**Roles**

**Exploratory Factor Analysis (EFA), Reliability and Validity**

For variables V10 – V19 with response options:

1 = Strongly disagree

2 = Disagree

3 = Neutral or Undecided

4 = Agree

5 = Strongly agree

An EFA is conducted to see whether these questions/items can be collapsed into factors, because then we can report on the factors.

**Exploratory Factor Analysis (EFA) Round 1**

First, an EFA using Promax rotation and Principal Component Analysis extraction is conducted. As part of the Promax output, the Component Correlation Matrix is generated, which provides information on the number of components/factors that were extracted and the correlation between the factors. One must first investigate the correlations between the factors/components to decide on whether an oblique or an orthogonal rotation should be used. The former allows the factors to be correlated, whereas the latter does not (Field, 2018).

**Table 1**

*Component Correlation Matrix of the EFA Round 1*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Component | 1 | 2 | 3 | 4 |
| 1 | 1.000 | 0.228 | 0.161 | 0.154 |
| 2 | 0.228 | 1.000 | 0.153 | 0.220 |
| 3 | 0.161 | 0.153 | 1.000 | 0.084 |
| 4 | 0.154 | 0.220 | 0.084 | 1.000 |

From Table 1 it can be seen that 4 components were extracted and are correlated with correlations ranging from 0.084 to 0.228, thus, an oblique rotation, specifically Promax rotation, was used when conducting the EFA. A Promax rotation allows for components to be correlated, which, from Table 1, we see they are. When conducting the EFA, the Kaiser-Meyer-Olkin (KMO) and Bartlett’s test of sphericity were considered to see whether the data is suitable for dimension reduction (i.e. factor analysis). The KMO value of 0.600 is acceptable (Hutcheson & Sofroniou, 1999), indicating that the data is suitable for factor analysis. The p-value of Bartlett’s test of sphericity is less than 0.05 (*p* < 0.001), indicating that there is evidence that dimension reduction can be done. Next, the communalities were considered (see Table 2).

|  |  |  |
| --- | --- | --- |
| *KMO and Bartlett's Test* | | |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.600 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 170.244 |
| df | 45 |
| Sig. | 0.000 |

**Table 2**

*Communalities of the EFA Round 1*

|  |  |  |
| --- | --- | --- |
| *Communalities* | | |
|  | Initial | Extraction |
| V10: Role of educational audiologist - It is the role of educational audiologists to train teachers to support learners with hearing loss. | 1.000 | 0.762 |
| V11: Role of educational audiologist - It is the role of educational audiologists to collaborate with other professionals when managing learners with hearing loss. | 1.000 | 0.662 |
| V12: Role of educational audiologist - Educational audiologists are responsible for providing appropriate hearing devices to learners with hearing loss. | 1.000 | 0.750 |
| V13: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a specialized education setting. | 1.000 | 0.711 |
| V14: Role of educational audiologist - Educational audiologists should provide appropriate suggestions for classroom accommodations to support learners with hearing loss. | 1.000 | 0.819 |
| V15: Role of educational audiologist - When managing learners with hearing loss, educational audiologists have a responsibility to work in partnership with other health professionals (e.g., educational psychologists, speech-language therapists, etc.) | 1.000 | 0.692 |
| V16: Role of educational audiologist - Educational audiologists must assess the educational impact of hearing loss to support learners with hearing loss. | 1.000 | 0.505 |
| V17: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a general (mainstream) education setting. | 1.000 | 0.737 |
| V18\_RS: Role of educational audiologist - Educational audiologists are not responsible for providing information about hearing loss to teachers (reverse-scored) | 1.000 | 0.707 |
| V19\_RS: Role of educational audiologist - It is not the role of educational audiologists to ensure learners with hearing loss have the appropriate hearing devices (reverse-scored) | 1.000 | 0.764 |

Child (2006) recommends that any item with a communality less than 0.2 be removed, Holm et al. (2019) recommend the cut-off be 0.3, with other suggestions of acceptable cut-off values being between 0.25 and 0.4 (Eaton et al., 2019). Since the lowest communality is 0.505, it was decided to keep all items in the EFA based on the communalities. The factor loadings will be investigated later to see whether any of the items should be dropped at a later point in time. Next, the Total Variance Explained output was considered (see Table 3).

**Table 3**

*Total Variance Explained of the EFA Round 1*

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Initial Eigenvalues | | |
| Total | % of Variance | Cumulative % |
| **1** | **2.975** | **29.747** | **29.747** |
| **2** | **1.631** | **16.312** | **46.059** |
| **3** | **1.374** | **13.736** | **59.795** |
| **4** | **1.131** | **11.305** | **71.100** |
| 5 | 0.790 | 7.901 | 79.001 |
| 6 | 0.609 | 6.089 | 85.090 |
| 7 | 0.492 | 4.921 | 90.011 |
| 8 | 0.452 | 4.523 | 94.534 |
| 9 | 0.351 | 3.511 | 98.045 |
| 10 | 0.195 | 1.955 | 100.000 |

From Table 3 it can be seen that 4 factors were extracted (since 4 eigenvalues were greater than 1; indicated in bold). Collectively, these 4 factors explain 71.1% of the variance. The Pattern Matrix was considered next (see Table 4), which contains the item loadings. The highest loading per item is indicated in bold.

**Table 4**

*Pattern Matrix of the EFA Round 1*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Component | | | |
| 1 | 2 | 3 | 4 |
| V14: Role of educational audiologist - Educational audiologists should provide appropriate suggestions for classroom accommodations to support learners with hearing loss. | **0.868** | -0.109 | 0.213 | -0.005 |
| V10: Role of educational audiologist - It is the role of educational audiologists to train teachers to support learners with hearing loss. | **0.848** | 0.125 | -0.100 | 0.003 |
| V11: Role of educational audiologist - It is the role of educational audiologists to collaborate with other professionals when managing learners with hearing loss. | **0.816** | 0.068 | -0.095 | -0.079 |
| V18\_RS: Role of educational audiologist - Educational audiologists are not responsible for providing information about hearing loss to teachers (reverse-scored) | -0.036 | **0.821** | 0.191 | -0.170 |
| V15: Role of educational audiologist - When managing learners with hearing loss, educational audiologists have a responsibility to work in partnership with other health professionals (e.g., educational psychologists, speech-language therapists, etc.) | 0.071 | **0.793** | -0.036 | 0.091 |
| V16: Role of educational audiologist - Educational audiologists must assess the educational impact of hearing loss to support learners with hearing loss. | 0.097 | **0.557** | -0.056 | 0.299 |
| V12: Role of educational audiologist - Educational audiologists are responsible for providing appropriate hearing devices to learners with hearing loss. | 0.102 | -0.125 | **0.843** | 0.108 |
| V19\_RS: Role of educational audiologist - It is not the role of educational audiologists to ensure learners with hearing loss have the appropriate hearing devices (reverse-scored) | -0.132 | 0.297 | **0.806** | -0.081 |
| V17: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a general (mainstream) education setting. | -0.078 | 0.142 | -0.197 | **0.822** |
| V13: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a specialized education setting. | -0.008 | -0.108 | 0.321 | **0.777** |

Different cut-off values for the factor loadings have been recommended in the literature, with the lowest being 0.3 (Costello & Osborne, 2005; Hair et al., 2019) and the highest being 0.6 (Morris et al., 2017; Yen et al., 2014). Note that, when comparing factor loadings to some cut-off value, the absolute value of the factor loading is considered (i.e. the plus or minus sign is ignored). Using a conservative approach in ensuring that items load highly onto factors, items with loadings less than 0.6 were dropped (highlighted in red in Table 4), and the EFA was conducted again, only keeping the items with loadings greater than 0.6 (highlighted in green in Table 4).

**Exploratory Factor Analysis (EFA) Round 2**

The correlations between the components for the EFA, where items with loadings less than 0.6 have been dropped, are shown in Table 5, and since some of the components are correlated (correlations range from 0.094 to 0.175), Promax rotation (which allows for components to be correlated) was used.

**Table 5**

*Component Correlation Matrix of the EFA Round 2*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Component | 1 | 2 | 3 | 4 |
| 1 | 1.000 | 0.174 | 0.173 | 0.120 |
| 2 | 0.174 | 1.000 | 0.125 | 0.094 |
| 3 | 0.173 | 0.125 | 1.000 | 0.175 |
| 4 | 0.120 | 0.094 | 0.175 | 1.000 |

The KMO value of 0.634 acceptable (Hutcheson & Sofroniou, 1999), indicating that the data is suitable for factor analysis. The p-value of Bartlett’s test of sphericity is less than 0.05 (*p* < 0.001), indicating that there is evidence that dimension reduction can be done. Next, the communalities are considered (see Table 6).

|  |  |  |
| --- | --- | --- |
| *KMO and Bartlett's Test* | | |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.634 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 141.779 |
| df | 36 |
| Sig. | 0.000 |

**Table 6**

*Communalities of the EFA Round 2*

|  |  |  |
| --- | --- | --- |
| *Communalities* | | |
|  | Initial | Extraction |
| V10: Role of educational audiologist - It is the role of educational audiologists to train teachers to support learners with hearing loss. | 1.000 | 0.768 |
| V11: Role of educational audiologist - It is the role of educational audiologists to collaborate with other professionals when managing learners with hearing loss. | 1.000 | 0.687 |
| V12: Role of educational audiologist - Educational audiologists are responsible for providing appropriate hearing devices to learners with hearing loss. | 1.000 | 0.747 |
| V13: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a specialized education setting. | 1.000 | 0.722 |
| V14: Role of educational audiologist - Educational audiologists should provide appropriate suggestions for classroom accommodations to support learners with hearing loss. | 1.000 | 0.838 |
| V15: Role of educational audiologist - When managing learners with hearing loss, educational audiologists have a responsibility to work in partnership with other health professionals (e.g., educational psychologists, speech-language therapists, etc.) | 1.000 | 0.708 |
| V17: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a general (mainstream) education setting. | 1.000 | 0.784 |
| V18\_RS: Role of educational audiologist - Educational audiologists are not responsible for providing information about hearing loss to teachers (reverse-scored) | 1.000 | 0.750 |
| V19\_RS: Role of educational audiologist - It is not the role of educational audiologists to ensure learners with hearing loss have the appropriate hearing devices (reverse-scored) | 1.000 | 0.765 |

Since the lowest communality is 0.687, it was decided to keep all items in the EFA based on the communalities. The factor loadings will be investigated later to see whether any of the items should be dropped at a later point in time. Next, the Total Variance Explained output was considered (see Table 7).

**Table 7**

*Total Variance Explained of the EFA Round 2*

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Initial Eigenvalues | | |
| Total | % of Variance | Cumulative % |
| **1** | **2.744** | **30.487** | **30.487** |
| **2** | **1.598** | **17.759** | **48.246** |
| **3** | **1.301** | **14.454** | **62.700** |
| **4** | **1.125** | **12.504** | **75.204** |
| 5 | 0.614 | 6.828 | 82.031 |
| 6 | 0.529 | 5.875 | 87.906 |
| 7 | 0.457 | 5.076 | 92.982 |
| 8 | 0.380 | 4.227 | 97.209 |
| 9 | 0.251 | 2.791 | 100.000 |

From Table 7 it can be seen that 4 factors were extracted (since 4 eigenvalues were greater than 1; indicated in bold). Collectively, these 4 factors explain 75.2% of the variance. The Pattern Matrix was considered next (see Table 8), which contains the item loadings. The highest loading per item is indicated in bold.

**Table 8**

*Pattern Matrix of the EFA Round 2*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Component | | | |
| 1 | 2 | 3 | 4 |
| V14: Role of educational audiologist - Educational audiologists should provide appropriate suggestions for classroom accommodations to support learners with hearing loss. | **0.861** | 0.249 | -0.167 | -0.048 |
| V10: Role of educational audiologist - It is the role of educational audiologists to train teachers to support learners with hearing loss. | **0.857** | -0.096 | 0.119 | 0.026 |
| V11: Role of educational audiologist - It is the role of educational audiologists to collaborate with other professionals when managing learners with hearing loss. | **0.812** | -0.130 | 0.137 | -0.023 |
| V12: Role of educational audiologist - Educational audiologists are responsible for providing appropriate hearing devices to learners with hearing loss. | 0.081 | **0.844** | -0.098 | 0.080 |
| V19\_RS: Role of educational audiologist - It is not the role of educational audiologists to ensure learners with hearing loss have the appropriate hearing devices (reverse-scored) | -0.136 | **0.797** | 0.331 | -0.073 |
| V18\_RS: Role of educational audiologist - Educational audiologists are not responsible for providing information about hearing loss to teachers (reverse-scored) | -0.001 | 0.171 | **0.841** | -0.096 |
| V15: Role of educational audiologist - When managing learners with hearing loss, educational audiologists have a responsibility to work in partnership with other health professionals (e.g., educational psychologists, speech-language therapists, etc.) | 0.120 | -0.039 | **0.773** | 0.158 |
| V17: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a general (mainstream) education setting. | -0.041 | -0.202 | 0.129 | **0.855** |
| V13: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a specialized education setting. | 0.004 | 0.326 | -0.112 | **0.771** |

From Table 8 it can be seen that all the item loadings are above 0.6. Factor 1 (???), Factor 2 (???), Factor 3 (???) and Factor 4 (???) have 3, 2, 2, and 2 items, respectively. In the next section, reliability is considered. Following that, validity is considered. Reliability is presented before validity, since a test measure can be reliable but not valid. However, a measure can not be valid unless it’s reliable.

**How will you write up the EFA**

I recommend you focus the write-up on the final EFA. You can write something like:

An exploratory factors analysis (EFA) was conducted to explore the underlying factor structure of the Likert-type items with response options 1 = “strongly disagree” to 5 = “strongly agree”. Two iterations were conducted, as the first round involved using all the items, however, V16 (Role of educational audiologist - Educational audiologists must assess the educational impact of hearing loss to support learners with hearing loss) was dropped as its factor loading was too low. Only the results of the final EFA are reported here.

< Then you can report on the final EFA >

**Reliability**

The generally agreed upon lower limit for Cronbach alpha is 0.70 although some researchers advocate that a value as low as 0.60 is acceptable in general (Daud et al., 2018; Hancock & Mueller, 2013; Nunnally & Bernstein, 1994; Zhan et al., 2021), in exploratory research (Hair et al., 2019, Robinson et al., 1991) and in social sciences (Ghazali, 2008; Widaman, 1993). Table 9 contains the Cronbach’s alpha values for each factor.

**Table 9**

*Factors and Corresponding Cronbach’s Alpha Coefficients*

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Items | Number of items | Cronbach’s alpha |
| Factor 1: Management and support of learners with hearing loss | V10: Role of educational audiologist - It is the role of educational audiologists to train teachers to support learners with hearing loss.  V11: Role of educational audiologist - It is the role of educational audiologists to collaborate with other professionals when managing learners with hearing loss.  V14: Role of educational audiologist - Educational audiologists should provide appropriate suggestions for classroom accommodations to support learners with hearing loss. | 3 | 0.802 |
| Factor 2: Provision of appropriate hearing devices | V12: Role of educational audiologist - Educational audiologists are responsible for providing appropriate hearing devices to learners with hearing loss.  V19\_RS: Role of educational audiologist - It is not the role of educational audiologists to ensure learners with hearing loss have the appropriate hearing devices (reverse-scored) | 2 | 0.624 |
| Factor 3: Collaboration with other healthcare professionals and teachers | V15: Role of educational audiologist - When managing learners with hearing loss, educational audiologists have a responsibility to work in partnership with other health professionals (e.g., educational psychologists, speech-language therapists, etc.)  V18\_RS: Role of educational audiologist - Educational audiologists are not responsible for providing information about hearing loss to teachers (reverse-scored) | 2 | 0.630 |
| Factor 4: Providing hearing screenings in schools | V13: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a specialized education setting.  V17: Role of educational audiologist - It is important for educational audiologists to provide hearing screening services in a general (mainstream) education setting. | 2 | 0.537 |

From Table 9 it can be seen that the Cronbach’s alpha coefficients for all the factors are acceptable, except for Factor 4.

Although Cronbach’s alpha is the most widely used statistic for establishing reliability; researchers have argued that it should not be applied to scales/constructs with few items (less than 10) as scales/constructs with fewer items are vulnerable to underestimation due to the property that Cronbach’s alpha value increases as the number of items on the scale/construct increases (Pallant, 2020; Robertson & Evans, 2020). The recommendation is that the mean inter-item correlation (MIIC) is a more appropriate measure of scale/construct reliability, with there being different recommendations ranging from 0.1 (Pallant, 2020) and 0.3 (Hajjar, 2018) or higher acceptable, with values between 0.2 and 0.4 being optimal (Robertson & Evans, 2020). Spearman correlation (rs) was used as the items are Likert-scale items. Thus, for Factor 4, since it only has 2 items and the Cronbach’s alpha value was below 0.6, the correlation between the two items was considered (*r* = 0.514, *p* < 0.001) and it was acceptable, thus, establishing the internal consistency of Factor 4. Now that the reliability has been established for all four factors, the validity is considered next.

**Validity**

To establish construct validity, convergent validity (items belonging to the same construct should correlate highly) and discriminant validity (items not belonging to the same construct should have low correlations) should be established (Healy & Twycross, 2015). The Spearman correlations (denoted rs) for Factors 1 to 4 are shown in Tables ??? to ???, respectively, and they provide evidence that convergent validity has been established.

**Table ???**

*Spearman Correlations for Factor 1*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | V10 | V11 | V14 |
| V10 | rs | 1.000 | 0.565\* | 0.368\* |
| p |  | <0.001 | 0.003 |
| n | 64 | 64 | 64 |
| V11 | rs | 0.565\* | 1.000 | 0.372\* |
| p | <0.001 |  | 0.003 |
| n | 64 | 64 | 64 |
| V14 | rs | 0.368\* | 0.372\* | 1.000 |
| p | 0.003 | 0.003 |  |
| n | 64 | 64 | 64 |

\*Statistically significant (*p* < 0.05)

Since all the p-values < 0.05, all correlations are statistically significant and range from 0.368 to 0.565.

**Table ???**

*Spearman Correlations for Factor 2*

|  |  |  |  |
| --- | --- | --- | --- |
|  | | V12 |  |
| V19\_RS | rs | 0.572\* |  |
| p | <0.001 |  |
| n | 64 |  |

\*Statistically significant (*p* < 0.05)

Since the p-value < 0.05, the correlation of 0.572 between V12 and V19\_RS is statistically significant.

**Table ???**

*Spearman Correlations for Factor 3*

|  |  |  |
| --- | --- | --- |
|  | | V15 |
| V18\_RS | rs | 0.426\* |
| p | <0.001 |
| n | 64 |

\*Statistically significant (*p* < 0.05)

Since the p-value < 0.05, the correlation of 0.426 between V15 and V18\_RS is statistically significant.

**Table ???**

|  |  |  |
| --- | --- | --- |
|  | | V13 |
| V17 | rs | 0.514\* |
| p | <0.001 |
| n | 64 |

\*Statistically significant (*p* < 0.05)

Since the p-value < 0.05, the correlation of 0.514 between V13 and V17 is statistically significant.

For discriminant validity, items not belonging to the same construct should have low correlations. As a table containing all correlations between different constructs is too large to fit into one page, it is simply mentioned here that the correlations of items between different constructs are low, indicating that discriminant validity has been established. However, one example is given for illustration purposes. The correlation between V10 (Factor 1) and V12 (Factor 2) is 0.043 with a p-value of 0.735 which is not statistically significant (p > 0.05).

Thus, since both convergent and discriminant validity have been established, construct validity is established.

# What happens now that the factors have been extracted and reliability and validity have been established?

Now that we have identified items loading onto factors, and shown them to be reliable and valid, we will next average over the items of a factor, creating an average which will represent the factor, and then we can compare the factors.

**Table YYY**

*Descriptive Statistics of the Factors*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Factor 1 | Factor 2 | Factor 3 | Factor 4 |
| Mean | 4.69 | 4.27 | 4.78 | 4.34 |
| Median | 5.00 | 4.50 | 5.00 | 4.50 |
| Std. Deviation | 0.59 | 0.88 | 0.36 | 0.67 |
| Minimum | 1.00 | 1.50 | 4.00 | 2.50 |
| Maximum | 5.00 | 5.00 | 5.00 | 5.00 |
| Range | 4.00 | 3.50 | 1.00 | 2.50 |
| Interquartile Range | 0.58 | 1.00 | 0.50 | 1.00 |

Since the Likert-scale ranged from 1 = “strongly disagree” to 5 = “strongly agree”, a mean (*M*) and median (*Mdn*) above the midpoint of 3 indicates that the respondents were in agreement with the statements of a factor and a value less than 3 indicates they were in disagreement. From Table YYY it can be seen that none of the *M* and *Mdn* values are below 3, indicating that the respondents were in agreement with the statements of the factors and agreed the most strongly with the statements of Factor 3 (*M* = 4.78, *Mdn* = 5.00), Factor 1 (*M* = 4.69, *Mdn* = 5.00), agreed less strongly with the statements of Factor 4 (*M* = 4.34, *Mdn* = 4.50) and were least in agreement with statements of Factor 2 (*M* = 4.27, *Mdn* = 4.50).

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