Efficacy of ordinal alpha reliability method using teacher literacy and practice of school-based assessment data

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Abstract

The credibility of research findings depends to a large extent on the quality of the instruments used to measure the variables involved. As important as reliability index of an instrument is, it is disappointing that many researchers use inappropriate methods, for instance, the use of Cronbach reliability method instead of Ordinal Alpha to establish the reliability index of an ordinal scale, which is inappropriate. A study that will establish the efficacy of the ordinal alpha method and also correct the error of misuse of Cronbach alpha method becomes imperative. Hence, the study adopted Survey approach. Teachers in the basic 1-9 classes in Bomadi, Patani and Ughelli local government areas in Delta State were sampled to complete the instrument. Completion and return rate was 84%. The results showed that estimated reliability index using Cronbach alpha and ordinal alpha methods were 0.64 and 0.71 respectively. Eleven items correlated negatively with the construct when Cronbach alpha method was used; whereas only 3 items fell into this category, when Ordinal alpha method was used. The use Qfordinal alpha leads to higher reliability index and retention of more items. Hence, scale developers and researchers should employ ordinal alpha method anytime ordinal scale is being constructed.

Introduction

Before any measuring instrument can have worth and credibility, it must possess reliability as one of its desirable qualities or characteristics. Reliability - together with its counterpart, validity -O are basic properties of measurement scales and tests (Gadermann et al., 2014). Reliability is the extent to which a measuring instrument is able to measure whatever it is out to measure consistently. The matter of consistency is key when we address the issue of reliability, such as the consistency of scores obtained from a test result; the consistency of scores obtained from the use of a particular instrument under certain specified circumstances, and by individuals with a particular set of defined characteristics.

For instance, researchers want to know if certain groups of persons will obtain the same scores on the same tests given at different times, or when given equivalent forms of the same tests about the same time or within a short interval. Reliability shows how dependable the results obtained from a test or instrument is; this is known as the level of internal consistency of that instrument or the level of its stability over a period of time. In other words, if this instrument is repeated among the same set of people at another time, or among a different set of people with similar characteristics, to what extent will they obtain the same scores or something very close; will it yield similar results? Furthermore, do such results obtained really reflect those characteristics being measured in real life? Do the scores reflect the extent of the real-life characteristics possessed by such individuals or are they just matter of chance? If a person consistently scores high in the trait of conscientiousness, for instance, to what extent is such a person really conscientious in real life? Reliability of psychological measuring instruments is not an easy feat to obtain because the measurement of psychological traits or variables is comparatively more difficult than that of physical traits due to the indirect means of obtaining them, and as such may not be completely stable over a period of time (Kothari, 2013). Also, reliable measuring instruments contribute to validity, but reliability does not necessarily connote validity. Determining the reliability of test is like comparing the test results to itself in order to determine how much of internal consistency it possesses, which will determine how stable it is very likely to be over time (hence the symbol of test reliability is rxx). In other words, reliability essentially involves computing the correlation coefficient on two sets of scores from the same group of people using a particular test or equivalent forms of the same test that is expected to produce similar results (Joshua, 2017; Kothari, 2013).

There are different types of reliability measures such as test-retest, equivalent forms, split- half, Kuder-Richardson KR 20 for objective items which are scored dichotomously (meaning that one is either right or wrong and where: right = I and wrong its counterpart KR21; and Cronbach coefficient alpha. According to Cronbach (1951), one of the most popular methods of Cronbach alpha is the Kuder Richardson coefficient of equivalence (popularly known as K-R 21). Cronbach alpha has been very a useful method of establishing reliability or as an estimate of an approximate value of an index of equivalence, especially for moderate and long tests (Flora & Curran, 2004).

The result of reliability using any of these methods yield a reliability index which can range from 0-1, where O indicates absolutely unreliable on one extreme end and I is an indication of perfect reliability on the other extreme. However, these absolute extreme hardly exist in real life. Of all these methods, Cronbach coefficient alpha is the most widely used and at the same time the most abused index of reliability in the social sciences (Zumbo & Rupp, 2004; Gadermann et al., 2014). This is most likely due to its popular use in determining the reliability of essay items and Likert scaled items such as questionnaires, rating scales, and any sets of scores involving a range of answers and where there are no right or wrong answers.

Of recent, the appropriateness of the use of Cronbach Alpha in establishing the reliability index of an ordinal scaled data such as a Likert scale has come under serious scrutiny. Zumbo & Rupp (2004) further assert that as important as the reliability of instrument is, it is disappointing to

note that many researchers use inappropriate methods. The reason Cronbach Alpha is not appropriate for establishing the reliability coefficient of a questionnaire and other nominal scaled data, and the efficacy of an alternative method- the Alpha reliability method- is the purpose of this paper.

As is well known, Cronbach's alpha is a function of the number of items, the inter-item correlations and the variance of the total scores. Traditionally, this inter-item correlation used in estimating alpha is done using Pearson correlation, which assumes a continuous variable (Zumbo et al., 2007). When dealing with ordinal data however, that is, when the scale items are at ordinal level, this approach may have some challenges (National Survey of Students' Engagement, 2018).

In other words, Cronbach's alpha estimates are typically computed using Pearson's covariate matrix. It should be noted that one of the basic assumptions necessitating the use of such a matrix is that the item response (data) must be continuous in nature, otherwise the result of the Pearson correlation matrix may be distorted (Zumbo & Rupp, 2004; Rupp et al., 2003; Osborn, 2000). Meanwhile, software packages such as SPSS and SAS, by default, use Cronbach alpha to estimate internal consistency using Pearson correlation matrix, while ignoring the Likert response format of such items which is ordinal in nature (Zumbo et.al., 2007).

Some researchers have argued that summing up any type of Likert scaled response will yield continuous data, and this is the reason why Cronbach has remained on stage for so long in estimating the reliability index of ordinal data. Some however maintained that unless the Likert type is above 5 points (actually 6- points and above), it cannot yield a sufficiently continuous data that will warrant the use of Pearson covariate matrix (Zumbo et.al., 2007). Gelin et al., (2003) as cited in NSSE (2018) specifically pointed out from studies conducted, that items having less than five scale points have their reliability estimates underestimated. This was seen as a threat to accurate measure of reliability. Thus, the problem should be addressed by using a correlation measure that is more suitable to ordinal data.

Rather than continue with this anomaly, Flora and Curran (2004), suggested that the polychronic correlation matrix is a better choice for the estimation of reliability for ordinal data from Likert scales because it is able to estimate the linear relationship for two unobserved continuous variables. Furthermore, the polychronic correlation matrix is able to account for the ordinal nature of the data, which the Pearson correlation matrix used by Cronbach's alpha cannot. Thus, more accurate reliability estimates have been observed using alternative methods such as ordinal alpha.

In other words, ordinal coefficient alpha, unlike its Cronbach alpha counterpart, estimates the internal consistency for scales involving ordinal data using poly-choric correlation matrix. Furthermore, ordinal alpha can be carried out in SPSS or inR.

Again, for tests having different subsets, Cronbach's alpha method of calculating the index of equivalence should be used only after the different subsets have been separated (Cronbach, 1951). According to a research carried out by Zumbo et.al, (2017), to compare the new ordinal reliability estimates obtained using ordinal coefficient alpha and ordinal coefficient theta, and then, comparing both with Cronbach's alpha for a Likert scaled data, it was discovered that Cronbach's coefficient alpha was generally negatively biased in estimating the reliability of Likert response items whereas, the ordinal coefficient alpha and theta were found to be consistently better and more suitable measures of reliability. Based on their findings, one of their recommendations as regards ordinal coefficient alpha is that it is a better alternative especially with factor analysis.

Zumbo et.al (2017) further noted that no matter the magnitude of theoretical reliability, and the number of scale points, ordinal alpha was able to consistently estimate reliability, unlike its Cronbach's alpha counterpart. Moreover, the skewness of item response distribution usually affect Cronbach's alpha, whereas, ordinal alpha

remains unaffected by such. The implication of this is that even when data is skewed, whether positively or negatively, ordinal alpha consistently yield positive reliability estimates. For Cronbach's alpha, on the other hand, the more the skewness, the more biased it becomes in its ability to estimate reliability.

The objectives of the study are therefore to find out:

1. The magnitude of the difference between the reliability coefficients as estimated by Cronbach's alpha and that obtained by ordinal alpha methods.
2. The extent of the item total correlation between Cronbach's alpha and ordinal alpha methods.
3. The extent of item weight correlation between Cronbach's alpha and ordinal alpha methods.
4. The method having the higher retention of items between Cronbach's alpha and ordinal alpha methods.

Research Questions

l . How different are the overall reliability Coefficients estimated by Ordinal Alpha and Cronbach 's Alpha methods?
2. How significantly different are the Ordinal Alpha and Cronbach Alpha methods in terms of Item total Correlation?
3. How significantly different are the Ordinal Alpha and Cronbach Alpha methods in terms of Item weight?
4. Which of the two methods (Ordinal Alpha and Cronbach Alpha methods) lead to retention of more items?

Methodology

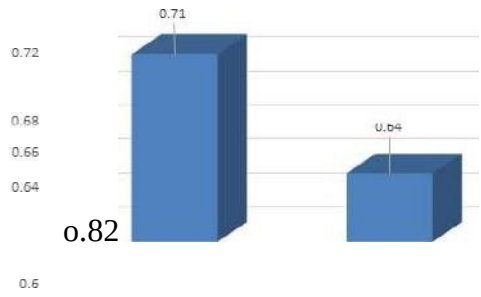
The study adopted a survey research design of comparative type using the data of a real study that was carried out in Bomadi, Patani and Ughelli North and South Local Government Areas of Delta State. The population of the study was 2310 Basic Education teachers, made up of 966 males and 1,344 females. A sample of 100 teachers from the lower, middle and upper basic classes (otherwise known as primaries 1-3, 4-6 and JSS 1-3 respectively) were obtained using the stratified random sampling method, since they exist in strata. Having obtained the total number of male and female teachers in the primary and secondary levels each in each of these local government areas, the sample size of 100 was constituted based on the number as contained in each strata in the population. Hence, a total number of 6, 6, 62 and 26 each were obtained from Bomadi, Patani, Ughelli North and Ughelli South respectively. The instrument used for data collection was the Teachers' Literacy and Practice of School Based Assessment Questionnaire (TLPSBAQ) containing 51 items which was constructed by the researchers using a 4-point Likert scale. The questionnaire was divided into three sections A, B and C, with Section A comprising the demographic data; section B having 22 items was on Teachers' Literacy of School-based assessment while section C was on Teachers' practice of School Based Assessment with 29 items. Only a total of84 respondents completely filled and returned their questionnaires, which resulted in a response rate of 84%. Real data for the trial testing of Teachers' literacy and practice of school-based assessment was used. Four research questions were raised and data collected was analyzed using descriptive statistics and t-test, Cronbach alpha and ordinal alpha reliability indices.

Results

Research Question 1

How different are the overall reliability coefficients estimated by Ordinal Alpha and Cronbach Alpha methods?

The descriptive statistics of the overall reliability coefficients by Cronbach alpha and ordinal alpha method was computed.



Ordinal Alpha Correction Cronbach Alpha Carr Sation

Figure 1: Overall reliability Coefficients by Ordinal Alpha and Cronbach Alpha methods

Figure I shows that reliability coefficient estimated on Teacher Literacy and Practice of School- Based Assessment Scale using Ordinal Alpha was 0.71 while Cronbach alpha method produced only 0.64 coefficients. These were computed using R software for Ordinal alpha and SPSS for Cronbach alpha. This result shows that ordinal alpha method of establishing reliability for ordinal data yielded a higher value than Cronbach alpha.

Research Question 2

How significantly different are the Ordinal Alpha and Cronbach Alpha methods in terms of item total correlation?

To answer this research question, the item correlation coefficients produced by both ordinal alpha and Cronbach alpha were subjected to paired t-test.

Table 2 shows that a significant difference exists between the item correlations produced by Ordinal alpha and Cronbach alpha methods (tso— I I .35; p<O.05). Ordinal alpha produced a higher item correlation mean of 0.26 (approximately 0.3), which is more acceptable than the estimate produced by Cronbach alpha which was O. 15.

Research Question3

How significantly different are the Ordinal Alpha and Cronbach Alpha methods in terms of item weight?

In order to answer this research question, the item mean weights produced by ordinal alpha and that of Cronbach alpha methods were again compared by subjecting to paired t-test.

Table 3: Paired t-test of Item weights produced by Ordinal Alpha and Cronbach Alpha method

	Mean	Std. Deviation	N	r	T		
Ordinal alpha Item total correlation	0.7092	0.00956	51		90.15	50	
Cronbach alpha Item total Correlation	0.641392	0.01177	51	0.89			0.00

Table 2: Paired t-test of the Item Correlations produced by Ordinal Alpha and Cronbach Alpha method

	Mean	Std. Deviation			t		
Ordinal alpha item total correlation	0.25541	0.175441	51	0.94		50	
Cronbach alpha item total correlation	0.154275	0.182547	51		11.35		0.00

Table 3 shows that a significant difference exists between the item weights produced by Ordinal Alpha and Cronbach Alpha methods ($t50 = 90.15$; $p<0.05$). Ordinal alpha produced the higher item mean weight of 0.71 which is more acceptable than the estimate produced by Cronbach alpha which was 0.64. The implication of this is that although both methods are good estimators of item weights since they correlate positively ($r = 0.89$), ordinal alpha proves to be a better estimate of reliability than Cronbach alpha where ordinal data is involved.

Research Question 4
Which of Ordinal Alpha and Cronbach Alpha methods lead to retention of more items?

To answer this research question, the item weights and item correlation were computed with both ordinal and Cronbach alpha methods.

Table 4: Item weights and Item Correlations using Ordinal Alpha and Cronbach Alpha methods

	Ordinal Alpha			Cronbach Alpha		
	Item Strength	Item Correlation	Item Status	Item Strength	Item Correlation	Item Status
Item I	0.71	0.251	Retained	0.632	0.323	Retained
Item2	0.71	0.278	Retained	0.637	0.224	Retained
Item 3	0.72	0.109	Retained	0.657	-0.115	Discarded
Item4	0.73	-0.136	Discarded	0.667	-0.217	Discarded
Item 5	0.72	0.016	Retained	0.659	-0.076	Discarded
Item 6	0.71	0.283	Retained	0.637	0.21	Retained
Item 7	0.72	0.116	Retained	0.649	0.027	Retained
Item 8	0.71	0.258	Retained	0.635	0.236	Retained
Item 9	0.72	0.024	Retained	0.659	-0.066	Discarded
Item48	0.7	0.369	Retained	0.634	0.249	Retained
Item49	0.69	0.535	Retained	0.625	().399	Retained
Item50	0.69	0.61	Retained	0.615	0.507	Retained
Item51	0.71	0.223	Retained	0.635	0.254	Retained

Number of Items Retained			48			
Number of Items Discarded			3			11
Iteml O	0.71	0.284	Retained	0.644	0.107	Retained
Iteml I	0.72	0.017	Retained	0.66	-0.182	Discarded
Item 12	o. 72	0.012	Retained	0.663	-0.214	Discarded
Iteml 3	0.71	0.178	Retained	0.648	0.038	Retained
Item 14	0.71	0.254	Retained	O. 64	0.173	Retained
Iteml 5	0.71	0.303	Retained	0.639	0.203	Retained
Iteml 6	0.7	O.43	Retained	0.629	0.328	Retained
Iteml 7	0.7	0.437	Retained	0.628	0.337	Retained
Iteml 8	0.71	0.314	Retained	0.641	0.169	Retained
Iteml 9	0.71	0.305	Retained	0.638	0.205	Retained
Item20	0.71	0.278	Retained	641	0.163	Retained
Item21		0.462	Retained	0.627	0.361	Retained
Item22	0.71	0.29	Retained	0.639	0.195	Retained
Item23	0.71	0.233	Retained	0.651	-0.03	Discarded
Item24		0.388	Retained	0.634	0.301	Retained
Item25	0.72	0.022	Retained	0.654	-0.026	Discarded
Item26	0.7	0.343	Retained	0.629	344	Retained
Item27	0.71	0.271	Retained	0.643	0.122	Retained
Item28	0.72	0.057	Retained	0.653	-0.003	Discarded
Item29	0.7	O.43	Retained	0.636	0.239	Retained
Item30	0.72	0.079	Retained	0.65	0.02	Retained
Item31	0.72	0.129	Retained	0.647	0.077	Retained
Item32	0.71	O. 141	Retained	0.648	0.047	Retained
Item33	0.7		Retained	0.634	0.267	Retained
Item34	0.72	-0.016	Discarded	0.663	-0.177	Discarded

Item35	0.72	0.131	Retained	0.646	0.08	Retained
Item36	0.71		Retained	0.648	0.057	Retained
Item37	0.72	0.133	Retained	0.645	0.091	Retained
Item38	0.7	0.353	Retained	0.636	0.258	Retained
Item39	0.7	0.459	Retained	0.633	0.315	Retained
Item40	0.69	0.58	Retained	0.629	0.392	Retained
Item41	0.71	0.308	Retained	0.638	0.205	Retained
Item42		0.459	Retained	0.622	0.437	Retained
Item43	0.71	0.209	Retained	O. 64	0.171	Retained
	0.71	0.199	Retained	0.645	0.091	Retained
Item45	0.72	-0,007	Discarded	0.656	-0.088	Discarded
Item46	0.69	0.536	Retained	0.625	6	Retained
Item47	0.7	7	Retained	0.628	4	Retained

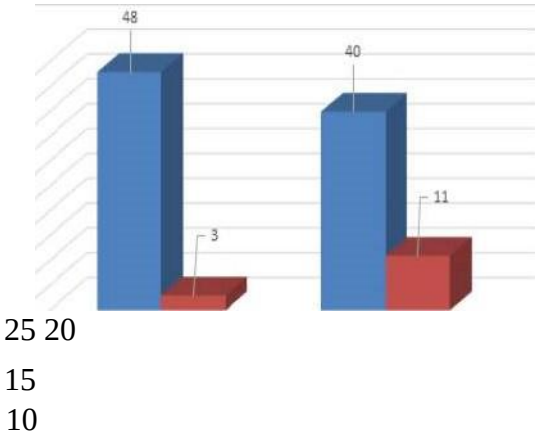


Figure 2: Number of Items retained and discarded using Ordinal and Cronbach Alpha methods

Table 4 and Fig 2: show that ordinal alpha method revealed only 3 items that did not correlate positively with the intended construct: teacher's literacy and practice of School-based assessment; while Cronbach alpha method revealed up to Il items that correlated negatively to the construct. This implied that more items were lost when Cronbach alpha method was used. In terms of strength, ordinal alpha methods were found to be consistently stronger than Cronbach alpha methods with item strengths ranging from 0.69 to 0.72 and from 0.62 to 0.67 respectively, for ordinal and Cronbach alpha. Thus, more items were retained in the former than the latter. Many of the items were lost while trying to strengthen reliability indices when Cronbach alpha was used. The result in Table4 also showed that whereas 48 out of the 51 items were retained for ordinal alpha, only 40 of the same items were retained for Cronbach alpha.

Discussion

Results of the study have shown that ordinal alpha method of establishing reliability for ordinal data yielded a higher value (0.71) than Cronbach alpha (0.64), thus establishing the efficacy of ordinal alpha for estimating the reliability of ordinal data. This means that the use of ordinal alpha for such data leads to a higher reliability index. Again, results in Table 2 shows that indeed a significant difference exists between the item correlations produced by Ordinal alpha and Cronbach alpha methods (t. Il .35; 05): whereas, Ordinal alpha produced a higher item correlation mean of 0.26 which can be approximated to 0.3, which is more acceptable than the estimate of 0.15 produced by Cronbach alpha. The implication of this is

that both methods of reliability estimation do the same work and are good estimates of reliability (positive direction) with r = 0.94; which is possibly the reason why Cronbach alpha has retained the stage of ordinal alpha for so long.

However, it should be recalled that software packages such as SPSS, by default, use Cronbach alpha (that is based on Pearson correlation matrix), to estimate internal consistency or reliability, which stipulates continuous data as one of the basic assumptions for its usage. When wrongly used for ordinal data, the Likert format response of such data which is ordinal in nature is ignored, thus flouting a very basic assumption (Flora & Curran, 2004 as cited in Zumbo et al., 2007). Instead, Flora and Curran (2004), have suggested that ordinal alpha, (which is based on the poly-choric correlation matrix), is a better choice when estimating the reliability for ordinal data from Likert scales. This is because it is able to account for the ordinal nature of the data, which the Pearson correlation matrix used by Cronbach's alpha cannot. Thus, Cronbach alpha should be reserved for continuous data while ordinal alpha are more effective with ordinal or polytomous data (Zumbo et.al., 2007). This is in agreement with the assertion of Zumbo and Rupp (2004) and Gadermann et.al, (2014) that basic assumptions should not continue to be violated with the wrong use of Cronbach alpha for ordinal data.

Results have also shown from Table 3 that a significant difference exists between the item weights produced by ordinal alpha and Cronbach alpha methods (t50 - — 90.15; p<O.05). Although both methods are good estimators of item weights since they correlate positively (r = 0.89), Ordinal alpha however produced a higher item mean weight of 0.71, while the one produced by Cronbach alpha was 0.64.

Finally, in order to find out which of Ordinal Alpha and Cronbach Alpha methods lead to retention of more items, the item weights and item correlation were computed with both ordinal and Cronbach alpha methods. It was discovered that more items were lost when Cronbach alpha method was used, whereas the use of ordinal alpha on ordinal data led to retention of more items. Ordinal alpha methods were also found to be consistently stronger than Cronbach alpha methods with item strengths ranging from 0.69 to 0.72 and from 0.62 to 0.67 respectively for both methods.

Many of the items were lost while trying to strengthen reliability indices by deleting supposedly 'weak items' when Cronbach alpha which should not have been used in the first place, was used. The result in Table 4 also showed that whereas 48 out of the 5 1 items were retained for ordinal alpha, only 40 of the same items were retained for Cronbach alpha. This forced reduction of items in order to comply with conditions for item retention is a disadvantage in the use of Cronbach alpha, because the higher the number of retained items the better the instrument in establishing reliability. Hence, ordinal alpha has been proved to be a very useful method of establishing reliability or as an estimate of an approximate value of an index of equivalence, especially for moderate and long tests (Flora & Curran, 2004).

Conclusion

Based on the findings of the study, the following conclusions were drawn:

Ordinal alpha method of establishing reliability of ordinal data yielded a higher value than Cronbach alpha in ordinal data / scale, thus establishing the efficacy of the former over the latter. Again, Ordinal alpha produced a higher item correlation mean than Cronbach alpha. A significant difference was also observed between the item weights generated by both methods. And finally, Ordinal alpha actually led to retention of more items when dealing with ordinal data.

The instrument used in eliciting statistical data is very important in data analyses; in fact the credibility of research findings depend very much to a large extent on the type and quality (in terms of validity and reliability) of the instruments used to measure the variables involved. These instruments are ofvarious types and their usage depends on the type of variables the researcher desires to measure. A good

instrument should not contain many items that correlate negatively with the intended construct. Again, the scale (whether nominal, ordinal, interval, or ratio) on which a particular attribute is measured determines, to a large extent, the type of statistical tool that will be suitable for analyzing it. Each of these tools has assumptions which must not be violated if the results from such analyses must be dependable, logical and useful. All the results from the research questions demonstrate that ordinal data are best estimated with ordinal alpha when 4 points scale or ordinal data is used.

Recommendation Based on the findings, it was therefore recommended that:
Cronbach alpha should be reserved for continuous data while ordinal alpha are more effective with ordinal data. Hence, scale developers and researchers should employ ordinal alpha method whenever polytomous data obtained from Likert scale is being analyzed for reliability estimates.

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