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QUANTITATIVE AND QUALITATIVE ANALYSIS OF DYSCALCULIA TEST

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ABSTRACT: *The study was The study aimed at Quantitative and Qualitative Analysis of Dyscalculia Test. Triangulation research design was employed in this study. The study was driven by three research questions. The study's population included all 4,758,800 pupils in Nigeria's upper elementary and junior secondary institutions in Nigeria. A total of 2340 students were randomly selected using a multistage sampling procedure. The data for the study was the Dyscalculia Test. Expert judgement and empirical evidence of factor analysis were used to establish the instruments' face, content, and construct validity. Split half Technique was used to ensure the instrument reliability The split-half reliability study for the Dyscalculia Test indicates that the first half of the test has a reliability estimate of.894 and the second half of the test has a reliability estimate of.780. Spearman-coefficient Brown's of.824 was used to evaluate the whole test's reliability. Research questions were answered using Mantel-Haenzel Statistics, Analysis of Variance (three way) number count, percentage and qualitative description. Result on analysis revealed that examinees performance on Dyscalculia Test is independent of ethnicity, i.e all the Dyscalculia test items are not bias towards any ethnic group in Nigeria. There is no significant influence of age, gender and educational level on the Dyscalculia Test .Also, the interaction influence of Ethnicity and gender, Ethnicity and educational level, gender and educational level and then Ethnicity, gender and Educational Level on Dyscalculia Test which were all not significant. Also, Respondents who took the Dyscalculia Test are classified as those that are severely Dyscalculic, Moderately Dyscalculic, Mildly Dyscalculic and those with No Dyscalculia. It was recommended based on findings that assessment instruments used within the school system be it at primary, secondary or higher institutions should be subjected to the DIF analysis for bias item analysis as this would provide the necessary statistical evidence that a particular assessment instrument is not bias*

KEY WORDS; dyscalculia, test, DIF, item bia, description, classification

INTRODUCTION

Good numerical-arithmetical skills are important not just to be able to succeed academically but also to be an effective member of a modern numerate society. There are contributing factors to

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good arithmetical-numeracy attainment – a well-structured curriculum, an attentive pupil, having average intelligence, adequate schooling and some other learning enhancing factors being in place and so on. However there seems to be a group of students and adults whose poor attainment in arithmetic cannot be ascribed to these factors. They struggle with the acquisition of numerical-arithmetical skills and are dyscalculic. Dyscalculia is a condition that makes it hard to make sense of numbers and mathematics concepts. Thus people with dyscalculia cannot grasp basic number concepts. In other words, they miss the logic behind it. Dyscalculia is Specific Learning Difficulty in arithmetic. It is a learning difficulty affecting the acquisition of numerical-arithmetical skills in children with normal intelligence and age-appropriate school education. That is with factors like normal intelligence and adequate schooling and some other learning enhancing factors being in place, there seems to be a group of students and adults whose poor attainment in arithmetic cannot be ascribed to these problems. They struggle with the acquisition of numerical-arithmetical skills, i.e they are dyscalculics. The Diagnostic and Statistical Manual of Mental Disorders (2013) refer to dyscalculia as a pattern of difficulties characterized by problems processing numerical information, learning arithmetic facts, and performing accurate or fluent calculations. Dyscalculia is characterised by impairment in number sense, arithmetic operations and working memory. The implication for such people is that they can have negative functional consequences across their lifespan, including lower academic attainment, higher rates of high school dropout, lower rates of postsecondary education, impair personality development, poorer overall mental health, higher rates of unemployment and under-employment, keeping a job and being promoted within employment, lower incomes and so on.

An observation of these consequences and a review of literature shows that in Nigeria, some individuals and mostly school students perform poorly in mathematics compared to other subjects and may be sufferers from some of the above stated problems. A reason that may not be farfetched from the fact most students are dyscalculic but are unaware of it. This group of people with dyscalculia is estimated to be about 4-15% of the population and dyscalculia is prevalent among both male and female; this means that between 4 million and 15 million people suffer from this difficulty. With such disturbing negative consequences associated with dyscalculia and its high prevalence, it is unfortunately sad to note that its one phenomenon that is not very recognized, detected or diagnosed and understood generally. A very clear reason for this is the most unfortunately fact that instruments or scale to measure or identify or diagnose dyscalculia specifically are almost not in existence; thus, most researchers rely on general standardized mathematics achievement tests or general tests of mathematical abilities, often in combination with measures of intelligence (IQ) like the Wechler Intelligent Scale for diagnoses which are not in themselves designed for the sole diagnosis of dyscalculia but are used due to unavailability of standardized and precise instruments.

Thought there has been very few selective attempts to measure dyscalculia in some ways. They include; The few attempts to measure dyscalculia is the Dyscalculia Screener, a software

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developed by Butterworth in 2003, the measure by Von Aster et al which is a standardized arithmetic test, the Neuropsychological Test Battery for Number Processing and Calculation in Children NUCALC in English, or ZAREKI in German, the TEDI-MATH and a few others. With these, some limitations has however been observed. The limitations include some of the test not having strong and comprehensive psychometric properties or improper establishment of psychometric properties of some of the instruments, inadequate information on the standardization process, so on. All these created a gap that birthed this research which was to carry out a quantitative and qualitative analysis of the Dyscalculia Test for use in Nigeria. The quantitative analysis was aimed at carrying out a differential item analysis which would indicate if bias was present in the test or not. It includes as well a quantitative analysis of the influence of age, gender, ethnicity and Educational level on the Dyscalculia Test. While for the Qualitative analysis, the analysis was a description of the prevalence of Dyscalculia test.

The following questions guided the study:

1. What is the Differential Item Analysis (Item Bias) of Dyscalculia Test using the Mantel-Haenszel Method?
2. What is the construct validity of Dyscalculia Test using hypothesis testing evidence: (i) there is no significant influence of ethnicity on the Dyscalculia Test (ii) there is no significant influence of age on the Dyscalculia Test and (iii) there is no significant influence of gender on the Dyscalculia Test
3. What is the classification and Description of Dyscalculia Test in Nigeria?

METHODOLOGY

The study was conducted using a triangulation research design. The population of the research included all Nigerian students (4,758,800) in upper primary and junior secondary. The study's sample size was 2340 students drawn using multi stage sampling procedure. The Dyscalculia Test is an instrument designed to diagnose and identify persons with specific learning difficulty in arithmetic. It is designed to assess students with specific learning difficulty in arithmetic between the ages of 7-13. The Dyscalculia test items comprised of three broad domain or core subset or dimension or components and eleven sub domain on which 85 multiple choice test items was drawn on. The domains are Number Sense, Arithmetic Operations and Working Memory. Expert judgments and a multivariate statistical method of factor analysis were used to determine the preliminary face, content, and construct validity of the Dyscalculia Test. The preliminary reliability was obtained using split-half reliability for the Dyscalculia Test, It indicated on analysis that the first half of the test has a reliability estimate of.894 and the second half of the test has a reliability estimate of.780. Spearman-coefficient Brown's of.824 was used to evaluate the whole test's reliability. As a result, a split half coefficient of.820 was found.

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Research questions one was answered using Mantel-Haenzel Statistics, research question two was answered using the Analysis of Variance (three way) and research question three was answered using number count, percentage and qualitative description.

Research Question 1; What is the DIF (item bias) using the mantel Haenszel method For the Dyscalculia Test?

Table 1.1 DIF Analysis (No item bias) using the Mantel-Haenszel method For the Dyscalculia Test

ITEM	Ethnicit	WRONG	RIGHT	Mantel-Haenszel χ^2	SIG
1	Min	150	799	.052	.820
	Majo	226	1165		
2	Min	212	737	.000	.984
	Majo	310	1081		
3					
	Min	288	661	.310	.577
	Majo	406	985		
4	Min	301	648	.660	.416
	Majo	418	973		
5	Min	273	421	.660	.416
	Majo	676	969		
6	Min	432	517	1.397	.237
	Majo	669	1101		
7	Min	513	436	.367	.545
	Majo	733	658		
8	Min	490	459	.000	.985
	Majo	720	671		
9	Min	408	541	.909	.340
	Majo	627	764		
10	Min	298	651	.586	.444

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	Majo	459	932		
11	Min	329	620	.645	.422
	Majo	506	885		
12	Min	410	539	11.181	.001
	Majo	700	691		
13	Min	304	644	2.824	.093
	Majo	469	922		
14	Min	278	671	.289	.591
	Majo	392	999		
15	Min	359	590	.319	.572
	Majo	509	882		
16	Min	361	587	.871	.351
	Majo	536	855		
17	Min	401	547	2.824	.093
	Majo	536	855		
18	Min	452	497	2.081	.149
	Majo	706	685		
19	Min	414	535	4.643	.331
	Majo	671	70		
20	Min	439	510	.871	.351
	Majo	672	719		
21	Min	409	540	.210	.647
	Majo	585	806		
22	Min	499	450	.319	.572
	Majo	774	617		
	Min	556	393	1.559	.212

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23					
	Majo	852	539		
24	Min	535	414		
	Majo	786	604	.871	.351
25	Min	579	368	.120	.729
	Majo	847	544		
26	Min	616	333	.939	.333
	Majo	931	460		
27	Min	587	362	.120	.729
	Majo	91	477		
28	Min	642	306	.871	.351
	Majo	956	435		
29	Min	403	546	.024	.877
	Majo	585	806		
30	Min	614	335	.120	.729
	Majo	889	502		
31	Min	417	532	.001	.973
	Majo	609	782		
32	Min	343	606	267	.605
	Majo	537	853		
33	Min	424	525	.439	.508
	Majo	601	790		
34	Min	450	499	267	.605
	Majo	677	713		
35	Min	346	603	.024	.877
	Majo	536	854		
	Min	351	596	.024	.877

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36					
	Majo	534	855		
37	Min	334	613	.363	.547
	Majo	498	893		
38	Min	355	592		
	Majo	554	836	267	.605
39	Min	366	581		
	Majo	562	829	.363	.547
40	Min	417	532	.363	.547
	Majo	630	761		
41	Min	459	490	3.921	.448
	Majo	732	659		
42					
	Min	482	467	5.791	.216
	Majo	778	613		
43	Min	367	582	267	.605
	Majo	552	869		
44	Min	405	544	175	67.6
	Majo	607	784		
45	Min	417	532	.363	.547
	Majo	636	754		
46	Min	457	492	3.516	.061
	Majo	726	665		
47	Min	439	510	2.952	.086
	Majo	695	696		
48	Min	509	440	1.259	.262
	Majo	780	611		
49	Min	528	421	1.059	.302

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	Majo	805	586		
50	Min	506	443	01.4	.906
	Majo	737	654		
51	Min	504	445	129	.719
	Majo	727	664		
52	Min	70	68	1.430	0.232
	Majo	115	147		
53	Min	465	484	.031	.859
	Majo	688	703		
54	Min	484	465	483	487
	Majo	731	660		
55	Min	508	790	2.301	129
	Majo	441	601		
56	Min	490	459	1.479	.224
	Majo	755	636		
57	Min	524	425	.026	.871
	Majo	774	617		
58	Min	581	388	.107	.743
	Majo	841	550		
59	Min	578	370	.363	.547
	Majo	876	515		
60	Min	594	355	0.000	.988
	Majo	869	522		
61	Min	491	457	.355	.551
	Majo	722	669		
62	Min	491	458	.355	.551
	Majo	701	690		

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63	Min	479	470	.040	.841
	Majo	695	696		
64	Min	523	426	1.228	.268
	Majo	800	591		
65	Min	522	427	.253	.615
	Majo	781	610		
66	Min	563	386	.257	.612
	Majo	841	550		
67	Min	556	393	2.561	.110
	Majo	862	529		
68	Min	565	384	2.233	.135
	Majo	872	519		
69	Min	621	328	3.003	.083
	Majo	959	432		
70	Min	632	317	.013	.910
	Majo	931	459		
71	Min	629	319	2.824	.093
	Majo	934	455		
72	Min	659	288	.026	.871
	Majo	1010	380		
73	Min	611	338	.223	.637
	Majo	910	481		
74	Min	629	320	2.824	.093
	Majo	969	422		
75	Min	624	325	.013	.910
	Majo	919	472		

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76	Min	631	318	.001	.975
	Majo	927	464		
77	Min	635	313	2.655	.103
	Majo	999	392		
78	Min	660	289	.329	.566
	Majo	984	407		
79	Min	572	377	8.777	.303
	Majo	923	468		
80	Min	648	301	.926	.336
	Majo	977	414		
81	Min	620	326	.026	.871
	Majo	983	408		
82	Min	706	243	.098	.755
	Majo	1044	347		
83	Min	663	286	2.655	.103
	Majo	1016	375		
84	Min	648	301	5.798	.016
	Majo	1015	376		
85	Min	652	297	2.251	.133
	Majo	997	394		

Table 1.1. shows the M-H DIF statistics. This statistics tested the hypothesis that examinees performance on item i (i = 1, 2, 3, 4 ……85) is independent of ethnicity (at $p < 0.05$ for two tailed). A level of significance value for an item that is less than 0.05 indicates that the responses of the examinees on the item is dependent on their ethnicity(whether they are from the majority group .i.e Hausa, Igbo, Yoruba or from Minority group, i.e Isoko, Ijaw, Efik, etc). That is bias towards ethnicity may exist and such item displays DIF. On the other hand, a level of significance greater

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than 0.05 indicates that testees performance on the item is independent of the testees ethnicity. From the above all the Dyscalculia test items are not bias towards any ethnic group in Nigeria

Research Question 2; What is the construct validity of Dyscalculia Test using hypothesis testing evidence: (i) there is no significant influence of ethnicity on the Dyscalculia Test (ii) there is no significant influence of age on the Dyscalculia Test and (iii) there is no significant influence of gender on the Dyscalculia Test (iv) there is no significant influence of Intelligence on the Dyscalculia Test

Table 1:2 Three way ANOVA of no significant influence of age, gender, and ethnicity on Dyscalculia Test

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	10881.433[a]	15	725.429	2.170	.006	.014
Intercept	54700.191	1	54700.191	163.639	.000	.066
ETHNICITY	155.096	1	155.096	.464	.496	.000
GENDER	1053.942	3	351.314	1.051	.369	.001
EDU LEVEL	1106.267	3	368.756	1.103	.347	.001
ETHNICITY * GENDER	591.633	2	295.816	.885	.413	.001
ETHNICITY * EDU LEVEL	1847.783	2	923.891	2.764	.063	.002
GENDER * EDU LEVEL	1232.418	2	616.209	1.843	.159	.002
ETHNICITY * GENDER * EDU LEVEL	898.933	2	449.466	1.345	.261	.001
Error	776853.406	2324	334.274			
Total	5924322.000	2340				
Corrected Total	787734.839	2339				

From the above Table 1.2 the F-ratio obtained for ethnicity influence on the Dyscalculia Test is .464, and this is statistically not significant at .496 probability; F (1; 464) = .496, P >0.05. This means that there is no significant influence of age (that is respondents whether they are between ages 7-10, or 11-13 as categorized in this research) on the Dyscalculia test.

The table reveals as well the F-ratio obtained for gender influence on the Dyscalculia Test and is 1.051, and this is statistically not significant at .369 probability; F (1; 1.051) = .369, P >0.05. This means that there is no significant influence of gender (that is respondents whether they are male or female) on Dyscalculia Test. The table further shows that the F-ratio obtained for Educational level of respondents in upper primary and junior secondary influence on the

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Dyscalculia Test and is 1.103, and this is statistically not significant at .347 probability; F (1; 103) = .347, P >0.05. This means that there is no significant influence of Educational level (respondents whether they are in upper primary and junior secondary) influence on the Dyscalculia Test

The table further shows the interaction influence of Ethnicity and gender, Ethnicity and educational level, gender and educational level and then Ethnicity, gender and Educational Level on Dyscalculia Test which where all not significant as all their p where greater than the chosen alpha. I,e p> 0.05.

Research Question 3; What is the classification and Description of Dyscalculia Test in Nigeria?

Table 4.3 The classification and Description of Dyscalculia Test in Nigeria?

Classification	**Percentage of population in Upper Primary**	**Percentage of population in Junior Sec**	**Brief description**
No Dyscalculia (Total scores of 64 above):	22%	24.1%	This shows that an individual does not have specific learning disorder in mathematics
Mild (Total scores between 43-63):	35%	29.3%	Some difficulties learning skills in the three core subsets or dimensions,
Moderate (Total scores between 22-42)	36.%	39.6%	Marked difficulties learning skills in the three core subsets or dimensions
Severe (Total scores between 0-21)	7.6%	7%	Severe difficulties learning skills in the three core subsets or dimensions.

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As shown in Table 1.3, it shows that the Dyscalculia test was able to identify persons with specific learning difficulty in Arithmetic in Nigeria. Respondents who took the Dyscalculia Test are classified as those that are severely Dyscalculic (having a score of 0-21), Moderatly Dyscalculic (having a score of 0-22 -42), Mildly Dyscalculic (having a score of 43-63) and those with No Dyscalculic (having a score of 64 and above), The students who are severely Dyscalculic form approximately 7.6% of Nigerian school students in Upper primary and 7% Lower Secondary. That is, out of every 100 Nigerian school students in Upper primary or Lower Secondary in this country, when randomly sampled, 7.6% are having Specific Learning Difficulty in Arithmetic while, out of every 100 Nigerian school students in Lower Secondary in this country, when randomly sampled, 7.% are having Specific Learning Difficulty in Arithmetic .About 36% in primary and 39.6% in junior secondary of the targeted population fall into the group classified as moderately Dyscalculic, about 35% in primary and 29.3% in junior secondary % of the targeted population fall into the group classified as Mildly Dyscalculic, and 22% in primary and 24.1% in junior secondary of the targeted population fall into the group with No Dyscalculic.

DISCUSSION OF FINDINGS

The M-H DIF statistics which tested the hypothesis that examinees performance on item i (i = 1, 2, 3, 4 ……85) is independent of ethnicity (at $p < 0.05$ for two tailed). From the above all the Dyscalculia test items were not bias towards any ethnic group in Nigeria. This is somewhat in line with Metibemu 2016 as well as that of Emekene 2017 findings where majority of the items in data was DIF free. All these findings significantly proves that the Dyscalculia test items are empirically fit to asses specific Learning difficulty in arithmetic

To establish the construct validity of Dyscalculia test, hypothesis evidence was employed. It revealed that there is no significant influence of age, gender and educational level on the Dyscalculia Test .Also, the interaction influence of Ethnicity and gender, Ethnicity and educational level, gender and educational level and then Ethnicity, gender and Educational Level on Dyscalculia Test which were all not significant as all their p where greater than the chosen alpha. i,e $p > 0.05$. These findings further significantly affirms that the Dyscalculia test items are empirically fit to asses specific Learning difficulty in arithmetic.

Respondents who took the Dyscalculia Test are classified as those that are severely Dyscalculic (having a score of 0-21), Moderatly Dyscalculic (having a score of 0-22 -42), Mildly Dyscalculic (having a score of 43-63) and those with No Dyscalculic (having a score of 64 and above), The students who are severely Dyscalculic form approximately 8.32% of Nigerian school students in Upper primary or Lower Secondary. That is, out of every 100 Nigerian school students in Upper primary or Lower Secondary in this country, when randomly sampled, 8.32% are having Specific Learning Difficulty in Arithmetic. About 33.81% of the targeted population fall into the group classified as moderately Dyscalculic, about 36.06% of the targeted population fall into the group classified as Mildly Dyscalculic,, and 24.27% of the targeted population fall into the group with

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No Dyscalculic. This finding is in order with the prevalence result of Haberstroh & Schulte-Körne; 2019 Looi & Kadoosh, 2019; Lahrichi 2019; Mazzocco and Myers 2003; Nikolaos et al, 2017; Shalev, et al, 2001; Shalev & Gross, 2005.

Recommendations

Based on the discussions of the findings, the following recommendation were made:

1. Dyscalculia test should be adopted by parents, school administrators and counselors to assess students who may be having difficulty in mathematics or arithmetic for proper diagnosis
2. Assessment instruments used within the school system be it at primary, secondary or higher institutions should be subjected to the DIF analysis for bias item analysis as this would provide the necessary statistical evidence that a particular assessment instrument is not bias.

Implications of the study

1. The implication for counselors, educationist and psychologists both in Nigeria and outside Nigeria, is that the dyscalculia test can easily identify persons with learning difficulties in arithmetic. This makes it a valuable tool for them to carry out their professional duties of educating, guiding and counseling effectively.

CONCLUSION

1. The M-H DIF statistics tested the hypothesis that examinees performance on item is significantly independent of ethnicity and as such the Dyscalculia test items are not bias towards any ethnic group in Nigeria.
2. It is concluded that the content and construct validity of dyscalculia was sufficiently established using hypothesis evidence.
3. It is also concluded that there is no significant single or interaction influence of age and gender on the Dyscalculia Test.
4. Dyscalculia test was able to identify and classify respondents who took the test as those that are severely Dyscalculic, Moderately Dyscalculic, Mildly Dyscalculic and those with No Dyscalculia

Suggestion for Further Research

The following areas are seen as necessary for further research;

1. Similar study could be conducted using students in higher institution of learning
2. Study should be carried out to investigate the predictors of Dyscalculia in Nigeria.

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