.332 0.056  5.904  0.000
## 67  A_crueltyfree1 ~~  A_crueltyfree1         0.222 0.041  5.358  0.000
## 68  A_crueltyfree2 ~~  A_crueltyfree2         0.369 0.052  7.058  0.000
## 69  A_crueltyfree3 ~~  A_crueltyfree3         0.217 0.044  4.938  0.000
##    ci.lower ci.upper
## 1     0.839    0.926
## 2     0.844    0.925
## 3     0.783    0.892
## 4     0.838    0.923
## 5     0.849    0.927
## 6     0.778    0.887
## 7     0.892    0.951
## 8     0.872    0.935
## 9     0.895    0.955
## 10    0.130    0.356
## 11    0.150    0.403
## 12    0.159    0.422
## 13    0.387    0.621
## 14    0.385    0.620
## 15    0.404    0.640
## 16    0.107    0.341
## 17    0.156    0.461
## 18    0.161    0.470
## 19    0.398    0.666
## 20    0.410    0.662
## 21    0.366    0.603
## 22    0.759    0.934
```

```
## 23     0.620     0.845
## 24     0.729     0.906
## 25     0.765     0.901
## 26     0.639     0.813
## 27     0.609     0.798
## 28     0.775     0.895
## 29     0.715     0.854
## 30     0.750     0.885
## 31     0.836     0.928
## 32     0.730     0.859
## 33     0.836     0.934
## 34     0.123     0.344
## 35     0.138     0.386
## 36     0.129     0.364
## 37     0.250     0.443
## 38     0.206     0.375
## 39     0.236     0.423
## 40     0.435     0.709
## 41     0.060     0.453
## 42    -0.118     0.331
## 43     1.000     1.000
## 44     1.000     1.000
## 45     1.000     1.000
## 46     0.640     0.826
## 47     0.517     0.747
## 48     0.612     0.803
## 49     0.586     0.782
## 50     0.589     0.774
## 51     0.636     0.800
## 52     0.145     0.298
## 53     0.147     0.290
## 54     0.208     0.390
## 55     0.149     0.300
## 56     0.143     0.280
## 57     0.215     0.397
## 58     0.096     0.205
## 59     0.126     0.241
## 60     0.089     0.201
## 61     0.193     0.420
## 62     0.347     0.599
## 63     0.373     0.639
## 64     0.203     0.404
## 65     0.276     0.493
## 66     0.222     0.442
## 67     0.141     0.303
## 68     0.266     0.471
## 69     0.131     0.303
```

The structural equation model shows that all correlations between latent variables are positive and highly significant.

- an increase of one unit in attitude_organic increases the behavior intention with 0.684.
- an increase of one unit in attitude_packaging increases the behavior intention with 0.681.

- an increase of one unit in attitude_crueltyfree increases the behavior intention with 0.718.

These population regression coefficients are quite similar so we next test a model that imposes that all three regression coefficients are the same.

1.3.1 The same population regression coefficient

```
## lavaan 0.6-12 ended normally after 65 iterations
##
##   Estimator                                         ML
##   Optimization method                           NLMINB
##   Number of model parameters                        63
##   Number of equality constraints                    14
##
##   Number of observations                           150
##
## Model Test User Model:
##
##   Test statistic                               152.126
##   Degrees of freedom                               122
##   P-value (Chi-square)                           0.034
##
## Parameter Estimates:
##
##   Standard errors                             Standard
##   Information                                 Expected
##   Information saturated (h1) model          Structured
##
## Latent Variables:
##                      Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic =~
##     BI_organic1         1.000
##     BI_organic2         0.960    0.058   16.500    0.000
##     BI_organic3         0.904    0.063   14.410    0.000
##   BI_packaging =~
##     BI_packaging1       1.000
##     BI_packaging2       0.980    0.057   17.314    0.000
##     BI_packaging3       0.901    0.061   14.681    0.000
##   BI_crueltyfree =~
##     BI_crueltyfre1      1.000
##     BI_crueltyfre2      0.993    0.052   19.147    0.000
##     BI_crueltyfre3      0.976    0.049   19.804    0.000
##   A_organic =~
##     A_organic1          0.714    0.059   12.183    0.000
##     A_organic2          0.624    0.062   10.136    0.000
##     A_organic3          0.741    0.075    9.913    0.000
##   A_packaging =~
##     A_packaging1        0.779    0.061   12.742    0.000
##     A_packaging2        0.673    0.057   11.774    0.000
##     A_packaging3        0.926    0.074   12.594    0.000
##   A_crueltyfree =~
##     A_crueltyfree1      0.815    0.059   13.818    0.000
```

```
##     A_crueltyfree2     0.786    0.067   11.713    0.000
##     A_crueltyfree3     0.960    0.070   13.758    0.000
##
## Regressions:
##                    Estimate  Std.Err  z-value  P(>|z|)
##   BI_organic ~
##     A_organic  (p)    0.640    0.053   12.185    0.000
##   BI_packaging ~
##     A_packagng (p)    0.640    0.053   12.185    0.000
##   BI_crueltyfree ~
##     A_crultyfr (p)    0.640    0.053   12.185    0.000
##
## Covariances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##  .BI_organic1 ~~
##    .BI_pckgng1 (c)    0.054    0.015    3.563    0.000
##    .BI_crltyf1 (c)    0.054    0.015    3.563    0.000
##  .BI_packaging1 ~~
##    .BI_crltyf1 (c)    0.054    0.015    3.563    0.000
##  .BI_organic2 ~~
##    .BI_pckgng2 (d)    0.106    0.017    6.099    0.000
##    .BI_crltyf2 (d)    0.106    0.017    6.099    0.000
##  .BI_packaging2 ~~
##    .BI_crltyf2 (d)    0.106    0.017    6.099    0.000
##  .BI_organic3 ~~
##    .BI_pckgng3 (e)    0.064    0.020    3.206    0.001
##    .BI_crltyf3 (e)    0.064    0.020    3.206    0.001
##  .BI_packaging3 ~~
##    .BI_crltyf3 (e)    0.064    0.020    3.206    0.001
##  .BI_organic ~~
##    .BI_packgng        0.358    0.061    5.913    0.000
##    .BI_crltyfr        0.333    0.059    5.658    0.000
##  .BI_packaging ~~
##    .BI_crltyfr        0.353    0.058    6.120    0.000
##  .A_organic1 ~~
##    .A_packgng1 (c)    0.054    0.015    3.563    0.000
##    .A_crltyfr1 (c)    0.054    0.015    3.563    0.000
##  .A_packaging1 ~~
##    .A_crltyfr1 (c)    0.054    0.015    3.563    0.000
##  .A_organic2 ~~
##    .A_packgng2 (d)    0.106    0.017    6.099    0.000
##    .A_crltyfr2 (d)    0.106    0.017    6.099    0.000
##  .A_packaging2 ~~
##    .A_crltyfr2 (d)    0.106    0.017    6.099    0.000
##  .A_organic3 ~~
##    .A_packgng3        0.268    0.055    4.848    0.000
##    .A_crltyfr3        0.099    0.044    2.269    0.023
##  .A_packaging3 ~~
##    .A_crltyfr3        0.036    0.039    0.912    0.362
##   A_organic ~~
##     A_packagng        0.742    0.046   16.269    0.000
```

```
##     A_crultyfr        0.632    0.059   10.729    0.000
##   A_packaging ~~
##     A_crultyfr        0.705    0.049   14.430    0.000
##
## Variances:
##                    Estimate  Std.Err  z-value  P(>|z|)
##    .BI_organic        0.444    0.078    5.698    0.000
##    .BI_packaging      0.404    0.068    5.924    0.000
##    .BI_crueltyfree    0.460    0.071    6.505    0.000
##     A_organic         1.000
##     A_packaging       1.000
##     A_crueltyfree     1.000
##    .BI_organic1       0.237    0.037    6.424    0.000
##    .BI_organic2       0.217    0.031    6.964    0.000
##    .BI_organic3       0.293    0.041    7.172    0.000
##    .BI_packaging1     0.214    0.033    6.561    0.000
##    .BI_packaging2     0.202    0.029    7.095    0.000
##    .BI_packaging3     0.280    0.038    7.336    0.000
##    .BI_crueltyfre1    0.168    0.027    6.323    0.000
##    .BI_crueltyfre2    0.201    0.027    7.457    0.000
##    .BI_crueltyfre3    0.146    0.026    5.632    0.000
##    .A_organic1        0.221    0.038    5.860    0.000
##    .A_organic2        0.346    0.043    7.996    0.000
##    .A_organic3        0.550    0.077    7.171    0.000
##    .A_packaging1      0.252    0.037    6.735    0.000
##    .A_packaging2      0.269    0.034    7.895    0.000
##    .A_packaging3      0.401    0.064    6.267    0.000
##    .A_crueltyfree1    0.197    0.033    6.014    0.000
##    .A_crueltyfree2    0.381    0.047    8.093    0.000
##    .A_crueltyfree3    0.269    0.050    5.389    0.000
```

```
##               lhs op             rhs label est.std    se      z pvalue
## 1      BI_organic =~     BI_organic1         0.885 0.020 43.602  0.000
## 2      BI_organic =~     BI_organic2         0.885 0.020 43.760  0.000
## 3      BI_organic =~     BI_organic3         0.839 0.027 31.012  0.000
## 4    BI_packaging =~   BI_packaging1         0.890 0.019 46.686  0.000
## 5    BI_packaging =~   BI_packaging2         0.891 0.019 47.276  0.000
## 6    BI_packaging =~   BI_packaging3         0.838 0.027 31.386  0.000
## 7  BI_crueltyfree =~ BI_crueltyfree1         0.915 0.015 59.969  0.000
## 8  BI_crueltyfree =~ BI_crueltyfree2         0.900 0.017 54.488  0.000
## 9  BI_crueltyfree =~ BI_crueltyfree3         0.922 0.016 58.082  0.000
## 10    BI_organic1 ~~   BI_packaging1     c   0.239 0.058  4.121  0.000
## 11    BI_organic1 ~~ BI_crueltyfree1     c   0.270 0.065  4.176  0.000
## 12  BI_packaging1 ~~ BI_crueltyfree1     c   0.284 0.067  4.234  0.000
## 13    BI_organic2 ~~   BI_packaging2     d   0.504 0.059  8.472  0.000
## 14    BI_organic2 ~~ BI_crueltyfree2     d   0.505 0.060  8.430  0.000
## 15  BI_packaging2 ~~ BI_crueltyfree2     d   0.524 0.060  8.764  0.000
## 16    BI_organic3 ~~   BI_packaging3     e   0.224 0.060  3.762  0.000
## 17    BI_organic3 ~~ BI_crueltyfree3     e   0.310 0.078  3.989  0.000
## 18  BI_packaging3 ~~ BI_crueltyfree3     e   0.317 0.079  4.022  0.000
## 19     BI_organic ~~      BI_organic         0.520 0.060  8.609  0.000
```

```
## 20    BI_packaging ~~    BI_packaging         0.496 0.059  8.474  0.000
## 21  BI_crueltyfree ~~  BI_crueltyfree         0.529 0.056  9.521  0.000
## 22      BI_organic ~~    BI_packaging         0.846 0.045 18.608  0.000
## 23      BI_organic ~~  BI_crueltyfree         0.738 0.056 13.083  0.000
## 24    BI_packaging ~~  BI_crueltyfree         0.819 0.045 18.130  0.000
## 25       A_organic =~      A_organic1         0.835 0.034 24.600  0.000
## 26       A_organic =~      A_organic2         0.728 0.043 16.789  0.000
## 27       A_organic =~      A_organic3         0.707 0.047 14.994  0.000
## 28     A_packaging =~    A_packaging1         0.841 0.029 28.938  0.000
## 29     A_packaging =~    A_packaging2         0.792 0.034 23.598  0.000
## 30     A_packaging =~    A_packaging3         0.826 0.032 25.440  0.000
## 31   A_crueltyfree =~  A_crueltyfree1         0.878 0.024 36.138  0.000
## 32   A_crueltyfree =~  A_crueltyfree2         0.786 0.034 23.387  0.000
## 33   A_crueltyfree =~  A_crueltyfree3         0.880 0.026 33.969  0.000
## 34      A_organic1 ~~    A_packaging1     c   0.229 0.056  4.048  0.000
## 35      A_organic1 ~~  A_crueltyfree1     c   0.258 0.064  4.063  0.000
## 36    A_packaging1 ~~  A_crueltyfree1     c   0.242 0.060  4.039  0.000
## 37      A_organic2 ~~    A_packaging2     d   0.347 0.049  7.064  0.000
## 38      A_organic2 ~~  A_crueltyfree2     d   0.291 0.043  6.745  0.000
## 39    A_packaging2 ~~  A_crueltyfree2     d   0.330 0.048  6.910  0.000
## 40      A_organic3 ~~    A_packaging3         0.570 0.070  8.157  0.000
## 41      A_organic3 ~~  A_crueltyfree3         0.258 0.100  2.566  0.010
## 42    A_packaging3 ~~  A_crueltyfree3         0.109 0.114  0.956  0.339
## 43       A_organic ~~       A_organic         1.000 0.000     NA     NA
## 44     A_packaging ~~     A_packaging         1.000 0.000     NA     NA
## 45   A_crueltyfree ~~   A_crueltyfree         1.000 0.000     NA     NA
## 46       A_organic ~~     A_packaging         0.742 0.046 16.269  0.000
## 47       A_organic ~~   A_crueltyfree         0.632 0.059 10.729  0.000
## 48     A_packaging ~~   A_crueltyfree         0.705 0.049 14.430  0.000
## 49      BI_organic  ~       A_organic     p   0.693 0.044 15.905  0.000
## 50    BI_packaging  ~     A_packaging     p   0.710 0.041 17.219  0.000
## 51  BI_crueltyfree  ~   A_crueltyfree     p   0.686 0.040 16.965  0.000
## 52     BI_organic1 ~~     BI_organic1         0.217 0.036  6.053  0.000
## 53     BI_organic2 ~~     BI_organic2         0.216 0.036  6.039  0.000
## 54     BI_organic3 ~~     BI_organic3         0.296 0.045  6.516  0.000
## 55   BI_packaging1 ~~   BI_packaging1         0.208 0.034  6.142  0.000
## 56   BI_packaging2 ~~   BI_packaging2         0.206 0.034  6.126  0.000
## 57   BI_packaging3 ~~   BI_packaging3         0.298 0.045  6.650  0.000
## 58 BI_crueltyfree1 ~~ BI_crueltyfree1         0.162 0.028  5.802  0.000
## 59 BI_crueltyfree2 ~~ BI_crueltyfree2         0.190 0.030  6.388  0.000
## 60 BI_crueltyfree3 ~~ BI_crueltyfree3         0.150 0.029  5.121  0.000
## 61      A_organic1 ~~      A_organic1         0.302 0.057  5.334  0.000
## 62      A_organic2 ~~      A_organic2         0.471 0.063  7.462  0.000
## 63      A_organic3 ~~      A_organic3         0.500 0.067  7.511  0.000
## 64    A_packaging1 ~~    A_packaging1         0.293 0.049  5.996  0.000
## 65    A_packaging2 ~~    A_packaging2         0.373 0.053  7.005  0.000
## 66    A_packaging3 ~~    A_packaging3         0.318 0.054  5.940  0.000
## 67  A_crueltyfree1 ~~  A_crueltyfree1         0.229 0.043  5.363  0.000
## 68  A_crueltyfree2 ~~  A_crueltyfree2         0.382 0.053  7.213  0.000
## 69  A_crueltyfree3 ~~  A_crueltyfree3         0.226 0.046  4.965  0.000
##    ci.lower ci.upper
```

```
## 1      0.845     0.924
## 2      0.846     0.925
## 3      0.786     0.892
## 4      0.852     0.927
## 5      0.854     0.928
## 6      0.786     0.890
## 7      0.885     0.945
## 8      0.868     0.932
## 9      0.891     0.953
## 10     0.126     0.353
## 11     0.143     0.397
## 12     0.153     0.415
## 13     0.387     0.620
## 14     0.388     0.623
## 15     0.407     0.641
## 16     0.107     0.341
## 17     0.158     0.462
## 18     0.163     0.472
## 19     0.401     0.638
## 20     0.381     0.611
## 21     0.420     0.638
## 22     0.757     0.935
## 23     0.627     0.848
## 24     0.730     0.907
## 25     0.769     0.902
## 26     0.643     0.813
## 27     0.614     0.799
## 28     0.784     0.898
## 29     0.726     0.858
## 30     0.762     0.889
## 31     0.831     0.926
## 32     0.721     0.852
## 33     0.829     0.930
## 34     0.118     0.339
## 35     0.134     0.383
## 36     0.125     0.360
## 37     0.250     0.443
## 38     0.207     0.376
## 39     0.237     0.424
## 40     0.433     0.708
## 41     0.061     0.454
## 42    -0.115     0.334
## 43     1.000     1.000
## 44     1.000     1.000
## 45     1.000     1.000
## 46     0.653     0.831
## 47     0.516     0.747
## 48     0.610     0.801
## 49     0.608     0.778
## 50     0.629     0.791
## 51     0.607     0.766
```

```
## 52     0.147     0.288
## 53     0.146     0.287
## 54     0.207     0.385
## 55     0.142     0.275
## 56     0.140     0.272
## 57     0.210     0.385
## 58     0.107     0.217
## 59     0.132     0.248
## 60     0.093     0.207
## 61     0.191     0.414
## 62     0.347     0.594
## 63     0.370     0.631
## 64     0.197     0.389
## 65     0.268     0.477
## 66     0.213     0.423
## 67     0.145     0.313
## 68     0.278     0.485
## 69     0.137     0.316
```

Since an anova test for the two sem models has a p-value of 0.264, we cannot reject the null hypothesis that the models are the same, meaning this new, simpler SEM fits as well as the more elaborate model.

- an increase of one unit in attitude_organic increases the behavior intention with 0.693.
- an increase of one unit in attitude_packaging increases the behavior intention with 0.71.
- an increase of one unit in attitude_crueltyfree increases the behavior intention with 0.686.

2 Task 2

2.1 Canonical correlation analysis

```
library(candisc)
zbenefits <- benefits
zbenefits[,2:14] <- scale(zbenefits[,2:14],scale=TRUE,center=TRUE)

cancor.out <- cancor(
  cbind(SL_pensioners, SL_unemployed, SL_old_gvntresp, SL_unemp_gvntresp)
~SB_strain_economy+SB_prevent_poverty+SB_equal_society+
SB_taxes_business+ SB_make_lazy+SB_caring_others+ unemployed_notmotivated+
SB_often_lessthanentitled+ SB_often_notentitled,
data=zbenefits)

#print summary results
summary(cancor.out)
```

```
##
## Canonical correlation analysis of:
##    9   X  variables:  SB_strain_economy, SB_prevent_poverty, SB_equal_society, SB_taxes_business, S
##    with    4   Y  variables:  SL_pensioners, SL_unemployed, SL_old_gvntresp, SL_unemp_gvntresp
##
##       CanR    CanRSQ    Eigen percent     cum                          scree
## 1 0.48323 0.233515 0.30466 79.8465  79.85 ******************************
## 2 0.22817 0.052061 0.05492 14.3939  94.24 *****
```

```
## 3 0.13741 0.018883 0.01925  5.0442  99.28 **
## 4 0.05218 0.002723 0.00273  0.7155 100.00
##
## Test of H0: The canonical correlations in the
## current row and all that follow are zero
##
##      CanR LR test stat approx F numDF   denDF   Pr(> F)
## 1 0.48323      0.71092   32.719    36 12357.1 < 2.2e-16 ***
## 2 0.22817      0.92751   10.477    24  9565.8 < 2.2e-16 ***
## 3 0.13741      0.97845    5.163    14  6598.0 8.545e-10 ***
## 4 0.05218      0.99728    1.501     6  3300.0    0.1735
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Raw canonical coefficients
##
##    X  variables:
##                                Xcan1      Xcan2     Xcan3     Xcan4
## SB_strain_economy          -0.0909717  0.4172121  0.564470 -0.059128
## SB_prevent_poverty          0.0779679 -0.0254661 -0.329579 -0.125299
## SB_equal_society            0.1279718  0.3828047 -0.585296 -0.097459
## SB_taxes_business          -0.0850983  0.0972611 -0.067364 -0.947887
## SB_make_lazy               -0.3819813  0.0411048 -0.206351  0.231770
## SB_caring_others            0.0069064  0.0060264  0.128499 -0.149934
## unemployed_notmotivated    -0.4933957 -0.1393655 -0.333507  0.134556
## SB_often_lessthanentitled   0.2525276 -0.6831611  0.127790 -0.360191
## SB_often_notentitled       -0.1393188 -0.4867982 -0.255268  0.146316
##
##    Y  variables:
##                       Ycan1     Ycan2    Ycan3    Ycan4
## SL_pensioners      0.220475  0.651836 -0.28265  0.78198
## SL_unemployed     -0.526682  0.156985 -0.64871 -0.63976
## SL_old_gvntresp   -0.098433 -0.599184 -0.55693  0.72377
## SL_unemp_gvntresp  0.764899  0.057483 -0.33698 -0.71784
```

```
#compute redundancies
R2tu<-cancor.out$cancor^2
R2tu<-cancor.out$cancor^2
VAFYbyt<-apply(cancor.out$structure$Y.yscores^2,2,sum)/3
redund<-R2tu*VAFYbyt
round(cbind(R2tu,VAFYbyt,redund,total=cumsum(redund)),4)
```

```
##         R2tu VAFYbyt redund  total
## Ycan1 0.2335  0.3799 0.0887 0.0887
## Ycan2 0.0521  0.4266 0.0222 0.1109
## Ycan3 0.0189  0.3635 0.0069 0.1178
## Ycan4 0.0027  0.1633 0.0004 0.1182
```

```
#print canonical loadings
round(cancor.out$structure$X.xscores,2)
```

```
##                            Xcan1 Xcan2 Xcan3 Xcan4
## SB_strain_economy          -0.54  0.27  0.44 -0.27
```

```
## SB_prevent_poverty         0.22  0.10 -0.53 -0.18
## SB_equal_society           0.33  0.33 -0.73 -0.15
## SB_taxes_business         -0.45  0.12  0.01 -0.85
## SB_make_lazy              -0.80 -0.02 -0.02 -0.05
## SB_caring_others          -0.56 -0.06  0.07 -0.21
## unemployed_notmotivated   -0.80 -0.19 -0.26 -0.02
## SB_often_lessthanentitled  0.30 -0.73  0.06 -0.36
## SB_often_notentitled      -0.56 -0.47 -0.19  0.00
```

```
round(cancor.out$structure$Y.yscores,2)
```

```
##                   Ycan1 Ycan2 Ycan3 Ycan4
## SL_pensioners      0.18  0.81 -0.36  0.42
## SL_unemployed     -0.61  0.31 -0.65 -0.32
## SL_old_gvntresp    0.11 -0.71 -0.60  0.34
## SL_unemp_gvntresp  0.85 -0.11 -0.42 -0.30
```

2.2 Split-half approach

```
train <- benefits[seq(2,3310,by=2),]
valid <- benefits[seq(1,3310,by=2),]
train[,2:14]<-scale(train[,2:14],center=TRUE,scale=TRUE)
valid[,2:14]<-scale(valid[,2:14],center=TRUE,scale=TRUE)

#conduct CCA on training data

cancor.train<-cancor(cbind(SL_pensioners, SL_unemployed, SL_old_gvntresp, SL_unemp_gvntresp)
~SB_strain_economy+SB_prevent_poverty+SB_equal_society+
SB_taxes_business+ SB_make_lazy+SB_caring_others+ unemployed_notmotivated+
SB_often_lessthanentitled+ SB_often_notentitled , data=train)

#conduct CCA on validation data

cancor.valid<-cancor(cbind(SL_pensioners, SL_unemployed, SL_old_gvntresp, SL_unemp_gvntresp)
~SB_strain_economy+SB_prevent_poverty+SB_equal_society+
SB_taxes_business+ SB_make_lazy+SB_caring_others+ unemployed_notmotivated+
SB_often_lessthanentitled+ SB_often_notentitled , data=valid)

# canonical variates calibration set
train.X1<-cancor.train$score$X
train.Y1<-cancor.train$score$Y

# compute canonical variates using data of calibration set and coefficients estimated on validation
train.X2<-as.matrix(train[,6:14])%*%cancor.valid$coef$X
train.Y2<-as.matrix(train[,2:5])%*%cancor.valid$coef$Y

round(cor(train.Y1,train.Y2),3)
```

```
##        Ycan1  Ycan2  Ycan3  Ycan4
## Ycan1 -0.985  0.121 -0.148  0.044
## Ycan2 -0.057 -0.989 -0.116 -0.036
## Ycan3  0.146  0.083 -0.973 -0.145
```

```
## Ycan4  0.069  0.006 -0.130  0.988
```

```r
round(cor(train.X1,train.X2),3)
```

```
##        Xcan1  Xcan2  Xcan3  Xcan4
## Xcan1 -0.985 -0.013 -0.058 -0.100
## Xcan2  0.040 -0.893 -0.219  0.283
## Xcan3  0.031  0.027 -0.557 -0.206
## Xcan4 -0.091  0.100  0.072  0.257
```

```r
round(cor(train.X1,train.Y1),3)
```

```
##       Ycan1 Ycan2 Ycan3 Ycan4
## Xcan1 0.482 0.000 0.000 0.000
## Xcan2 0.000 0.244 0.000 0.000
## Xcan3 0.000 0.000 0.145 0.000
## Xcan4 0.000 0.000 0.000 0.046
```

```r
round(cor(train.X2,train.Y2),3)
```

```
##       Ycan1  Ycan2 Ycan3  Ycan4
## Xcan1 0.468 -0.067 0.065 -0.026
## Xcan2 0.019  0.215 0.022  0.011
## Xcan3 0.019  0.043 0.089  0.016
## Xcan4 0.040 -0.076 0.027  0.011
```

```r
round(cor(train.Y2,train.Y2),3)
```

```
##        Ycan1  Ycan2 Ycan3 Ycan4
## Ycan1  1.000 -0.050 0.001 0.006
## Ycan2 -0.050  1.000 0.014 0.034
## Ycan3  0.001  0.014 1.000 0.010
## Ycan4  0.006  0.034 0.010 1.000
```

```r
round(cor(train.X2,train.X2),3)
```

```
##        Xcan1  Xcan2  Xcan3 Xcan4
## Xcan1  1.000 -0.037 -0.047 0.020
## Xcan2 -0.037  1.000  0.024 0.017
## Xcan3 -0.047  0.024  1.000 0.035
## Xcan4  0.020  0.017  0.035 1.000
```

3 Appendix

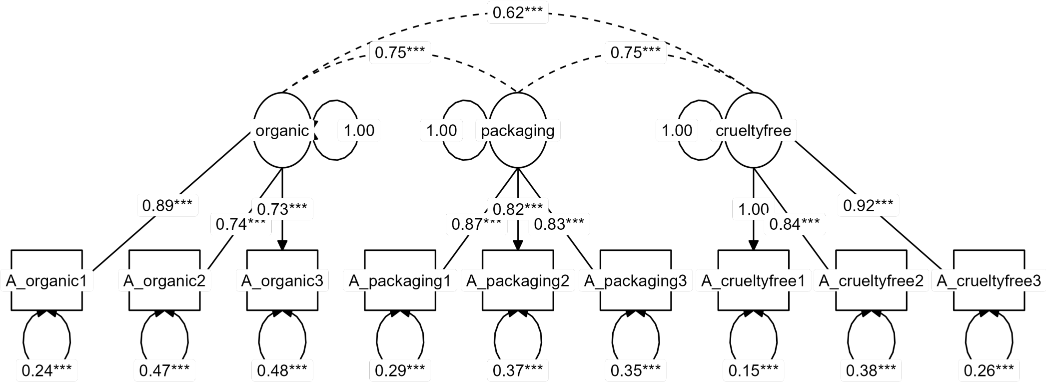

Figure 1: A graphical representation of the simple model for the attitudes.

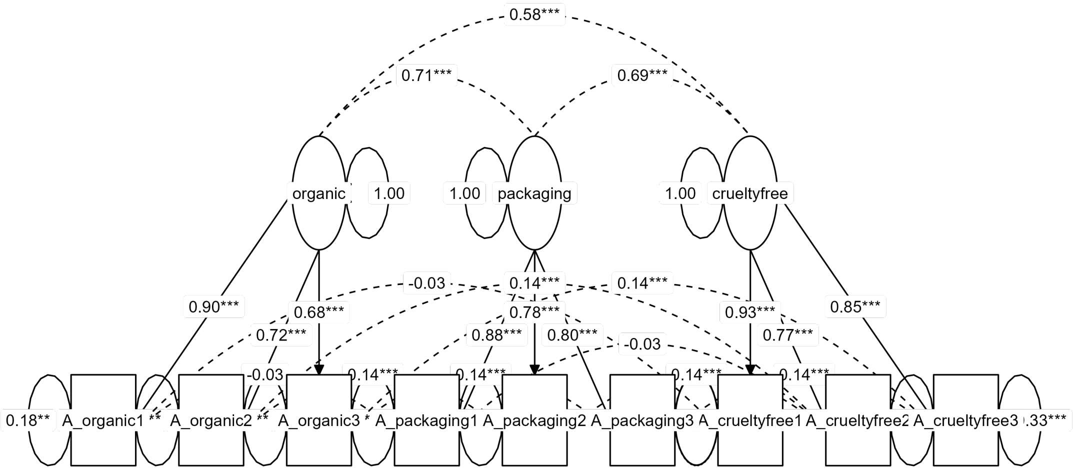

Figure 2: A graphical representation of the model for the attitudeswith correlated error terms for all pairs of items that focus on the same aspect.

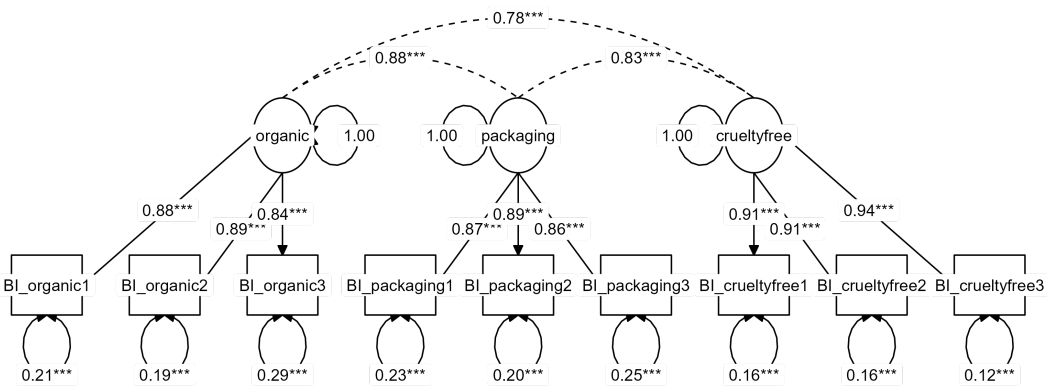

Figure 3: A graphical representation of the simple model for the behavior-intent items.

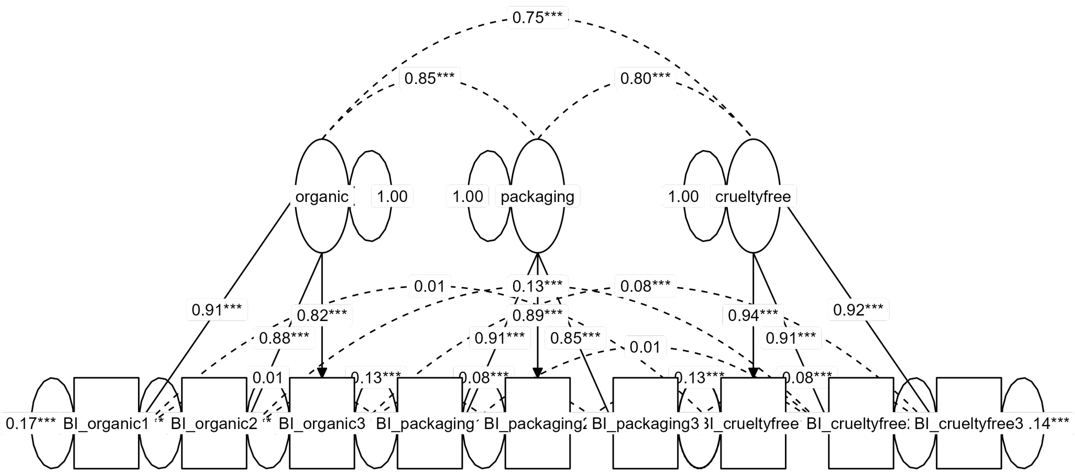

Figure 4: A graphical representation of the model with correlated error terms for the behavior-intent items that focus on the same aspect.