

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.

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. Table 1 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. Figure 1 shows a graphical representation of the model, including all loadings (which are equal to the covariance between the variable and the factor since the data was first standardized), correlations and variances.

In the standardized solution, the standardized loadings represent correlations between a variable and a factor (Table 2) and the error variances indicate the proportion of the variance in a variable that cannot be explained by the model (Table 2).

Table 1: Performance of the simple model for the attitudes.

Performance measure	Value
user model Chisq. (df)	120.89 (24)***
baseline model Chisq. (df)	906.01 (36) ***
comparative fit index (CFI)	0.889
Tucker-Lewis index (TLI)	0.833
Loglik user model (H0)	-1518.492
Loglik unrestricted model(H1)	-1458.049
Akaike (AIC)	3078.984
Bayesian (BIC)	3142.207
RMSEA (ll,ul)	0.16 (0.14, 0.19)***
Standardized root mean square residual	0.057

Table 2: The solution of the simple model for the attitudes.

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)***
(co)variance	value
10 organic~~organic	0.75 ***
11 packaging~~packaging	0.71 ***
12 crueltyfree~~crueltyfree	0.83 ***
13 organic~~packaging	0.54 ***
14 organic~~crueltyfree	0.48 ***
15 packaging~~crueltyfree	0.55 ***
16 A_organic1~~A_organic1	0.24 ***
17 A_organic2~~A_organic2	0.47 ***
18 A_organic3~~A_organic3	0.48 ***
19 A_packaging1~~A_packaging1	0.29 ***
20 A_packaging2~~A_packaging2	0.37 ***
21 A_packaging3~~A_packaging3	0.35 ***
22 A_crueltyfree1~~A_crueltyfree1	0.17 ***
23 A_crueltyfree2~~A_crueltyfree2	0.37 ***
24 A_crueltyfree3~~A_crueltyfree3	0.25 ***

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.

Table 3: Performance of the model for the attitudes with correlated error terms.

Performance measure	Value
user model Chisq. (df)	58.94 (21)***
baseline model Chisq. (df)	906.01 (36) ***
comparative fit index (CFI)	0.956
Tucker-Lewis index (TLI)	0.925
Loglik user model (H0)	-1487.518
Loglik unrestricted model(H1)	-1458.049
Akaike (AIC)	3023.036
Bayesian (BIC)	3095.292
RMSEA (ll,ul)	0.11 (0.08, 0.14)**
Standardized root mean square residual	0.041

1.1.3 Conclusion

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

Since, however, the performance measures (Table 3) shows less-than-perfect fit, we look at the residual correlations and notice that 7 (19.44%) of all correlations are larger than 0.05 or smaller than -0.05. 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 (0.966), CFI (0.982), RMSEA (0.074), and SRMR (0.03). The Chi-square goodness of fit test still has a p-value of 0.016

Table 4: The standardized solution of the model with correlated error terms for the attitudes.

loading	value
organic =~ A_organic1	0.88 (0.81, 0.96)***
organic =~ A_organic2	0.73 (0.64, 0.82)***
organic =~ A_organic3	0.72 (0.63, 0.81)***
packaging =~ A_packaging1	0.87 (0.80, 0.93)***
packaging =~ A_packaging2	0.80 (0.73, 0.87)***
packaging =~ A_packaging3	0.80 (0.73, 0.87)***
crueltyfree =~ A_crueltyfree1	0.93 (0.87, 0.98)***
crueltyfree =~ A_crueltyfree2	0.77 (0.69, 0.84)***
crueltyfree =~ A_crueltyfree3	0.83 (0.77, 0.90)***
(co)variance	value
10 A_organic1~~A_packaging1	0.01
11 A_organic1~~A_crueltyfree1	0.01
12 A_packaging1~~A_crueltyfree1	0.01
13 A_organic2~~A_packaging2	0.13 ***
14 A_organic2~~A_crueltyfree2	0.13 ***
15 A_packaging2~~A_crueltyfree2	0.13 ***
16 A_organic3~~A_packaging3	0.12 ***
17 A_organic3~~A_crueltyfree3	0.12 ***
18 A_packaging3~~A_crueltyfree3	0.12 ***
19 organic~~organic	0.78 ***
20 packaging~~packaging	0.74 ***
21 crueltyfree~~crueltyfree	0.85 ***
22 organic~~packaging	0.53 ***
23 organic~~crueltyfree	0.46 ***
24 packaging~~crueltyfree	0.55 ***
25 A_organic1~~A_organic1	0.22 ***
26 A_organic2~~A_organic2	0.47 ***
27 A_organic3~~A_organic3	0.44 ***
28 A_packaging1~~A_packaging1	0.25 ***
29 A_packaging2~~A_packaging2	0.35 ***
30 A_packaging3~~A_packaging3	0.36 ***
31 A_crueltyfree1~~A_crueltyfree1	0.14 **
32 A_crueltyfree2~~A_crueltyfree2	0.41 ***
33 A_crueltyfree3~~A_crueltyfree3	0.32 ***

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.

1.2.1 A simple 3-factor model

Table 5: Performance of the simple model for the behavior-intent items.

Performance measure	Value
user model Chisq. (df)	147.81 (24)***
baseline model Chisq. (df)	1478.43 (36) ***
comparative fit index (CFI)	0.914
Tucker-Lewis index (TLI)	0.871
Loglik user model (H0)	-1245.746
Loglik unrestricted model(H1)	-1171.838
Akaike (AIC)	2533.491
Bayesian (BIC)	2596.714
RMSEA (ll,ul)	0.19 (0.16, 0.21)***
Standardized root mean square residual	0.033

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.

Table 7: Performance of the model for the behavior-intent items with correlated error terms.

Performance measure	Value
user model Chisq. (df)	25.72 (21)
baseline model Chisq. (df)	1478.43 (36) ***
comparative fit index (CFI)	0.997
Tucker-Lewis index (TLI)	0.994
Loglik user model (H0)	-1184.699
Loglik unrestricted model(H1)	-1171.838
Akaike (AIC)	2417.397
Bayesian (BIC)	2489.653
RMSEA (ll,ul)	0.04 (0.00, 0.08)
Standardized root mean square residual	0.02

Table 6: The standardized solution of the simple model for the behavior-intent items.

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)***
error.variance	value
16 BI_organic1	0.22 (0.14, 0.29)***
17 BI_organic2	0.20 (0.12, 0.27)***
18 BI_organic3	0.29 (0.20, 0.38)***
19 BI_packaging1	0.23 (0.15, 0.31)***
20 BI_packaging2	0.21 (0.13, 0.28)***
21 BI_packaging3	0.25 (0.17, 0.33)***
22 BI_crueltyfree1	0.16 (0.10, 0.22)***
23 BI_crueltyfree2	0.16 (0.10, 0.22)***
24 BI_crueltyfree3	0.12 (0.07, 0.17)***

Table 8: The standardized solution of the model with correlated error terms for the behavior-intent items.

loading		value
organic =~ BI_organic1		0.88 (0.84, 0.93)***
organic =~ BI_organic2		0.89 (0.84, 0.93)***
organic =~ BI_organic3		0.85 (0.80, 0.91)***
packaging =~ BI_packaging1		0.88 (0.83, 0.92)***
packaging =~ BI_packaging2		0.90 (0.86, 0.94)***
packaging =~ BI_packaging3		0.85 (0.80, 0.91)***
crueltyfree =~ BI_crueltyfree1		0.92 (0.89, 0.95)***
crueltyfree =~ BI_crueltyfree2		0.91 (0.88, 0.95)***
crueltyfree =~ BI_crueltyfree3		0.94 (0.91, 0.97)***
error.variance		value
22	organic	0.84 (0.78, 0.90)***
23	organic	0.75 (0.67, 0.83)***
24	packaging	0.81 (0.74, 0.87)***
25	BI_organic1	0.22 (0.14, 0.30)***
26	BI_organic2	0.21 (0.14, 0.29)***
27	BI_organic3	0.27 (0.18, 0.36)***
28	BI_packaging1	0.23 (0.15, 0.31)***
29	BI_packaging2	0.19 (0.12, 0.27)***
30	BI_packaging3	0.27 (0.18, 0.36)***
31	BI_crueltyfree1	0.15 (0.10, 0.21)***
32	BI_crueltyfree2	0.16 (0.11, 0.22)***
33	BI_crueltyfree3	0.12 (0.06, 0.17)***
resid.correlation		value
10	BI_organic1 ~~ BI_packaging1	0.31 (0.17, 0.44)***
11	BI_organic1 ~~ BI_crueltyfree1	0.38 (0.22, 0.54)***
12	BI_packaging1 ~~ BI_crueltyfree1	0.37 (0.21, 0.52)***
13	BI_organic2 ~~ BI_packaging2	0.47 (0.34, 0.61)***
14	BI_organic2 ~~ BI_crueltyfree2	0.51 (0.37, 0.66)***
15	BI_packaging2 ~~ BI_crueltyfree2	0.54 (0.40, 0.69)***
16	BI_organic3 ~~ BI_packaging3	0.21 (0.09, 0.33)***
17	BI_organic3 ~~ BI_crueltyfree3	0.33 (0.16, 0.50)***
18	BI_packaging3 ~~ BI_crueltyfree3	0.32 (0.15, 0.49)***

1.2.3 Conclusion

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

The performance measures (Table 7) show a good fit and most residual correlations are between -0.05 and 0.05 (only 0 have an absolute value that is slightly higher with a maximum of 0.047). 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 145.74 with 120 degrees of freedom, the chi-square p-value is 0.0550075 which means we cannot reject the null hypothesis that the model fits well.

```
## lavaan 0.6-12 ended normally after 63 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                  145.742
##      Degrees of freedom              120
##      P-value (Chi-square)            0.055
##
## 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      1.009    0.065   15.469    0.000
##      BI_organic3      0.946    0.068   13.819    0.000
##      BI_packaging =~
##      BI_packaging1    1.000
```



```

##      BI_packaging2      1.010      0.064      15.764      0.000
##      BI_packaging3      0.959      0.070      13.706      0.000
##      BI_crueltyfree =~
##      BI_crueltyfre1      1.000
##      BI_crueltyfre2      0.982      0.052      19.068      0.000
##      BI_crueltyfre3      1.008      0.050      19.966      0.000
##      A_organic =~
##      A_organic1          0.842      0.071      11.907      0.000
##      A_organic2          0.738      0.073      10.076      0.000
##      A_organic3          0.692      0.072       9.641      0.000
##      A_packaging =~
##      A_packaging1        0.831      0.068      12.301      0.000
##      A_packaging2        0.792      0.069      11.468      0.000
##      A_packaging3        0.818      0.068      11.993      0.000
##      A_crueltyfree =~
##      A_crueltyfree1      0.895      0.066      13.580      0.000
##      A_crueltyfree2      0.798      0.068      11.658      0.000
##      A_crueltyfree3      0.881      0.066      13.450      0.000
##
## Regressions:
##              Estimate   Std.Err   z-value   P(>|z|)
##      BI_organic ~
##      A_organic          0.582     0.063     9.260     0.000
##      BI_packaging ~
##      A_packaging        0.574     0.060     9.536     0.000
##      BI_crueltyfree ~
##      A_crueltyfree      0.614     0.059    10.450     0.000
##
## Covariances:
##              Estimate   Std.Err   z-value   P(>|z|)
##      .BI_organic1 ~~
##      .BI_pckgng1 (c)    0.058     0.015     3.791     0.000
##      .BI_crltyf1 (c)    0.058     0.015     3.791     0.000
##      .BI_packaging1 ~~
##      .BI_crltyf1 (c)    0.058     0.015     3.791     0.000
##      .BI_organic2 ~~
##      .BI_pckgng2 (d)    0.104     0.018     5.918     0.000
##      .BI_crltyf2 (d)    0.104     0.018     5.918     0.000
##      .BI_packaging2 ~~
##      .BI_crltyf2 (d)    0.104     0.018     5.918     0.000
##      .BI_organic3 ~~
##      .BI_pckgng3 (e)    0.056     0.018     3.008     0.003

```

```

##      .BI_crltyf3 (e)      0.056      0.018      3.008      0.003
##      .BI_packaging3 ~~
##      .BI_crltyf3 (e)      0.056      0.018      3.008      0.003
##      .BI_organic ~~
##      .BI_packgng      0.323      0.054      5.931      0.000
##      .BI_crltyfr      0.267      0.048      5.545      0.000
##      .BI_packaging ~~
##      .BI_crltyfr      0.295      0.049      6.032      0.000
##      .A_organic1 ~~
##      .A_packgng1 (c)      0.058      0.015      3.791      0.000
##      .A_crltyfr1 (c)      0.058      0.015      3.791      0.000
##      .A_packaging1 ~~
##      .A_crltyfr1 (c)      0.058      0.015      3.791      0.000
##      .A_organic2 ~~
##      .A_packgng2 (d)      0.104      0.018      5.918      0.000
##      .A_crltyfr2 (d)      0.104      0.018      5.918      0.000
##      .A_packaging2 ~~
##      .A_crltyfr2 (d)      0.104      0.018      5.918      0.000
##      .A_organic3 ~~
##      .A_packgng3      0.238      0.048      5.001      0.000
##      .A_crltyfr3      0.089      0.037      2.411      0.016
##      .A_packaging3 ~~
##      .A_crltyfr3      0.034      0.032      1.060      0.289
##      A_organic ~~
##      A_packagng      0.737      0.047      15.699      0.000
##      A_crultyfr      0.634      0.058      10.834      0.000
##      A_packaging ~~
##      A_crultyfr      0.709      0.049      14.571      0.000
##
## Variances:
##              Estimate  Std.Err  z-value  P(>|z|)
##      .BI_organic      0.382    0.067    5.674    0.000
##      .BI_packaging     0.376    0.064    5.877    0.000
##      .BI_crueltyfree   0.349    0.054    6.421    0.000
##      A_organic         1.000
##      A_packaging       1.000
##      A_crueltyfree     1.000
##      .BI_organic1      0.216    0.033    6.570    0.000
##      .BI_organic2      0.214    0.031    6.996    0.000
##      .BI_organic3      0.267    0.038    7.034    0.000
##      .BI_packaging1     0.212    0.031    6.762    0.000
##      .BI_packaging2     0.198    0.028    6.999    0.000

```

##	.BI_packaging3	0.279	0.039	7.239	0.000
##	.BI_crueltyfre1	0.136	0.022	6.226	0.000
##	.BI_crueltyfre2	0.173	0.023	7.461	0.000
##	.BI_crueltyfre3	0.121	0.022	5.432	0.000
##	.A_organic1	0.307	0.052	5.882	0.000
##	.A_organic2	0.456	0.059	7.702	0.000
##	.A_organic3	0.497	0.069	7.258	0.000
##	.A_packaging1	0.290	0.043	6.679	0.000
##	.A_packaging2	0.361	0.047	7.604	0.000
##	.A_packaging3	0.341	0.053	6.411	0.000
##	.A_crueltyfree1	0.218	0.036	6.049	0.000
##	.A_crueltyfree2	0.360	0.045	7.961	0.000
##	.A_crueltyfree3	0.221	0.040	5.604	0.000

##	lhs	op	rhs	label	est.	std	se	z	pvalue
## 1	BI_organic	=~	BI_organic1		0.877	0.023	38.571	0.000	
## 2	BI_organic	=~	BI_organic2		0.880	0.021	41.636	0.000	
## 3	BI_organic	=~	BI_organic3		0.841	0.027	30.622	0.000	
## 4	BI_packaging	=~	BI_packaging1		0.877	0.022	39.491	0.000	
## 5	BI_packaging	=~	BI_packaging2		0.886	0.020	44.199	0.000	
## 6	BI_packaging	=~	BI_packaging3		0.836	0.028	30.332	0.000	
## 7	BI_crueltyfree	=~	BI_crueltyfree1		0.918	0.016	58.323	0.000	
## 8	BI_crueltyfree	=~	BI_crueltyfree2		0.896	0.017	51.532	0.000	
## 9	BI_crueltyfree	=~	BI_crueltyfree3		0.927	0.016	59.787	0.000	
## 10	BI_organic1	~~	BI_packaging1	c	0.269	0.059	4.560	0.000	
## 11	BI_organic1	~~	BI_crueltyfree1	c	0.336	0.071	4.756	0.000	
## 12	BI_packaging1	~~	BI_crueltyfree1	c	0.339	0.071	4.804	0.000	
## 13	BI_organic2	~~	BI_packaging2	d	0.506	0.059	8.556	0.000	
## 14	BI_organic2	~~	BI_crueltyfree2	d	0.541	0.061	8.852	0.000	
## 15	BI_packaging2	~~	BI_crueltyfree2	d	0.562	0.061	9.244	0.000	
## 16	BI_organic3	~~	BI_packaging3	e	0.204	0.058	3.507	0.000	
## 17	BI_organic3	~~	BI_crueltyfree3	e	0.309	0.082	3.771	0.000	
## 18	BI_packaging3	~~	BI_crueltyfree3	e	0.302	0.080	3.771	0.000	
## 19	BI_organic	~~	BI_organic		0.530	0.068	7.784	0.000	
## 20	BI_packaging	~~	BI_packaging		0.533	0.064	8.293	0.000	
## 21	BI_crueltyfree	~~	BI_crueltyfree		0.481	0.060	7.978	0.000	
## 22	BI_organic	~~	BI_packaging		0.852	0.044	19.159	0.000	
## 23	BI_organic	~~	BI_crueltyfree		0.729	0.058	12.630	0.000	
## 24	BI_packaging	~~	BI_crueltyfree		0.814	0.046	17.853	0.000	
## 25	A_organic	=~	A_organic1		0.835	0.034	24.572	0.000	
## 26	A_organic	=~	A_organic2		0.738	0.043	17.068	0.000	
## 27	A_organic	=~	A_organic3		0.700	0.048	14.582	0.000	

## 28	A_packaging	==	A_packaging1		0.839	0.030	28.082	0.000
## 29	A_packaging	==	A_packaging2		0.797	0.034	23.312	0.000
## 30	A_packaging	==	A_packaging3		0.814	0.034	23.743	0.000
## 31	A_crueltyfree	==	A_crueltyfree1		0.887	0.023	38.896	0.000
## 32	A_crueltyfree	==	A_crueltyfree2		0.799	0.032	24.613	0.000
## 33	A_crueltyfree	==	A_crueltyfree3		0.882	0.025	35.590	0.000
## 34	A_organic1	~~	A_packaging1	c	0.193	0.047	4.099	0.000
## 35	A_organic1	~~	A_crueltyfree1	c	0.222	0.054	4.104	0.000
## 36	A_packaging1	~~	A_crueltyfree1	c	0.229	0.055	4.140	0.000
## 37	A_organic2	~~	A_packaging2	d	0.257	0.041	6.259	0.000
## 38	A_organic2	~~	A_crueltyfree2	d	0.257	0.041	6.221	0.000
## 39	A_packaging2	~~	A_crueltyfree2	d	0.289	0.046	6.327	0.000
## 40	A_organic3	~~	A_packaging3		0.579	0.068	8.467	0.000
## 41	A_organic3	~~	A_crueltyfree3		0.268	0.098	2.731	0.006
## 42	A_packaging3	~~	A_crueltyfree3		0.123	0.111	1.114	0.265
## 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		0.737	0.047	15.699	0.000
## 47	A_organic	~~	A_crueltyfree		0.634	0.058	10.834	0.000
## 48	A_packaging	~~	A_crueltyfree		0.709	0.049	14.571	0.000
## 49	BI_organic	~	A_organic		0.686	0.050	13.803	0.000
## 50	BI_packaging	~	A_packaging		0.683	0.047	14.538	0.000
## 51	BI_crueltyfree	~	A_crueltyfree		0.721	0.042	17.230	0.000
## 52	BI_organic1	~~	BI_organic1		0.231	0.040	5.782	0.000
## 53	BI_organic2	~~	BI_organic2		0.225	0.037	6.059	0.000
## 54	BI_organic3	~~	BI_organic3		0.293	0.046	6.339	0.000
## 55	BI_packaging1	~~	BI_packaging1		0.231	0.039	5.937	0.000
## 56	BI_packaging2	~~	BI_packaging2		0.216	0.035	6.081	0.000
## 57	BI_packaging3	~~	BI_packaging3		0.301	0.046	6.523	0.000
## 58	BI_crueltyfree1	~~	BI_crueltyfree1		0.157	0.029	5.444	0.000
## 59	BI_crueltyfree2	~~	BI_crueltyfree2		0.198	0.031	6.353	0.000
## 60	BI_crueltyfree3	~~	BI_crueltyfree3		0.141	0.029	4.915	0.000
## 61	A_organic1	~~	A_organic1		0.302	0.057	5.320	0.000
## 62	A_organic2	~~	A_organic2		0.455	0.064	7.136	0.000
## 63	A_organic3	~~	A_organic3		0.510	0.067	7.580	0.000
## 64	A_packaging1	~~	A_packaging1		0.295	0.050	5.889	0.000
## 65	A_packaging2	~~	A_packaging2		0.365	0.054	6.700	0.000
## 66	A_packaging3	~~	A_packaging3		0.338	0.056	6.056	0.000
## 67	A_crueltyfree1	~~	A_crueltyfree1		0.214	0.040	5.293	0.000
## 68	A_crueltyfree2	~~	A_crueltyfree2		0.361	0.052	6.955	0.000
## 69	A_crueltyfree3	~~	A_crueltyfree3		0.222	0.044	5.073	0.000

##	ci.lower	ci.upper
## 1	0.833	0.922
## 2	0.839	0.922
## 3	0.787	0.895
## 4	0.833	0.920
## 5	0.846	0.925
## 6	0.782	0.890
## 7	0.887	0.949
## 8	0.862	0.930
## 9	0.896	0.957
## 10	0.153	0.384
## 11	0.197	0.474
## 12	0.201	0.477
## 13	0.390	0.621
## 14	0.421	0.661
## 15	0.443	0.681
## 16	0.090	0.317
## 17	0.148	0.469
## 18	0.145	0.459
## 19	0.397	0.664
## 20	0.407	0.659
## 21	0.363	0.599
## 22	0.765	0.939
## 23	0.616	0.843
## 24	0.725	0.904
## 25	0.769	0.902
## 26	0.653	0.823
## 27	0.606	0.794
## 28	0.781	0.898
## 29	0.730	0.864
## 30	0.747	0.881
## 31	0.842	0.931
## 32	0.736	0.863
## 33	0.834	0.931
## 34	0.101	0.285
## 35	0.116	0.329
## 36	0.121	0.337
## 37	0.176	0.337
## 38	0.176	0.338
## 39	0.199	0.378
## 40	0.445	0.713
## 41	0.076	0.460

## 42	-0.094	0.340
## 43	1.000	1.000
## 44	1.000	1.000
## 45	1.000	1.000
## 46	0.645	0.829
## 47	0.519	0.748
## 48	0.613	0.804
## 49	0.588	0.783
## 50	0.591	0.776
## 51	0.639	0.803
## 52	0.152	0.309
## 53	0.153	0.298
## 54	0.202	0.383
## 55	0.155	0.307
## 56	0.146	0.285
## 57	0.210	0.391
## 58	0.101	0.214
## 59	0.137	0.259
## 60	0.085	0.198
## 61	0.191	0.413
## 62	0.330	0.580
## 63	0.378	0.642
## 64	0.197	0.394
## 65	0.258	0.472
## 66	0.228	0.447
## 67	0.135	0.293
## 68	0.259	0.463
## 69	0.136	0.308

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 0.686.
- an increase of one unit in attitude_packaging increases the behavior intention with 0.683.
- an increase of one unit in attitude_crueltyfree increases the behavior intention with 0.721.

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 60 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 146.205
## Degrees of freedom 122
## P-value (Chi-square) 0.067
##
## 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 1.006 0.062 16.302 0.000
## BI_organic3 0.943 0.066 14.391 0.000
## BI_packaging =~
## BI_packaging1 1.000
## BI_packaging2 1.001 0.059 16.885 0.000
## BI_packaging3 0.951 0.066 14.426 0.000
## BI_crueltyfree =~
## BI_crueltyfre1 1.000
## BI_crueltyfre2 0.987 0.052 19.098 0.000
## BI_crueltyfre3 1.014 0.051 20.042 0.000
## A_organic =~
## A_organic1 0.847 0.069 12.225 0.000
## A_organic2 0.742 0.072 10.294 0.000
## A_organic3 0.696 0.070 9.882 0.000
## A_packaging =~
## A_packaging1 0.839 0.066 12.723 0.000
## A_packaging2 0.800 0.068 11.828 0.000
## A_packaging3 0.827 0.067 12.406 0.000
## A_crueltyfree =~
## A_crueltyfree1 0.884 0.063 14.034 0.000

```

```

##      A_crueltyfree2      0.788      0.066      11.902      0.000
##      A_crueltyfree3      0.871      0.063      13.843      0.000
##
## Regressions:
##              Estimate   Std.Err   z-value   P(>|z|)
## BI_organic ~
##      A_organic (p)      0.594      0.049      12.197      0.000
## BI_packaging ~
##      A_packagng (p)      0.594      0.049      12.197      0.000
## BI_crueltyfree ~
##      A_crultyfr (p)      0.594      0.049      12.197      0.000
##
## Covariances:
##              Estimate   Std.Err   z-value   P(>|z|)
## .BI_organic1 ~~
##      .BI_pckgng1 (c)      0.057      0.015      3.770      0.000
##      .BI_crltyf1 (c)      0.057      0.015      3.770      0.000
## .BI_packaging1 ~~
##      .BI_crltyf1 (c)      0.057      0.015      3.770      0.000
## .BI_organic2 ~~
##      .BI_pckgng2 (d)      0.104      0.018      5.928      0.000
##      .BI_crltyf2 (d)      0.104      0.018      5.928      0.000
## .BI_packaging2 ~~
##      .BI_crltyf2 (d)      0.104      0.018      5.928      0.000
## .BI_organic3 ~~
##      .BI_pckgng3 (e)      0.056      0.018      3.008      0.003
##      .BI_crltyf3 (e)      0.056      0.018      3.008      0.003
## .BI_packaging3 ~~
##      .BI_crltyf3 (e)      0.056      0.018      3.008      0.003
## .BI_organic ~~
##      .BI_packgng          0.323      0.054      5.929      0.000
##      .BI_crltyfr          0.268      0.048      5.569      0.000
## .BI_packaging ~~
##      .BI_crltyfr          0.297      0.049      6.053      0.000
## .A_organic1 ~~
##      .A_packgng1 (c)      0.057      0.015      3.770      0.000
##      .A_crltyfr1 (c)      0.057      0.015      3.770      0.000
## .A_packaging1 ~~
##      .A_crltyfr1 (c)      0.057      0.015      3.770      0.000
## .A_organic2 ~~
##      .A_packgng2 (d)      0.104      0.018      5.928      0.000
##      .A_crltyfr2 (d)      0.104      0.018      5.928      0.000

```



```

## .A_packaging2 ~~
##   .A_crltyfr2 (d)    0.104    0.018    5.928    0.000
## .A_organic3 ~~
##   .A_packgng3        0.238    0.048    4.994    0.000
##   .A_crltyfr3        0.089    0.037    2.409    0.016
## .A_packaging3 ~~
##   .A_crltyfr3        0.034    0.032    1.061    0.289
## A_organic ~~
##   A_packagng         0.742    0.046   16.165    0.000
##   A_crultyfr         0.634    0.058   10.861    0.000
## A_packaging ~~
##   A_crultyfr         0.708    0.049   14.592    0.000
##
## Variances:
##           Estimate Std.Err  z-value  P(>|z|)
## .BI_organic      0.381    0.067    5.676    0.000
## .BI_packaging    0.377    0.064    5.913    0.000
## .BI_crueltyfree  0.351    0.055    6.442    0.000
## A_organic        1.000
## A_packaging      1.000
## A_crueltyfree    1.000
## .BI_organic1     0.216    0.033    6.570    0.000
## .BI_organic2     0.214    0.030    7.019    0.000
## .BI_organic3     0.267    0.038    7.045    0.000
## .BI_packaging1   0.211    0.031    6.746    0.000
## .BI_packaging2   0.199    0.028    7.042    0.000
## .BI_packaging3   0.279    0.038    7.255    0.000
## .BI_crueltyfre1  0.136    0.022    6.258    0.000
## .BI_crueltyfre2  0.173    0.023    7.445    0.000
## .BI_crueltyfre3  0.121    0.022    5.405    0.000
## .A_organic1      0.308    0.052    5.909    0.000
## .A_organic2      0.457    0.059    7.722    0.000
## .A_organic3      0.497    0.068    7.262    0.000
## .A_packaging1    0.291    0.043    6.701    0.000
## .A_packaging2    0.361    0.047    7.622    0.000
## .A_packaging3    0.340    0.053    6.418    0.000
## .A_crueltyfree1  0.217    0.036    6.011    0.000
## .A_crueltyfree2  0.360    0.045    7.954    0.000
## .A_crueltyfree3  0.222    0.040    5.585    0.000
##
##           lhs op           rhs label est.std  se      z pvalue
## 1      BI_organic =~      BI_organic1      0.879 0.021 42.166  0.000

```

## 2	BI_organic	=~	BI_organic2		0.881	0.021	42.487	0.000
## 3	BI_organic	=~	BI_organic3		0.842	0.027	31.306	0.000
## 4	BI_packaging	=~	BI_packaging1		0.881	0.020	43.877	0.000
## 5	BI_packaging	=~	BI_packaging2		0.887	0.020	45.204	0.000
## 6	BI_packaging	=~	BI_packaging3		0.838	0.027	31.102	0.000
## 7	BI_crueltyfree	=~	BI_crueltyfree1		0.915	0.015	59.215	0.000
## 8	BI_crueltyfree	=~	BI_crueltyfree2		0.894	0.017	51.405	0.000
## 9	BI_crueltyfree	=~	BI_crueltyfree3		0.926	0.016	59.066	0.000
## 10	BI_organic1	~~	BI_packaging1	c	0.268	0.059	4.533	0.000
## 11	BI_organic1	~~	BI_crueltyfree1	c	0.334	0.071	4.724	0.000
## 12	BI_packaging1	~~	BI_crueltyfree1	c	0.337	0.071	4.769	0.000
## 13	BI_organic2	~~	BI_packaging2	d	0.505	0.059	8.572	0.000
## 14	BI_organic2	~~	BI_crueltyfree2	d	0.542	0.061	8.881	0.000
## 15	BI_packaging2	~~	BI_crueltyfree2	d	0.563	0.061	9.273	0.000
## 16	BI_organic3	~~	BI_packaging3	e	0.203	0.058	3.506	0.000
## 17	BI_organic3	~~	BI_crueltyfree3	e	0.309	0.082	3.774	0.000
## 18	BI_packaging3	~~	BI_crueltyfree3	e	0.302	0.080	3.773	0.000
## 19	BI_organic	~~	BI_organic		0.519	0.060	8.633	0.000
## 20	BI_packaging	~~	BI_packaging		0.517	0.058	8.872	0.000
## 21	BI_crueltyfree	~~	BI_crueltyfree		0.499	0.056	8.946	0.000
## 22	BI_organic	~~	BI_packaging		0.852	0.045	19.014	0.000
## 23	BI_organic	~~	BI_crueltyfree		0.732	0.057	12.750	0.000
## 24	BI_packaging	~~	BI_crueltyfree		0.816	0.045	17.938	0.000
## 25	A_organic	=~	A_organic1		0.836	0.033	24.997	0.000
## 26	A_organic	=~	A_organic2		0.739	0.043	17.374	0.000
## 27	A_organic	=~	A_organic3		0.703	0.047	14.909	0.000
## 28	A_packaging	=~	A_packaging1		0.841	0.029	28.903	0.000
## 29	A_packaging	=~	A_packaging2		0.799	0.033	24.011	0.000
## 30	A_packaging	=~	A_packaging3		0.817	0.033	24.514	0.000
## 31	A_crueltyfree	=~	A_crueltyfree1		0.885	0.023	38.450	0.000
## 32	A_crueltyfree	=~	A_crueltyfree2		0.796	0.033	24.460	0.000
## 33	A_crueltyfree	=~	A_crueltyfree3		0.880	0.025	35.030	0.000
## 34	A_organic1	~~	A_packaging1	c	0.191	0.047	4.074	0.000
## 35	A_organic1	~~	A_crueltyfree1	c	0.221	0.054	4.081	0.000
## 36	A_packaging1	~~	A_crueltyfree1	c	0.228	0.055	4.116	0.000
## 37	A_organic2	~~	A_packaging2	d	0.256	0.041	6.268	0.000
## 38	A_organic2	~~	A_crueltyfree2	d	0.257	0.041	6.231	0.000
## 39	A_packaging2	~~	A_crueltyfree2	d	0.289	0.046	6.337	0.000
## 40	A_organic3	~~	A_packaging3		0.578	0.068	8.445	0.000
## 41	A_organic3	~~	A_crueltyfree3		0.268	0.098	2.729	0.006
## 42	A_packaging3	~~	A_crueltyfree3		0.124	0.111	1.115	0.265
## 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	16.165	0.000
## 47	A_organic	~~	A_crueltyfree		0.634	0.058	10.861	0.000
## 48	A_packaging	~~	A_crueltyfree		0.708	0.049	14.592	0.000
## 49	BI_organic	~	A_organic	p	0.693	0.043	15.973	0.000
## 50	BI_packaging	~	A_packaging	p	0.695	0.042	16.595	0.000
## 51	BI_crueltyfree	~	A_crueltyfree	p	0.708	0.039	17.959	0.000
## 52	BI_organic1	~~	BI_organic1		0.227	0.037	6.193	0.000
## 53	BI_organic2	~~	BI_organic2		0.224	0.037	6.117	0.000
## 54	BI_organic3	~~	BI_organic3		0.291	0.045	6.412	0.000
## 55	BI_packaging1	~~	BI_packaging1		0.225	0.035	6.355	0.000
## 56	BI_packaging2	~~	BI_packaging2		0.213	0.035	6.134	0.000
## 57	BI_packaging3	~~	BI_packaging3		0.297	0.045	6.581	0.000
## 58	BI_crueltyfree1	~~	BI_crueltyfree1		0.162	0.028	5.732	0.000
## 59	BI_crueltyfree2	~~	BI_crueltyfree2		0.201	0.031	6.462	0.000
## 60	BI_crueltyfree3	~~	BI_crueltyfree3		0.143	0.029	4.940	0.000
## 61	A_organic1	~~	A_organic1		0.300	0.056	5.364	0.000
## 62	A_organic2	~~	A_organic2		0.454	0.063	7.214	0.000
## 63	A_organic3	~~	A_organic3		0.506	0.066	7.645	0.000
## 64	A_packaging1	~~	A_packaging1		0.292	0.049	5.966	0.000
## 65	A_packaging2	~~	A_packaging2		0.361	0.053	6.783	0.000
## 66	A_packaging3	~~	A_packaging3		0.333	0.054	6.108	0.000
## 67	A_crueltyfree1	~~	A_crueltyfree1		0.217	0.041	5.339	0.000
## 68	A_crueltyfree2	~~	A_crueltyfree2		0.367	0.052	7.087	0.000
## 69	A_crueltyfree3	~~	A_crueltyfree3		0.226	0.044	5.119	0.000
##	ci.lower	ci.upper						
## 1	0.838	0.920						
## 2	0.841	0.922						
## 3	0.790	0.895						
## 4	0.841	0.920						
## 5	0.848	0.925						
## 6	0.785	0.891						
## 7	0.885	0.946						
## 8	0.860	0.928						
## 9	0.895	0.956						
## 10	0.152	0.384						
## 11	0.195	0.472						
## 12	0.198	0.475						
## 13	0.390	0.621						
## 14	0.422	0.662						
## 15	0.444	0.682						

## 16	0.090	0.317
## 17	0.149	0.469
## 18	0.145	0.459
## 19	0.402	0.637
## 20	0.403	0.631
## 21	0.390	0.608
## 22	0.764	0.940
## 23	0.619	0.844
## 24	0.726	0.905
## 25	0.771	0.902
## 26	0.656	0.823
## 27	0.610	0.795
## 28	0.784	0.898
## 29	0.734	0.865
## 30	0.752	0.882
## 31	0.840	0.930
## 32	0.732	0.859
## 33	0.830	0.929
## 34	0.099	0.283
## 35	0.115	0.327
## 36	0.119	0.336
## 37	0.176	0.336
## 38	0.176	0.338
## 39	0.199	0.378
## 40	0.444	0.712
## 41	0.075	0.460
## 42	-0.094	0.341
## 43	1.000	1.000
## 44	1.000	1.000
## 45	1.000	1.000
## 46	0.652	0.831
## 47	0.520	0.749
## 48	0.613	0.803
## 49	0.608	0.778
## 50	0.613	0.777
## 51	0.631	0.785
## 52	0.155	0.299
## 53	0.152	0.295
## 54	0.202	0.379
## 55	0.155	0.294
## 56	0.145	0.282
## 57	0.209	0.386

## 58	0.107	0.218
## 59	0.140	0.262
## 60	0.086	0.200
## 61	0.191	0.410
## 62	0.330	0.577
## 63	0.376	0.636
## 64	0.196	0.388
## 65	0.257	0.465
## 66	0.226	0.439
## 67	0.138	0.297
## 68	0.265	0.468
## 69	0.140	0.313

Since an anova test for the two sem models has a p-value of 0.794, 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 0.695.
- an increase of one unit in attitude_crueltyfree increases the behavior intention with 0.708.

2 Task 2

2.1 Canonical correlation analysis

2.2 Split-half approach

3 Appendix

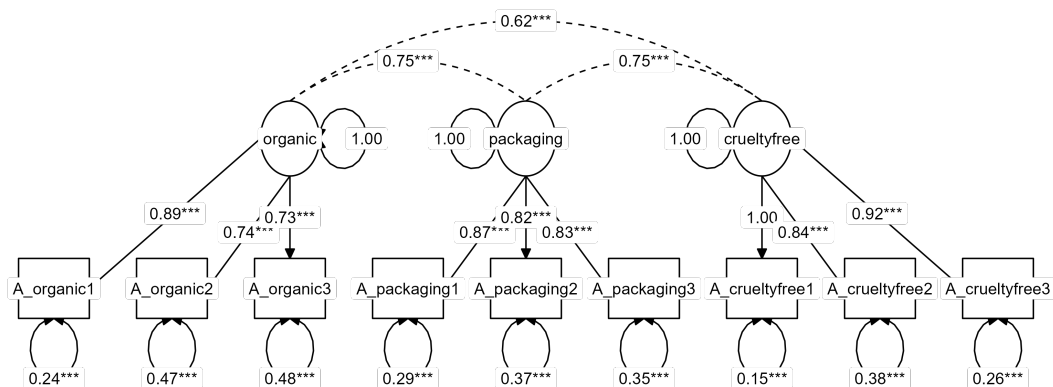


Figure 1: A graphical representation of the simple model for the attitudes.

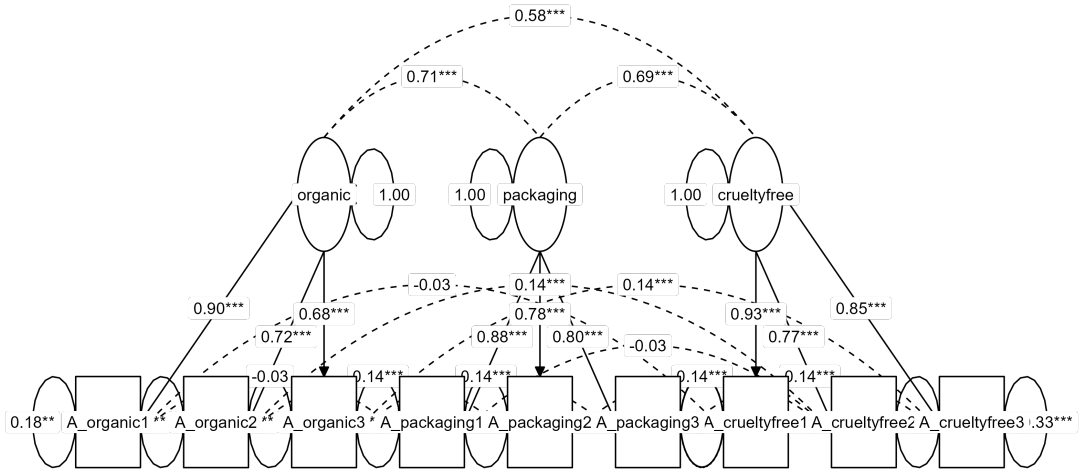


Figure 2: A graphical representation of the model for the attitudes with correlated error terms for all pairs of items that focus on the same aspect.

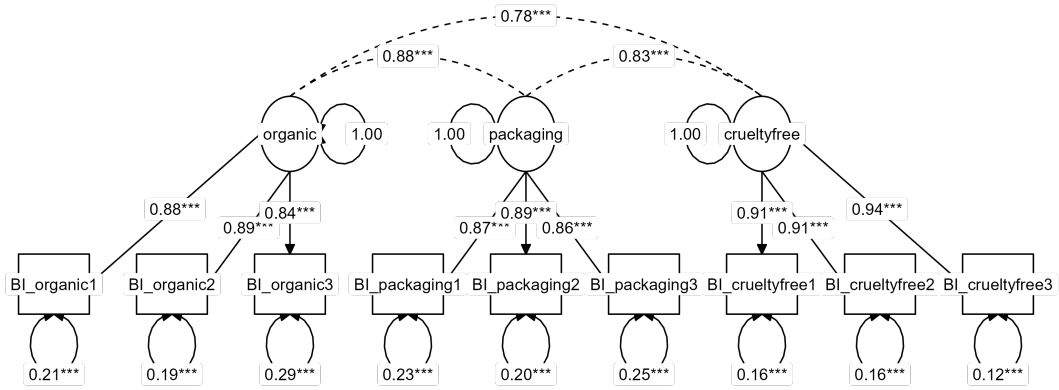


Figure 3: A graphical representation of the simple model for the behavior-intent items.

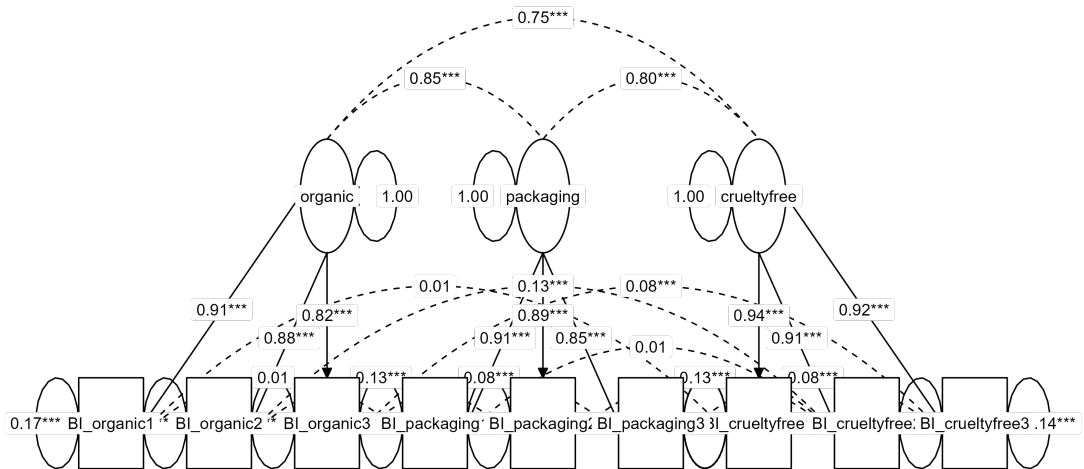


Figure 4: A graphical representation of the model with correlated error terms for the behavior-intent items that focus on the same aspect.