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# The Researcher, its Experiment and Statistical Errors; Who Bear the Cost Implication of the Errors

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**ABSTRACT**

This paper is designed to answer the question "It is assumed that every experiment has a cost which has to be paid for and the statistician must meet the cost of a working decision by paying the fine corresponding to his or her error". The paper discusses extensively the concept of experiment, by reviewing it as the scientific approach of learning about things around us. The paper also reviewed that statistical error is the difference between the obtained value of the collected data and the actual value of the collected data and identified type 1 and type 2 errors as types of statistical errors committed in educational research. Strategies to minimize statistical error were reviewed. The paper reviewed that if errors are spotted in the handling of statistics by journals, the authors (researcher) may be asked to make extensive changes or may even face rejection for errors committed. It is, therefore, concluded that the researcher is liable for every error in every research, if the right design, Population, Sample, analysis, hypothesis testing, and reporting among others were used, the potential error would have been reduced. Finally, the paper suggested that researchers should be careful and critical in selecting design, sample, instrument and statistical tests, researchers should study carefully data collection, sampling, measurement, and reporting methods should be implored to reduce hypothesis testing errors and researchers should use statistical software that allows for programming, this will eliminate possibility of errors from copying the wrong values or pasting them incorrectly.

**Keyword: Statistician, Experiment, Errors, Statistical Errors**

## INTRODUCTION

Retracting a mistake in everyday life is difficult, especially at first. However, in a public station, making an error and continuing to do so after it is discovered damages one's reputation as well as their financial situation. Statisticians play a crucial role in scientific research and decision-making processes, where they design experiments, analyze data, and draw conclusions. However, no experiment is free from errors, whether they stem from the design phase, data collection, or analysis. These errors can have significant consequences, both in terms of the validity of research findings and their real-world implications. We may also add that men's thoughts get agitated and more attached to their errors as a result of disappointment and opposition (Alexander in Andrew et al., 2017).The idea that science is self-correcting came about because it is crucial to recognise and fix faults. The implication is that science cannot assert that it is self-correcting, a notion that has drawn criticism (Ioannidis, 2012). If errors are not found and fixed, science cannot claim to be.Knowledge cannot grow if it is constrained by the precepts of conventional thought and methodology.Errors have plagued science throughout its history (Boca, 2017).

Horace Secrist, a professor and the author of a book on statistical procedures (Horace in Andrew et al., 2017), drew significant inferences about company performance from patterns that a statistical specialist of the time should have recognized as regression to the mean. A renowned researcher "Student" wrote a review of a failed experiment in which 20,000 infants were studied to determine the effects of milk on growth, but the time, money, and effort invested in the study were in vain (Andrew et al., 2017). The study's conception and execution were careless, and the results were inconclusive. Such issues are hardly new to science.Similar errors continue today, are sometimes severe enough to call entire studies into question and may occur with nontrivial frequency (Carlisle, 2017).The dangerously high mistake rate might have serious repercussions. Inconsistencies in reporting may influence whether an effect is considered to be substantial or not, which may have an impact on substantive results. If a result is inconsistent, it is sometimes hard to tell whether the test statistic, the degrees of freedom, or the p-value were reported properly (in the absence of raw data). If the test statistic used to determine the effect size for a meta-analysis is inaccurate, this effect size will also be error, which might have an impact on the meta-analysis's results(Bakker & Wicherts, 2011).Even though reporting errors might be unintentional, they have also been classified as one of numerous often occurring dubious research practises (QRPs) in psychology(John, Loewenstein, & Prelec, 2012).

We will concentrate on behaviours that, in theory, well qualified researchers who were engaged in their field and aware of the current state of knowledge should have or might have understood were mistakes or lacked rigour.Our focus is on mistakes that could frequently have been prevented in the future, as opposed to the errors stated above that could only have been detected in retrospect thanks to scientific advancements.Even while reporting errors can be unintentional, they have also been listed among the many very widespread dubious research practises (QRPs) in psychology (John, et al., 2012).

Research errors has been the primary focus of efforts to ensure research integrity to date. errors in research refers to deliberate behaviour intended to create fraudulent study findings. Unintentional mistakes, however, which might also lead to the publication of false study findings, have received less attention.Christiansen and Flanagin (2017) pushed researchers to reveal errors since "To Err Is Human, to Correct Divine".

This issue's scope and relevance are unknown. Researchers may fail to notice many of the errors or may learn about them after the fact but fail to disclose them. The research process is complicated and has many potential for mistake, and it often involves several researchers. It is therefore unreasonable to expect research activity to be error-free in the absence of purposeful steps to lower the risk of errors occurring and improve researchers' capacity to recognise and correct them when they do. No recommendations exist that address how to deal with inadvertent mistakes in research, as far as we are aware.

The objective is to minimize the possibility of error occurring and increase the chances of seeing and fixing it before it affects the individual and might cause harm in the educational system.In this paper we will explore the question of who bears the cost implications of errors in statistical experiments. Understanding the distribution of these costs is vital not only for responsible research but also for ensuring accountability and fairness in various domains.

### *The Statistician/Researcher*

A researcher is an individual who conducts systematic and investigative studies, investigations, or experiments in order to gather and analyze information, data, or evidence to advance knowledge in a particular field of study or to address a specific research question or problem.The term "researcher-as-instrument" refers to a researcher who actively participates in the research process as a responder (Hammersley & Atkinson, 1995). Researchers are often employed in academic institutions, government agencies, private companies, or non-profit organizations and contribute to the development of new theories, methods, or technologies by conducting rigorous and objective research.A researcher is somebody who performs research, independently as a principal investigator, the search for knowledge or in general any systematic investigation to establish facts. Researchers can work in academic, industrial, government, or private institutions.

In order to grasp the items under investigation, researchers "use their sensory organs, mirroring them in their consciousness, where they are then converted into phenomenological representations to be interpreted" (Turato, 2005). A conversational space is produced by the researcher's facilitative engagement with the participants, which acts as a setting where people feel comfortable sharing tales about their experiences and personal lives (Owens, 2006).

Over the years, academics have taken into account the character of the researcher-as-instrument as an interpreter of empirical data and as someone who participates in the development of ideas (Janesick, 2001; Singer et al., 1983). Feminist ethnographers like Stack (1995), who provided groundbreaking research on "dramatising both writer and subject" in fieldwork on neighbourhoods and communities, further developed this idea after feminist UK scholars such as Oakley (1981) and Graham (1983) criticised quantitative research methods that assumed a detached and value-free researcher in the acquisition and interpretation of gathered data.Scholars' interest in research tools has more recently expanded to include particular interviewing techniques. The nuances of interview talks have frequently been studied using conversation analysis methods, examining the ways in which the "how" of a particular interview impacts the "what" that is generated (Holstein and Gubrium, 1995; Pillow, 2003).

## CONCEPT OF EXPERIMENT

An experiment is, in its most basic sense, just a hypothesis that is tested. A hypothesis is a suggested connection between or explanation for a phenomenon.A controlled experiment is a study in which the researcher aims to comprehend the cause-and-effect connection Gordon (2002).The scientific method, a methodical approach to learning about things around you, is built on the experiment. Despite the fact that certain tests are carried out in labs, you can conduct an experiment at anytime and anywhere.The study is "controlled" in the sense that the researcher has control over how participants are divided into groups and what procedures are applied to each group. In the analysis stage, the researcher evaluates the results for each group on the independent variables and makes a determination on whether the treatment's independent factors had a causal impact on the dependent variables. A scientific experiment is a test in which a sequence of activities are taken and their results are carefully observed in order to learn more about a subject. The scientific method is a methodical approach to learning about the world around us, and experimentation is its cornerstone (Bailey, 2008). Though some may be done in labs and others in actual study areas, they may all be done whenever and whenever.

### *Types of Experiment*

According to Bailey (2008),the following are consideredas types of experiment:

- **Natural Experiment**: A natural experiment is one in which a prediction or hypothesis is made, followed by data collection by system observation. It is sometimes referred to as a quasi-experiment because the variables are not under control.

- **Controlled Experiments**: Although you can conduct them outside of a lab environment, they are known as lab experiments. An experimental group and a control group are compared in a controlled experiment. The independent variable, which differentiates between these two groups, is what should be different.
- **Field Experiments**: A field experiment may be either a natural experiment or a controlled experiment. It takes place in a real-world setting, rather than under lab conditions. For example, an experiment involving an animal in its natural habitat would be a field experiment.

### *Experimental Variables*

Variable is anything one can change or control in an experiment. There are three common kinds of variables in anexperiment Dawn, (2009) this includes; Simply put, a variable is anything you can change or control in an experiment. Common examples of variables include temperature, duration of the experiment, composition of a material, amount of light, etc. There are three kinds of variables in an experiment: controlled variables, independent variables and dependent variables.

- **Controlled variables**, sometimes called constant variables are variables that are kept constant or unchanging. For example, if you are doing an experiment measuring the fizz released from different types of soda, you might control the size of the container so that all brands of soda would be in 12-oz cans. If you are performing an experiment on the effect of spraying plants with different chemicals, you would try to maintain the same pressure and maybe the same volume when spraying your plants.
- **Independent Variable** is the one factor that you are changing. It is *one* factor because usually in an experiment you try to change one thing at a time. This makes measurements and interpretation of the data much easier. If you are trying to determine whether heating water allows you to dissolve more sugar in the water then your independent variable is the temperature of the water. This is the variable you are purposely controlling.
- **Dependent Variable** is the variable you observe, to see whether it is affected by your independent variable. In the example where you are heating water to see if this affects the amount of sugar you can dissolve, the mass or volume of sugar (whichever you choose to measure) would be your dependent variable.

## CONCEPT OF ERRORS

By errors, we mean actions or conclusions that are demonstrably and unequivocally incorrect from a logical or epistemological point of view (e.g., logical fallacies, mathematical mistakes, statements not supported by the data, incorrect statistical procedures, or analyzing the wrong dataset). We are not referring to matters of opinion (e.g., whether one measure of anxiety might have been preferable to another) or ethics that do not directly relate to the epistemic value of a study (e.g., whether authors had a legitimate right to access data reported in a study). Finally, by labeling something an error, we declare only its lack of objective correctness, and make no implication about the intentions of those making the error. In this way, our definition of invalidating errors may include fabrication and falsification (two types of misconduct). Because they are defined by intentionality and egregiousness, we will not specifically address them herein. Furthermore, we fully recognize that categorizing errors requires a degree of subjectivity and is something that others have struggled with.

### *Statistical Error*

Statistical error is the difference between the obtained value of the collected data and the actual value of thecollected data. Statistical error is the difference between a measured value and the actual value of the collected dataASA, (2015). According to Guopta, (2010) Statistical errors has its source from sampling, measurement, estimation,hypothesis testing and reporting. Data savvy professionals are believed to be rare combination of statistical andcomputational ingenuity; however, these data pros are also prone to errors. Statistician provides these answers but insome cases its confusing. Fawcett, (2016) opined that there are six common errors statisticians or data scientistmakes; correctional error, Biased data, regression error, misunderstanding P-Value, inadequate handling of outliersand influential Data points, loss of information.

- **Correction error**: correction is art causation Fawcett (2016) that just became two things appear to berelated to each other doesn’t mean that one causes the other. This is apparently the common mistakes intime series Fawcett lutes an example of a stock market index and the unrelated time series number of timesJennifer Lawrence was mentioned in the media. The line looks amusingly similar. Stated that whenexploring relationship between two time series, all one wants to know is whether the variations in oneseries are correlated with variations in another.
- **Sampling Errors:** These arise when the sample used in an experiment is not representative of the population, leading to incorrect generalizations.
- **Measurement Errors:** Errors can occur in data collection, where instruments or procedures do not precisely measure the variables of interest.
- **Basic data**: We bare hear of biased algorithm, but there is bias data as well. Biased sampling can lead tomeasurement errors because of unpresentative samples. In most cases, data scientist (statistician) can arriveresults that are close but not accurate due to biased estimators. An estimator is the rule for calculating anestimate of a given quantity based on the observed data. In fact non-random samples are believed to bebiased and their data cannot be used to represent any other population beyond themselves.

- **Regression error**: In a basic linear or logistic regression, mistakes arise fro not knowing what should betested on the regression table. In regression analysis, one weighs the dependant variables that varies basedon the value of the independent variable. The first step here is to specify the model, by defining theresponse and the predictor variables. And most statistician strip up here by mis-specifying the model. Inother to avoid the model misspecification. The truth is that one must find out if there is any functionedrelationship between the variables that are to be considered.
- **Misunderstanding p-value**: Long pegged as the "Gold Standard" of statistical validity, P-values are anebulous concepts and statistician believes that are not as reliable as many researchers assume. P-values areused to determined statistical significance in an hypothesis test. According to American Association, P-value do not measure the probability that the studied hypothesis is true or the probability that the data wasproduced by random chance alone. Hence, businesses and organizational decisions should not be basedonly on whether a P-value parses a specific threshold. Of counts, many believe that data manipulation andsignificance chasing can make it impossible to come to right conclusion from findings.
- **Inadequate handling of outliers and influential data points**: Outliers can affect any statistical analysis;this should be investigated and deleted, corrected or explained as appropriate. For auditable works, thedecision on how to treat any outliers should be documented. Sometimes loss of information may be a validtradeoff in return for enhanced comprehension.
- **Loss of information**: The main objective of statistical data analysis is to provide the best businessoutcome, with minimal modeling or human bias. Sometimes, a loss of information individual data pointscan impact the result and its relationship with data set.

### *Types of Statistical Errors*

There are two types of statistical errors according to Kaur (2017). This include:Type I error and Type II error

Type I and Type II errors are subjected to the result of the null hypothesis. In case of type I or type-1 error, the null hypothesis is rejected though it is true whereas type II or type-2 error, the null hypothesis is not rejected even when the alternative hypothesis is true. Both the error type-i and type-ii are also known as "false negative". A lot of statistical theory rotates around the reduction of one or both of these errors, still, the total elimination of both is explained as a statistical impossibility.

### *Type I Error*

A type I error appears when the null hypothesis ($H_0$) of an experiment is true, but still, it is rejected. It is stating something which is not present or a false hit. A type I error is often called a false positive (an event that shows that a given condition is present when it is absent). In words of community tales, a person may see the bear when there is none (raising a false alarm) where the null hypothesis ($H_0$) contains the statement: "There is no bear".

The type I error significance level or rate level is the probability of refusing the null hypothesis given that it is true. It is represented by Greek letter α (alpha) and is also known as alpha level. Usually, the significance level or the probability of type i error is set to 0.05 (5%), assuming that it is satisfactory to have a 5% probability of inaccurately rejecting the null hypothesis.

### *Type II Error*

A type II error appears when the null hypothesis is false but mistakenly fails to be refused. It is losing to state what is present and a miss. A type II error is also known as false negative (where a real hit was rejected by the test and is observed as a miss), in an experiment checking for a condition with a final outcome of true or false.

A type II error is assigned when a true alternative hypothesis is not acknowledged. In other words, an examiner may miss discovering the bear when in fact a bear is present (hence fails in raising the alarm). Again, H0, the null hypothesis, consists of the statement that, "There is no bear", wherein, if a wolf is indeed present, is a type II error on the part of the investigator. Here, the bear either exists or does not exist within given circumstances, the question arises here is if it is correctly identified or not, either missing detecting it when it is present, or identifying it when it is not present.

The rate level of the type II error is represented by the Greek letter β (beta) and linked to the power of a test (which equals $1-\beta$).

### *Errors Committed by Researchers in Educational Research*

Glem and Roseaun, (2011); Qualitrics(2010) identified common errors encountered in educational research, which include:

1. **Sampling error:** is the deviation of the selected sample from the true characteristics, traits, behaviours, qualities or figures of the entire population.
2. **Population specification error:** This type of error occurs when the researcher selects an inappropriate population from which data is obtained (Qualitrics, 2010).

3. **Accidental Errors:**As the name suggests, accidental errors are the result of factors that are beyond the control of the researcher. Put simply, this type of surveying errors occur due to the unavoidable situations such as variations in the atmospheric conditions, etc. In addition, errors in survey as a result of imperfection in the measuring tools or techniques fall in this survey error category. The errors may be positive or may change the sign, but it cannot be accounted for the process.
4. **Mistakes**: This type of survey errors arise due to inexperience, inattention, poor judgement or carelessness of the researcher. Mistakes do not follow the law of probability or any mathematical rule. It can be large or small, negative or positive but cannot be measured. However, it can be detected by performing the whole procedure on repeatedly. If a mistake goes undetected, it can affect the final outcome of the data analysis process. Therefore, every value should be thoroughly checked by independent field observer.
5. **Systematic errors**: Systematic error, also known as cumulative error, in an error which are of the same size and size under the same conditions. This type of error follows definite physical or mathematical law. As a result, a solution can be identified and applied. Systematic errors can be positive or negative and have an impact on the final outcome of the analysis process. I.e., they make the result large or small. These errors arise due to number of reasons such as leveling of instrument, temperature, and many more.
6. **Compensating errors**: This kind of error occurs in both directions, i.e., in negative as well as positive direction, thereby compensating each other. This type of error follows mathematical laws of probability and hence can be solved by determining the apt solution.

***Cost Implications of Statistical Errors***

Handling data correctly is important from the perspective of receiving accurate results. However, statistical soundness is also crucial from the perspective of getting published. If errors are spotted in the handling of statistics by the journals, the authors (statistician) may be asked to make extensive changes or may even face rejection. Unfortunately, statistical errors are not that uncommon. If errors are part of the description of the statistical analysis, revisions may be easy to incorporate. However, if the errors are made in data analysis, data interpretation, and discussion of the results, extensive changes would be required throughout the paper. In contrast, errors made in the study design often result in manuscript rejection as such errors cannot be corrected without repeating the whole study.

***Strategies to Minimize Statistical Error***

Some of the possible ways to avoid survey errors and make the most out of it include:

1. The main intent of getting open ended questions is to understand the mindset and thoughts. Don’t use too many open ended questions making the respondents feel like they are writing essays instead of filling up the questionnaire.
2. Use similar type of questions by using likert scale making. It’s easy for respondents to give valuable feedback in one go by using rating scale.
3. Use digital platform to create survey to increase the ease of filling and giving some additional feedback and coupons codes to increase the responsive of the respondents.
4. Use statistical software that allows for programming and direct export of tables and any associated text instead of copying/pasting values from analytic output. This eliminates possibility of errors from copying the wrong values or pasting them incorrectly into the table.
5. Use direct data entry into computer devices (e.g use tablets or laptops to directly enter data as you collect it) rather than writing on paper forms and then reentering the data into computer. The data entry programs should include checks for inconsistencies or out-of-range responses.
6. Create a study data management plan that details how data elements will be handled and adequately train research team members performing data handling tasks.

## Conclusion

Like any other profession, research is subject to errors. Despite researchers' best attempts to be careful, it is unreasonable to expect research work to be error-free given the complexity of research operations and procedures. Many researchers are committing errors in their research methodologies and selection of statistical tests. Errors may go undetected and lead to inaccurate conclusions, which can have a severe influence on educational practice and increase the discrepancy in research findings between researchers if proactive measures are not taken to identify errors. The increasing awareness about errors in research, and applying systematic strategies to prevent and detect them is warranted. The assumption is that every experiment has a cost that has to be paid for, and the statistician must meet this cost of a wrong decision by paying the fine corresponding to his or her error, to the author the researcher is liable for every error in every research. This is in line with the view of Yobolo and Timidi (2023) who opined that It is a shared obligation to make a mistake and continuing with it after it is discovered, damages one's image and finances. If the right design, Population, Sample, analyzing, hypothesis testing and reporting among others were used, the potential error would have been reduced.

## Suggestions

The paper suggested the following for the improvement of research and use of statistical tests/tools:

1. Researchers should be careful and critical in selecting the design, sample, instruments and statistical tests.
2. Researchers should be study carefully data collection, sampling, measurement and reportingmethods should be implored to reduce hypothesis testing errors.
3. Researchers should use statistical software that allows for programming, this will eliminates possibility of errors from copying the wrong values or pasting them incorrectly.

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