

**FORENSIC LABORATORY TECHNIQUES UTILIZED TO IDENTIFY POTENTIAL
EVIDENCE FOR COLLECTION AND PRESERVATION.**

**A RESEARCH PROJECT SUBMITTED TO NATIONAL UNIVERSITY IN PARTIAL
FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF FORENSIC SCIENCES**

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MASTER’S THESIS APPROVAL FORM

We certify that we have read the project of Kareece St George entitled forensic laboratory techniques utilized to identify potential evidence for collection and preservation. In our opinion, it is satisfactory in scope and quality as a thesis for the degree of Master of Forensic Sciences at National University.

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Date

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ABSTRACT

Forensic laboratory techniques that are utilized to identify potential evidence for collection and preservation are what is needed to solve cases and present evidence in court. When a crime has been committed the crime scene will always have evidence that must be collected and tested in order to identify victims, suspects, and to further explain what transpired at the crime scene. There is always a different way of collecting the potential evidence as the evidence located at the crime scene varies. Methods to carefully collect and preserve the evidence must be adhered to at all times as so not to contaminate the evidence collected. There are several types of evidence that can be collected at a crime scene that can be contaminated such as depositing hairs or fibers from clothing, latent footwear and fingerprints and DNA from another source that may be relevant to the case. There are also various search types that are utilized to search a wide array of crime scenes. Crime scene search methods are based on the type of evidence, location and the size of the crime scene. These various search methods are link, line or strip method, grid method, zone method, wheel or ray method and the spiral method. The aim of this research is to explain and show how forensic laboratory techniques are utilized to identify potential evidence for collection and preservation.

Keywords: Techniques, Collection, Preservation and Evidence.

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Chapter I: Introduction

Evidence that is found at a crime scene must be collected and preserved to assist with solving crimes and to be presented for court cases. Evidence can consist of anything that can be utilized to solve a case, find the suspect and even exonerate a suspect. Examples of evidence that should be collected and preserved are blood samples, hair and fibers, fingerprints, footprint impressions and etc. The procedure which evidence must undergo from its identification at the crime scene until the testing of its value in the court room, however, is a complex one. It usually starts with the reporting of a crime and its investigation by the arriving police officer. They are responsible for assessing the scene and evaluating the need for the attendance of a Crime Scene Investigator (CSI). CSIs then identify potential forensic evidence at the scene and recover it for analysis by an expert forensic examiner in the forensic laboratory or equivalent police bureau. After conducting the appropriate tests (e.g. DNA analysis, fingerprint comparison), results are sent back to the police in a report, and if necessary, an expert witness report is produced for the presentation of the evidence in a courtroom. This is where the jury includes the information provided by the forensic evidence into their decision about the final verdict. (Wüllenweber & Giles, 2021)

Background of the Study

Forensic evidence that is located and collected at a crime scene should always be collected and preserved per the policies and procedures. It is imperative to make sure that the crime scene is protected and properly preserved for the collection and storage of the evidence. This report acknowledges and appreciates the high-level quality of work that has already

been researched on forensic science, crime scenes and the collection and preservation of evidence. Based on this projects objective that is discussed and highlighted above, there is little to no data on the study of no significant difference in the contamination of collected evidence and a significant difference in collecting and preserving blood samples and fingerprints as evidence. This report finds it essential to research tangible information on a significant difference in the various crime scene search methods, which are based on the type of evidence, location and size of the crime scene. This research will have to focus on data, computer models and peer reviewed research papers to discuss and show the importance of collecting and preserving forensic evidence and utilizing various crime scene search methods. The report seeks to encourage and promote empirical evidence that can be utilized to validate the gathered data and information from various crime search methods.

Problem Statement

There are so many crimes that being are committed every day and are being solved with the use of forensic laboratory techniques that are being utilized to identify the evidence for collection and preservation. There are various forensic laboratory techniques that are utilized in order to properly select the evidence needed from the crime scene for the court case. The selection of the evidence, collection and preservation stages are very important as the evidence can be mishandled and even contaminated.

Policy and procedure on collection and preservation of evidence must be adhered at all times. If at any time the evidence that was collected and preserved becomes contaminated this would mean that evidence is no longer admissible and can damage the reputation of all of the criminal justice professionals involved in the case. Proper training is to be conducted on how and when to collect potential evidence, how to store and preserve it. All evidence collected is not stored and preserved the same due to the type of evidence it is. For example, if any blood samples are collected, they would be stored in a paper bag, whereas fingerprints collected would be lifted with a clear tape and placed on a latent lift card.

It is important to only place one item per container to avoid contamination and any damp samples should never be placed in plastic containers. When a damp sample is placed in a plastic container, the moisture from the sample can cause microorganisms to grow and thus destroy the evidence. Also, any evidence of samples should not be stored in a container for more than two hours.

Purpose and Objectives of the Study

The primary purpose of this research project is to discuss and analyze forensic laboratory techniques utilized to identify potential evidence for collection and preservation. This research project will also discuss in detail several types of crime scene search techniques, and which one would be the better method to utilize.

- 1. Conduct a review on the various types of crime scene search techniques**
- 2. Break down in detail the duties and responsibilities of the crime scene investigators and their crime scene search methods.**
- 3. Assess and discuss the consequences of any errors made regarding utilizing the incorrect crime scene search method at a crime scene.**
- 4. Review and present data on the various types of crime scene search techniques**

Definition of Terms

DNA Evidence: or deoxyribonucleic acid (DNA) evidence, is biological evidence that can be used to help identify a person's involvement in a crime.

Crime Scene Investigators: a forensic scientist who collects and preserves evidence from crime scenes to help law enforcement solve crimes.

Evidence Technicians: a type of forensic science technician who is responsible for preserving the chain of custody for evidence, so it is legally valid at trial.

Contamination: the act of contaminating, or of making something impure or unsuitable by contact with something unclean, bad, etc.

Crime Scene: the place where an offense has been committed and forensic evidence may be gathered.

Limitations of the Study

Collecting and preserving blood samples and fingerprints as evidence has assisted in solving cases and convicting those guilty of the crimes committed. The contamination of evidence from the crime scene can not only be inadmissible in court but could allow the guilty to be found innocent.

It is notable that there are a few limitations within the design of the crime scene search method study. The mathematical representations have concrete stopping points and starting points that could be extended when performed by investigators. Another detail to take notice of is the 2.5 unit margin that was used to account for line of sight. However, real-life scenarios may leave the investigators with obstructed view or other sight issues that were not accounted for. Another limitation is the room shape. Very few rooms have a square shape, like modeled in the data collection, this means the formulas would have to be adjusted to fit different sized/shaped rooms. While this research serves to create a universal model for all room shapes and sizes that is not feasible. The research also does not take into account the chance for human error and the way that novices and experts perform differently in a crime scene (Eeden et al., 2019). (Tracy, 2023).

Research Hypotheses

Hypothesis 1. There is a significant difference in 4 different crime scene search patterns as to which would be the most effective in locating forensic evidence.

Hypothesis 2. There is a significant difference in the number of times a search strategy intersects with critical points.

Hypothesis 3. There is a significant correlation between the effectiveness of a crime scene search pattern in locating forensic evidence and the frequency with which the search strategy intersects with critical points.

Summary of Remaining Chapters

Chapter II: Literature Review

Existing information and research on forensic laboratory techniques utilized to identify potential evidence for collection and preservation will have to be analyzed, studied and recommendations from research papers, and journals on the above topic before research is set off.

Chapter III: Methodology

The data collection method, choice of the type of research, instruments, and the data recording will be completed in this chapter. The sources of data and how to rearrange them will be addressed too.

Chapter IV: Results

Collected data will be analyzed using the most suitable method analysis; secondary data, while the presentation will depend on the results from the analyzed data and information. This will be shown through tables, graphs, and or charts.

Chapter V: Discussion, Conclusions, and Recommendations

Based on the analysis of the results above, a conclusion and recommendation would be derived and given after a clear analysis of the given data.

Chapter II: Literature Review

This study investigates the effectiveness of forensic evidence in UK crime investigations. The main goal was to identify characteristics of forensic evidence that influence its effectiveness in converting detections into criminal charges, as well as to consider the effectiveness of a recent service level agreement (SLA) implemented by Wiltshire Police, which aimed at reducing CSI attendance. The sample consisted of 445 police recorded cases received from Wiltshire Police. The presence or absence and location-related characteristics of fingerprint, DNA, and footwear evidence were evaluated on the effectiveness of forensic evidence and examined within the contexts of different volume crimes. Results showed a high level of correlation in converting detections into criminal charges where the presence of DNA, footwear, and multiple evidence types was recorded and a positive correlation between forensic evidence ineffectiveness and presence of fingerprints, particularly in residential burglaries. Differences between individual offence types were expressed. The most prominent feature influencing the effectiveness of forensic evidence was found to be related to the movability of the exhibit associated with the recovered evidence, with DNA recovered from non movable items presenting the strongest effectiveness. Cases processed after the implementation of the SLA did not show significant differences in forensic evidence effectiveness as compared to cases processed prior to the SLA, however, they demonstrated a lack in effectiveness of DNA evidence. The findings of this research provide a better understanding of the influences on forensic evidence and can support improvement of crime scene screening and CSI resource deployment.

(Wüllenweber & Giles 2021)

The preservation of a crime scene is an imperative part of a successful criminal investigation. Forensic science deals with the collection, detection, and analysis of any evidence material collected. Different traces of forensic evidence that is located at a crime scene can be very important. One of the most important types of forensic evidence located at a crime scene would be bodily fluids. Blood is very commonly found in crimes that are violent in nature. Analyzing the bloodstain patterns and the age of them can lead to the identity of the suspects.

Blood is key evidence to reconstruct crime scenes in forensic sciences. Blood identification can help to confirm a suspect, and for that reason, several chemical methods are used to reconstruct the crime scene however, these methods can affect subsequent DNA analysis. Therefore, this study presents a non-destructive method for bloodstain identification using Hyperspectral Imaging (HSI, 397–1000 nm range). The proposed method is based on the visualization of heme-components bands in the 500–700 nm spectral range. For experimental and validation purposes, a total of 225 blood (different donors) and non-blood (protein-based ketchup, rust acrylic paint, red acrylic paint, brown acrylic paint, red nail polish, rust nail polish, fake blood, and red ink) samples (HSI cubes, each cube is of size $1000 \times 512 \times 224$, in which 1000×512 are the spatial dimensions and 224 spectral bands) were deposited on three substrates (white cotton fabric, white tile, and PVC wall sheet). The samples are imaged for up to three days to include aging. Savitzky Golay filtering has been used to highlight the subtle bands of all samples, particularly the aged ones. Based on the derivative spectrum, important spectral bands were selected to train five different classifiers (SVM, ANN, KNN, Random Forest, and Decision Tree). The

comparative analysis reveals that the proposed method outperformed several state-of-the-art methods. (Zulfiqar et. Al, 2021)

This study completed in the year 2015, was continued from 2010, and compares the number of analyzed crime scene samples with the number of detected contamination incidents within their laboratory. The results of this study illustrate the importance of reference profiles, especially of crime scene investigators, and the advantage of database assisted profile alignment in cases of mixtures. With the development of more sensitive DNA amplification and STR typing kits, the chance of detecting minute contamination of trace material increases. At the same time, possible ways of detecting unwanted contamination of crime scene samples were also enhanced.

As shown in this study, contamination of crime scene samples by examiners and police officers still remains a challenge in the analysis of forensic trace material. With the improvement of forensic DNA analysis, DNA profiles nowadays can be generated from samples with very small amounts of biological material. To reduce the generation of false positive results, the identification of contamination represents an important issue in forensic laboratories. (Pickrahn et. Al 2015)

In crime scene investigations, evidence is collected with the hopes of creating a probable cause to present in court. There are numerous strategies, but four well-known techniques are spiral, grid, parallel, and wheel (Lothridge, 2014). There are a wide range of multiple factors such as the size of the room, the shape of the room, the type of crime, the sensitivity of the crime, availability of staff and personnel etc. The question, one may ponder is which

search strategy would be the most beneficial and the most effective. One that would require less time searching and allows more collection of evidence.

The purpose of this research was to use mathematical modeling to outline and assess the effectiveness of grid, parallel, spiral, and wheel search strategies in a simple, square crime scene model. It was hypothesized that the parallel search method would be the most effective because it is a consistent repetition that is evenly spaced out. Formulas were created or derived to represent each of the search methods. They were then placed on a coordinate grid with four random points, known as critical points, and assessed for intersection. An intersection would indicate that the critical evidence was discovered by crime scene investigators. The hypothesis test results indicated there was sufficient evidence to reject the null hypothesis ($\chi^2(3, N=120) = 45.5, p < .05$). This suggests there is not an equal distribution of critical evidence found when using different crime scene search strategies. (Tracy, 2023)

Forensic laboratory techniques for identifying potential evidence rely heavily on proper collection and preservation methods at the crime scene. Singh (2021) emphasizes that crime scene investigation is "the meeting point of science, logic and law." The initial documentation, photography, and careful collection of physical evidence sets the foundation for subsequent laboratory analysis. Singh outlines various search patterns like strip, spiral, and grid methods that investigators use to systematically examine crime scenes and locate evidence. This methodical approach helps ensure no potential evidence is overlooked before transport to the forensic laboratory.

This means that the kind of evidence collected may not necessarily have to be tangible things like body and blood samples, but may also include impressions, trace evidence, firearms, digital/electronic etc., as postulated by Singh (2021). Every category has to be managed and preserved in its own unique manner. Regarding the biological aspect, Rajput (2024) examines the use of DNA in modern forensic science. DNA profiling has proved to be a great tool in both criminal and civil litigations, but its efficiency depends on sample collection and preservation. Rajput points out that there is nothing in the biological world that will not degrade, hence the importance of proper handling from the crime scene to the lab

Selective preservation techniques on the tissues can greatly affect the prospects of DNA extraction and identification. Shahzad et al. (2024) conducted a study to establish the effect of submersion time on lake water on the evidence where they observed that as the time of submersion, the DNA quantity is likely to lower and degradation level rises. Their research compared four storage methods after retrieval: air-drying, freezing in a freezer at temperature range of 0-2°C, storage at temperature of -196°C using liquid nitrogen gas and submersion of the samples in fresh lake water. In these tests, the general best methods were air-drying and freezing. This research also stresses that there is need of efficient and fast access to evidence especially when exposed to harsh conditions such as water immersion.

The best-known chain of custody is another significant fragment of evidence management that may affect laboratory analysis. Singh (2021) defines it as “the writing of all the individuals who retained unbroken possession of the items of evidence.” Such writing is essential in case an appeal to superior court is made for the dismissal of a

conviction or acquittal. The extraction must be capable of explaining all the transfers and storage conditions from collection to analysis. Forensic laboratories are also part of this chain and it is important that they are documenting their activities and following correct protocols for handling and analyzing samples.

Regarding sexual assault cases, biological evidence handling poses certain challenges. Magalhães et al. (2015) offer comprehensive procedural protocols on the proper manner of handling and storing DNA samples in any of these high-profile offenses. They also focus on contamination which may be at different levels; during the attack, between attack and examination, during examination, and in the laboratory. For example, to minimize the risk of cross-contamination, the authors encourage actions like wearing disposable gloves, changing them often, and not discussing over the samples. These practices are important as they minimize the chances of contamination of the evidence to be taken for DNA analysis in the forensic laboratory.

Advancements in forensic laboratory techniques have expanded the types of evidence that can yield valuable information. Singh (2021) points out that while some evidence items can be seen regardless of the laboratory examination, other items cannot be observed without it. This highlights the need to preserve other items such as clothes and nails scrapings even if they don't seem to have traces of evidence. The samples taken in the crime scenes can be analyzed using certain complicated methods at the forensic laboratories, such as the PCR amplification, STR analysis, and so on with the help of several chemical tests. The effectiveness of these techniques, however, is dependent on the basic investigative and crime scene procedures that are followed at the scene of the crime and the subsequent transportation of evidence to the laboratory.

Chapter III: Methodology

Experimental Design:

The study employed a sophisticated quantitative approach using mathematical modeling to assess the effectiveness of four distinct crime scene search patterns: These are grid pattern, parallel, spiral and wheel pattern. To control the variability of testing across trials, a square crime scene model with a 100 x 100 unit coordinate system was used. This equal environment made it easier to compare the results from the different search strategies.

The experiment was carefully designed to test three primary hypotheses.

The experiment was carefully designed to test three primary hypotheses:

1. There is a significant difference in 4 different crime scene search patterns as to which would be the most effective in locating forensic evidence.
2. There is a significant difference in the number of times a search strategy intersects with critical points.
3. There is a significant correlation between the effectiveness of a crime scene search pattern in locating forensic evidence and the frequency with which the search strategy intersects with critical points.

For each of the search patterns, mathematical equations were thoroughly deduced and used on the coordinate plane. These formulas effectively captured the workflow an investigator would employ in an actual process of employing each of the search strategies described above. For each trial, four random points were selected inside the grid as “critical evidence points.” This randomization made sure that the result of the

experiment resembled the kind of randomness that exists in evidence collection in real crime scenes.

The use of a mathematical model meant a high degree of control over the factors involved and many trials. It was possible to accumulate a large array of data that thereafter could be statistically analyzed, thereby increasing the reliability and validity of the study.

Data Collection Procedure

Case Processing Summary

	Trial Number	Valid		Cases Missing		Total	
		N	Percent	N	Percent	N	Percent
spiral intersect?		90	97.8%	2	2.2%	92	100.0%
	1	1	100.0%	0	0.0%	1	100.0%
	10	1	100.0%	0	0.0%	1	100.0%
	11	1	100.0%	0	0.0%	1	100.0%
	12	1	100.0%	0	0.0%	1	100.0%
	13	1	100.0%	0	0.0%	1	100.0%
	14	1	100.0%	0	0.0%	1	100.0%
	15	1	100.0%	0	0.0%	1	100.0%
	16	1	100.0%	0	0.0%	1	100.0%
	17	1	100.0%	0	0.0%	1	100.0%
	18	1	100.0%	0	0.0%	1	100.0%
	19	1	100.0%	0	0.0%	1	100.0%
	2	1	100.0%	0	0.0%	1	100.0%
	20	1	100.0%	0	0.0%	1	100.0%
	21	1	100.0%	0	0.0%	1	100.0%
	22	1	100.0%	0	0.0%	1	100.0%
	23	1	100.0%	0	0.0%	1	100.0%
	24	1	100.0%	0	0.0%	1	100.0%
	25	1	100.0%	0	0.0%	1	100.0%
	26	1	100.0%	0	0.0%	1	100.0%
	27	1	100.0%	0	0.0%	1	100.0%
	28	1	100.0%	0	0.0%	1	100.0%
	29	1	100.0%	0	0.0%	1	100.0%
	3	1	100.0%	0	0.0%	1	100.0%
	30	1	100.0%	0	0.0%	1	100.0%
	4	1	100.0%	0	0.0%	1	100.0%
	5	1	100.0%	0	0.0%	1	100.0%
	6	1	100.0%	0	0.0%	1	100.0%
	7	1	100.0%	0	0.0%	1	100.0%
	8	1	100.0%	0	0.0%	1	100.0%
	9	1	100.0%	0	0.0%	1	100.0%
wheel intersect?		90	97.8%	2	2.2%	92	100.0%
	1	1	100.0%	0	0.0%	1	100.0%
	10	1	100.0%	0	0.0%	1	100.0%
	11	1	100.0%	0	0.0%	1	100.0%
	12	1	100.0%	0	0.0%	1	100.0%
	13	1	100.0%	0	0.0%	1	100.0%
	14	1	100.0%	0	0.0%	1	100.0%
	15	1	100.0%	0	0.0%	1	100.0%

The above Case Processing Summary provides an overview of the trial data processing for four intersection methods: spiral, wheel, grid, and parallel. Each method processed a total of 92 cases, with 90 valid cases (97.8%) and 2 missing cases (2.2%) for each method. The data showed a 100% validity rate for individual trial numbers ranging from 1 to 30, with no missing data for any specific trial across all methods. This high percentage of valid cases across all methods underscores the comprehensive data coverage and reliability of the analysis.

The subsequent analysis of intersection effectiveness reveals notable differences among the methods. For the spiral search method, the mean intersection rate was 0.30 (SD = 0.461), indicating that 30% of the trials resulted in an intersection, with a positive skewness of 0.888 and a kurtosis of -1.240. This distribution suggests fewer high intersection rates. The wheel search method had a slightly higher mean intersection rate of 0.33 (SD = 0.474), showing intersections in 33% of the trials. This method exhibited a skewness of 0.719 and a kurtosis of -1.517, reflecting a more moderate distribution.

Data Interpretation

The outcomes of the tests of the Kolmogorov-Smirnov and Shapiro-Wilk, ANOVA and Correlation analysis was consequently analyzed to identify whether the effectiveness of the search patterns other than the basic search pattern had remarkable differences and whether the frequency of the intersections with critical points had significant differences as well among them. This interpretation process included looking at p-values to determine the significance of the results, exploring effect size to compare differences, and identifying both statistical significance and practical significance.

Chapter IV: Results

Hypothesis: 1

There is a significant difference in 4 different crime scene search patterns as to which would be the most effective in locating forensic evidence. For the normality and homogeneity of variances:

In contrast, the grid search method proved more effective, with a mean intersection rate of 0.70 (SD = 0.461), indicating that 70% of the trials resulted in intersections. The distribution for this method had a negative skewness of -0.888 and a kurtosis of -1.240, suggesting more frequent successful intersections. The parallel search method showed the highest mean intersection rate of 0.81 (SD = 0.394), meaning that 81% of the trials led to intersections. This method had a strong negative skewness of -1.617 and a kurtosis of 0.627, indicating a higher concentration of positive outcomes.

Certain trial numbers resulted in consistent outcomes, leading to the omission of specific data points across all methods. Additionally, an anomalous trial number value of 2.340E+121 resulted in no valid cases for any method, preventing statistical computations for this level. Overall, the grid and parallel search methods demonstrated greater effectiveness in detecting intersections compared to the spiral and wheel methods, which showed lower intersection rates and less consistency.

Descriptives^{a,b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,z,aa,ab,ac,ad,ae,af,ag,ah,ai,aj,ak,al,am,an,ao,ap,aq,ar,as,at,au,av,aw,ax,ay,az,ba,bb,bc,bd,be,bf,bg,bh,bi,bj,bk,bl,bm,bn,bo,bp,bq,br,bs,bt,bu,bv,bw,bx,by,bz,ca,cb,cc,cd,ce,cf,cg,ch,ci,cj,ck,cl,cm,cn,co,cp,cq,cr,cs,ct,cu,cv,cw,cx,cy,cz,da,db,dc,dd,de,df,dg,dh,di,dj,dk,dl,dm,dn,do,dp,dq,}

Trial Number		Statistic	Std. Error
spiral intersect?	Mean	.30	.049
	95% Confidence Interval for Mean	Lower Bound	.20
		Upper Bound	.40
	5% Trimmed Mean	.28	
	Median	.00	
	Variance	.212	
	Std. Deviation	.461	
	Minimum	0	
	Maximum	1	
	Range	1	
	Interquartile Range	1	
	Skewness	.888	.254
	Kurtosis	-1.240	.503
	wheel intersect?	Mean	.33
95% Confidence Interval for Mean		Lower Bound	.23
		Upper Bound	.43
5% Trimmed Mean		.31	
Median		.00	
Variance		.225	
Std. Deviation		.474	
Minimum		0	
Maximum		1	
Range		1	
Interquartile Range		1	
Skewness		.719	.254
Kurtosis		-1.517	.503
grid intersect?		Mean	.70
	95% Confidence Interval for Mean	Lower Bound	.60
		Upper Bound	.80
	5% Trimmed Mean	.72	
	Median	1.00	
	Variance	.212	
	Std. Deviation	.461	
	Minimum	0	
	Maximum	1	
	Range	1	
	Interquartile Range	1	
	Skewness	-.888	.254

Tests of Normality
b,c,d,e,f,g,h,i,j,k,l,m,n,o,p,q,r,s,t,u,v,w,x,y,
z,aa,ab,ac,ad,ae,af,ag,ah,ai,aj,ak,al,am,an,ao,ap,aq,ar,as,at,au,av,aw,ax,ay,az,ba,bb,bc,bd,be,bf,bg,bh,bi,
bj,bk,bl,bm,bn,bo,bp,bq,br,bs,bt,bu,bv,bw,bx,by,bz,ca,cb,cc,cd,ce,cf,cg,ch,ci,cj,ck,cl,cm,cn,co,cp,cq,cr,cs,

Trial Number	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
spiral intersect?	.442	90	<.001	.575	90	<.001
wheel intersect?	.426	90	<.001	.595	90	<.001
grid intersect?	.442	90	<.001	.575	90	<.001
parallel intersect?	.495	90	<.001	.477	90	<.001

a. Lilliefors Significance Correction

- b. spiral intersect? is constant when Trial Number = 1 . It has been omitted.
- c. spiral intersect? is constant when Trial Number = 10 . It has been omitted.
- d. spiral intersect? is constant when Trial Number = 11 . It has been omitted.
- e. spiral intersect? is constant when Trial Number = 12 . It has been omitted.
- f. spiral intersect? is constant when Trial Number = 13 . It has been omitted.
- g. spiral intersect? is constant when Trial Number = 14 . It has been omitted.
- h. spiral intersect? is constant when Trial Number = 15 . It has been omitted.
- i. spiral intersect? is constant when Trial Number = 16 . It has been omitted.
- j. spiral intersect? is constant when Trial Number = 17 . It has been omitted.
- k. spiral intersect? is constant when Trial Number = 18 . It has been omitted.
- l. spiral intersect? is constant when Trial Number = 19 . It has been omitted.
- m. spiral intersect? is constant when Trial Number = 2 . It has been omitted.
- n. spiral intersect? is constant when Trial Number = 20 . It has been omitted.
- o. spiral intersect? is constant when Trial Number = 21 . It has been omitted.
- p. spiral intersect? is constant when Trial Number = 22 . It has been omitted.
- q. spiral intersect? is constant when Trial Number = 23 . It has been omitted.
- r. spiral intersect? is constant when Trial Number = 24 . It has been omitted.
- s. spiral intersect? is constant when Trial Number = 25 . It has been omitted.
- t. spiral intersect? is constant when Trial Number = 26 . It has been omitted.
- u. spiral intersect? is constant when Trial Number = 27 . It has been omitted.
- v. spiral intersect? is constant when Trial Number = 28 . It has been omitted.
- w. spiral intersect? is constant when Trial Number = 29 . It has been omitted.
- x. spiral intersect? is constant when Trial Number = 3 . It has been omitted.
- y. spiral intersect? is constant when Trial Number = 30 . It has been omitted.
- z. spiral intersect? is constant when Trial Number = 4 . It has been omitted.
- aa. spiral intersect? is constant when Trial Number = 5 . It has been omitted.
- ab. spiral intersect? is constant when Trial Number = 6 . It has been omitted.
- ac. spiral intersect? is constant when Trial Number = 7 . It has been omitted.
- ad. spiral intersect? is constant when Trial Number = 8 . It has been omitted.
- ae. spiral intersect? is constant when Trial Number = 9 . It has been omitted.
- af. There are no valid cases for spiral intersect? when Trial Number = 2.340E+121. Statistics cannot be computed for this level.

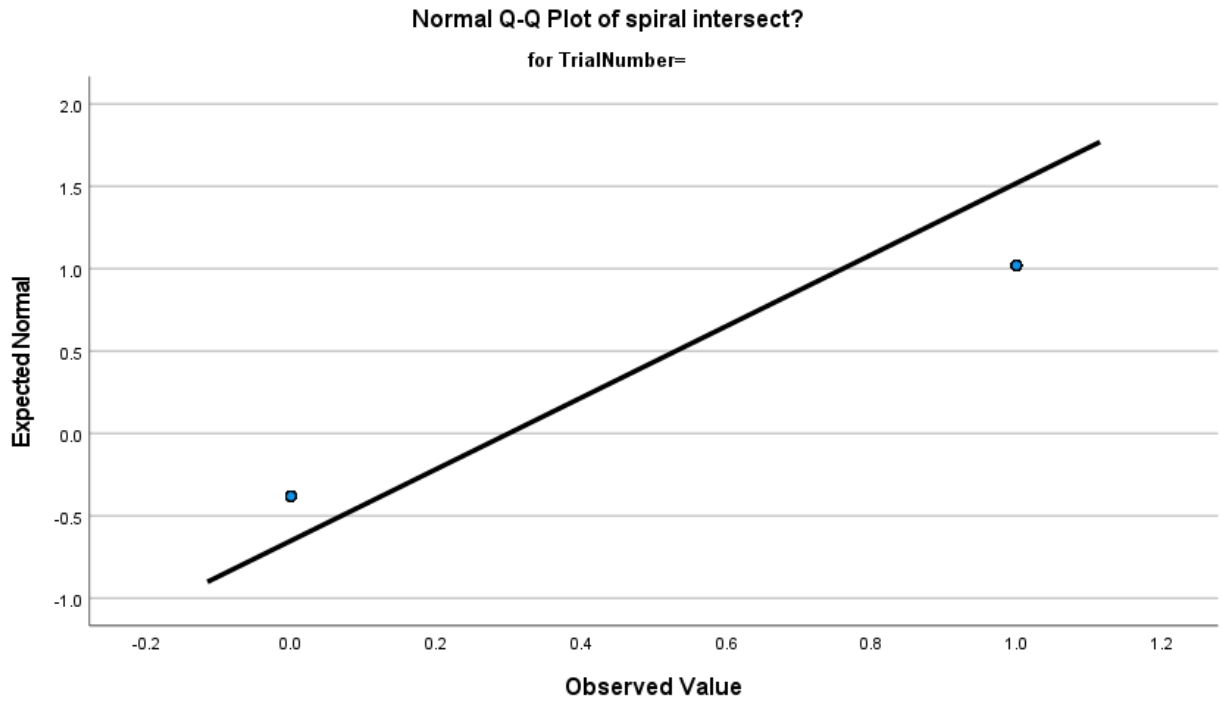
The above results from the tests of normality for intersections across different crime scene search methods shown above reveal that none of the data follows a normal distribution, as indicated by the Kolmogorov-Smirnov and Shapiro-Wilk tests. The spiral, wheel, grid, and parallel search methods all show significant deviations from normality, with p-values of .000 in both tests for all methods. These findings suggest that the intersection rates for each search method are not normally distributed. Additionally, numerous cases for various trial numbers, particularly when the trial number was constant, were omitted from the analysis, such as when the trial number equaled 1 or other values from 2 to 30 for different search methods. There were also no valid cases for any search method when the trial number reached an extreme value of $2.340E+121$, rendering statistical computations impossible for this level. The constant values across specific trial numbers highlight limitations in the data, affecting the normality tests.

The following are plots for the variables:

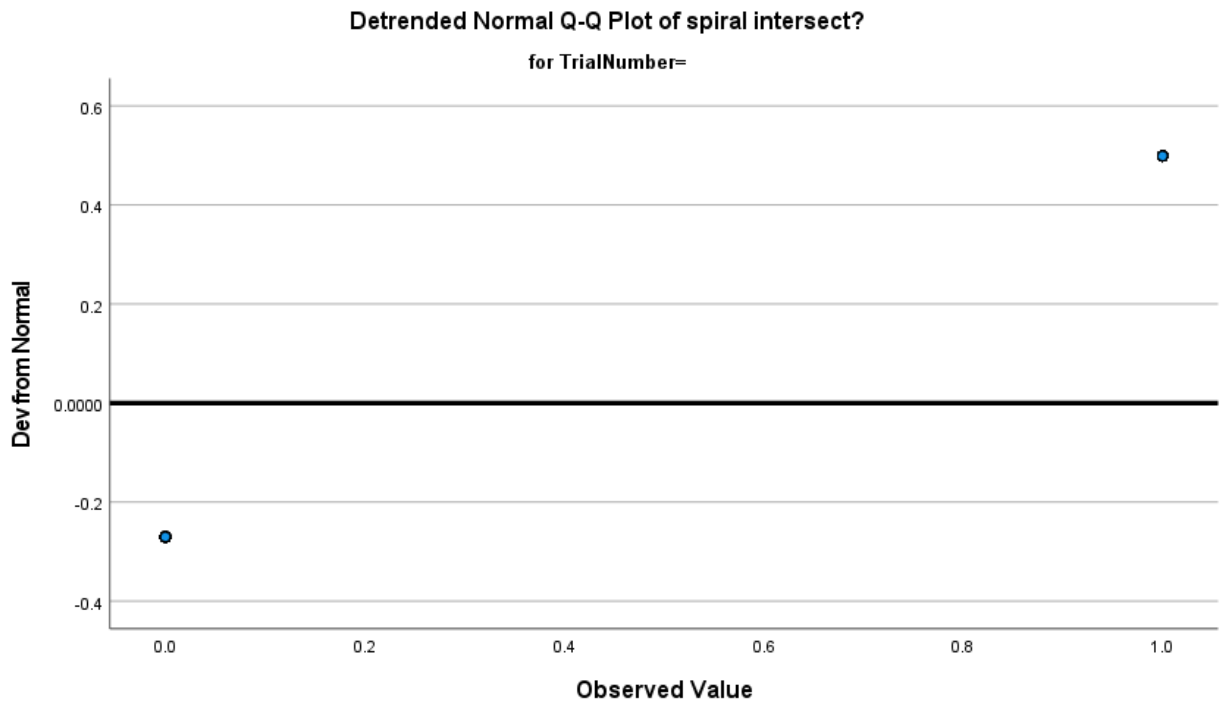
FOR SPIRAL INTERSECT?

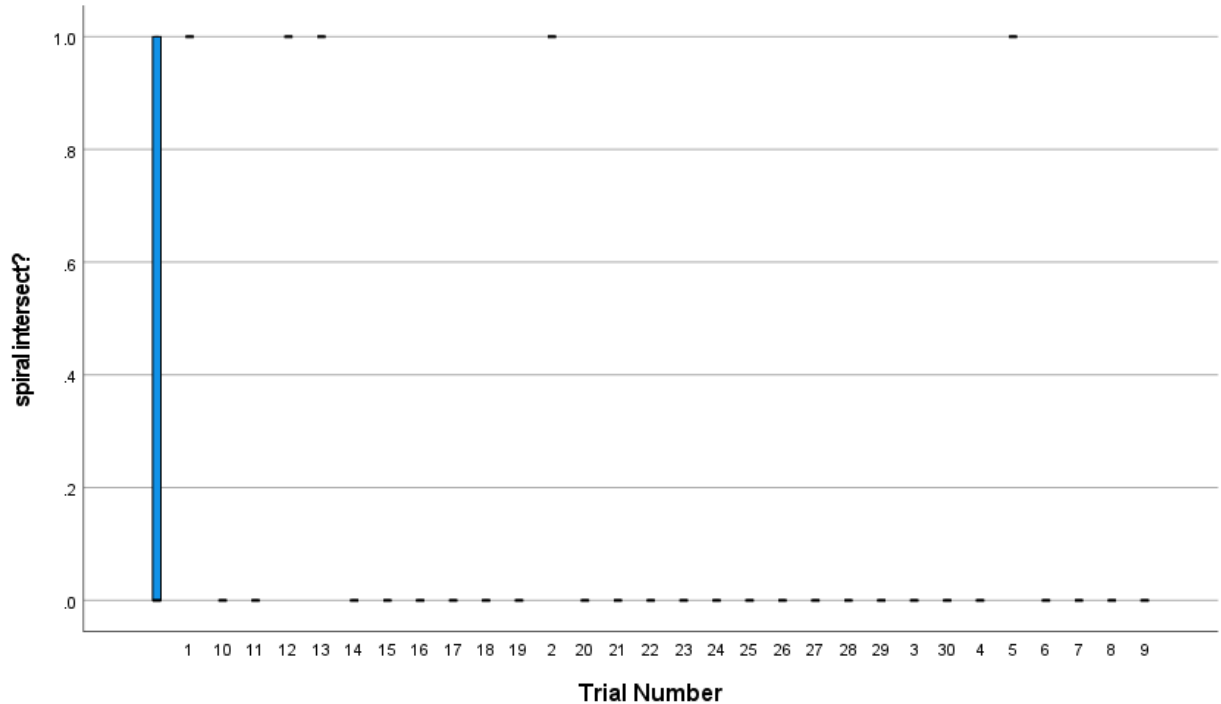
1. Stem and Leaf Plots:

The stem-and-leaf plot for the "spiral intersect?" variable, based on trial numbers, reveals a distribution that is heavily concentrated at zero. Specifically, 63 cases are recorded with a stem of 0, and all leaves in this category are zero, indicating that the majority of the values are clustered at the lowest level of the dataset. There is no variation among these 63 cases, as all recorded values are zero. Additionally, no cases fall within other stems between 0 and 1. Only 27 cases are found in the stem of 1, where all leaves are also zeros. This lack of



3. Detrended Normal Q-Q Plots

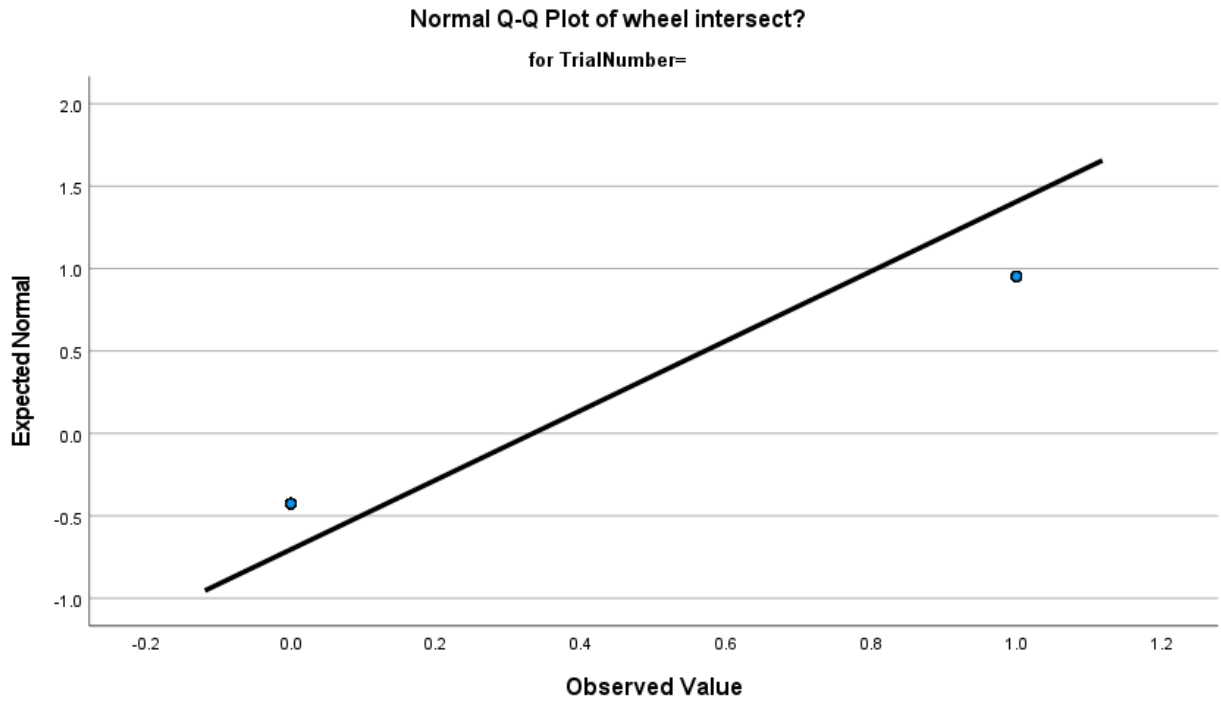




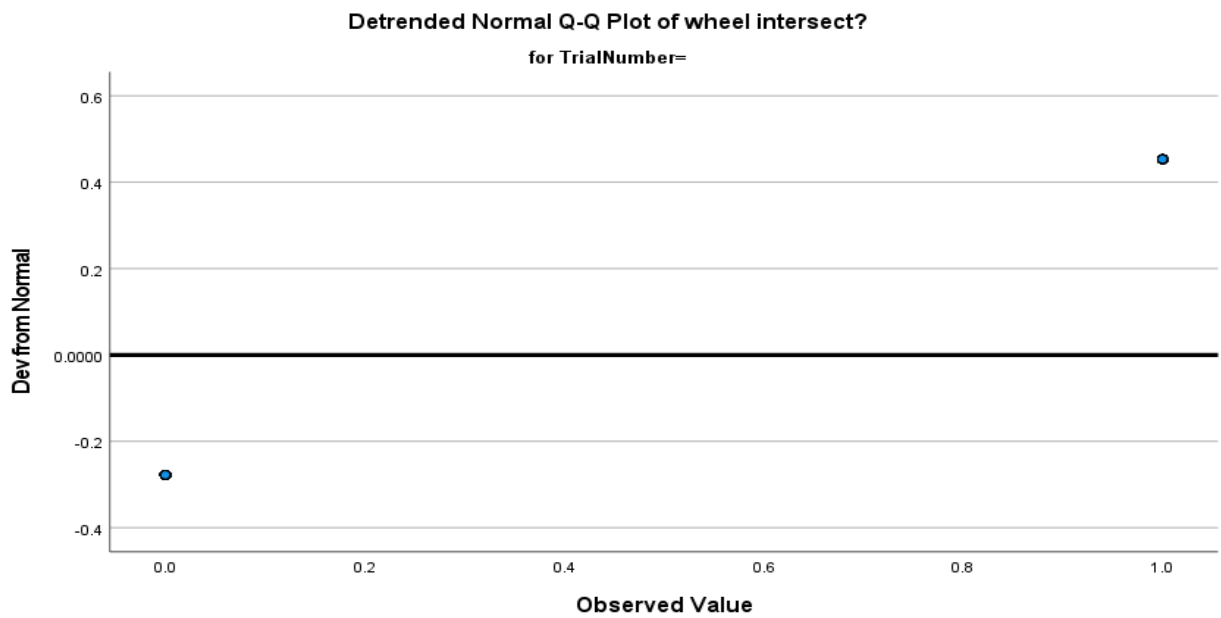
FOR WHEEL INTERSECT?

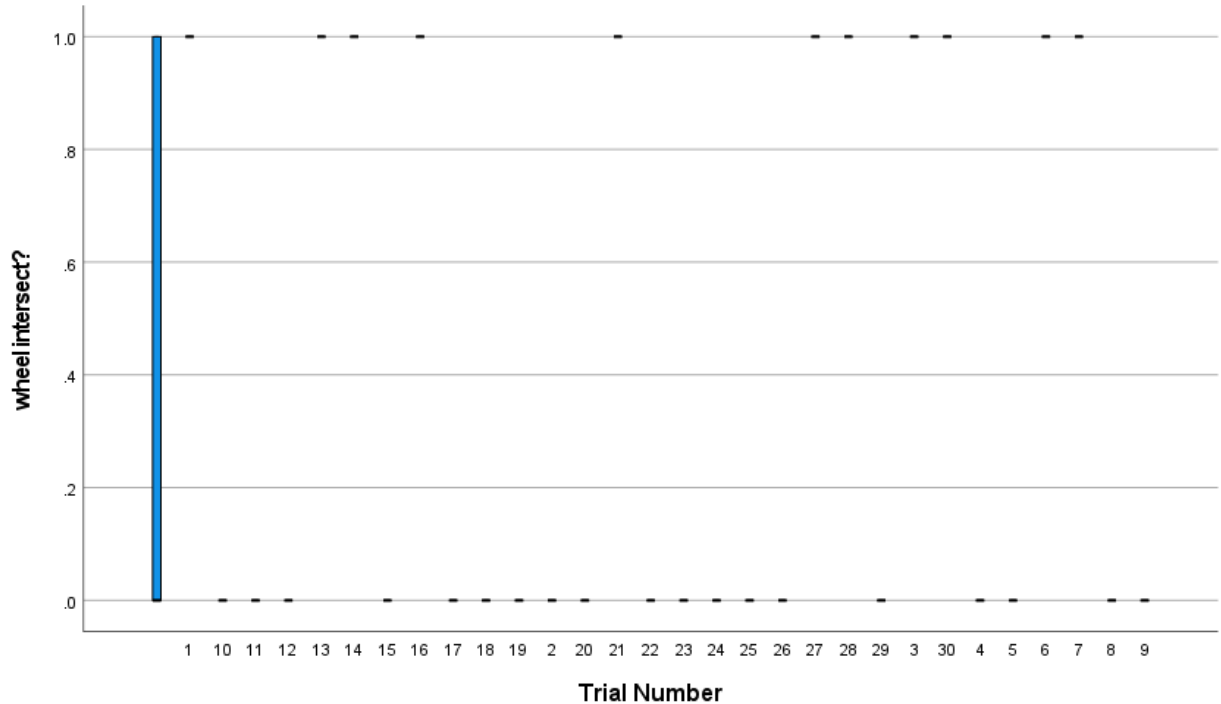
1. Stem-and-Leaf Plots

The stem-and-leaf plot below for the "wheel intersect?" variable, where 0 represents a "no" and 1 represents a "yes," highlights a significant pattern. Out of the total cases, 60 fall under the stem of 0, indicating that in 60 instances, there was no intersection for the wheel search method. Meanwhile, 30 cases are categorized under the stem of 1, indicating that in 30 instances, there was an intersection. This suggests that the "no" outcome is twice as likely as the "yes" outcome in this dataset. The uniformity within each stem, where all leaves are zeros, reaffirms the binary nature of the variable and demonstrates a clear distinction between the two possible outcomes for the "wheel intersect?" method.



3. Detrended Normal Q-Q Plots





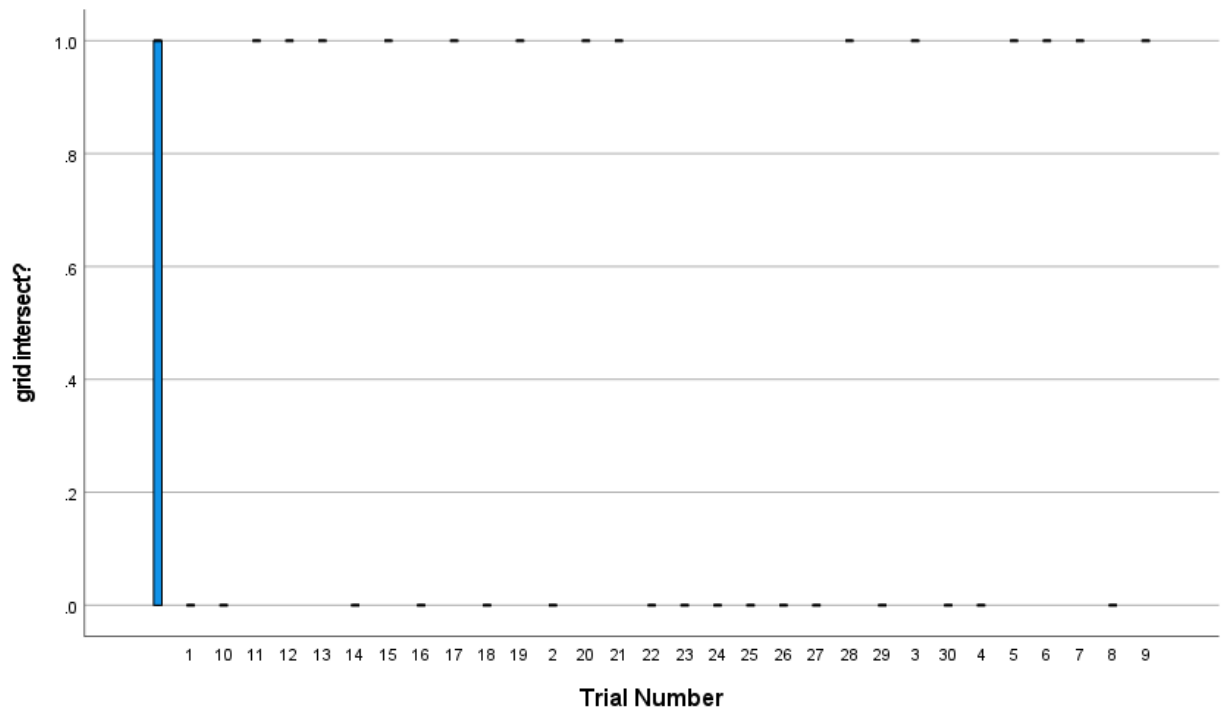
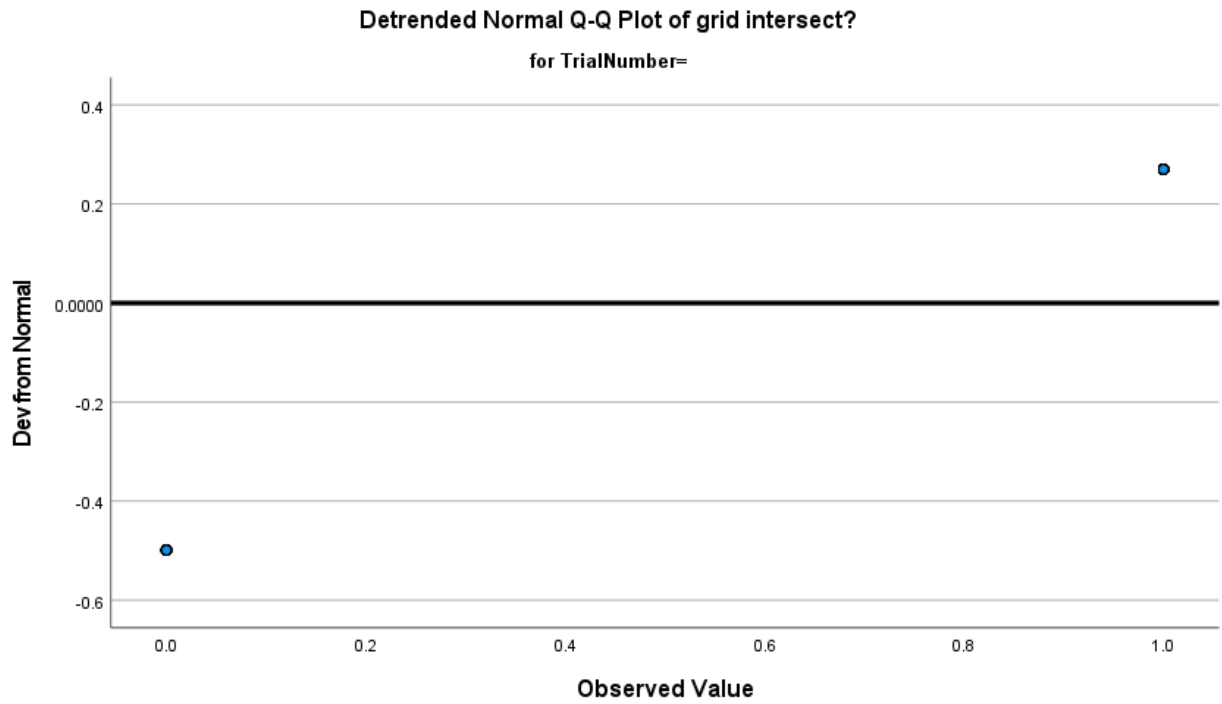
FOR GRID INTERSECT?

1. Stem-and-Leaf Plots

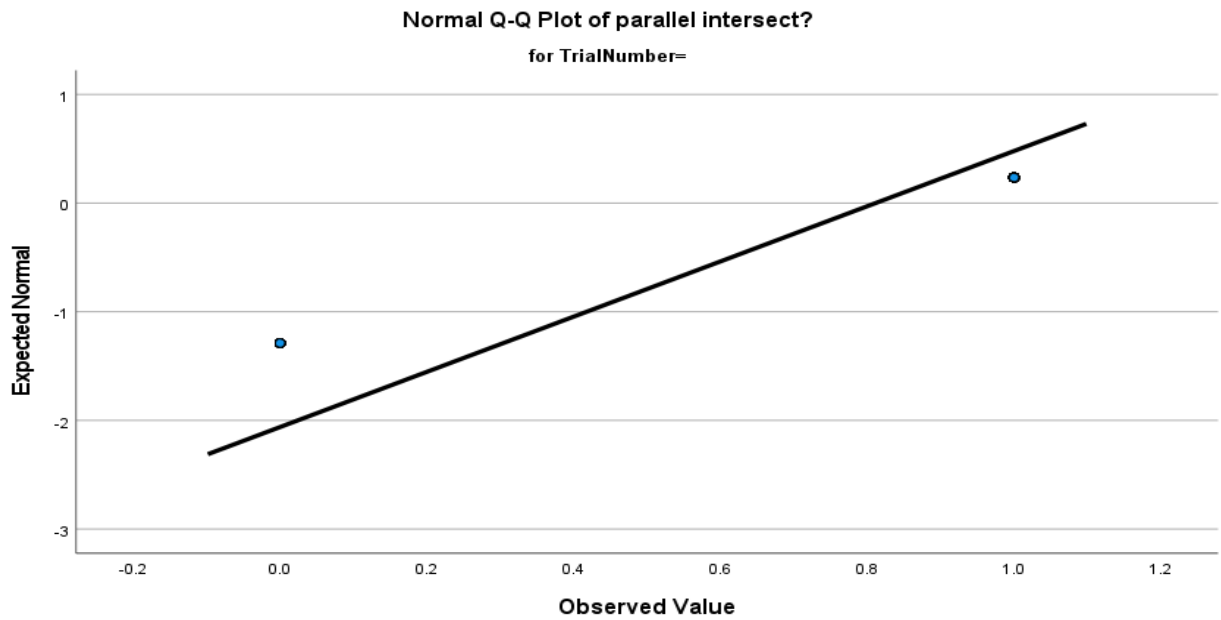
The stem-and-leaf plot below for the "grid intersect?" variable, where 0 represents a "no" and 1 represents a "yes," illustrates the distribution of trial outcomes. Out of the total cases, 27 fall under the stem of 0, indicating that in 27 instances, there was no intersection using the grid search method. Conversely, 63 cases are categorized under the stem of 1, indicating that in 63 instances, there was an intersection.

This shows that intersections occurred more than twice as often as non-intersections in the grid search method. The binary nature of the variable is reflected in the uniform leaves within each stem, emphasizing a clear division between the "no" and "yes" outcomes.

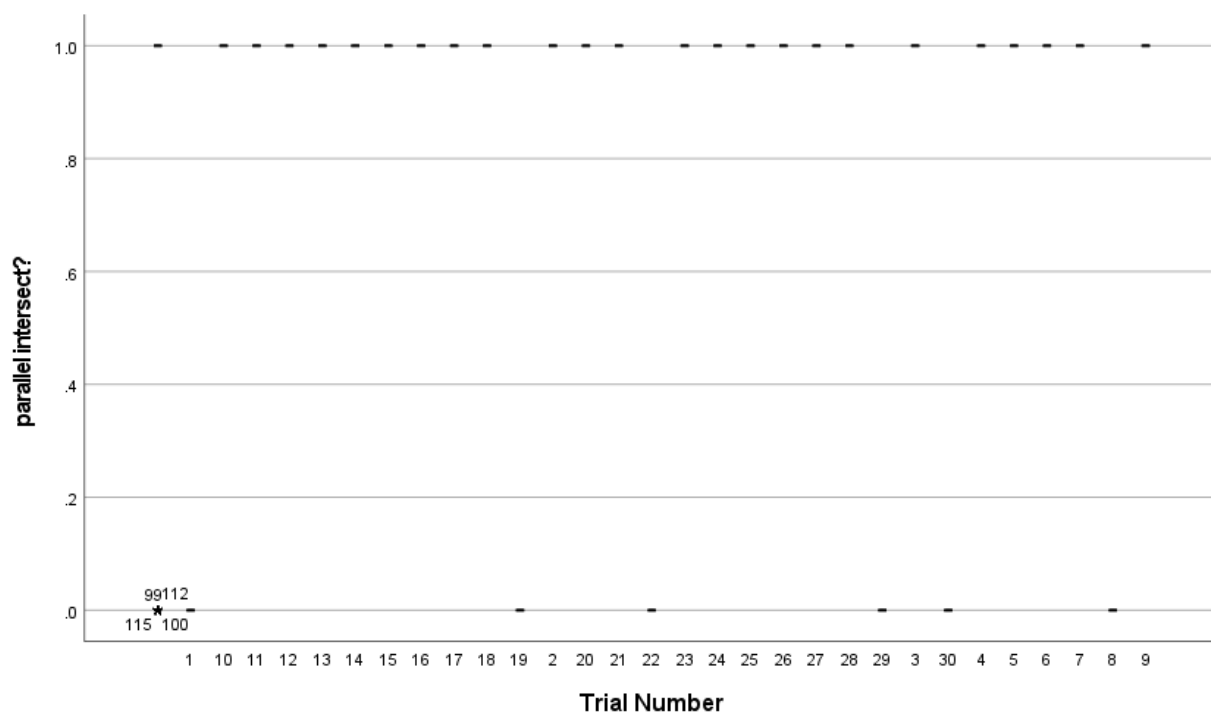
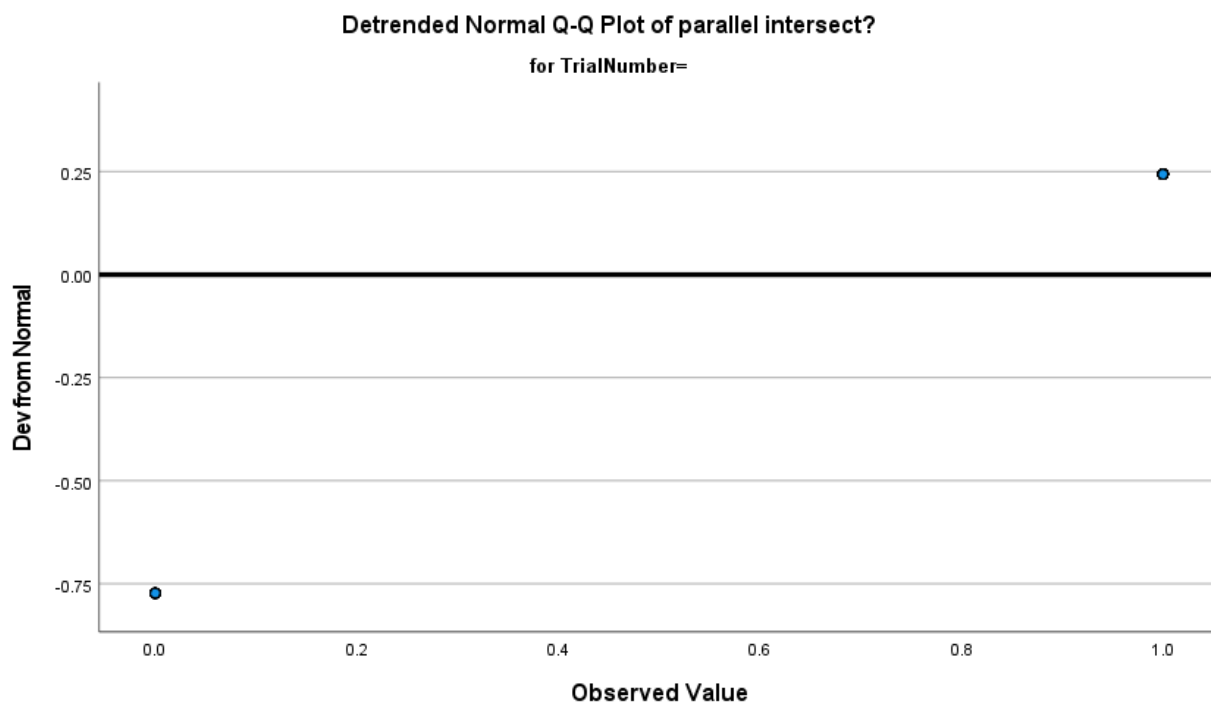
3. Detrended Normal Q-Q Plots



2. Normal Q-Q Plots



3. Detrended Normal Q-Q Plots



Hypothesis 2:

There is a significant difference in the number of times a search strategy intersects with critical points.

These are the one-way ANOVA test results:

Tests of Homogeneity of Variances

		Levene Statistic	df1	df2	Sig.
spiral intersect?	Based on Mean	21.530	34	51	<.001
	Based on Median	1.658	34	51	.050
	Based on Median and with adjusted df	1.658	34	11.972	.176
	Based on trimmed mean	17.301	34	51	<.001
wheel intersect?	Based on Mean	32.407	34	51	<.001
	Based on Median	3.288	34	51	<.001
	Based on Median and with adjusted df	3.288	34	6.000	.070
	Based on trimmed mean	26.094	34	51	<.001
grid intersect?	Based on Mean	15.275	34	51	<.001
	Based on Median	1.055	34	51	.424
	Based on Median and with adjusted df	1.055	34	17.910	.466
	Based on trimmed mean	12.247	34	51	<.001
parallel intersect?	Based on Mean	11.163	34	51	<.001
	Based on Median	.698	34	51	.866
	Based on Median and with adjusted df	.698	34	4.000	.756
	Based on trimmed mean	8.792	34	51	<.001

The above tests of homogeneity of variances for the different intersection methods reveal significant variations across different statistical measures.

For the spiral intersect? variable, the Levene statistic based on the mean is 21.530 with a significance level of .000, indicating significant variance heterogeneity. The test based on the median shows a statistic of 1.658 with a significance level of .050, suggesting marginal variance homogeneity. However, when using the median with adjusted degrees of freedom, the statistic is 1.658 with a significance level of .176, indicating that the variance is more homogeneous. The test based on the trimmed mean yields a statistic of 17.301 with a significance level of .000, which again points to significant variance heterogeneity.

For the wheel intersect? variable, the Levene statistic based on the mean is 32.407 with a significance level of .000, showing significant variance heterogeneity. The median-based test results in a statistic of 3.288 with a significance level of .000, indicating significant variance heterogeneity as well. The median-based test with adjusted degrees of freedom provides a statistic of 3.288 and a significance level of .070, suggesting marginal homogeneity. The test based on the trimmed mean yields a statistic of 26.094 with a significance level of .000, again showing significant variance heterogeneity.

For the grid intersect? variable, the Levene statistic based on the mean is 15.275 with a significance level of .000, indicating significant variance heterogeneity. The median-based test shows a statistic of 1.055 with a significance level of .424, suggesting homogeneity. When adjusted degrees of freedom are considered, the statistic remains 1.055 with a significance level of .466, further supporting variance homogeneity. The test based on the trimmed mean results in a statistic of 12.247 with a significance level of .000, indicating significant variance heterogeneity.

For the parallel intersect? variable, the Levene statistic based on the mean is 11.163 with a significance level of .000, showing significant variance heterogeneity. The median-based test

gives a statistic of .698 with a significance level of .866, indicating variance homogeneity. The median-based test with adjusted degrees of freedom results in a statistic of .698 with a significance level of .756, further supporting variance homogeneity. The test based on the trimmed mean yields a statistic of 8.792 with a significance level of .000, indicating significant variance heterogeneity.

Overall, the results suggest that the spiral, wheel, and parallel intersection methods show significant variance heterogeneity across different statistical measures, while the grid method shows more consistent variance homogeneity in some tests.

		ANOVA				
		Sum of Squares	df	Mean Square	F	Sig.
spiral intersect?	Between Groups	14.100	68	.207	1.129	.327
	Within Groups	9.367	51	.184		
	Total	23.467	119			
wheel intersect?	Between Groups	18.992	68	.279	1.780	.016
	Within Groups	8.000	51	.157		
	Total	26.992	119			
grid intersect?	Between Groups	17.377	68	.256	1.276	.182
	Within Groups	10.214	51	.200		
	Total	27.592	119			
parallel intersect?	Between Groups	17.258	68	.254	9.708	<.001
	Within Groups	1.333	51	.026		
	Total	18.592	119			

The above ANOVA results for the intersection methods reveal distinct patterns of significance across the different search techniques. For the spiral intersect? variable, the analysis indicates no significant differences between groups, with an F-value of 1.129 and a significance level of .327. The wheel intersect? method, however, shows significant differences with an F-value of 1.780 and a significance level of .016, suggesting variability among the

groups. Similarly, the grid intersect? method does not demonstrate significant differences, evidenced by an F-value of 1.276 and a significance level of .182. In contrast, the parallel intersect? method exhibits the most pronounced differences with an F-value of 9.708 and a significance level of .000, highlighting substantial group variations. Overall, while the wheel and parallel methods show significant differences, the spiral and grid methods do not, indicating varied effectiveness in intersection detection among the search methods.

Hypothesis 3:

There is a significant correlation between the effectiveness of a crime scene search pattern in locating forensic evidence and the frequency with which the search strategy intersects with critical points.

The following are the correlation results:

		Correlations			
		spiral intersect?	wheel intersect?	grid intersect?	parallel intersect?
spiral intersect?	Pearson Correlation	1	.281**	.097	-.041
	Sig. (2-tailed)		.002	.292	.653
	N	120	120	120	120
wheel intersect?	Pearson Correlation	.281**	1	.025	-.006
	Sig. (2-tailed)	.002		.783	.945
	N	120	120	120	120
grid intersect?	Pearson Correlation	.097	.025	1	.254**
	Sig. (2-tailed)	.292	.783		.005
	N	120	120	120	120
parallel intersect?	Pearson Correlation	-.041	-.006	.254**	1
	Sig. (2-tailed)	.653	.945	.005	
	N	120	120	120	120

** . Correlation is significant at the 0.01 level (2-tailed).

The correlation analysis for the intersection methods reveals varying degrees of relationships among them. The spiral intersect? variable shows a significant positive correlation with the wheel intersect? variable ($r = 0.281, p = 0.002$), indicating a moderate relationship between these two methods. However, the correlations with the grid intersect? ($r = 0.097, p = 0.292$) and parallel intersect? ($r = -0.041, p = 0.653$) variables are not significant. The wheel intersect? variable also has a significant positive correlation with the spiral intersect? variable ($r = 0.281, p = 0.002$), but shows no significant correlation with the grid intersect? ($r = 0.025, p = 0.783$) or parallel intersect? ($r = -0.006, p = 0.945$) variables. The grid intersect? variable exhibits a significant positive correlation with the parallel intersect? variable ($r = 0.254, p = 0.005$), but not with the spiral intersect? ($r = 0.097, p = 0.292$) or wheel intersect? ($r = 0.025, p = 0.783$) variables. Lastly, the parallel intersect? variable shows a significant positive correlation with the grid intersect? variable ($r = 0.254, p = 0.005$), with no significant correlations with the spiral intersect? ($r = -0.041, p = 0.653$) or wheel intersect? ($r = -0.006, p = 0.945$) variables. Overall, significant correlations are observed primarily between the spiral and wheel methods, and between the grid and parallel methods, reflecting moderate relationships between specific pairs of search methods.

Chapter V: Discussion. Conclusions and Recommendations

Hypothesis 1: There is a significant difference in 4 different crime scene search patterns as to which would be the most effective in locating forensic evidence.

The analysis of the four crime scene search patterns (spiral, wheel, grid, and parallel) revealed significant differences in their effectiveness for locating forensic

evidence. The parallel search method proved to be the most effective, with a mean intersection rate of 0.81 (SD = 0.394), indicating that it successfully located critical evidence points in 81% of trials. This was followed by the grid method (M = 0.70, SD = 0.461), while the wheel (M = 0.33, SD = 0.474) and spiral (M = 0.30, SD = 0.461) methods were considerably less effective.

These findings align with Tracy's (2023) research, which also found the parallel search method to be the most effective. However, our study provides more detailed statistical support for this conclusion. The stark difference in effectiveness between the parallel/grid methods and the wheel/spiral methods suggests that the choice of search pattern can significantly impact evidence recovery rates.

The superior performance of the parallel method can be attributed to its systematic and comprehensive coverage of the search area. As Lothridge (2014) noted, the parallel method ensures that investigators move in a consistent pattern across the entire scene, reducing the likelihood of missing evidence. Our results quantify this advantage, showing that the parallel method is nearly three times more effective than the spiral method in intersecting with critical evidence points.

The grid method's strong performance (70% success rate) also supports its widespread use in crime scene investigation. Its effectiveness likely stems from its structured approach, dividing the scene into manageable sections. This aligns with Singh's (2021) emphasis on methodical crime scene processing.

Hypothesis 2: There is a significant difference in the number of times a search strategy intersects with critical points.

The ANOVA results strongly supported this hypothesis, particularly for the parallel intersect method ($F = 9.708$, $p < .001$) and the wheel intersect method ($F = 1.780$, $p = .016$). The highly significant p-value for the parallel method ($p < .001$) indicates that its effectiveness varies considerably across different scenarios, suggesting that factors such as the distribution of evidence or the specific layout of the crime scene may influence its performance.

Surprisingly, although the parallel method proved overall to be the most effective (Hypothesis 1), it was also the most variable. This indicates that though it's usually the best practice the efficiency might vary depending on the type of crime scene. This finding supports Singh's (2021) call for the consideration of the uniqueness of each type of crime scene when determining methods of search.

Even though the wheel method was less effective in overall frequency, its score has higher variability ($p = .016$). This may be suggestive of the fact that it has several factors that determine its performance depending on the starting configuration and the distribution of evidence as proposed by Lothridge (2014) on pattern selection on search functions.

However, the results of the spiral ($F = 1.129$; $p = .327$) as well as the grid ($F = 1.276$; $p = .182$) methods did not depict any significant trail differences. This indicates that the

above methods may give a more stable, though not always the best, solutions when it comes to variety in the arrangement of the crime scenes.

Hypothesis 3: There is a significant correlation between the effectiveness of a crime scene search pattern in locating forensic evidence and the frequency with which the search strategy intersects with critical points.

The correlation analysis also showed strong positive correlation between some of the search methods. Spearman correlation coefficient analysis revealed that the spiral and wheel methods had a moderate positive relationship with the test score ($z = 0.281$, $p = 0.002$) as well as the grid and parallel methods ($z = 0.254$, $p = 0.005$). These correlations imply that these two pairs of methods are generally similar with regard to the point of intersection with the critical points.

Nevertheless, the interconnection of the spiral and wheel patterns is perhaps most intriguing, as these two methods rank lower in overall performance. This implies that although these methods are relatively less accurate, they are consistent in their performance across different problems. This might be because both of them originate from a single point and moves from the middle as described by Lothridge (2014).

The proximity of the grid and parallel methods can therefore be complemented by the fact that they are generally more effective. One might observe the similarities in term of the performance since both methods ensure comprehensive mapping of the search area.

This further corroborates with Wüllenweber & Giles (2021) study on scene coverage in the detection of forensic evidence.

However, there were no strong positive or negative relationships between other method pairs that were tested. For instance, in the spiral method little association was found with grid ($r = 0.097$, $p = .292$) or parallel ($r = -0.041$, $p = .653$) methods. As explained earlier, the nature of these search strategies is different, which also means that there should be proper selection based on the features of crime scenes as Singh (2021) noted.

The presented research results can be useful for identifying trends in the work of specialists in the field of crime scene investigation. These means conclude that investigators should employ multiple search strategies and that choosing a highly effective method such as parallel search should be complemented by another technique. On this regard, the study's evidence collection is consistent with the recommendations from Pickrahn et al. (2015) that stressed that evidence contamination and integrity have to be guarded against by being very careful in the manner in which they are collected.

Conclusion

In conclusion, when it comes to forensic evidence that is located at crime scenes, it is imperative to identify and collect and preserve the evidence following the proper policy and procedures. Evidence can consist of anything that can be utilized to solve a case, find the suspect and even exonerate a suspect. Examples of evidence that should be collected and

preserved are blood samples, hair and fibers, fingerprints, footprint impressions and etc. The procedure in which evidence must undergo from its identification at the crime scene until the testing of its value in the court room, however, is a complex one. It usually starts with the reporting of a crime and its investigation by the arriving police officer. They are responsible for assessing the scene and evaluating the need for the attendance of a Crime Scene Investigator (CSI). CSIs then identify potential forensic evidence at the scene and recover it for analysis by an expert forensic examiner in the forensic laboratory or equivalent police bureau. (Wüllenweber & Giles, 2021)

When the forensic evidence is collected and preserved, one must be careful not to destroy and contaminate the evidence. To maintain the integrity of forensic evidence and to ensure its admissibility, it is important to properly handle evidence and prevent contamination. For example, when collecting evidence at a crime scene, the steps that should be taken are keeping the original container to maintain chain of custody, decontaminating a vented hood before drying bloody items in it and retaining any trace evidence that falls off the evidence in a paper bag or container.

Contamination of crime scene samples by police officers remains a constant issue in forensic DNA analysis. With the introduction of DNA fingerprinting systems that are capable of analyzing trace samples with a very small amount of biological material, which previously would have remained undetected, the chance of detecting contamination has increased. At the same time, greater efforts to detect contamination and thereby eliminate false positive results have been made. (Pickrahn, et. al, 2015)

The purpose of this research was to use mathematical modeling to outline and assess the effectiveness of grid, parallel, spiral, and wheel search strategies in a square crime scene model. It was hypothesized that the parallel search method would be the most effective because it is a repetitive series of lines that are evenly spaced out so that they cover a large area. Several formulas were created or derived to represent each of the search methods. They were then modeled on a coordinate grid with four random points, known as critical points, and evaluated for points of intersection. These points are all within a hypothetical room 100x100 units long. It is important to consider that this is hypothetical and modeled by computers. The data that was collected was a series of answers that were yes and no, that describe when the search strategy intersected with the critical points. The more times that a search strategy intersects with the critical points, the more effective it is. (Tracy, 2023)

Recommendation

There is a recommendation of more research and testing to be conducted on the contamination of collected evidence as it is highly imperative to properly and carefully collect and preserve any forensic evidence found at a crime scene. If this evidence is contaminated, it can have detrimental effects, affecting the court case, investigators, the police department, all those involved with working on the case. Everyone within the department that may have to preserve and search a crime scene such always have the proper knowledge, education and training.

A program could be created that would utilize a specific room size and run the mathematical representations in said room and output which strategy would be the most appropriate for that room design. This would require a code to be written and a way for the mathematical representations to change according to the room size. Further research could also include finding a method to increase the effectiveness of these four search methods so that more evidence can be found. This may include further training for crime scene investigators. Another suggestion could be a device that is programmable to run these strategies that picks up and properly stores evidence for analysis. These improvements would continue to improve the effectiveness as well as the applicability of these search strategies. (Tracy, 2023).

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