Developing a scale to measure factors influencing skier's self-perceived group dynamics (FISSGD)

Rong Guang

Contents

1 Data Wrangling

For the interest of space, codes in this section will not be shown. Yet they are available in the .rmd file.

1.1 Read in the data

The data were collected across years 2022 (CARE panel, n=218) and 2023 (Students joining an avalanche course, n =59).

1.2 Combine 2022 and 2023 data

They were combined into one data set (n = 277). An index variable was generated as the unique identifier for each case.

1.3 Reomove cases

1.3.1 Remove careless responses (according to attention trap)

Q10_2 and Q10_5, as well as Q19_1 and Q19_4 were same questions with different wordings. If the responses had conflictory results between them, they would be regarded as careless responses and hence deleted (n = 24).

1.3.2 Remove cases who did not consent

Respondents who did not consent to participate were removed from the data (n = 4).

1.3.3 Remove cases with NA for if having a leader

Respondents who did not disclose if the ski group had a leader were removed from the data (n = 27).

1.4 Replace value of -99 with NA

-99 was used to label seen but unanswered questions. They were relabeled as NA.

1.5 Unify value labels

Values of some of the variables had been inconsistently labeled by Qualtrics. They were unified here.

1.6 Relabel variables

Properly label the variables so that the interpretation can be better managed. For the label, see Table 1.

1.7 Unify the direction of item wording

Four items of the SOCIAL were worded in negative direction (e.g. XXXX). Basic factor analysis attempts to identify latent variance through exploring the **co-variance** in measured variables. As such, the direction of the item wording (positive vs negative) does not influence the analysis. However, we still unify the results into same wording direction (positive) for the interest of easy interpretation.

1.8 Generate Norwegian variable labels

The survey was carried out in Norwegian and the initial language of text is Norwegian. Norwegian labels were created here.

2 Create data sets for analysis

Four data sets were created. They are a. 18 item with leader; b. 6 item with leader; c. 17 item without leader; d. 5 item without leader; 3. background. The case identifier is “index” variable across data sets.

Table 1: Item labels (Item highlighted in red are short version; others are long version)

Skill	
i_skill0	The level of avalanche assessment and rescue skills differed greatly across the group.
i_skill1	The least knowledgeable group member could conduct satisfactory avalanche assessments for this trip
i_skill2	There was no large gap in avalanche assessment skills between the group members
i_skill3	There was no important difference in skiing skill level between group members, given the terrain
i_skill4	All group members were equipped with standard avalanche safety equipment (beacon, shovel, probe) and trained in the use of it
Organization	
i_orga0	The group was well-set up and organized for this trip
i_orga1	The group members knew each other well
i_orga2	The group size was appropriate for the trip (time, difficulty)
i_orga3	The roles of the group members were clearly defined
Communication	
i_comm0	The communication in the group was good
i_comm1	Decisions concerning avalanche hazard were well discussed in the group
i_comm2	Everyone in the group understood the decisions that were made
i_comm3	Everyone voiced their concerns whenever they felt necessary
Identification	
i_iden0	The group was cohesive and had a shared vision
i_iden1	There were clear expectations of each group member
i_iden2	A reasonable alternative trip existed in case of disagreements
i_iden3	Everyone was happy with the decisions that were made
Anomaly	
i_anom0	Social interactions in the group negatively impacted decision
i_anom1	The group decisions at the decision points were unanimous
i_anom2	Someone tried to impress others.
i_anom3	Love stories were going on in the group
i_anom4	The presence of other groups impacted my group's decision making
Leader	
i_leader0	The decisions were followed by all group members.
i_leader1	The leader (formal or informal) was the best suited person in the group to make the decisions.
i_leader2	The leader (formal or informal) communicated openly and clearly
i_leader3	Everyone could voice their concerns to the leader (formal or informal)

Table 2: Item labels (Item highlighted in red are short version; others are long version)

Skill	
i_skill0_NO	Ferdighetsnivået i skredvurdering og kammeratredning var svært ulikt i gruppen
i_skill1_NO	Den i gruppen med minst kunnskap kunne utføre tilfredstillende skredfare-vurderinger på denne turen
i_skill2_NO	Det var ingen vesentlig forskjell i gruppemedlemmenes kompetanse til å utføre skredvurderinger
i_skill3_NO	Det var ingen vesentlig forskjell i skiferdighetsnivå mellom gruppemedlemmene, gitt terrenget
i_skill4_NO	Alle gruppemedlemene var utstyrt med standard skredutstyr (spade, søkestang og sender-mottaker) og trent i å bruke de
Organization	
i_orga0_NO	Gruppen var godt sammensveiset og forberedt for denne turen
i_orga1_NO	Gruppemedlemmene kjente hverandre godt
i_orga2_NO	Størrelsen på gruppen stod i forhold til den gjennomførte turen (tid, vanskelighetsgrad)
i_orga3_NO	Rollene i gruppen var avklart
Communication	
i_comm0_NO	Kommunikasjonen i gruppen var god
i_comm1_NO	Beslutningene knyttet til skredfare ble diskutert nøye i gruppen
i_comm2_NO	Alle i gruppen forsto beslutningene som ble tatt
i_comm3_NO	Alle i gruppen sa sin mening når de følte at det var nødvendig
Identification	
i_iden0_NO	Gruppen var samkjørt og hadde et felles mål
i_iden1_NO	Det var klare forventninger til hvert gruppemedlem
i_iden2_NO	Det fantes et fornuftig turalternativ dersom det oppstod uenigheter
i_iden3_NO	Alle var fornøyde med beslutningene som ble tatt
Anomaly	
i_anom0_NO	Negative sosiale faktorer påvirket gruppens evnen til å ta fornuftige beslutninger
i_anom1_NO	Alle i gruppen var enig i gruppens beslutninger på hvert beslutningspunkt
i_anom2_NO	Noen prøvde å imponere andre.
i_anom3_NO	Det var pågående flørting eller forelskelse i gruppen
i_anom4_NO	Tilstedeværelsen av andre grupper påvirket beslutningene i min gruppe
Leader	
i_leader0_NO	Alle medlemmene i gruppen fulgte beslutningene som ble tatt
i_leader1_NO	Lederen (formell eller uformell) var den i gruppen som var best skikket til å ta beslutningene
i_leader2_NO	Lederen (formell eller uformell) kommuniserte åpent og tydelig
i_leader3_NO	Alle kunne si i fra om sine bekymringer til lederen (formell eller uformell)

2.1 Create with-leader and without-leader data-sets

Before generating 4 data sets, the data were first separated according to with (n = 104) or with-out leader (n = 118).

2.2 Remove cases with 50% NAs across major questions for each data sets

Within in each data set (with/without leader), cases with 50% NAs were removed from data. Three cases (#213,253,276) were removed from with-leader group; Four cases (#94, 252, 258, 275) were removed from without-leader group.

2.3 Create data set: 17 item without leader

Without-leader group respondents answered 22 out of 26 questions in the survey (the remaining 4 questions were about leader). Within the 22 questions, 17 were adapted from Zeiweiful's long version, 5 were from short version. They were further split into two data sets. They were subsequently referred to as without-leader long and without-leader short, respectively. The sample size is 114. According the publications, the minimum sample size for an exploratory factor analysis should be 5 $\times$ (number of items). In our case, the without-leader group's long version analysis involves 17 items, indicating at least 17$\times$5=85 samples. Our sample size meets this requirement.

2.4 Create data set: 5 item without leader

According the publications, the minimum sample size for an exploratory factor analysis should be 5 $\times$ (number of items). In our case, the without-leader group's long version analysis involves 5 items, indicating at least 5$\times$5=25 samples. Our sample size meets this requirement.

2.5 Create data set: 20 item with leader

Without-leader group respondents answered all 26 questions in the survey. Among the questions, 20 were adapted from Zeiweiful's long version, 6 were from short version. They were further split into two data sets. They were subsequently referred to as with-leader long and with-leader short, respectively. The sample size is 101. According the publications, the minimum sample size for an exploratory factor analysis should be 5 $\times$ (number of items). In our case, the without-leader group's long version analysis involves 20 items, indicating at least 20$\times$5=100 samples. Our sample size meets this requirement.

2.6 Create data set: 6 item with leader

According the publications, the minimum sample size for an exploratory factor analysis should be 5 $\times$ (number of items). In our case, the without-leader group's long version analysis involves 5 items, indicating at least 6$\times$5=30 samples. Our sample size meets this requirement.

3 Check and impute NAs and IDNs

3.1 Discritpive statistics with number of NAs and IDNs for each item

Table 3: Descriptive statistics for with-leader group (long)

					Central tendency		Dispersion tendency	
var	Question	n*	n of IDN†	n of NA	Mean	Median	SD	Q1~Q3
i_leader2	The leader (formal or informal) communicated openly and clearly	100	2	1	4.3	4.0	0.8	4.0 ~ 5.0
i_leader3	Everyone could voice their concerns to the leader (formal or informal)	100	3	1	4.6	5.0	0.7	4.0 ~ 5.0
i_skill1	The least knowledgeable group member could conduct satisfactory avalanche assessments for this trip	101	1	0	3.2	4.0	1.3	2.0 ~ 4.0
i_skill2	There was no large gap in avalanche assessment skills between the group members	101	2	0	2.5	2.0	1.3	1.0 ~ 4.0
i_skill3	There was no important difference in skiing skill level between group members, given the terrain	101	1	0	2.9	3.0	1.4	2.0 ~ 4.0
i_skill4	All group members were equipped with standard avalanche safety equipment (beacon, shovel, probe) and trained in the use of it	101	2	0	4.3	5.0	1.1	4.0 ~ 5.0
i_orga1	The group members knew each other well	101	0	0	3.8	4.0	1.2	3.0 ~ 5.0
i_orga2	The group size was appropriate for the trip (time, difficulty)	100	1	1	4.5	5.0	0.8	4.0 ~ 5.0
i_orga3	The roles of the group members were clearly defined	101	1	0	3.2	3.0	1.2	2.0 ~ 4.0
i_comm1	Decisions concerning avalanche hazard were well discussed in the group	101	1	0	4.1	4.0	0.9	4.0 ~ 5.0
i_comm2	Everyone in the group understood the decisions that were made	101	4	0	4.1	4.0	1.0	4.0 ~ 5.0
i_comm3	Everyone voiced their concerns whenever they felt necessary	101	5	0	4.0	4.0	1.1	3.0 ~ 5.0
i_iden1	There were clear expectations of each group member	101	1	0	3.4	3.0	1.0	3.0 ~ 4.0
i_iden2	A reasonable alternative trip existed in case of disagreements	101	1	0	3.8	4.0	1.2	3.0 ~ 5.0
i_iden3	Everyone was happy with the decisions that were made	101	4	0	4.3	4.0	1.0	4.0 ~ 5.0
i_anom1	The group decisions at the decision points were unanimous	100	3	1	4.0	4.0	1.1	4.0 ~ 5.0
i_anom2	Someone tried to impress others.	101	1	0	4.1	4.0	1.0	4.0 ~ 5.0
i_anom3	Love stories were going on in the group	101	6	0	4.1	5.0	1.4	3.0 ~ 5.0
i_anom4	The presence of other groups impacted my group's decision making	101	2	0	4.1	5.0	1.2	3.0 ~ 5.0

* number of cases minus number of NA

† IDN: Don't know

Table 4: Descriptive statistics for without-leader group (long)

					Central tendency		Dispersion tendency	
var	Question	n*	n of IDN†	n of NA	Mean	Median	SD	Q1~Q3
i_skill2	There was no large gap in avalanche assessment skills between the group members	114	0	0	3.2	3.0	1.3	2.0 ~ 4.0
i_skill3	There was no important difference in skiing skill level between group members, given the terrain	114	0	0	3.6	4.0	1.3	2.0 ~ 5.0
i_skill4	All group members were equipped with standard avalanche safety equipment (beacon, shovel, probe) and trained in the use of it	114	1	0	4.5	5.0	1.0	4.0 ~ 5.0
i_orga1	The group members knew each other well	113	0	1	4.2	5.0	1.0	4.0 ~ 5.0
i_orga2	The group size was appropriate for the trip (time, difficulty)	113	1	1	4.6	5.0	0.8	4.0 ~ 5.0
i_orga3	The roles of the group members were clearly defined	113	5	1	3.2	3.0	1.4	2.0 ~ 5.0
i_comm1	Decisions concerning avalanche hazard were well discussed in the group	114	0	0	4.0	4.0	1.0	4.0 ~ 5.0
i_comm2	Everyone in the group understood the decisions that were made	114	1	0	4.3	5.0	0.9	4.0 ~ 5.0
i_comm3	Everyone voiced their concerns whenever they felt necessary	114	6	0	4.3	4.0	1.0	4.0 ~ 5.0
i_iden1	There were clear expectations of each group member	114	0	0	3.6	4.0	1.0	3.0 ~ 4.0
i_iden2	A reasonable alternative trip existed in case of disagreements	114	1	0	3.9	4.0	1.1	3.0 ~ 5.0
i_iden3	Everyone was happy with the decisions that were made	114	1	0	4.4	5.0	0.8	4.0 ~ 5.0
i_anom1	The group decisions at the decision points were unanimous	114	7	0	4.2	4.0	1.1	4.0 ~ 5.0
i_anom2	Someone tried to impress others.	114	2	0	4.2	4.0	1.1	4.0 ~ 5.0
i_anom3	Love stories were going on in the group	114	2	0	4.3	5.0	1.2	4.0 ~ 5.0
i_anom4	The presence of other groups impacted my group's decision making	114	1	0	3.8	4.0	1.4	2.0 ~ 5.0

* number of cases minus number of NA

† IDN: Don't know

Table 5: Descriptive statistics for with-leader group (short)

					Central tendency		Dispersion tendency	
var	Question	n*	n of IDN†	n of NA	Mean	Median	SD	Q1~Q3
i_skill0	The level of avalanche assessment and rescue skills differed greatly across the group.	101	2	0	2.7	2.0	1.4	2.0 ~ 4.0
i_orga0	The group was well-set up and organized for this trip	101	0	0	3.9	4.0	0.9	3.0 ~ 4.0
i_comm0	The communication in the group was good	101	1	0	4.4	4.0	0.7	4.0 ~ 5.0
i_iden0	The group was cohesive and had a shared vision	100	1	1	4.2	4.0	0.8	4.0 ~ 5.0
i_anom0	Social interactions in the group negatively impacted decision	101	3	0	4.4	5.0	1.0	4.0 ~ 5.0

* number of cases minus number of NA

† IDN: Don't know

Table 6: Descriptive statistics for without-leader group (short)

					Central tendency		Dispersion tendency	
var	Question	n*	n of IDN†	n of NA	Mean	Median	SD	Q1~Q3
i_orga0	The group was well-set up and organized for this trip	114	0	0	4.1	4.0	0.9	4.0 ~ 5.0
i_comm0	The communication in the group was good	114	0	0	4.3	5.0	1.0	4.0 ~ 5.0
i_iden0	The group was cohesive and had a shared vision	114	0	0	4.2	4.0	0.8	4.0 ~ 5.0
i_anom0	Social interactions in the group negatively impacted decision	113	3	1	4.3	5.0	1.0	4.0 ~ 5.0

* number of cases minus number of NA

† IDN: Don't know

3.2 Adress NA and IDN casewise

The number of NAs and IDNs were few in number comparing with the sample size for each data set. Hence, the NAs and IDNs were checked case-wise, and decisions for each case were made accordingly. Please go to file "NA_and_IDN.md" for full description. A quck summary here: case #82 (in without group) were removed due to high proportion of IDNs, while other cases with NAs/IDNs does not show much logical issue. These NAs/IDNs will be imputed by within-subgroup median.

3.3 Sumarize data clensing

The full processes of data cleansing were summarized in the following flowchart.

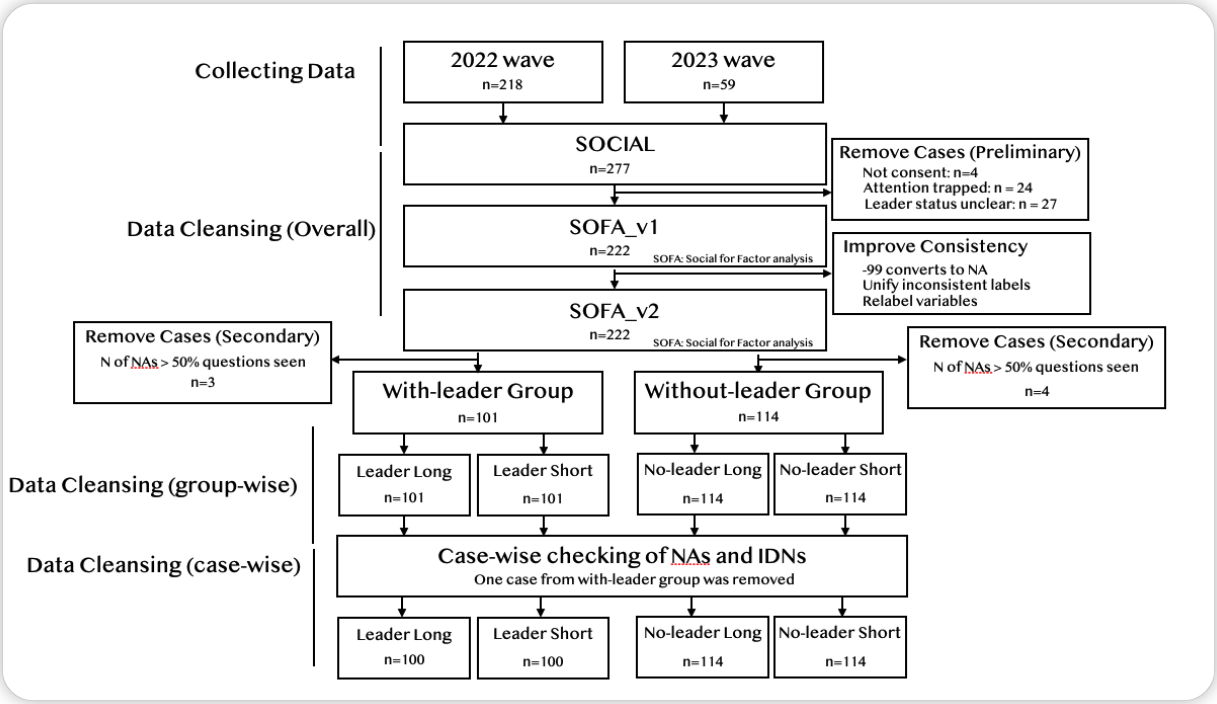


Figure 1: Flowchart for data cleansing

4 Data analysis plan

The full processes of data analysis plan were demonstrated in the following flowchart, see figure 2.

For each of the four data set created, the analysis will be done as follows:

(1) Check factorability

Correlation Matrix

Factorability is the assumption that there are at least some correlations amongst the variables so that coherent factors can be identified.

There are several well-recognized criteria for checking factorability, including correlation matrix, KMO test, and Bartlett sphericity test. Our decision will be based on all the three.

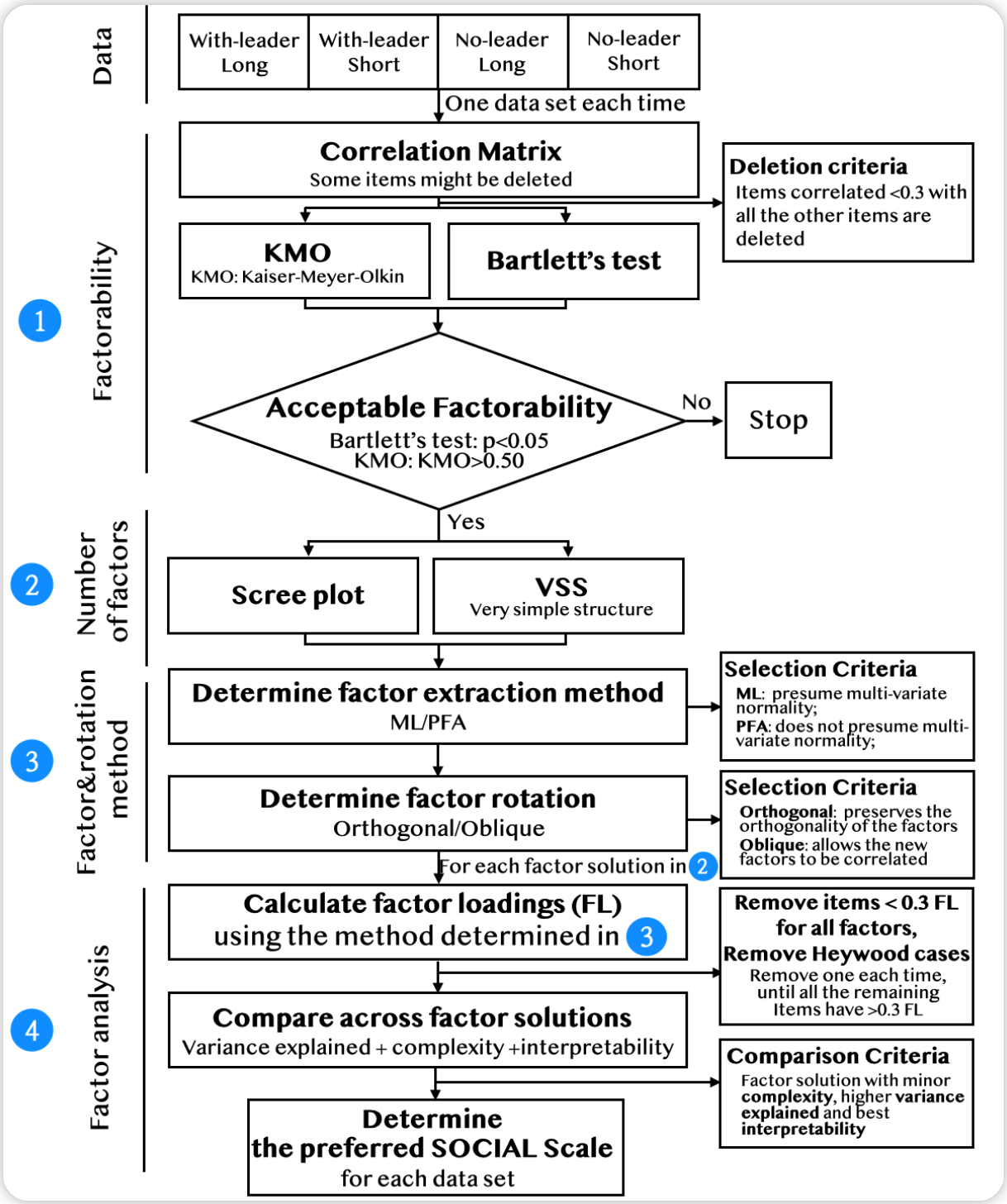


Figure 2: Flowchart for data analysis

Table 7: Level of acceptance of the Kaiser-Meyer-Olkin (KMO) value

KMO value	Level of acceptance
Above 0.90	Superb
0.80 to 0.90	Great
0.70 to 0.80	Good
0.50 to 0.70	Mediocre
Below 0.50	Unacceptable

For correlation matrix, if all the items have >0.3 correlation with at least one other item, we can expect some redunduncy among these items and assume good factorability. For the items that do not meet this standard, we plan to remove them from the following analysis.

KMO test

The Kaiser–Meyer–Olkin (KMO) test is a statistical measure to determine how suited data is for factor analysis. The test measures sampling adequacy for each variable in the model and the complete model. The statistic is a measure of the proportion of variance among variables that might be common variance. KMO returns values between 0 and 1. Table 5 summarizes a rule of thumb for interpreting the statistic. We set a cutoff >0.6 to determine if our data is suitable for factor analysis.

Bartlett's test

Bartlett's Test of Sphericity compares an observed correlation matrix to the identity matrix. Essentially it checks to see if there is a certain redundancy between the variables that we can summarize with a few number of factors.

The null hypothesis of the test is that the variables are orthogonal, i.e. not correlated. The alternative hypothesis is that the variables are not orthogonal, i.e. they are correlated enough to where the correlation matrix diverges significantly from the identity matrix. We expect the null hypothesis to be rejected as the evidence for good factorability. In our study we will make the conclusion based on an $\alpha = 0.05$.

(2) Determine number of factors (factor solutions)

Determining the appropriate number of factors from a factor analysis is perhaps one of the greatest challenges in factor analysis. There are many solutions to this problem, none of which is uniformly the best.

In the current study, we will use the results from four methods: scree plots (parallel analysis), very simple structure (VSS), Velicer MAP and BIC. Each will calculate and generate a most suitable number of factors for the data. Their result can either be different or same. When they give different factor solutions, we will test all solutions in actual factor analysis and compare across them.

(3) Factor extract method and matrix rotation method

Factor extraction method

Factor extraction method refers to the mathematical approach for extracting the factors from your dataset. The most common choices are maximum likelihood (ML), principal axis factoring (PAF), and principal components analysis (PCA). PCA is least preferred since it is mainly for dimensionality reduction and does not assess the underlying commonalities that unobserved factors cause. In the present study maximum likelihood (fm = "ml") was used considering its robustness in dealing with data of different distributions.

Factor rotation

Rotating the factors maximizes and minimizes the entire set of factor loadings, creating sharp contrast between high and low loadings. It makes intepretations easier. There are two main types of rotation

methods: orthogonal (Varimax) and oblique. Orthogonal preserves the orthogonality of the factors, while oblique allows the new factors to be correlated. We considers that the latent aspects of SOCIAL are not expected to be correlated with each other (e.g. skill and communication), and hence will use Varimax rotation all along.

(4) Item removal

For each factor solution identified in step (2), we will carry out factor analysis and improve the factor structure by removing one item with low loading each time. We set a cutoff for factor loading of ± 0.3. The item with the lowest loading on all factors across all items will be removed from the factor structure, until all the remaining items have a factor loading >0.3 on at least one factor.

Aftering removing items based on factor loading, we further examine if there is cross-loading (one item having >0.3 factor loadings on ≥ 2 factors). Ifthe the items with cross loading having factor loading very close to 0.3 or the gap between the largest and second largest factor loadings are smaller than 0.1, or they are very hard to interpret, we will remove the item for the following analysis. Cross-loaded items will also be removed one for each time.

(5) Factor solution comparison

After item removal for each of the factor solution identified, we will compare the goodness of these solutions. The criteria will include: an acceptable trade-off between minor complexity and higher variance explained, and good intepretability.

5 Variable distribution and correlation matrix

5.1 Distribution

Since the data were collected from Likert scale, which usually skewed towards an end, I do not seek normality from these graphs. Instead, I scanned through the distributions to get a sense of the features of each item, such as left skewness (e.g. i_anom3), right skewness (e.g. i_skill4), kurtosis (e.g. i_orga3), polarization (e.g. i_skill3). These also shed light on skiers' overall performance pattern across sub-groups. To illustrate, it could be interesting to find that the organization of without-leader group wasn't rated notably lower than that of with-leader group. However, the skills were rated higher in without-leader group. This indicates people who ski without a leader are more confident in his and his teammates skiing/avalanche-forecasting skills. Of course, I hope for a normal distribution from the factor scores obtained by the following factor analysis.

Figure 3 Distributions of the item for with−leader group (long)

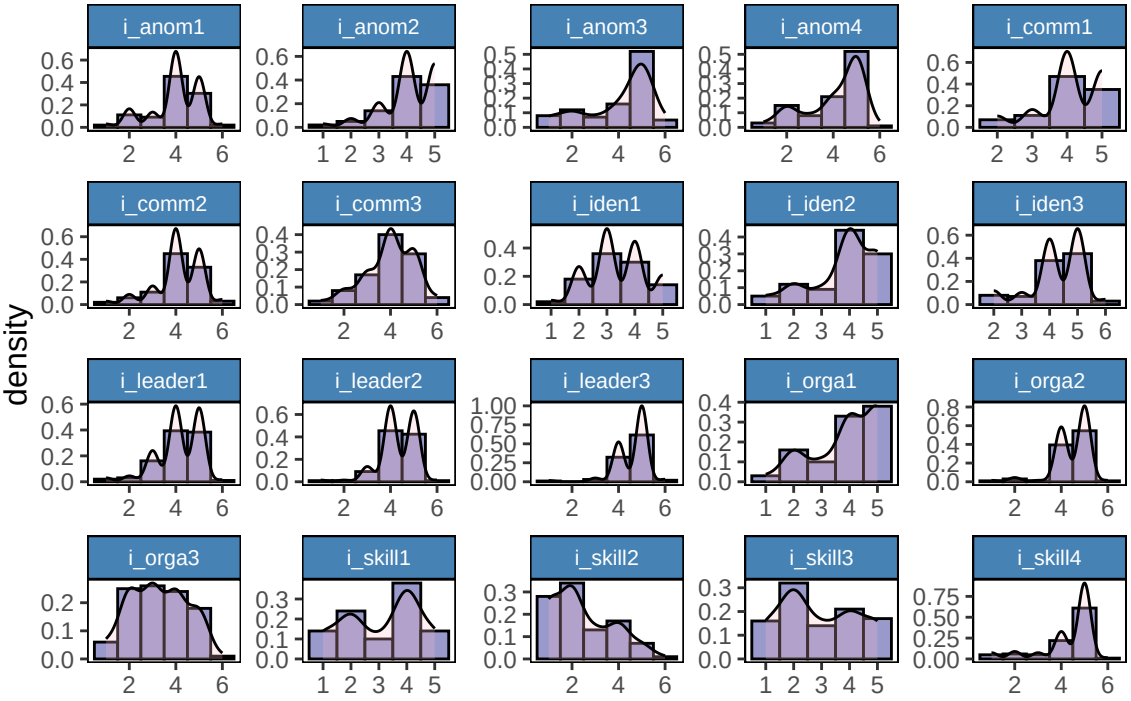


Figure 4 Distribtuions of the item for without−leader group (long)

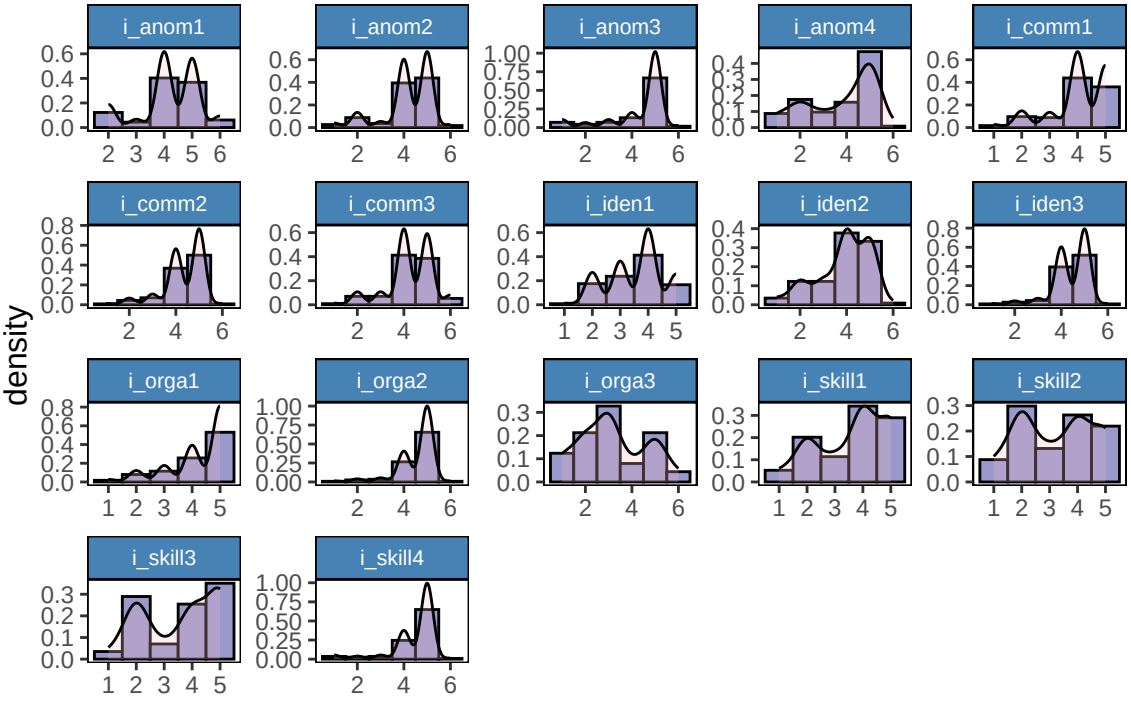


Figure 5 Distributions of the item for with−leader group (short)

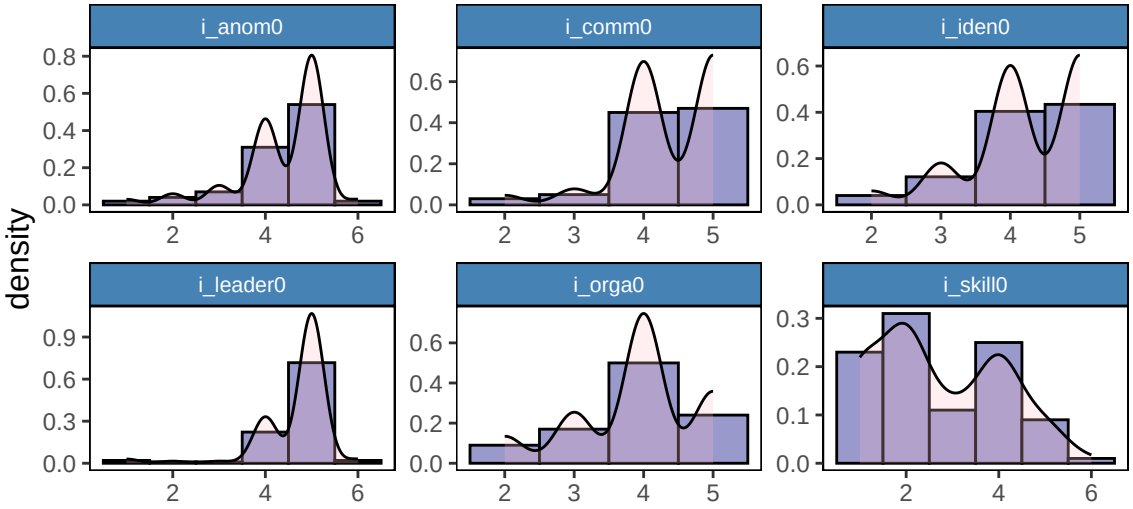
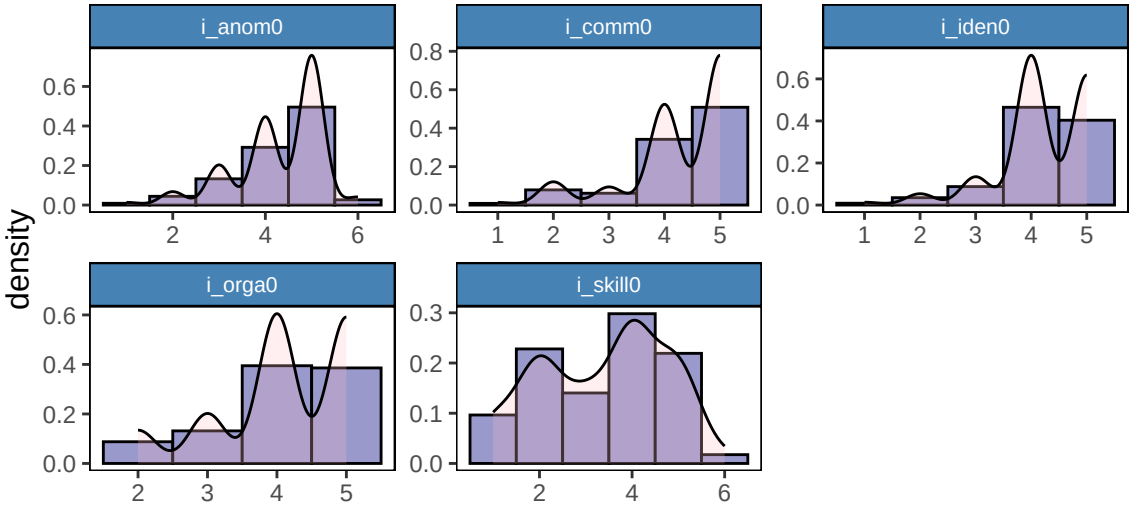


Figure 6 Distributions of the item for without−leader group (short)



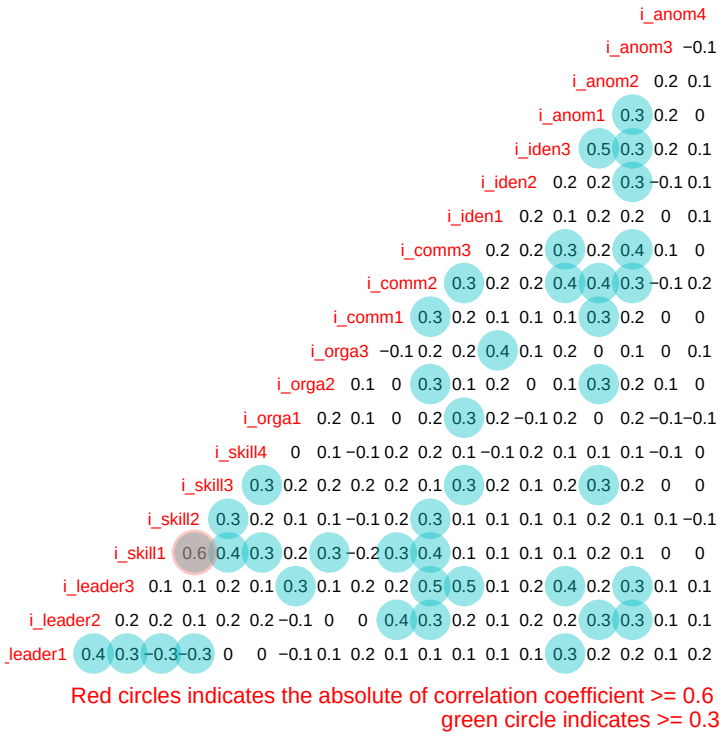
5.2 Correlation matrix

Correlation matrix was created for each of the four scales (2 long and 2 short). Pearson correlation coefficients were reported. Any coefficients 0.3 were highlighted in green circle; any coefficients 0.3 were highlighted in read circle.

For the planned methods for factorability check, including correlation matrix, KMO test, and Bartlett sphericity test, correlation matrix was examined in this section. Other criteria were checked in the following section. We hope that the majority of the items have a correlation coefficient 0.3 with at least one other item, which suggest good factorability.

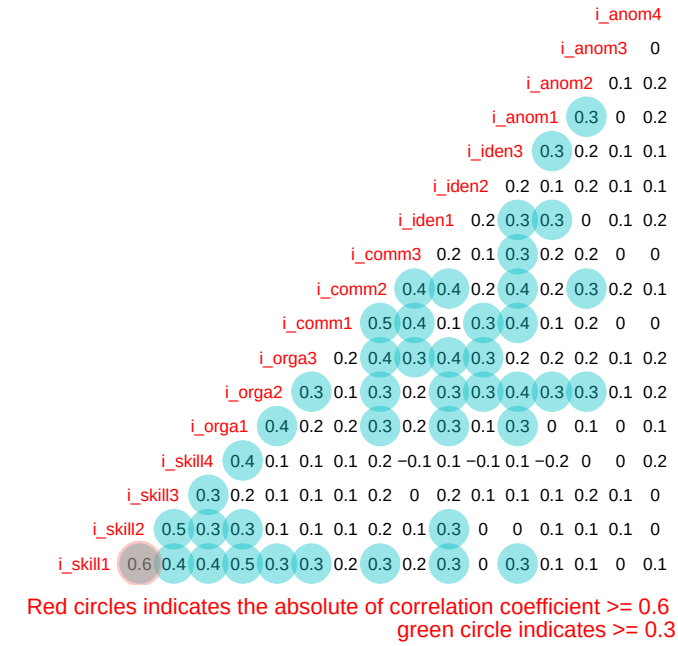
For with-leader group (long), it was observed that 18 of the 20 items correlated at least .3 with at least one other item, suggesting reasonable factorability. See figure 6.

Figure 7 Correlation matrix of the item for with−leader group (long)



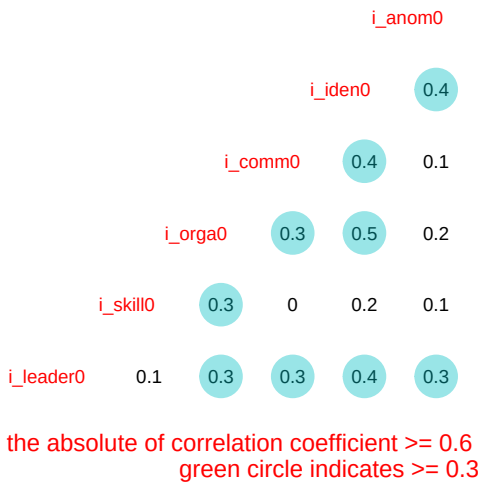
For without-leader group (long), it was observed that 16 of the 17 items correlated at least .3 with at least one other item, suggesting reasonable factorability. See figure 7.

Figure 8 Correlation matrix of the item for without−leader group (long)



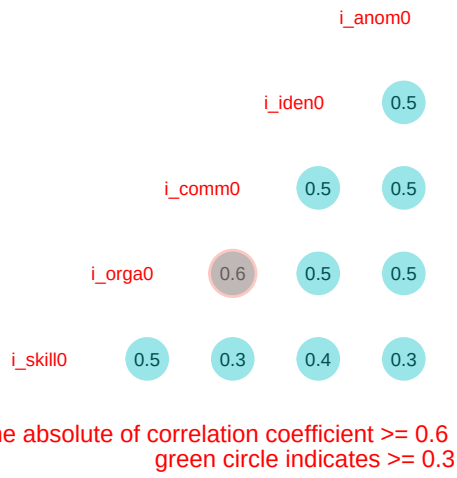
For with-leader group (short), it was observed that 6 of the 6 items correlated at least .3 with at least one other item, suggesting reasonable factorability. See figure 8.

Figure 9 Correlation matrix of the item for with−leader group (short)



For without-leader group (short), it was observed that 6 of the 6 items correlated at least .3 with at least one other item, suggesting reasonable factorability. See figure 9.

Figure 10 Correlation matrix of the item for without−leader group (short)



6 Factor analysis for with-leader group (long)

6.1 Check factoribility

The Kaiser-Meyer-Olkin measure of sampling adequacy was .68, above the commonly recommended value of .6. However, when the two items with <0.3 correlation with any other items were removed, the adequacy increased to 0.713, reaching "Good acceptance", see table 6.

Table 8: Results of KMO test of sampling adequacy for with-leader group (long)

Item	KMO	if correlation acceptable*
i_leader1	0.633	Yes
i_leader2	0.707	Yes
i_leader3	0.751	Yes
i_skill1	0.661	Yes
i_skill2	0.697	Yes
i_skill3	0.730	Yes
i_skill4	0.762	Yes
i_orga1	0.580	Yes
i_orga2	0.521	Yes
i_orga3	0.533	Yes
i_comm1	0.807	Yes
i_comm2	0.722	Yes
i_comm3	0.809	Yes
i_iden1	0.632	Yes
i_iden2	0.608	Yes
i_iden3	0.706	Yes
i_anom1	0.732	Yes
i_anom2	0.810	Yes
i_anom3	0.364	No
i_anom4	0.546	No
Overall	0.687	
Selected†	0.713	

* having>0.3 correlation coefficient with at least one other item

† excluing i_anom3 and i_anom4

Table 9: Results of bartlett test for with-leader group (long)

Dataset	Chi-square	p-value	DF
Overall	483.671	<0.001	153
Select*	483.671	<0.001	153

* excluing i_anom3 and i_anom4, see section 4.2

Bartlett's test of sphericity were significant for full items (2 (190) = 518.94, p < .001) and selected items (2 (153) = 483.67, p < .001) , suggesting that there is a certain redundancy between the variables that we can summarize with a few number of factors.

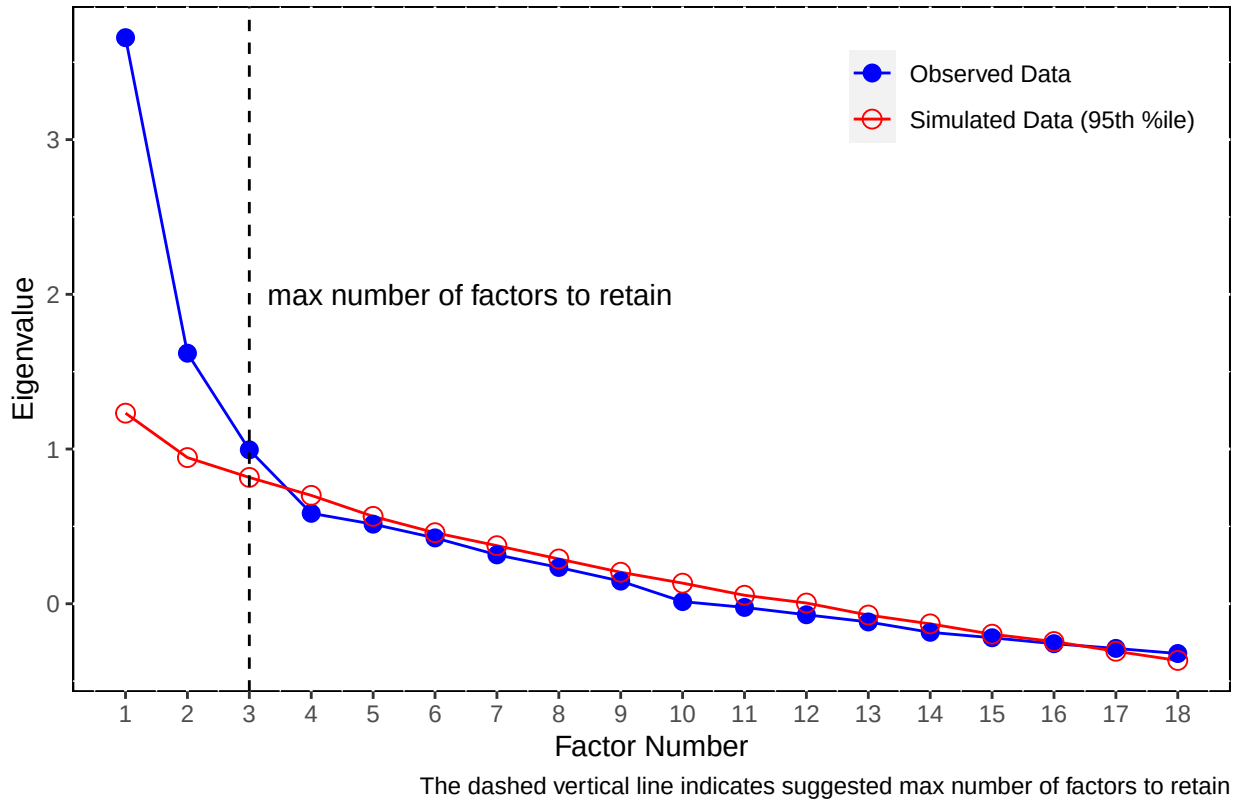
Given these overall indicators, factor analysis was deemed to be suitable with all 18 of the 20 items (excluding two anomaly items). The following factor analysis were done on the these 18 items.

6.2 Explore number of factors

Scree plots and VSS indicated an 3 factor solution (figures 11 and 12), while Velicer MAP, Empirical BIC and Sample size adjusted BIC suggested 2-, 4-, and 5-factor solution, respectively. Solutions for three, four and five were separately examined using varimax rotations of the factor loading matrix.

```
## Parallel analysis suggests that the number of factors =  3  and the number of components =  NA
```

Figure 11. Scree plot for with−leader group (long)

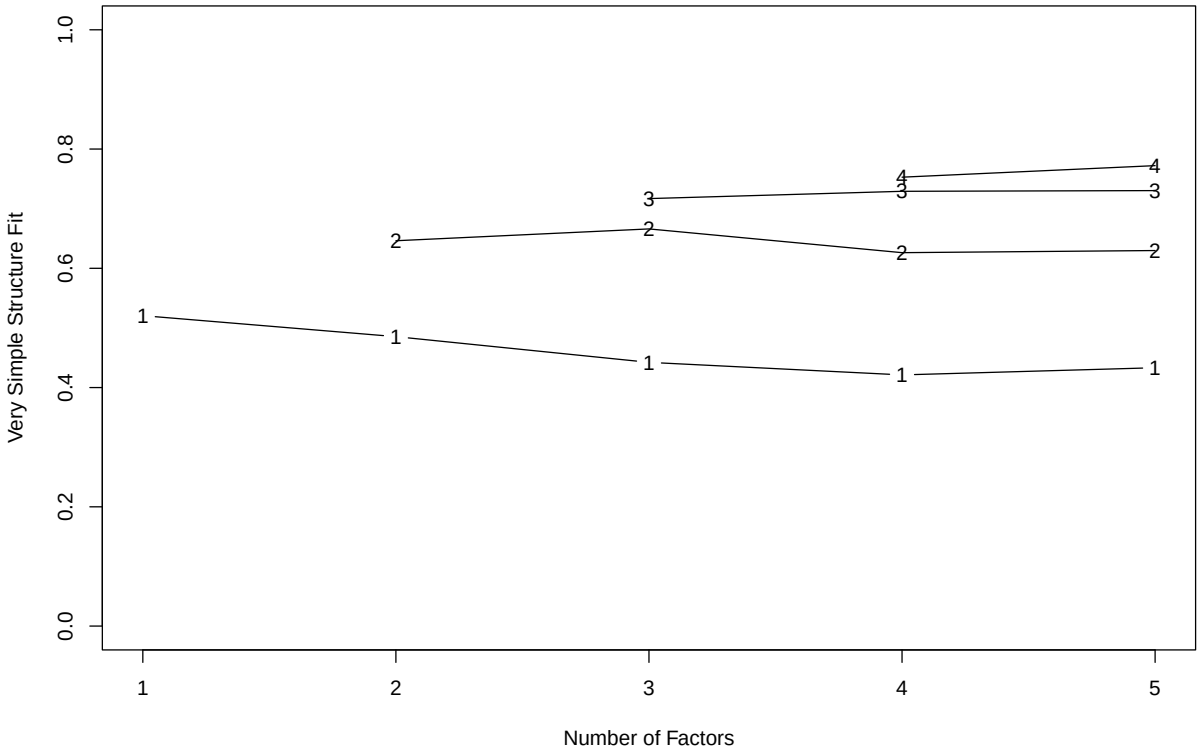


The dashed vertical line indicates suggested max number of factors to retain

```
## $cfit.1
```

```
## [1] 0.5205708 0.4854068 0.4422584 0.4212212 0.4332335
```

Figure 12. VSS plot for with−leader group (long)



6.3 Explore factor solutions

6.3.1 Explore 5-factor solution

After fitting 8 models, we achieved the most optimal model for 5 factor solution. The item removal process was encapsulated in table 8. One item was removed due to cross loading and other seven items were removed due to factor loading <0.4. The final model has 10 items, with 60.8% variance explained, see table 9 and figure 13. Note that one of the factor identified only involves one item (i_comm2), which is not a preferred situation.

Table 10: Item removing process for 5 factor solution

		Factor loadings of the items removed					
Iteration	Item removed†	ML2	ML5	ML4	ML1	ML3	Variance Explained
model1	i_skill4	0.332	0.062	0.235	0.085	-0.161	0.447
model2	i_orga1	0.109	0.231	-0.167	0.324	0.185	0.463
model3	i_leader1	0.122	0.246	0.232	0.342	-0.384	0.487
model4	i_iden2	0.045	0.307	0.131	0.066	0.038	0.479
model5	i_comm1	-0.076	0.322	0.108	0.154	0.259	0.508
model6	i_leader2	-0.004	0.260	0.153	0.257	0.129	0.532
model7	i_orga2	0.298	0.049	0.083	0.173	0.230	0.552
model8*	i_leader3	0.086	0.455	0.547	0.096	0.041	0.608

* The item removed for the model is due to cross-loading

† The items removed a model include the ones in the current and preceding rows

Table 11: Factor loadings of the 5 factor solution for with-leader group (long)

Item	ML4	ML1	ML2	ML5	ML3
i_skill1	0.866				
i_skill2	0.68				
i_skill3	0.43				
i_orga3			0.974		
i_comm2					0.853
i_comm3				0.634	
i_iden1			0.412		
i_iden3		0.448			
i_anom1		0.962			
i_anom2				0.593	

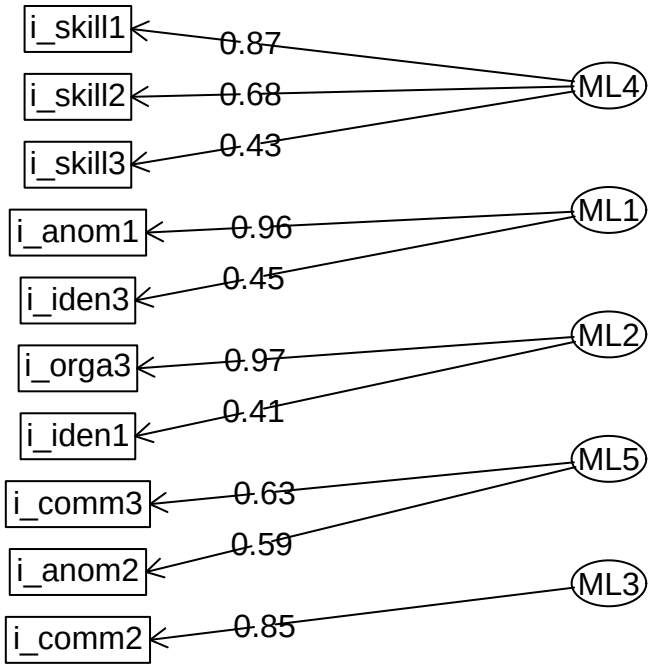
Table 12: Item removing process for 4 factor solution

		Factor loadings of the items removed				
Iteration	Item removed†	ML1	ML3	ML2	ML4	Variance Explained
model1	i_skill4	0.358	0.250	0.048	-0.076	0.392
model2	i_iden2	0.013	0.262	0.127	0.171	0.404
model3	i_orga1	0.159	-0.179	0.382	0.256	0.422
model4	i_orga3	-0.047	-0.256	0.147	0.359	0.450
model5	i_iden1	0.083	0.051	0.055	0.305	0.467
model6	i_orga2	0.015	0.250	-0.023	0.339	0.494
model7	i_anom2	0.330	0.008	0.222	0.358	0.526
model8	i_skill3	0.124	0.183	0.362	0.168	0.575

* '*' indicates the model is by removing a cross-loading item

† The items removed a model include the ones in the current and preceding rows

Figure 13. Path diagram of 5 factor solution, with−leader group (long)



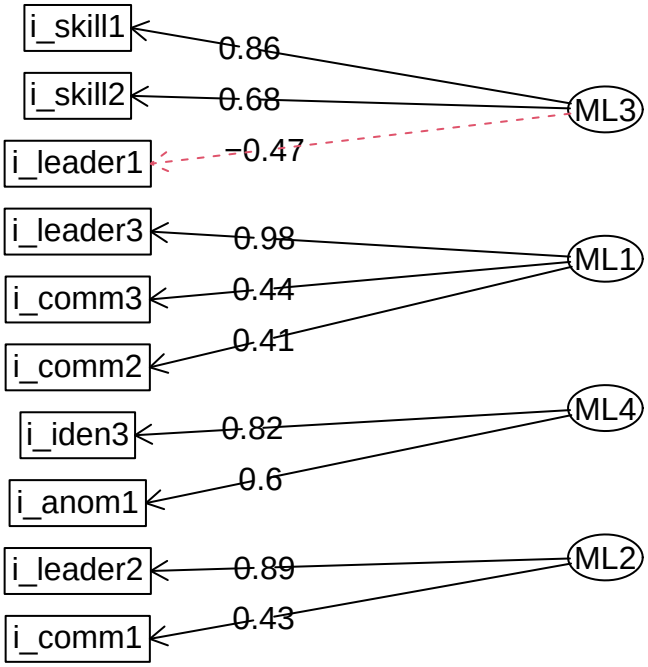
6.3.2 Explore 4-factor solution

After fitting 8 models, we achieved the most optimal model for 4 factor solution. The item removal process was encapsulated in table 10. All items were removed due to factor loading <0.4. The final model has 10 items, with 57.5% variance explained, see table 11 and figure 14. Note that one item (i_leader1) has a negative loading onto the factor, albeit it has positive wording. To check the questions for this factor, see table 12.

Table 13: Factor loadings of the 4 factor solution for with-leader group (long)

Item	ML3	ML1	ML4	ML2
i_leader1	-0.47			
i_leader2				0.889
i_leader3		0.98		
i_skill1	0.858			
i_skill2	0.678			
i_comm1				0.432
i_comm2		0.414		
i_comm3		0.444		
i_iden3			0.82	
i_anom1			0.601	

Figure 14. Path diagram of 4 factor solution, with−leader group (long)



6.3.3 Explore 3-factor solution

After fitting 12 models, we achieved the most optimal model for 3 factor solution. The item removal process was encapsulated in table 13. Two items were removed due to cross-loading, and others due to factor loading <0.4. The final model has 6 items, with 62.4% variance explained, see table 14 and figure 15. To check the questions for this factor, see table 12.

Table 14: Item with negative loading and other items under the same factor

	Item	loadings
i_skill1	The least knowledgeable group member could conduct satisfactory avalanche assessments for this trip	0.86
i_skill2	There was no large gap in avalanche assessment skills between the group members	0.68
i_leader1	The leader (formal or informal) was the best suited person in the group to make the decisions.	-0.47

Table 15: Item removing process for 3 factor solution

	Factor loadings of the items removed				
Iteration	Item removed†	ML2	ML1	ML3	Variance Explained
model1	i_iden2	0.197	0.036	0.273	0.349
model2	i_iden1	0.384	0.049	0.053	0.363
model3	i_orga2	0.261	0.270	0.024	0.376
model4	i_orga3	0.384	-0.247	0.000	0.392
model5	i_skill4	0.184	0.375	0.064	0.406
model6	i_skill3	0.172	0.367	0.237	0.423
model7*	i_leader1	0.519	-0.462	0.189	0.439
model8	i_leader2	0.383	0.133	0.138	0.437
model9	i_comm1	0.217	0.280	0.182	0.469
model10	i_anom2	0.337	0.016	0.369	0.497
model11	i_orga1	0.395	0.120	0.035	0.522
model12*	i_comm2	0.368	0.416	0.410	0.624

* The item removed for the model is due to cross-loading

† The items removed a model include the ones in the current and preceding rows

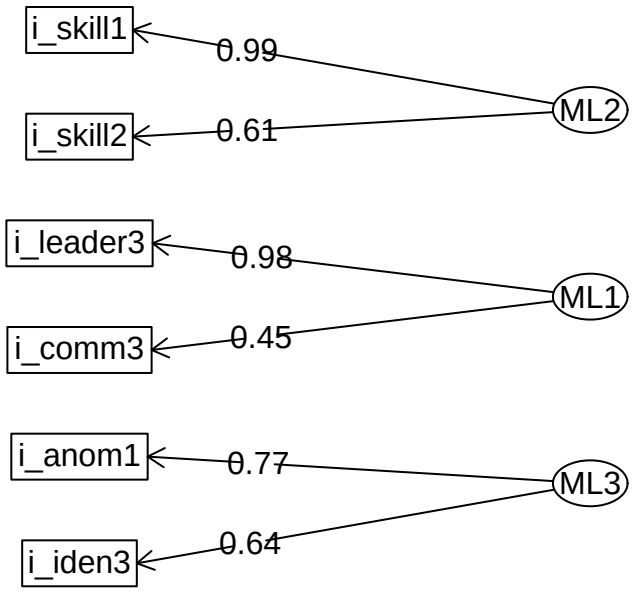
Table 16: Factor loadings of the 3 factor solution for with-leader group (long)

Item	ML2	ML1	ML3
i_leader3		0.984	
i_skill1	0.988		
i_skill2	0.609		
i_comm3		0.447	
i_iden3			0.636
i_anom1			0.771

Table 17: Items of 3-factor solution, with-leader group (long)

	Item
factor1	
i_skill1	The least knowledgeable group member could conduct satisfactory avalanche assessments for this trip
i_skill2	There was no large gap in avalanche assessment skills between the group members
factor2	
i_leader3	Everyone could voice their concerns to the leader (formal or informal)
i_comm3	Everyone voiced their concerns whenever they felt necessary
factor3	
i_anom1	The group decisions at the decision points were unanimous
i_iden3	Everyone was happy with the decisions that were made

Figure 15. Path diagram of 3 factor solution, with−leader group (long)



After fitting 10 models, we achieved the most optimal model for 2 factor solution. The item removal process was encapsulated in table 16. one items was removed due to cross-loading, and others due to factor loading <0.4. The final model has 8 items, with 44.8% variance explained, see table 17 and figure 16.

Table 18: Item removing process for 2 factor solution

	Factor loadings of the items removed			
Iteration	Item removed†	ML2	ML1	Variance Explained
model1	i_orga3	0.382	-0.184	0.291
model2	i_orga1	0.211	0.185	0.298
model3	i_iden1	0.299	0.093	0.312
model4	i_iden2	0.328	0.077	0.326
model5	i_orga2	0.198	0.289	0.341
model6	i_skill4	0.162	0.360	0.359
model7	i_comm1	0.341	0.295	0.376
model8	i_skill3	0.277	0.366	0.391
model9*	i_leader1	0.467	-0.431	0.408
model10	i_leader2	0.381	0.140	0.448

* The item removed for the model is due to cross-loading

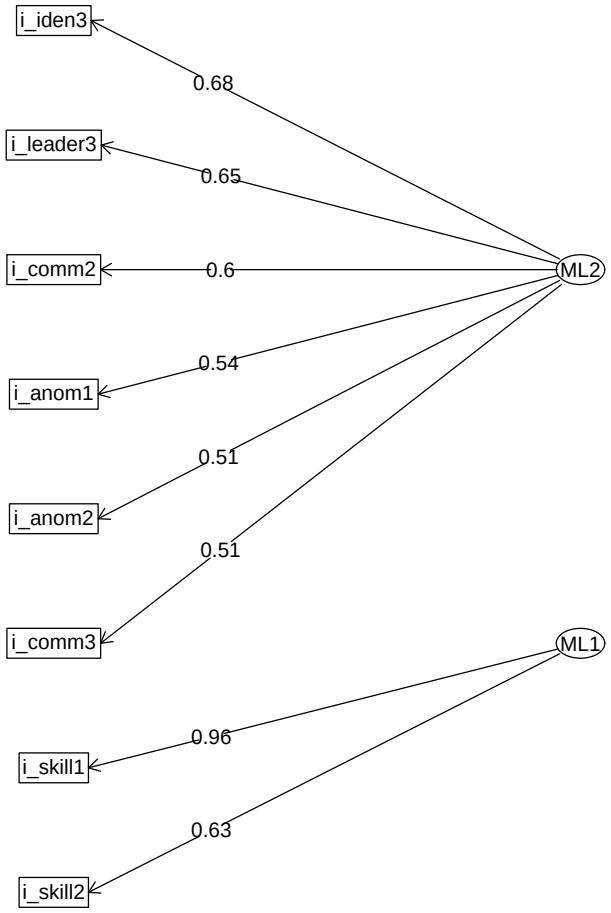
† The items removed a model include the ones in the current and preceding rows

Table 19: Factor loadings of the 2 factor solution for with-leader group (long)

Item	ML2	ML1
i_leader3	0.649	
i_skill1		0.962
i_skill2		0.628
i_comm2	0.597	
i_comm3	0.51	
i_iden3	0.676	
i_anom1	0.54	
i_anom2	0.512	

6.3.4 Explore 2-factor solution

Figure 16. Path diagram of 2 factor solution, with−leader group (long)



6.4 Comparison between factor solutions, with-leader (long)

3-factor solution is the most optimal solution with regards to both parsimony and variance explained, see table 18.

6.4.1 Check the factor connotation for 3-factor solution

3-factor has fairly good intetrepability, see table 19.

Table 20: Comparison between factor solutions, with-leader (long)

	VarianceExplained	Number of items
2-factor solution	0.448	8
3-factor solution	0.624	6
4-factor solution	0.575	10
5-factor solution	0.608	10

Table 21: Items of 3-factor solution, with-leader group (long)

	Item
Factor1: Skill (proportion variance: 0.231)	
i_skill1	The least knowledgeable group member could conduct satisfactory avalanche assessments for this trip
i_skill2	There was no large gap in avalanche assessment skills between the group members
Factor2: Communication (proportion variance: 0.213)	
i_leader3	Everyone could voice their concerns to the leader (formal or informal)
i_comm3	Everyone voiced their concerns whenever they felt necessary
Factor3: Individual contribution (proportion variance: 0.180)	
i_anom1	The group decisions at the decision points were unanimous
i_iden3	Everyone was happy with the decisions that were made

7 Factor analysis for with-leader group (short)

7.1 Check factoribility

For with-leader group (short), it was observed that 6 of the 6 items correlated at least .3 with at least one other item, suggesting reasonable factorability. As such, no item was dropped for factoribility tests.

The Kaiser-Meyer-Olkin measure of sampling adequacy was .735, achieving "Good acceptance", see table 21.

Bartlett's test of sphericity were significant for the items (2 (15) = 94.2, p < .001) , suggesting that there is a certain redundancy between the variables that we can summarize with a few number of factors. See table 22.

Table 22: Results of KMO test of sampling adequacy for with-leader group (short)

	KMO
i_leader0	0.808
i_skill0	0.639
i_orga0	0.727
i_comm0	0.755
i_iden0	0.700
i_anom0	0.783
Overall	0.735

Table 23: Results of bartlett test for with-leader group (short)

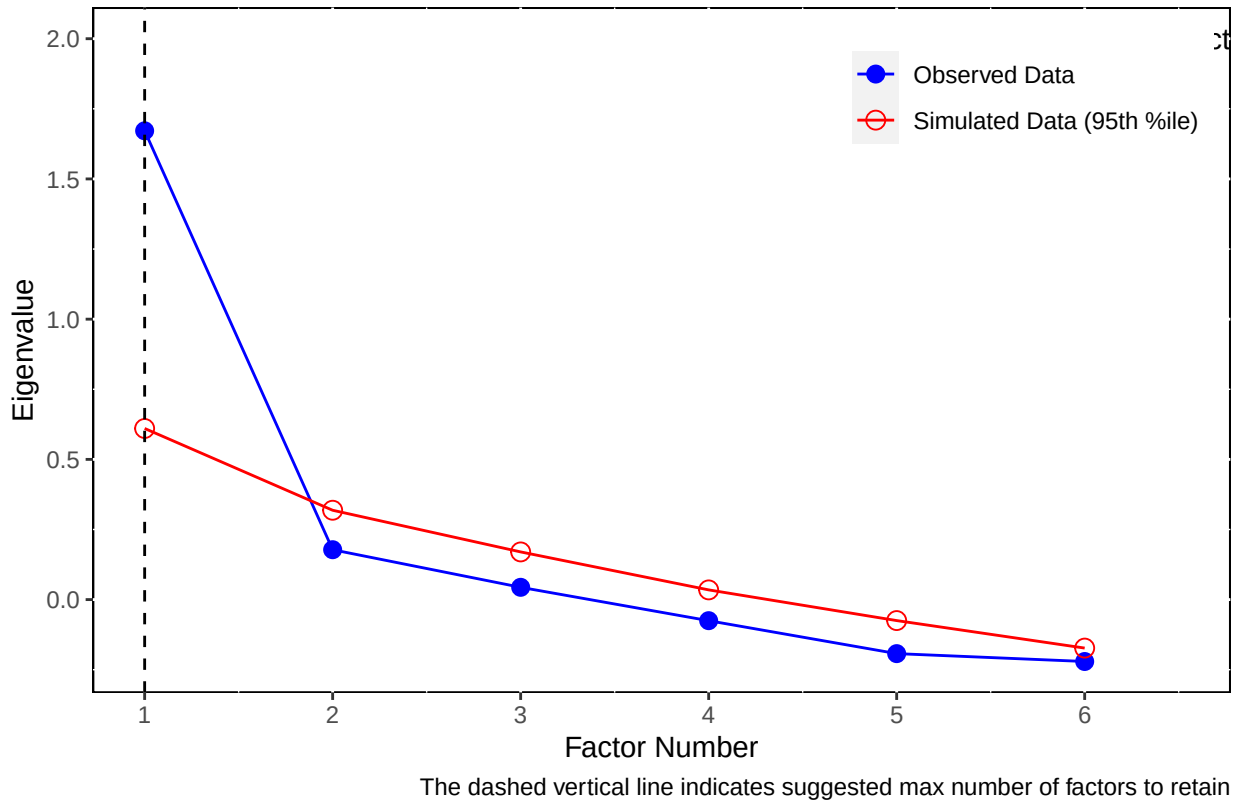
Chi-square	p-value	DF
94.2	<0.001	15

7.2 Explore number of factors

Scree plots (figures 17), BIC and Velicer MAP indicated an 1 factor solution, while and VSS suggested 2-factor solution (figures 18). Solutions for two was examined using varimax rotations of the factor loading matrix.

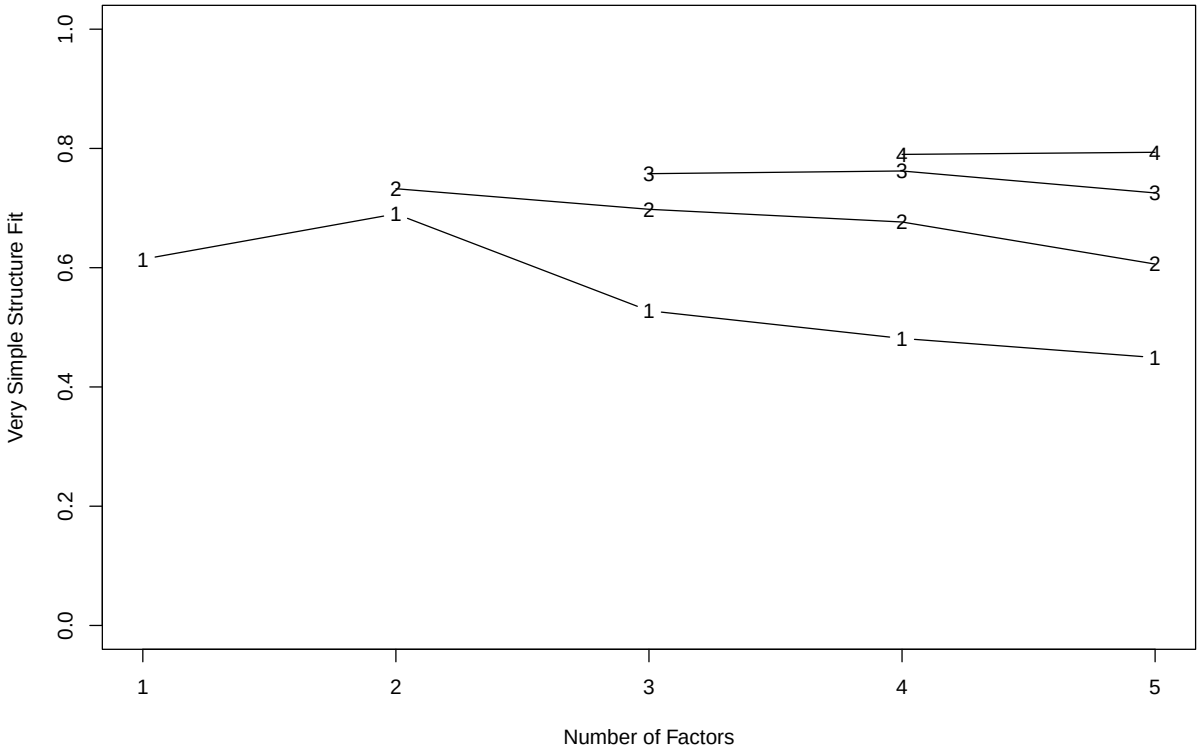
```
## Parallel analysis suggests that the number of factors =  1  and the number of components =  NA
```

Figure 17. Scree plot for with−leader group (short)




```
## $cfit.1
## [1] 0.6141660 0.6902390 0.5277708 0.4813618 0.4493051
```

Figure 18. VSS plot for with−leader group (short)



7.3 Explore factor solutions

7.3.1 Explore 2-factor solution

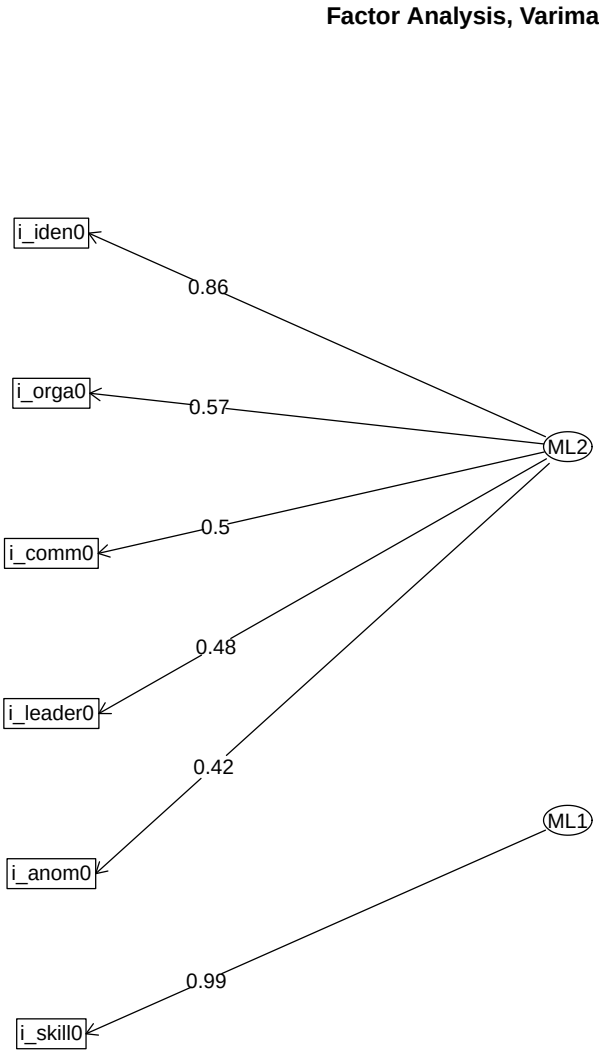


Table 24: Figure 19. Factor loadings of the 2-factor solution for with-leader group (short)

Item	ML2	ML1
i_leader0	0.485	
i_skill0		0.993
i_orga0	0.566	
i_comm0	0.504	
i_iden0	0.855	
i_anom0	0.421	

7.3.2 Explore 3-factor solution

Figure 20. Factor loadings of the 3−factor solution for with−leader group (short)

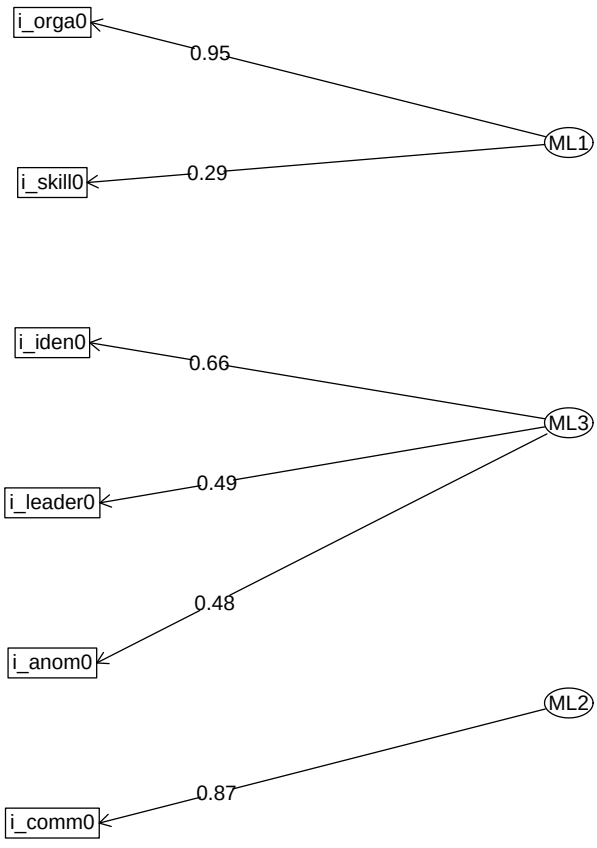


Table 25: Factor loadings of the 3-factor solution for with-leader group (short)

Item	ML1	ML3	ML2
i_leader0		0.487	
i_skill0			
i_orga0	0.947		
i_comm0			0.869
i_iden0	0.311	0.664	
i_anom0		0.478	

Table 26: Results of KMO test of sampling adequacy for without-leader group (long)

Item	KMO	if correlation acceptable*
i_skill1	0.778	Yes
i_skill2	0.686	Yes
i_skill3	0.731	Yes
i_skill4	0.678	Yes
i_orga1	0.833	Yes
i_orga2	0.748	Yes
i_orga3	0.806	Yes
i_comm1	0.717	Yes
i_comm2	0.805	Yes
i_comm3	0.809	Yes
i_iden1	0.809	Yes
i_iden2	0.621	Yes
i_iden3	0.808	Yes
i_anom1	0.654	Yes
i_anom2	0.684	Yes
i_anom3	0.472	No
i_anom4	0.596	No
Overall	0.745	
Selected†	0.762	

* having>0.3 correlation coefficient with at least one other item

† excluing i_anom3 and i_anom4

8 Factor analysis for without-leader group (long)

8.1 Check factoribility

The Kaiser-Meyer-Olkin measure of sampling adequacy was .745, above the commonly recommended value of .6. When the two items with <0.3 correlation with any other items were removed, the adequacy increased to 0.762, see table 24 and table 7.

Bartlett's test of sphericity were significant for full items (2 (136) = 476.483, p < .001) and selected items (2 (105) = 448.005, p < .001) , suggesting that there is a certain redundancy between the variables that we can summarize with a few number of factors.

Given these overall indicators, factor analysis was deemed to be suitable with all 15 of the 17 items (excluding two anomaly items). The following factor analysis were done on the these 18 items.

Table 27: Results of bartlett test for without-leader group (long)

Dataset	Chi-square	p-value	DF
Overall	476.483	<0.001	136
Select*	448.005	<0.001	105

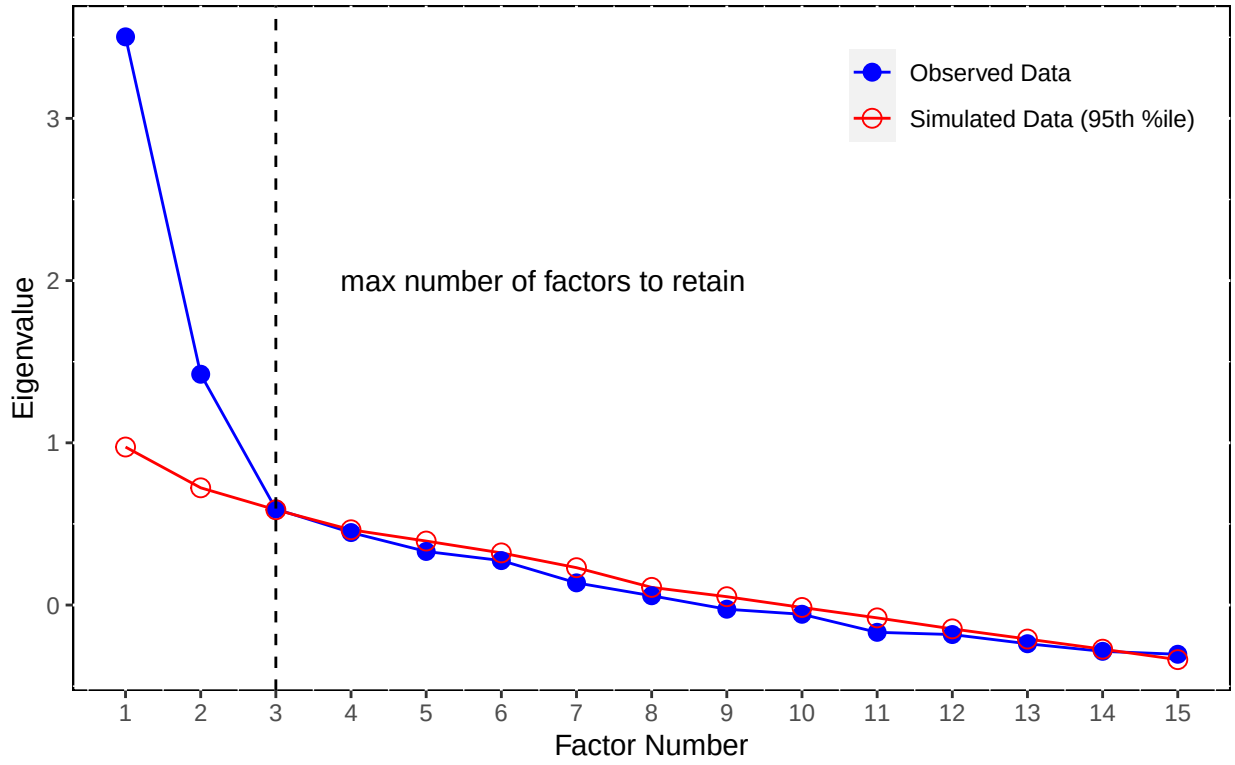
* excluing i_anom3 and i_anom4

8.2 Explore number of factors

Solutions for two, three, four and five were separately examined using varimax rotations of the factor loading matrix according to the results from scree plot, VSS, BIC and Velicer MAP.

```
## Parallel analysis suggests that the number of factors =  3  and the number of components =  NA
```

Figure 11. Scree plot for with−leader group (long)



The dashed vertical line indicates suggested max number of factors to retain

```
## $cfit.1
## [1] 0.5786478 0.5938570 0.4973617 0.4482269 0.4628736
```

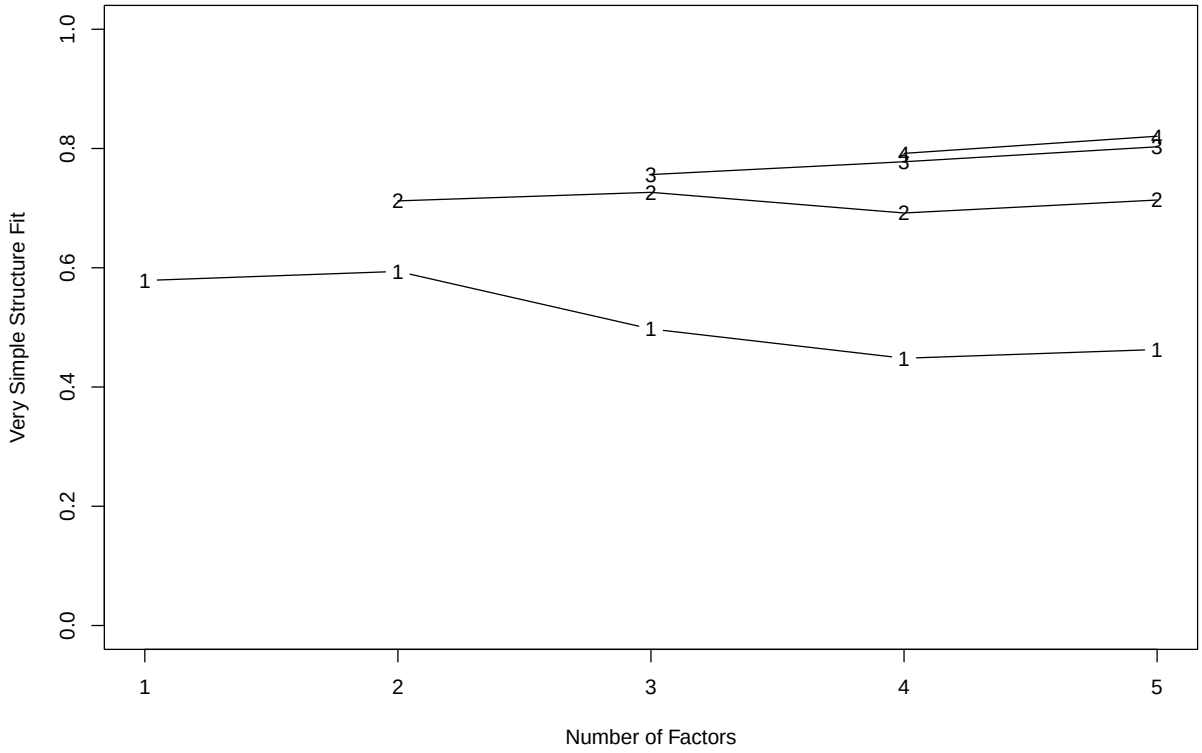
Table 28: Item removing process for 5 factor solution

		Factor loadings of the items removed					
Iteration	Item removed†	ML4	ML1	ML3	ML2	ML5	Variance Explained
model1	i_iden2	0.213	0.339	-0.003	0.064	-0.023	0.502
model2*	i_iden3	0.427	0.052	0.491	-0.050	0.231	0.513
model3*	i_skill1	0.253	-0.027	0.185	0.580	0.415	0.513
model4*	i_anom1	0.547	0.018	0.054	-0.062	0.426	0.484
model5*	i_comm2	0.133	0.092	0.575	0.149	0.435	0.543
model6	i_comm1	0.122	0.377	0.133	0.098	0.113	0.604

* The item removed for the model is due to cross-loading

† The items removed a model include the ones in the current and preceding rows

Figure 21. VSS plot for without−leader group (long)



8.3 Explore factor solutions

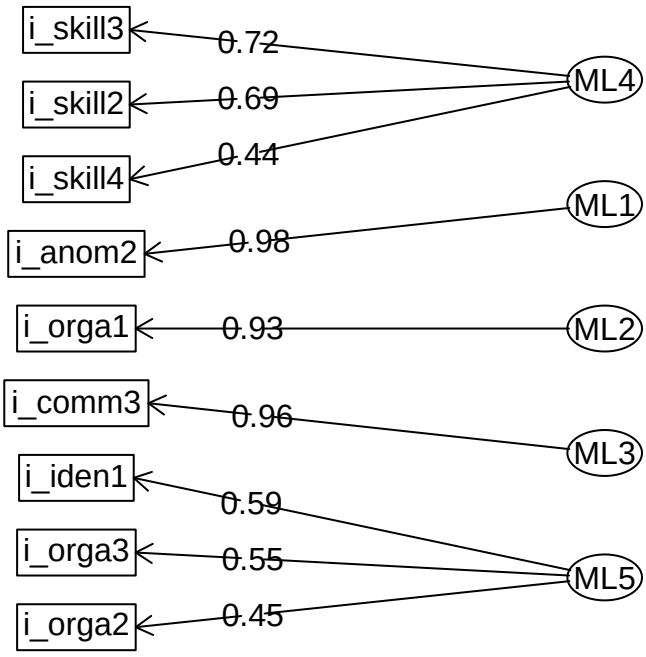
8.3.1 Explore 5-factor solution

After fitting 6 models, we achieved the most optimal model for 5 factor solution. The item removal process was encapsulated in table 26. Four item was removed due to cross loading and others were removed due to factor loading <0.4. The final model has 9 items, with 60.4% variance explained, see table 27 and figure 22. Note that three of the factor identified only involves one item (i_anom2, i_comm3, i_orga1), which is not a preferred situation.

Table 29: Factor loadings of the 5 factor solution for without-leader group (long)

Item	ML4	ML1	ML2	ML3	ML5
i_skill2	0.694				
i_skill3	0.724				
i_skill4	0.441				
i_orga1			0.935		
i_orga2					0.45
i_orga3					0.546
i_comm3				0.964	
i_iden1					0.588
i_anom2		0.983			

Figure 22. Path diagram of 5 factor solution, without−leader group (long)



8.3.2 Explore 4-factor solution

After fitting 8 models, we achieved the most optimal model for 4 factor solution. The item removal process was encapsulated in table 28. Three items were removed due to cross-loading, others removed due to factor loading <0.4. The final model has 7 items, with 58.7% variance explained, see table 29 and figure 23 Note that one factor identified only involves one item (i_comm3), which is not a preferred situation.

Table 30: Item removing process for 4 factor solution

		Factor loadings of the items removed				
Iteration	Item removed†	ML3	ML1	ML2	ML4	Variance Explained
model1	i_iden2	0.224	0.333	-0.007	0.028	0.440
model2	i_anom2	0.372	0.061	0.240	0.082	0.450
model3*	i_iden3	0.480	-0.037	0.476	0.149	0.470
model4*	i_skill1	0.439	0.548	0.176	0.260	0.467
model5	i_orga3	0.245	0.248	0.100	0.372	0.441
model6	i_iden1	0.277	0.213	0.249	0.332	0.463
model7*	i_skill4	0.074	0.202	0.454	-0.487	0.502
model8	i_orga1	0.291	-0.049	0.379	0.251	0.586

* '*' indicates the model is by removing a cross-loading item

† The items removed a model include the ones in the current and preceding rows

Table 31: Factor loadings of the 4 factor solution for with-leader group (long)

Item	ML1	ML3	ML2	ML4
i_skill2		0.877		
i_skill3		0.578		
i_orga2				0.465
i_comm1	0.487			
i_comm2	0.955			
i_comm3			0.94	
i_anom1				0.616

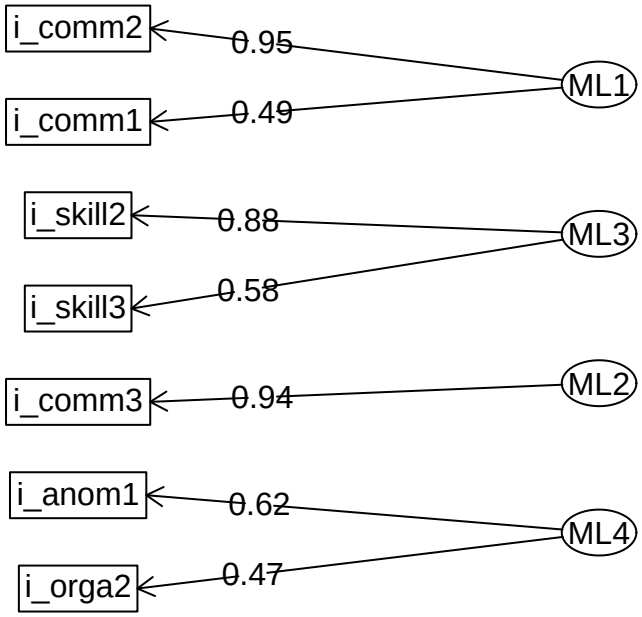
Table 32: Item removing process for 3 factor solution

		Factor loadings of the items removed			
Iteration	Item removed†	ML2	ML3	ML1	Variance Explained
model1	i_iden2	-0.025	0.247	0.332	0.392
model2	i_anom2	0.045	0.340	0.213	0.398
model3*	i_iden3	0.030	0.522	0.453	0.417
model4*	i_comm2	0.588	0.408	0.176	0.407
model5*	i_skill1	0.281	0.441	0.586	0.390
model6	i_anom1	-0.044	0.395	0.156	0.396
model7	i_comm1	0.125	0.165	0.380	0.433

* The item removed for the model is due to cross-loading

† The items removed a model include the ones in the current and preceding rows

Figure 23. Path diagram of 4 factor solution, without−leader group (long)



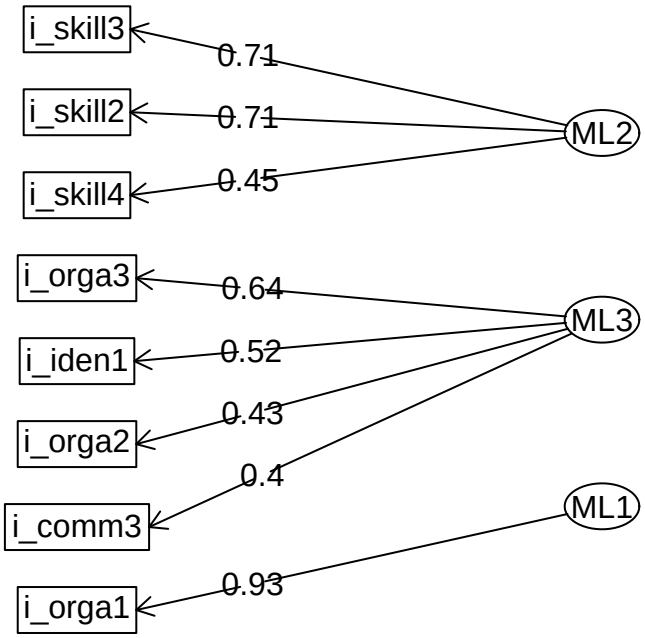
8.3.3 Explore 3-factor solution

After fitting 7 models, we achieved the most optimal model for 3 factor solution. The item removal process was encapsulated in table 30. Three items were removed due tocross-loading, and others due to factor loading <0.4. The final model has 8 items, with 43.3% variance explained, see table 31 and figure 24.

Table 33: Factor loadings of the 3 factor solution for without-leader group (long)

Item	ML2	ML3	ML1
i_skill2	0.707		
i_skill3	0.709		
i_skill4	0.447		
i_orga1			0.927
i_orga2		0.428	
i_orga3		0.641	
i_comm3		0.4	
i_iden1		0.52	

Figure 24. Path diagram of 3 factor solution, without−leader group (long)



8.3.4 Explore 2-factor solution

After fitting 4 models, we achieved the most optimal model for 2 factor solution. The item removal process was encapsulated in table 32 All items were removed due to factor loading <0.4. The final model has 11 items, with 38.2% variance explained, see table 33 and figure 25.

Table 34: Item removing process for 2 factor solution

	Factor loadings of the items removed			
Iteration	Item removed†	ML2	ML1	Variance Explained
model1	i_iden2	0.384	-0.016	0.326
model2	i_anom2	0.382	0.061	0.339
model3	i_anom1	0.383	-0.016	0.353
model4	i_iden1	0.397	0.286	0.382

* The item removed for the model is due to cross-loading

† The items removed a model include the ones in the current and preceding rows

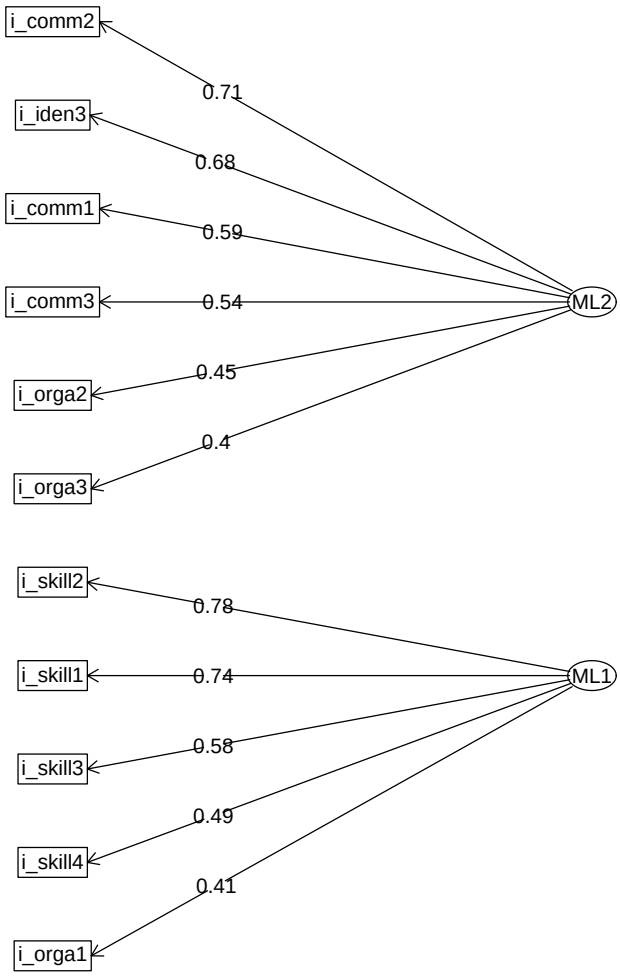
Table 35: Factor loadings of the 2 factor solution for with-noleader group (long)

Item	ML2	ML1
i_skill1		0.739
i_skill2		0.777
i_skill3		0.584
i_skill4		0.491
i_orga1		0.405
i_orga2	0.452	
i_orga3	0.402	
i_comm1	0.59	
i_comm2	0.707	
i_comm3	0.539	
i_iden3	0.677	

Table 36: Comparison between factor solutions, without-leader (long)

	VarianceExplained	Number of items
2-factor solution	0.382	11
3-factor solution	0.433	8
4-factor solution	0.586	7
5-factor solution	0.604	9

Figure 25. Path diagram of 2 factor solution, without−leader group (long)



8.4 Comparison between factor solutions, with-leader (long)

To be discussed.

Table 37: Results of KMO test of sampling adequacy for without-leader group (short)

	KMO
i_skill0	0.805
i_orga0	0.808
i_comm0	0.799
i_iden0	0.820
i_anom0	0.793
Overall	0.805

Table 38: Results of bartlett test for with-leader group (short)

Chi-square	p-value	DF
172.282	<0.001	10

9 Factor analysis for without-leader group (short)

9.1 Check factoribility

For without-leader group (short), it was observed that 5 of the 5 items correlated at least .3 with at least one other item, suggesting reasonable factorability. As such, no item was dropped for factoribility tests.

The Kaiser-Meyer-Olkin measure of sampling adequacy was .805, achieving "Good acceptance", see table 35.

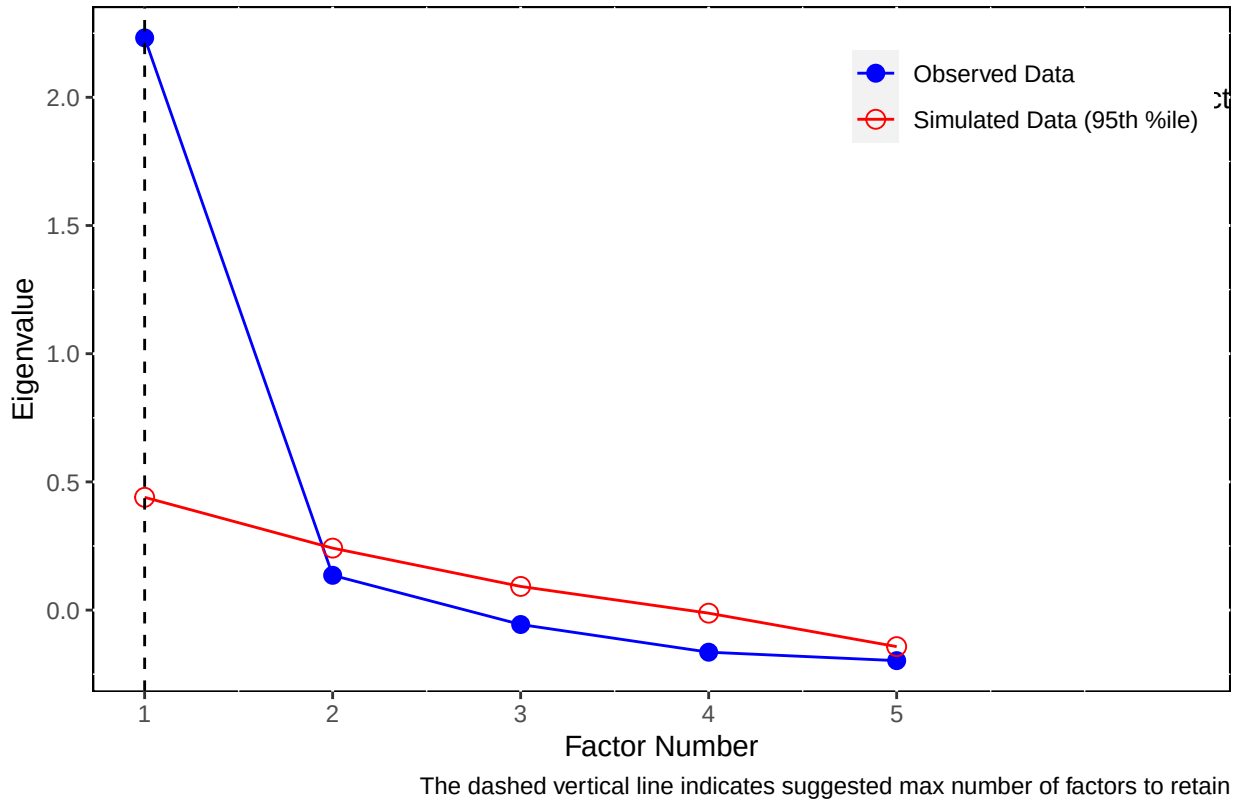
Bartlett's test of sphericity were significant for the items (2 (10) = 172.282, p < .001) , suggesting that there is a certain redundancy between the variables that we can summarize with a few number of factors. See table 36.

9.2 Explore number of factors

Scree plots (figures 26), Velicer MAP indicated an 1 factor solution, while and BIC and VSS suggested 2-factor solution (figures 27). Solutions for two was examined using varimax rotations of the factor loading matrix.

```
## Parallel analysis suggests that the number of factors =  1  and the number of components =  NA
```

Figure 26 Scree plot for with−leader group (short)




```
## $cfit.1
## [1] 0.8326668 0.6605220 0.4628216 0.3804124 0.4709021
```

Figure 27. VSS plot for with−leader group (short)

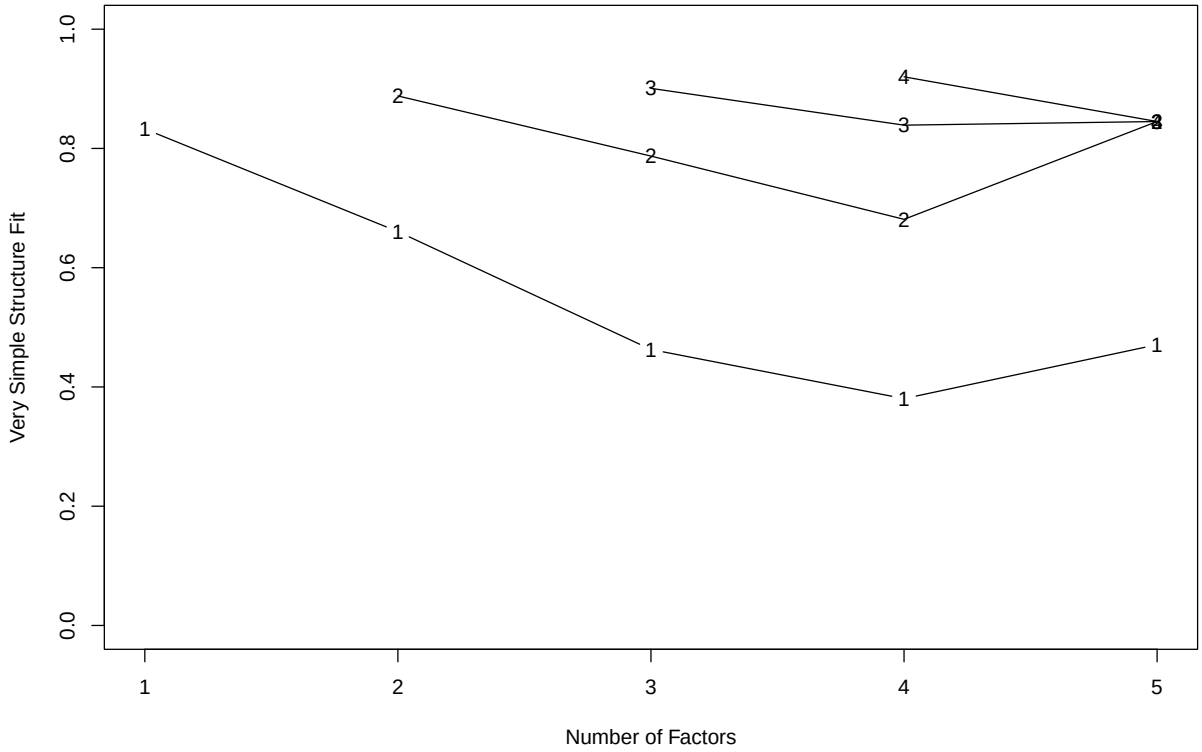
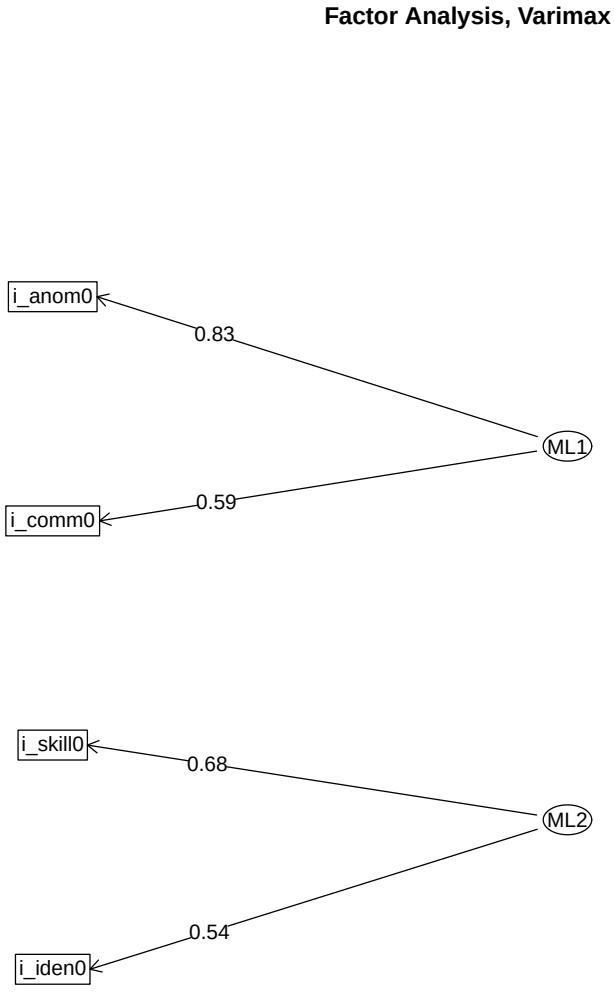


Table 39: Figure 28 Factor loadings of the 5-factor solution for without-leader group (short)

Item	ML1	ML2
i_skill0		0.678
i_comm0	0.585	0.348
i_iden0	0.482	0.545
i_anom0	0.832	

9.3 Explore 2-factor solution



10 Supplement File: case-wise discussion on NA and IDN

See the standalone md file