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-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

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.

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 ***

1.2.1 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

1.2.3 Conclusion

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)***

```
anova(fit1corr, fit1)
```

```
## Chi-Squared Difference Test
##
##          Df    AIC    BIC   Chisq Chisq diff Df diff Pr(>Chisq)
## fit1corr 21 2417.4 2489.7  25.721
## fit1     24 2533.5 2596.7 147.814     122.09       3  < 2.2e-16 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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

With a test statistics of 351.16 with 126 degrees of freedom, the chi-square p-value is 0

2 Task 2

2.1 Canonical correlation analysis

2.2 Split-half approach

3 Appendix

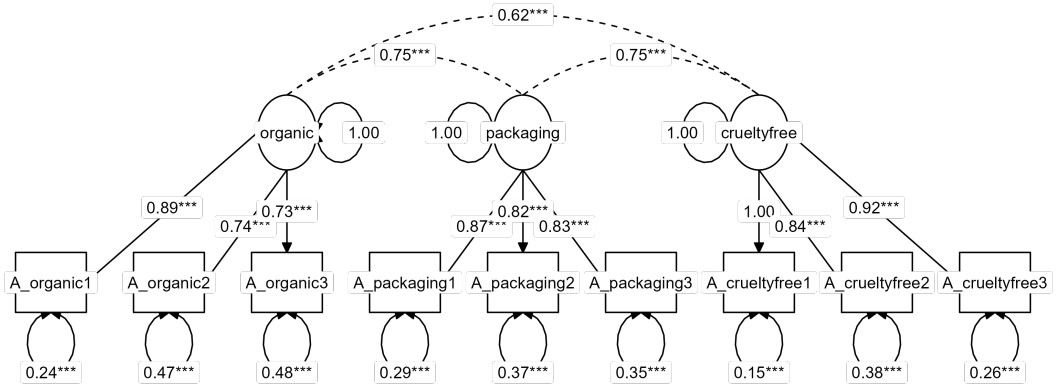

Figure 1: A graphical representation of the simple model for the attitudes.

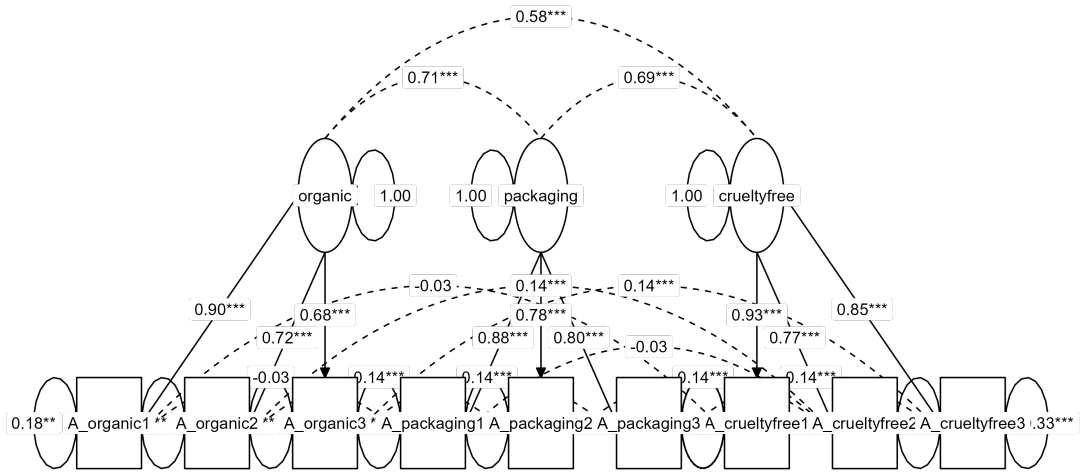

Figure 2: A graphical representation of the model for the attitudeswith correlated error terms for all pairs of items that focus on the same aspect.

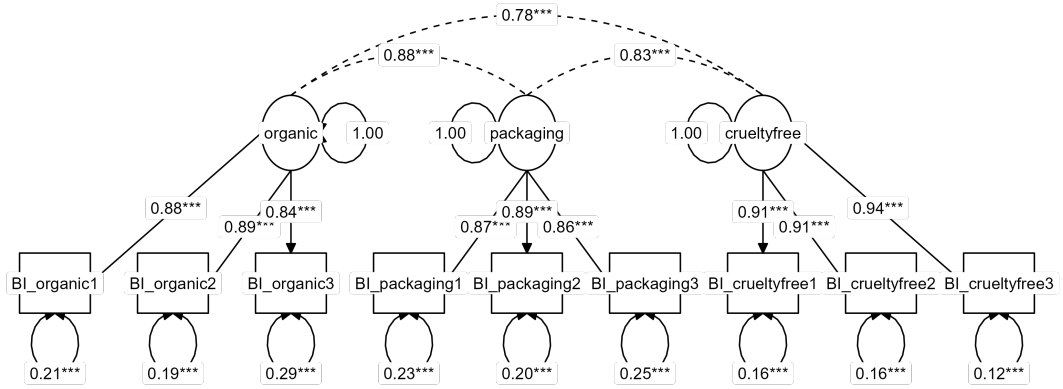

Figure 3: A graphical representation of the simple model for the behavior-intent items.

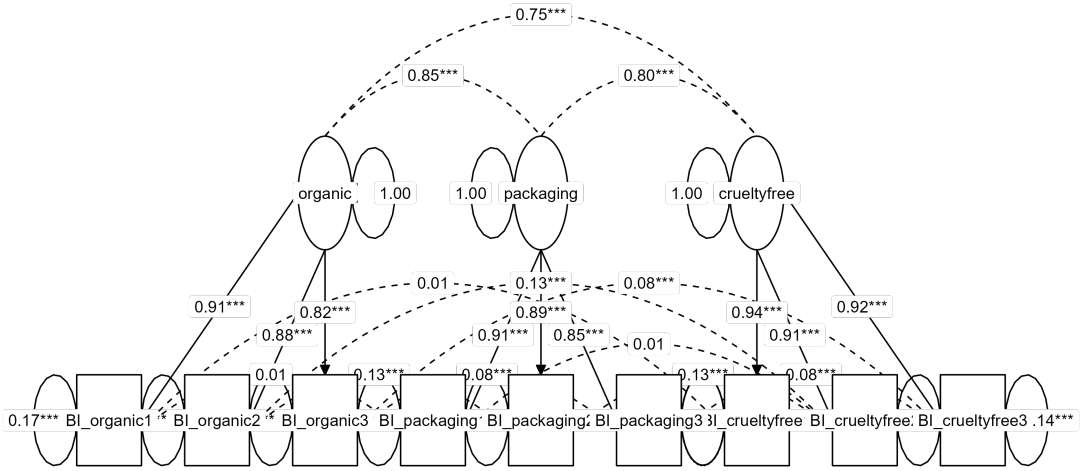

Figure 4: A graphical representation of the model with correlated error terms for the behavior-intent items that focus on the same aspect.