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BINARY DICHOTOMIZATION OF EDUCATIONAL AND NON-EDUCATIONAL VARIABLES USING COEFFICIENT OF ASSOCIATION (A) MATRIX WITH SECONDARY SCHOOL STUDENTS IN CALABAR SOUTH LOCAL GOVERNMENT AREA, CROSS RIVER STATE, NIGERIA

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ABSTRACT

This study ascertained the Coefficient of Association in a fourfold matrix using dichotomized educational and non-educational attributes among SS 3 students in Calabar South Local Government Area, Nigeria. To achieve the purpose of the study, two specific objectives were formulated and converted to two research questions. The survey design method was used and 200 SS 3 students were selected through the use of accidental sampling techniques. The assumptions for using the Coefficient of Association in educational and scientific research highlighting its advantages and disadvantages were stated. The study found that the strength or level of association between (educational attributes and non-educational attributes) students' age and their preference for the colour of shirt is 83%, and students' school location and their preference for the colour of shirt 20%. respectively. It was concluded that the use of coefficient of association is a fundamental requirement for research with educational attributes and non-variable data.

(Keyword: *Association of Coefficient, Educational & Non-Educational Attributes, Age, School location, Correlation, Measures)*

INTRODUCTION

In science and research, an attribute is a quality of a person, object or element. Attributes are synonymous to variables (Sunday et al, 2023). A variable is a logical set of attributes. A variable is a concept, construct, condition, or attribute that can have several values. For example, people's intelligent quotient (IQ) is measured on a scale from low to high. Gender is another variable that can have two values, such as 'Male' or 'Female'. According to Ndiyo (2016), variables can "vary" – for example, be high or low. How high, or how low, is determined by the value of the attribute. Values of each variable statistically "vary" (or are distributed) across the variable's domain. A domain is a set of all possible values that a variable is allowed to have. The values are ordered in a logical way and must be defined for each variable.

All educational research depends upon variables. It is essential from the start to the finish of a research study. That is, variables are required to write an introduction, an operational definition, search for research articles for a literature review, prepare research methods, research tools that measure variables during data collection, statistical analysis based on variables, and, finally, write a discussion and conclusion to a research study. Isangedighi et al (2004) stated that once a research topic has been determined, the researcher should determine the essential variables of the chosen research study. It's crucial to know how to investigate the important variables after they have been identified. Which is the foundation of all research design. So, before starting any educational research work, it is critical to understand what defines a variable. How many types of variables are used in educational research? How will they be studied? And how will they be measured? Etc. The purpose of research is to describe and explain variance in the world, that is, variance that occurs naturally in the world or change that we create due to manipulation. Variables are therefore the names that are given to the variance we wish to explain and it is very critical to the research because the way the researcher uses or handles them in the research process could determine the nature and direction of the research (Nwankwo & Emunemu, 2014).

Educational attributes or variables in research are elements that can have different values or vary across learners. That is, variable refers to the quantifiable form of a concept, construct, condition, or characteristic. For example, educational attributes are students' intelligent quotient (IQ) that varies from low to high, and gender is another variable that has two values: 'Male' or 'Female' (Titz, 2015).

A non-educational variable means being consistent or having a fixed pattern; not liable to change. A constant does not change its value and it remains the same forever. In scientific research, various formulae/ relationships between dependent and independent variables have been established and the value of non-variables as required have been found. For examples: pi

constant, universal gravitational constant G, earth's acceleration due to gravity g, Rydberg constant R, Joule constant J, Avagadro's number, etc. Maybe, some of the scientific laws including local or universal non-variable research in future can include human relationships of attraction or repulsion, disciplines of peace as dependent variable(s) and efforts (individual or universal) as independent variables.

More so, dichotomous attributes are variables that have only two possible values or categories. These variables are often used in research, statistics, and data analysis to represent binary outcomes or characteristics (Sunday, 2017). Dichotomous variables are useful for simplifying complex data and facilitating analysis, but they may not always capture the full nuance of a phenomenon (Ndiyo, 2016; Sunday, 2024). A dichotomous educational variable is a variable that has only two distinct categories or values in binary form. Dichotomous variables can be used as predictors or outcomes in statistical models. They can be used to compare groups or analyze relationships between variables (Sunday & Etuk, 2024). Similarly, Non-educational variable or attributes are characteristics or properties that remain constant and unchanged, often used to describe fixed or stable features (Sunday et al, 2023).

Coefficients of association (A) are statistical tools in data analysis that measure the strength of a relationship between two non-variables. A traditional measure for the 2 × 2 metrical table is the tetrachoric correlation (Pearson, 1900). The coefficient is an estimate of the Pearson Product-Moment Correlation Coefficient (PPMCC) between hypothetical row and column variables with normal distributions that would reproduce the observed contingency table if they were divided into two categories in the appropriate proportions. Because an approximate estimate of the Pearson correlation may well be as adequate in many applications, particularly in small samples, various authors have introduced approximations to the tetrachoric correlation (Digby, 1983; Castellan, 1966). Importantly, the measures of association are a wide variety of coefficients (including bivariate correlation and regression coefficients) that measure the strength and direction of the relationship between variables; these measures of strength, or association, can be described in several ways, depending on the analysis (Sunday, 2024). There are certain points that researchers should know in order to better understand the measures of statistical association. First, the researcher should know that measures of association are not the same as measures of statistical significance. It is possible for a weak association to be statistically significant; it is also possible for a strong association to not be statistically significant. Second, for measures of association, a value of zero signifies that no relationship exists. In a correlation analysis, if the coefficient (r) has a value of one, it signifies a perfect relationship on the variables of interest. In regression analyses, if the standardized beta weight (β) has a value of one, it also signifies a perfect relationship on the variables of interest. The researcher should note that bivariate measures of association (e.g., Pearson correlations) are inappropriate for curvilinear relationships or discontinuous relationships.

The Yule's Q is a nominal level measure of association that could be used to determine the association or relationship between variables (Baddie and Fred, 1995; Kolawole, 2001). Yule originated this measure of association for variables which have two and only two values. It is

used with 2 x 2 tables; each variable being expressed as a dichotomy. These educational non-variables dichotomies may be male-female, yes-no, true-false, for-against, agreed-disagree, graduate-non-graduate, tall-short, high-low and so on (Adeyemi, 2002). The Yule's Q coefficient is a distribution-free statistic. For variables having infinite values, the researcher may want to put these variables into dichotomies. The process involves the construction of dichotomies that would affect the value of the Yule depending on how the original categories were collapsed. Yule' Q is, therefore, the ratio of the differences between the products of the diagonal cell frequencies and the sum of the products of the diagonal cell frequencies (Campbell, 1999; Oppenhelm, 1992; Adeyemi, 2003). This could be done by using the following formula.

$Q = (ad - bc) / (ad + bc)$

where, a, b, c, d are frequencies found in cells a,b,c, d of a 2 x 2 table.

Assumptions for using Yule's Q:

i. The Yule's Q coefficient is a distribution- free statistic (Awosami et al., 1999).

ii. One major assumption of Yule's Q coefficient is that the data has to be dichotomized.

Advantages of using the Yule's Q:

i. An advantage of Yule's Q is that no correction needs to be made for it.

ii. Q is computed from a 2x2 table without first computing the chi-square test.

iii. It is best meaningfully applied where data are in dichotomies.

iv. It has no stringent assumptions for its application

v. It is quickly and easily computed.

vi. It a measure of the proportional reduction in error associated with predicting one variable from the order (Baddie & Fred, 1995).

Disadvantages of using the Yule's Q:

i. One disadvantage of Q is that it is limited to only 2 x 2 tables.

ii. When the researcher's data fit into larger tables, for example, a 2x3, 3, 3x4 or 3x6 table, Yule's Q cannot be computed unless the data are "collapsed" into a 2x2 table.

iii. The idea of collapsing data into fewer categories may lead to the loss of vital information. Hence, it is better to avoid collapsing data when using the Yule's Q (Bandele, 1999).

It is worrisome to know that in the history of methods for computing correlation coefficients by educational researchers, most attention has been given to variables that index the degree of correlation or association between variable attributes. This may be due to the fact that most

research studies in Educational Psychology and related fields have been concerned with data of variables rather than non-variables. According to Sunday (2017), an observation and interaction with most research scholars revealed that they employ statistical tools/techniques without minding when and how to employ them (assumptions).

The most widely used method of indexing the degree of correlation between two variables is the Pearson-Moment Method originally developed by Galton and perfected by Karl Pearson. Many years ago. However, Yule presented methods that yield an index for the correlation between non-variable as well as variable attributes, which are dichotomized or divided into only a few categories (Ndiyo, 2006). The method developed by Yule for indexing the degree of correlation between two dichotomized non-variable attributes yields a coefficient known as the Coefficient of Association. This paper applies a dichotomized educational attribute vis-a-vis a dichotomized non-educational attribute.

Literature Review

Association of Attributes

The meaning of association in statistical language is quite different from the common meaning of association. Commonly, if two attributes A and B appear together number of times then, they can be said to be as associated. But according to Pankush (2020), "Statistics A and B are associated only if they appear together in a greater number of cases than is to be expected, if they are independent." Methods used to measure the association of attributes refer to those techniques, which are used to measure the relationship between two such phenomena, whose size cannot be measured and where one can only find the presence or absence of an attribute.

In the case of correlation analysis, we study the relationship between two variables, which we can measure quantitatively. Similarly, in the case of association we study the relationship between two attributes, which are not quantitatively measurable. For example, level of education and crime. In association no variables are involved. As it has been stated earlier an attribute divides the universe into two classes, one possessing the attribute and another not possessing the attribute whereas the variable can divide the universe into any number of classes. Correlation coefficient is a measure of degree or extent of linear relationship between two variables, whereas the coefficient of association indicates association between two attributes and also whether the association is positive or negative. But with the help of coefficient of association we cannot find expected change in A for a given change in B and vice-versa, as possible by regression coefficient, which is derived from correlation coefficient.

Types of Association

Two attributes A and B are said to be associated if they are not independent but are related in some way or the other. There are three kinds of associations, which possibly occur between attributes.

1. Positive association

2. Negative association or disassociation

3. No association or independence.

Notation

The simplest possible form of statistical classification is " division" (as the logicians term it) " by dichotomy," that is, the sorting of the objects or individuals observed into one or other of two mutually exclusive classes according as they do or do not possess some character or attribute, as one may divide men into sane and insane, the members of a species of plants into hairy and glabrous, or the members of a race of animals into males and females (Esuabana, 2020). The mere fact that we do employ such a classification in any case must not of course be held to imply a natural and clearly defined boundary between the two classes; for example, sanity and insanity, hairiness and glabrousness, may pass into each other by such fine gradations that judgments may differ as to the class in which a given individual should be entered.

Notation; terminology; relations between the class frequencies; tabulation. The notation used is as follows:

N = total number of observations,

(A) = number of objects or individuals possessing attribute A,

(α) = number of objects or individuals not possessing attribute A,

(AB) = number of objects or individuals possessing both attributes A and B,

(A/B) = number of objects or individuals possessing attribute A but not B.

(α/B) = number of objects or individuals possessing attribute B but not A,

(α/β) = number of objects or individuals not possessing either attribute A or B, and so on for as many attributes as are specified. A class specified by n attributes in this notation may be termed a class of the nth order. The attributes denoted by English capitals may be termed positive attributes, and their contraries, denoted by the Greek letters, negative attributes. If two classes are such that every attribute in the one is the negative or contrary of the corresponding attribute in the other, they may be termed contrary classes, and their frequencies contrary frequencies; (AB) and (αB), (ABy) and (αBC) are for instance pairs of contraries (Yule, 1903). This coefficient ranges from –1 to +1. The values between –1 and 0 indicate inverse relationship (association) between the attributes. The values between 0 and +1 indicate direct relationship (association) between the attributes.

Yule's coefficient: $\mathbf{Q = [\ (AB)\ (\alpha\beta\ ) - (\ A\beta\ )(\alpha\ B)\ ]\ /\ [\ (\ AB\ )(\alpha\beta\ ) + (\ A\beta\ )(\alpha\ B)\ ]}$

Association is a very general relationship: one variable provides information about another. Correlation is more specific: two variables are correlated when they display an increasing or decreasing trend.

Association Rules

The goal of data mining is to extract higher level information from an abundance of raw data. Association rules are a key tool used for this purpose. An association rule is a rule of the form X + Y, where X and Y are events, which states that when X occurs in the database so does Y, with a certain probability (coined the confidence of the rule). A well-known application of association rules is in market basket data analysis. The problem of mining association rules was first introduced by Agrawal, Imielinski and Swami (1993), and later broadened by Agrawal and Srikant (1994), for the case of databases consisting of categorical attributes alone. Categorical association rules are rules where the events X and Y on both sides of the rule, are the appearance of given categorical items. In this case, we wish to find all rules with confidence and support above user-defined thresholds (minconf and minsup). Several efficient algorithms for mining categorical association rules have been published for just a few examples). A variation of categorical association rules was recently introduced by Brin, Motwani, and Silverstein (1997). Their new definition is based on relating to associations as statistically interesting correlations. In all, the problem of mining categorical association rules is well understood and extensively researched, on both the algorithmic and conceptual levels.

Quantitative Association Rules

In practice the information in many, if not most, databases is not limited to categorical attributes, but also contains much quantitative data. Unfortunately, the definition of categorical association rules does not translate directly to the case of quantitative attributes. It is therefore necessary to provide a definition of association rules for the case of a database containing quantitative attributes. Srikant and Agrawal (1996) extended the categorical definition to include quantitative data. The basis for their definition is to build categorical events from the quantitative data by considering intervals of the numeric values. Thus, each basic event is either a categorical item or a range of numerical values. An example of a rule according to this definition would be:

Sex = female and male

Age = 10-20 years and 21 years and above

Given this definition, Srikant and Agrawal (1996) provides an algorithm which approximately finds all rules by employing a discretization technique. In addition, Srikant and Agrawal (1996) provides an interest filter, aimed at reducing the problem of many similar rules.

The purpose of the study is to examine the association between educational and non-educational attributes such as the preference for the colour of shirt and educational attributes such as age, sex, school location and school type among SS 3 students of Calabar South Local Government Area of Cross River State, Nigeria. Specifically, the study sought to examine;

1. The association between students' age and their preference for the colour of shirt

2. The association between students' school location and their preference for the colour of shirt

To guide the study, the following research questions were posed.

1. How does students' age associate with their preference for the colour of shirt?

2. How does students' school location associate with their preference for the colour of shirt?

METHODOLOGY

The research design adopted was the survey design. Survey design is a design where the researcher describes the status of affairs as they exist (Isangedighi, Joshua, Asim & Ekuri (2004). This is a method of collecting information by means of interviews and administering questionnaires. The rationale for using this design is that it allows in-depth study of the subject matter and it is suitable to describe attitudes, views or opinions and behaviour patterns of people. This type of design is possible when human subjects are used in real situations and the researcher comes in after the effects. This study will report its findings through coding, classification, analysis, comparison and interpretation of the data collected.

The population of comprised all SS 3 students in Calabar South Local Government Area Calabar, Cross River State, Nigeria. The total population of SS 3 students in both public and private schools is unknown. In selecting the respondents, the accidental sampling technique was used. In this method, it was only the SS 3 students that the researcher finds convenient that was sampled for the study. This included male and female SS 3 students who are accessible and those who were willing to respond to the instrument. The sample was made up of 200 male and female SS 3 students in Calabar South Local Government Area of Cross River State, Nigeria.

Questionnaire was the basic instrument used to elicit information from the respondents. The questionnaire titled “Educational Attributes and Shirt Colour Preference Questionnaire (EDSCPQ)" consisted of two sections.

Results and Analysis

Presentation of results

The results of the data collected are presented according to the research question stated:

Research question 1: How does students' age associate with their preference for the colour of shirt? The variable ‘students age’ had the following categories: 12-15 years (A) and 16-20 years (B). This variable was discretely measured in frequencies of 1 and 2. To answer the research question, the students' age was discreetly measured with their preference for the colour of shirt with respect to: Red and Black. Coefficient of Association Analysis was used to summarize the students’ responses. The result of the analysis is presented in Table 1.

TABLE 1

Matrix of students' age and their preference for the colour of shirt

	Preference for the Colour of Shirt		
Students' Age	**Red Shirt**	**Black Shirt**	**N**
12-15 years	72[a]	21[b]	93
16-20 years	26[c]	81[d]	107
Total	98	102	200

These data give in a fourfold table, the cross-tabulation of the age category and answers of the respondents to the question: How often do you prefer to use Red or Black shirt? Cell a of Table 1 indicates that 43 of the 88 students whose age is ranges from 12-15 years old had used Red shirt, cell b indicates that 45 of the students whose age ranges from 12-15 years old only use Black shirts; Cell c indicates that students whose age ranges from 16-20 year old had used Red shirts, while cell d indicates that students whose ages are between 16 and 20 years old only used Black shirts. This means that the cross tabulation implies a considerable correlation between students' age and their preference for shirt colours. The Yule's Coefficient of Association is computed by the formulae;

$$A = \frac{ad - bc}{ad + bc}$$

in which a, b, c, and d represent the statistical frequencies of these respective cells in the 2 X 2 matrix table.

Coefficient of Association A is therefore,

$$A = \frac{(72)(81) - (21)(26)}{(43)(53) + (45)(59)} = \frac{5832 - 546}{5832 + 546}$$

$$A = \frac{5286}{6378} = 0.828 \text{ or } 0.83$$

The strength or level of association between students' age (educational attribute) and preference for shirt colours (non-variable attribute) is 83% indicating a very high or strong positive relationship.

Research question 2: How does students' school location associate with their preference for the colour of shirts? The variable ‘students school location’ had the following categories: Urban (1) and Rural (2). This variable was discretely measured in frequencies of 1 and 2. To answer the research question, the students' school location was discreetly measured with the preference of clour of shirts among students. Coefficient of Association Analysis was used to summarize the students’ responses. The result of the analysis is presented in Table 2.

TABLE 2

Tabulation of students' school location and their preference for colour of shirts

Preference for the Use of Polyethylene Bag

School Location	Red shirt	Black shirt	N
Urban	57[a]	28[b]	93
Rural	69[c]	46[d]	107
Total	126	74	200

These data give in a fourfold table the cross-tabulation of the school location category and answers of the respondents to the question: How does students' school location associate with their preference for colour of shirts?

Cell "a" of Table 1 indicates that 57 of the 93 students whose school location was urban had used Red colour of shirts "; cell "b" indicates that 28 of the rural students only use Black colour of shirts; Cell "c" indicates that 69 rural students had used Red colour of shirts, while cell "d" indicates that 46 rural students only use Black colour of shirts. This means that the cross tabulation implies a considerable correlation between students' school location and their preference for colour of shirts. The Yule's Coefficient of Association is computed by the formulae;

$$A = \frac{ad - bc}{ad + bc}$$

in which a, b, c, and d represent the statistical frequencies of these respective cells in the 2 X 2 matrix table. Coefficient of Association A is therefore,

$$A = \frac{(57)(46) - (28)(69)}{(57)(46) + (28)(69)} = \frac{2622 - 1932}{2622 + 1932}$$

$$A = \frac{690}{4554} = 0.151 \text{ or } 0.2$$

The strength or level of association between students' school location (educational attribute) and preference for colour of shirts (non-variable attribute) is 20% indicating a weak or low positive relationship.

Conclusion

Variables are basic ingredients of every research and the new entrant to the field should

study this aspect of research very critically because failure to have well defined variables at the beginning of the studies will definitely lead to blind alley along the line. Also, to further achieve the fundamental purpose of research by making enquiry into the unknown with a view of finding solution to the problem, effective communication of research report must be done by researcher. To this end, it is therefore very essential to define terms or concepts that are subject to different meanings in a research work so as to guide against confusion of intended meaning.

In view of the foregoing, it was concluded that Measures of Association are critical requirement for research into problems dealing with relationships or association. The Coefficient of Association (A) is based upon the ratio of the difference of the products of the frequencies in the diagonal cells to the sum of the products of the frequencies in the diagonal cells. For dichotomized non-variable attributes, a negative value does not really signify negative correlation. Whether or not the coefficient A, as may be computed, its negative or positive is arbitrary, since the result depends upon the arrangement of the respective categories of each attribute in the fourfold metrical table. This measure is used to know the existence of relationship between the two attributes A and B (binary complementary variables).

This is evident in the sense that the solving of a particular research problem in scientific and behavioural studies is a function of the required Measure of Association. Hence, researchers would find this study as a pointer to how they could effectively utilize Coefficient of Association to solve research problems in Education and Behavioural Sciences.

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