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. 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 standardized 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)***

	error.variance	value
16	A_organic1	0.24 (0.12, 0.36)***
17	A_organic2	0.47 (0.34, 0.61)***
18	A_organic3	0.48 (0.35, 0.62)***
19	A_packaging1	0.29 (0.18, 0.40)***
20	A_packaging2	0.37 (0.25, 0.49)***
21	A_packaging3	0.35 (0.24, 0.47)***
22	A_crueltyfree1	0.17 (0.08, 0.25)***
23	A_crueltyfree2	0.38 (0.26, 0.49)***
24	A_crueltyfree3	0.25 (0.16, 0.35)***

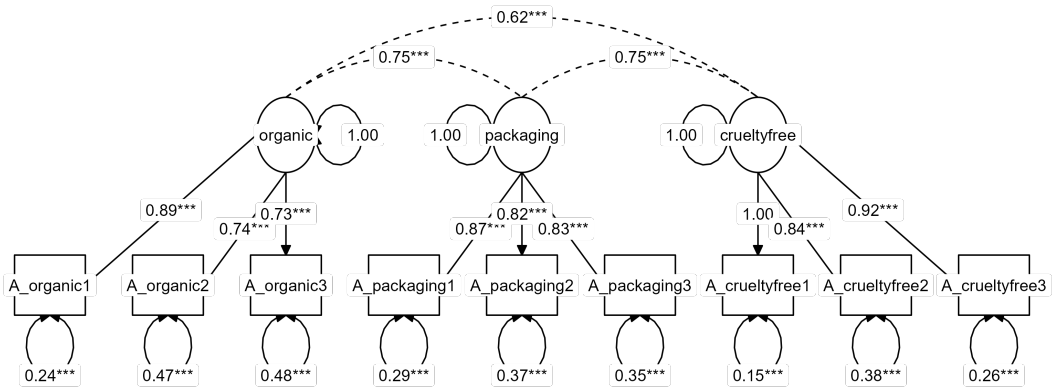

Figure 1: A graphical representation of the simple model for the attitudes.

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 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)	57.23 (21)***
baseline model Chisq. (df)	906.01 (36) ***
comparative fit index (CFI)	0.958
Tucker-Lewis index (TLI)	0.929
Loglik user model (H0)	-1486.664
Loglik unrestricted model(H1)	-1458.049
Akaike (AIC)	3021.328
Bayesian (BIC)	3093.583
RMSEA (ll,ul)	0.11 (0.07, 0.14)**
Standardized root mean square residual	0.041

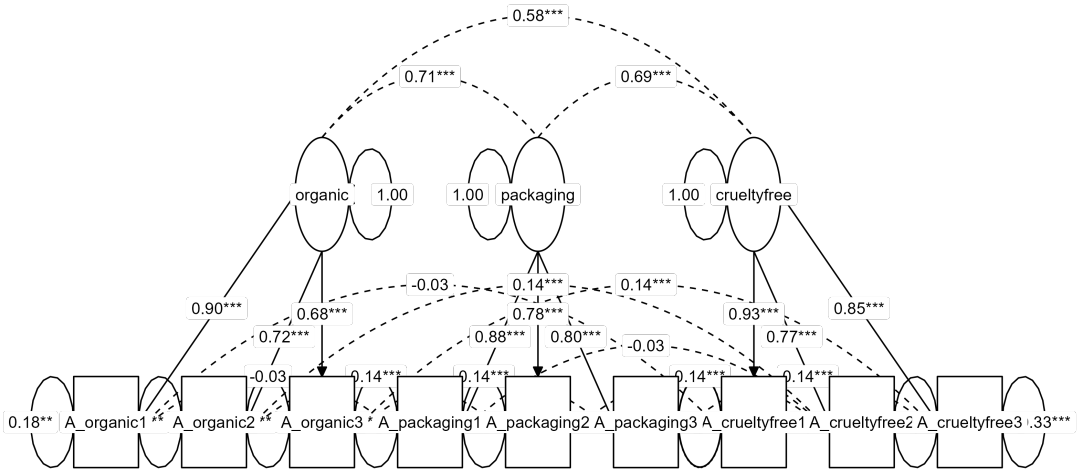

Figure 2: A graphical representation of the simple model for the attitudes.

1.1.3 Conclusion

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

```
## Chi-Squared Difference Test
##
##          Df    AIC    BIC   Chisq Chisq diff Df diff Pr(>Chisq)
```

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

loading	value
organic =~ A_organic1	0.91 (0.84, 0.98)***
organic =~ A_organic2	0.72 (0.63, 0.81)***
organic =~ A_organic3	0.71 (0.62, 0.80)***
packaging =~ A_packaging1	0.88 (0.82, 0.93)***
packaging =~ A_packaging2	0.78 (0.71, 0.86)***
packaging =~ A_packaging3	0.80 (0.73, 0.87)***
crueltyfree =~ A_crueltyfree1	0.93 (0.89, 0.98)***
crueltyfree =~ A_crueltyfree2	0.77 (0.69, 0.84)***
crueltyfree =~ A_crueltyfree3	0.83 (0.77, 0.89)***

	error.variance	value
22	organic	0.71 (0.60, 0.81)***
23	organic	0.58 (0.46, 0.71)***
24	packaging	0.69 (0.59, 0.80)***
25	A_organic1	0.18 (0.05, 0.31)**
26	A_organic2	0.48 (0.35, 0.61)***
27	A_organic3	0.50 (0.37, 0.62)***
28	A_packaging1	0.23 (0.13, 0.33)***
29	A_packaging2	0.39 (0.27, 0.50)***
30	A_packaging3	0.37 (0.25, 0.48)***
31	A_crueltyfree1	0.13 (0.04, 0.21)**
32	A_crueltyfree2	0.41 (0.30, 0.53)***
33	A_crueltyfree3	0.31 (0.21, 0.41)***

	resid.correlation	value
10	A_organic1 ~~ A_packaging1	-0.14 (-0.35, 0.08)
11	A_organic1 ~~ A_crueltyfree1	-0.19 (-0.48, 0.11)
12	A_packaging1 ~~ A_crueltyfree2	-0.09 (-0.22, 0.04)
13	A_organic2 ~~ A_packaging2	0.33 (0.21, 0.45)***
14	A_organic2 ~~ A_crueltyfree2	0.31 (0.20, 0.43)***
15	A_packaging2 ~~ A_crueltyfree2	0.35 (0.23, 0.48)***
16	A_organic3 ~~ A_packaging3	0.33 (0.21, 0.45)***
17	A_organic3 ~~ A_crueltyfree3	0.35 (0.23, 0.48)***
18	A_packaging3 ~~ A_crueltyfree3	0.39 (0.25, 0.53)***

```
## fit1corr 21 3021.3 3093.6  57.229
## fit1     24 3079.0 3142.2 120.886     63.656       3  9.721e-14 ***
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

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

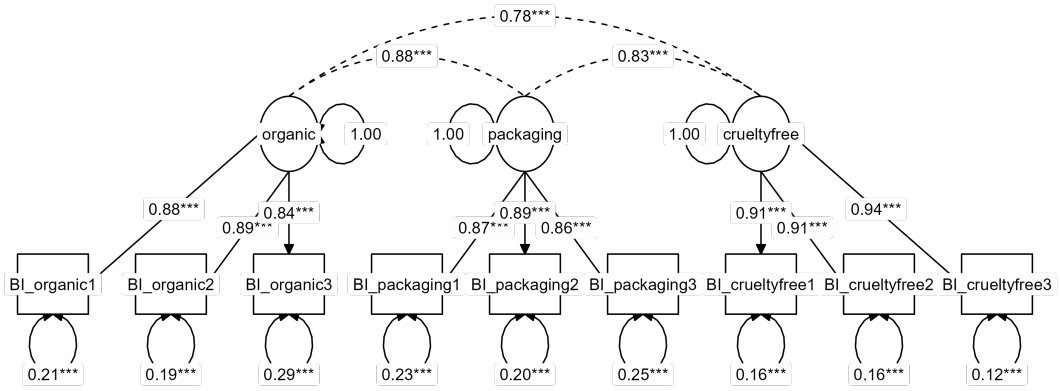

Figure 3: A graphical representation of the simple model for the behavior-intent items.

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

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)***

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)	39.49 (21)**
baseline model Chisq. (df)	1478.43 (36) ***
comparative fit index (CFI)	0.987
Tucker-Lewis index (TLI)	0.978
Loglik user model (H0)	-1191.581
Loglik unrestricted model(H1)	-1171.838
Akaike (AIC)	2431.162
Bayesian (BIC)	2503.418
RMSEA (ll,ul)	0.08 (0.04, 0.11)
Standardized root mean square residual	0.026

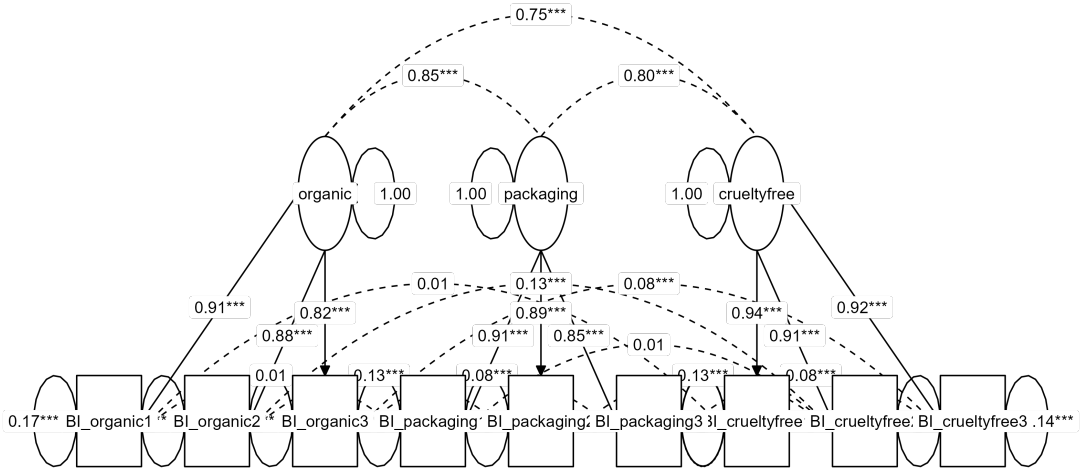

Figure 4: A graphical representation of the model with correlated error terms for the behavior-intent items.

1.2.3 Conclusion

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

```
## Chi-Squared Difference Test
##
##          Df    AIC    BIC   Chisq Chisq diff Df diff Pr(>Chisq)
## fit1corr 21 2431.2 2503.4  39.486
## fit1     24 2533.5 2596.7 147.814     108.33       3  < 2.2e-16 ***
## ---
```

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

loading	value
organic =~ BI_organic1	0.91 (0.87, 0.95)***
organic =~ BI_organic2	0.87 (0.83, 0.92)***
organic =~ BI_organic3	0.84 (0.78, 0.89)***
packaging =~ BI_packaging1	0.91 (0.87, 0.95)***
packaging =~ BI_packaging2	0.88 (0.84, 0.92)***
packaging =~ BI_packaging3	0.85 (0.80, 0.90)***
crueltyfree =~ BI_crueltyfree1	0.94 (0.92, 0.97)***
crueltyfree =~ BI_crueltyfree2	0.90 (0.87, 0.94)***
crueltyfree =~ BI_crueltyfree3	0.92 (0.89, 0.95)***

	error.variance	value
22	organic	0.85 (0.79, 0.90)***
23	organic	0.75 (0.67, 0.83)***
24	packaging	0.80 (0.74, 0.87)***
25	BI_organic1	0.17 (0.10, 0.25)***
26	BI_organic2	0.24 (0.16, 0.32)***
27	BI_organic3	0.30 (0.21, 0.39)***
28	BI_packaging1	0.18 (0.11, 0.25)***
29	BI_packaging2	0.22 (0.15, 0.30)***
30	BI_packaging3	0.28 (0.20, 0.37)***
31	BI_crueltyfree1	0.11 (0.07, 0.16)***
32	BI_crueltyfree2	0.19 (0.12, 0.25)***
33	BI_crueltyfree3	0.15 (0.09, 0.20)***

	resid.correlation	value
10	BI_organic1 ~~ BI_packaging1	0.06 (-0.06, 0.18)
11	BI_organic1 ~~ BI_crueltyfree1	0.08 (-0.07, 0.22)
12	BI_packaging1 ~~ BI_crueltyfree2	0.06 (-0.06, 0.18)
13	BI_organic2 ~~ BI_packaging2	0.54 (0.42, 0.66)***
14	BI_organic2 ~~ BI_crueltyfree2	0.59 (0.47, 0.71)***
15	BI_packaging2 ~~ BI_crueltyfree2	0.62 (0.49, 0.74)***
16	BI_organic3 ~~ BI_packaging3	0.28 (0.17, 0.39)***
17	BI_organic3 ~~ BI_crueltyfree3	0.39 (0.25, 0.54)***
18	BI_packaging3 ~~ BI_crueltyfree3	0.39 (0.25, 0.54)***

```
## 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