**Responsibilities**

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

For variables V20 – V31 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 | 0.356 | 0.440 | -0.040 |
| 2 | 0.356 | 1.000 | 0.268 | -0.064 |
| 3 | 0.440 | 0.268 | 1.000 | -0.143 |
| 4 | -0.040 | -0.064 | -0.143 | 1.000 |

From Table 1 it can be seen that 4 components were extracted and are correlated with correlations ranging from 0.040 to 0.440 in absolute value, 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 0.690 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. | | 0.690 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 293.169 |
| df | 66 |
| Sig. | 0.000 |

**Table 2**

*Communalities of the EFA Round 1*

|  |  |  |
| --- | --- | --- |
|  | Initial | Extraction |
| V20: Responsibilities of educational audiologist - Administering a school-based hearing screening program is the responsibility of educational audiologists. | 1.000 | 0.798 |
| V21: Responsibilities of educational audiologist - Educational audiologists have to assess learners’ functional listening performance. | 1.000 | 0.621 |
| V22: Responsibilities of educational audiologist - Educational audiologists have a responsibility to counsel parents, teachers, and learners on hearing loss. | 1.000 | 0.733 |
| V23: Responsibilities of educational audiologist - Educational audiologists should ensure that learners' hearing devices are operating optimally. | 1.000 | 0.858 |
| V24: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to facilitate group activities with learners with hearing loss. | 1.000 | 0.661 |
| V25: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that recommendations are followed by the team managing learners with hearing loss. | 1.000 | 0.729 |
| V26: Responsibilities of educational audiologist - It is necessary for educational audiologists to educate parents and teachers about ways to prevent hearing loss. | 1.000 | 0.522 |
| V27: Responsibilities of educational audiologist - Educational audiologists should be in charge of managing a school-based hearing screening program. | 1.000 | 0.833 |
| V28\_RS: Responsibilities of educational audiologist - It is not the responsibility of educational audiologists to perform classroom acoustic measurements (reverse-scored). | 1.000 | 0.831 |
| V29: Responsibilities of educational audiologist - Working with a team is an important responsibility of educational audiologists. | 1.000 | 0.343 |
| V30: Responsibilities of educational audiologist - Educational audiologists must coach families of learners with hearing loss to participate in group activities for learners with hearing loss | 1.000 | 0.658 |
| V31: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that learners’ hearing devices are functioning optimally. | 1.000 | 0.776 |

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); in the current study, a conservative approach was used and 0.4 was used as the cut-off criterium. Only the communality of V29 is below 0.4 (communality = 0.343) and, accordingly, V29 was dropped and the EFA was re-run.

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

The correlations between the components for the EFA, where V29 has been dropped, are shown in Table 3, and since some of the components are correlated (correlations range from 0.042 to 0.449 in absolute value), Promax rotation (which allows for components to be correlated) was used.

**Table 3**

*Component Correlation Matrix of the EFA Round 2*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Component | 1 | 2 | 3 | 4 |
| 1 | 1.000 | 0.350 | 0.301 | -0.046 |
| 2 | 0.350 | 1.000 | 0.449 | -0.042 |
| 3 | 0.301 | 0.449 | 1.000 | -0.145 |
| 4 | -0.046 | -0.042 | -0.145 | 1.000 |

The KMO value of 0.678 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 4).

|  |  |  |
| --- | --- | --- |
| *KMO and Bartlett's Test* | | |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.678 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 280.246 |
| df | 55 |
| Sig. | 0.000 |

**Table 4**

*Communalities of the EFA Round 2*

|  |  |  |
| --- | --- | --- |
|  | Initial | Extraction |
| V20: Responsibilities of educational audiologist - Administering a school-based hearing screening program is the responsibility of educational audiologists. | 1.000 | 0.824 |
| V21: Responsibilities of educational audiologist - Educational audiologists have to assess learners’ functional listening performance. | 1.000 | 0.635 |
| V22: Responsibilities of educational audiologist - Educational audiologists have a responsibility to counsel parents, teachers, and learners on hearing loss. | 1.000 | 0.711 |
| V23: Responsibilities of educational audiologist - Educational audiologists should ensure that learners' hearing devices are operating optimally. | 1.000 | 0.852 |
| V24: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to facilitate group activities with learners with hearing loss. | 1.000 | 0.689 |
| V25: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that recommendations are followed by the team managing learners with hearing loss. | 1.000 | 0.748 |
| V26: Responsibilities of educational audiologist - It is necessary for educational audiologists to educate parents and teachers about ways to prevent hearing loss. | 1.000 | 0.527 |
| V27: Responsibilities of educational audiologist - Educational audiologists should be in charge of managing a school-based hearing screening program. | 1.000 | 0.867 |
| V28\_RS: Responsibilities of educational audiologist - It is not the responsibility of educational audiologists to perform classroom acoustic measurements (reverse-scored). | 1.000 | 0.834 |
| V30: Responsibilities of educational audiologist - Educational audiologists must coach families of learners with hearing loss to participate in group activities for learners with hearing loss | 1.000 | 0.672 |
| V31: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that learners’ hearing devices are functioning optimally. | 1.000 | 0.790 |

Since the lowest communality is 0.527, 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 5).

**Table 5**

*Total Variance Explained of the EFA Round 2*

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Initial Eigenvalues | | |
| Total | % of Variance | Cumulative % |
| **1** | **3.838** | **34.892** | **34.892** |
| **2** | **1.887** | **17.158** | **52.051** |
| **3** | **1.387** | **12.609** | **64.660** |
| **4** | **1.036** | **9.422** | **74.081** |
| 5 | 0.652 | 5.926 | 80.007 |
| 6 | 0.580 | 5.269 | 85.276 |
| 7 | 0.512 | 4.654 | 89.930 |
| 8 | 0.441 | 4.007 | 93.937 |
| 9 | 0.298 | 2.707 | 96.644 |
| 10 | 0.236 | 2.145 | 98.789 |
| 11 | 0.133 | 1.211 | 100.000 |

From Table 5 it can be seen that 4 factors were extracted (since 4 eigenvalues were greater than 1; indicated in bold). Collectively, these 4 factors explain 74.1% of the variance. The Pattern Matrix was considered next (see Table 6), which contains the item loadings. The highest loading per item is indicated in bold.

**Table 6**

*Pattern Matrix of the EFA Round 2*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Component | | | |
| 1 | 2 | 3 | 4 |
| V23: Responsibilities of educational audiologist - Educational audiologists should ensure that learners' hearing devices are operating optimally. | **0.975** | -0.139 | -0.113 | 0.156 |
| V31: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that learners’ hearing devices are functioning optimally. | **0.930** | -0.090 | -0.070 | 0.096 |
| V26: Responsibilities of educational audiologist - It is necessary for educational audiologists to educate parents and teachers about ways to prevent hearing loss. | **0.582** | 0.090 | 0.214 | -0.033 |
| V25: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that recommendations are followed by the team managing learners with hearing loss. | -0.056 | **0.946** | -0.204 | 0.119 |
| V21: Responsibilities of educational audiologist - Educational audiologists have to assess learners’ functional listening performance. | -0.194 | **0.869** | -0.066 | 0.010 |
| V24: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to facilitate group activities with learners with hearing loss. | 0.092 | **0.731** | 0.102 | -0.085 |
| V30: Responsibilities of educational audiologist - Educational audiologists must coach families of learners with hearing loss to participate in group activities for learners with hearing loss | 0.085 | **0.534** | 0.386 | 0.091 |
| V27: Responsibilities of educational audiologist - Educational audiologists should be in charge of managing a school-based hearing screening program. | 0.019 | -0.123 | **0.972** | -0.014 |
| V20: Responsibilities of educational audiologist - Administering a school-based hearing screening program is the responsibility of educational audiologists. | -0.120 | -0.031 | **0.955** | 0.054 |
| V28\_RS: Responsibilities of educational audiologist - It is not the responsibility of educational audiologists to perform classroom acoustic measurements (reverse-scored). | 0.276 | 0.133 | 0.046 | **0.862** |
| V22: Responsibilities of educational audiologist - Educational audiologists have a responsibility to counsel parents, teachers, and learners on hearing loss. | 0.527 | 0.153 | -0.010 | **-0.569** |

From Table 6, it can be seen that V22, V26 and V30 have factor loadings less than 0.6 and, accordingly, these items were dropped. V28\_RS also had to be dropped, since a factor (in this case, Factor 4) can not consist of only one item, and V28\_RS didn’t load significantly (loading more than 0.6) onto any of the other factors.

**Exploratory Factor Analysis (EFA) Round 3**

The correlations between the components for the EFA Round 3 are shown in Table 7, and since some of the components are correlated (correlations range from 0.128 to 0.313), Promax rotation (which allows for components to be correlated) was used.

**Table 7**

*Component Correlation Matrix of the EFA Round 3*

|  |  |  |  |
| --- | --- | --- | --- |
| Component | 1 | 2 | 3 |
| 1 | 1.000 | 0.150 | 0.313 |
| 2 | 0.150 | 1.000 | 0.128 |
| 3 | 0.313 | 0.128 | 1.000 |

The KMO value of 0.539 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 are considered (see Table 8).

KMO and Bartlett's Test

|  |  |  |
| --- | --- | --- |
| Kaiser-Meyer-Olkin Measure of Sampling Adequacy. | | 0.539 |
| Bartlett's Test of Sphericity | Approx. Chi-Square | 174.590 |
| df | 21 |
| Sig. | 0.000 |

**Table 8**

*Communalities of the EFA Round 3*

|  |  |  |
| --- | --- | --- |
|  | Initial | Extraction |
| V20: Responsibilities of educational audiologist - Administering a school-based hearing screening program is the responsibility of educational audiologists. | 1.000 | 0.862 |
| V21: Responsibilities of educational audiologist - Educational audiologists have to assess learners’ functional listening performance. | 1.000 | 0.660 |
| V23: Responsibilities of educational audiologist - Educational audiologists should ensure that learners' hearing devices are operating optimally. | 1.000 | 0.883 |
| V24: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to facilitate group activities with learners with hearing loss. | 1.000 | 0.710 |
| V25: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that recommendations are followed by the team managing learners with hearing loss. | 1.000 | 0.744 |
| V27: Responsibilities of educational audiologist - Educational audiologists should be in charge of managing a school-based hearing screening program. | 1.000 | 0.863 |
| V31: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that learners’ hearing devices are functioning optimally. | 1.000 | 0.892 |

Since the lowest communality is 0.660, 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 9).

**Table 9**

*Total Variance Explained of the EFA Round 3*

|  |  |  |  |
| --- | --- | --- | --- |
| Component | Initial Eigenvalues | | |
| Total | % of Variance | Cumulative % |
| **1** | **2.619** | **37.420** | **37.420** |
| **2** | **1.686** | **24.088** | **61.508** |
| **3** | **1.309** | **18.706** | **80.214** |
| 4 | 0.540 | 7.714 | 87.928 |
| 5 | 0.409 | 5.839 | 93.766 |
| 6 | 0.291 | 4.153 | 97.919 |
| 7 | 0.146 | 2.081 | 100.000 |

From Table 9 it can be seen that 3 factors were extracted (since 3 eigenvalues were greater than 1; indicated in bold). Collectively, these 3 factors explain 80.2% of the variance. The Pattern Matrix was considered next (see Table 10), which contains the item loadings. The highest loading per item is indicated in bold.

**Table 10**

*Pattern Matrix of the EFA Round 3*

|  |  |  |  |
| --- | --- | --- | --- |
|  | Component | | |
| 1 | 2 | 3 |
| V25: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that recommendations are followed by the team managing learners with hearing loss. | **0.889** | 0.037 | -0.135 |
| V21: Responsibilities of educational audiologist - Educational audiologists have to assess learners’ functional listening performance. | **0.825** | -0.158 | -0.013 |
| V24: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to facilitate group activities with learners with hearing loss. | **0.725** | 0.140 | 0.196 |
| V23: Responsibilities of educational audiologist - Educational audiologists should ensure that learners' hearing devices are operating optimally. | -0.041 | **0.949** | -0.038 |
| V31: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that learners’ hearing devices are functioning optimally. | 0.019 | **0.939** | 0.015 |
| V27: Responsibilities of educational audiologist - Educational audiologists should be in charge of managing a school-based hearing screening program. | -0.060 | 0.025 | **0.943** |
| V20: Responsibilities of educational audiologist - Administering a school-based hearing screening program is the responsibility of educational audiologists. | 0.031 | -0.053 | **0.924** |

From Table 10 it can be seen that all the item loadings are above 0.6. Factor 1 (???), Factor 2 (???) and Factor 3 (???) have 3, 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”. A couple of iterations were done, as the first round involved using all the items, however some items were dropped iteratively since the communalities and factor loadings were too low. We removed items with communalities less than 0.4 (Eaton et al., 2019) and factor loadings less than 0.6 (Morris et al., 2017). As this was an iterative process, the EFA was conducted a couple of times with items not meeting the cut-off criteria be dropped at each iteration, and only the final EFA is reported on.

< 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 11 contains the Cronbach’s alpha values for each factor.

**Table 11**

*Factors and Corresponding Cronbach’s Alpha Coefficients*

|  |  |  |  |
| --- | --- | --- | --- |
| Factor | Items | Number of items | Cronbach’s alpha |
| Factor 1: Ensuring optimal listening performance and interactions with peers | V21: Responsibilities of educational audiologist - Educational audiologists have to assess learners’ functional listening performance.  V24: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to facilitate group activities with learners with hearing loss.  V25: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that recommendations are followed by the team managing learners with hearing loss. | 3 | 0.756 |
| Factor 2: Ensuring optimal function of learners’ hearing devices | V23: Responsibilities of educational audiologist - Educational audiologists should ensure that learners' hearing devices are operating optimally.  V31: Responsibilities of educational audiologist - It is the responsibility of educational audiologists to ensure that learners’ hearing devices are functioning optimally. | 2 | 0.875 |
| Factor 3: Administering and managing a school-based hearing screening program | V20: Responsibilities of educational audiologist - Administering a school-based hearing screening program is the responsibility of educational audiologists.  V27: Responsibilities of educational audiologist - Educational audiologists should be in charge of managing a school-based hearing screening program. | 2 | 0.846 |

From Table 11 it can be seen that the Cronbach’s alpha coefficients for all the factors are acceptable. 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 3 are shown in Tables ??? to ???, respectively, and they provide evidence that convergent validity has been established.

**Table ???**

*Spearman Correlations for Factor 1*

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | V21 | V24 | V25 |
| V21 | rs | 1.000 | 0.468\* | 0.434\* |
| p |  | <0.001 | <0.001 |
| n | 64 | 64 | 64 |
| V24 | rs | 0.468\* | 1.000 | 0.617\* |
| p | <0.001 |  | <0.001 |
| n | 64 | 64 | 64 |
| V25 | rs | 0.434\* | 0.617\* | 1.000 |
| p | <0.001 | <0.001 |  |
| n | 64 | 64 | 64 |

\*Statistically significant (*p* < 0.05)

Since all the p-values < 0.05, all correlations are statistically significant and range from 0.434 to 0.617.

**Table ???**

*Spearman Correlations for Factor 2*

|  |  |  |
| --- | --- | --- |
|  | | V23 |
| V31 | rs | 0.767\* |
| p | <0.001 |
| n | 64 |

\*Statistically significant (*p* < 0.05)

Since the p-value < 0.05, the correlation of 0.767 between V23 and V31 is statistically significant.

**Table ???**

*Spearman Correlations for Factor 3*

|  |  |  |
| --- | --- | --- |
|  | | V20 |
| V27 | rs | 0.656\* |
| p | <0.001 |
| n | 64 |

\*Statistically significant (*p* < 0.05)

Since the p-value < 0.05, the correlation of 0.656 between V20 and V27 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 V20 (Factor 3) and V23 (Factor 2) is 0.077 with a p-value of 0.544 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 |
| Mean | 4.12 | 4.56 | 4.06 |
| Median | 4.00 | 5.00 | 4.00 |
| Std. Deviation | 0.63 | 0.61 | 0.78 |
| Minimum | 2.33 | 3.00 | 2.00 |
| Maximum | 5.00 | 5.00 | 5.00 |
| Range | 2.67 | 2.00 | 3.00 |
| Interquartile Range | 1.00 | 1.00 | 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 2 (*M* = 4.56, *Mdn* = 5.00), agreed less strongly with the statements of Factor 1 (*M* = 4.12, *Mdn* = 4.00) and were least in agreement with statements of Factor 3 (*M* = 4.06, *Mdn* = 4.00).

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