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MODELLING IMPACT SPATTER AS A METHOD OF DIFFERENTIATION

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The Problem:

Does discriminatory data exist in impact spatter patterns? If present, does it provide sufficient detail to differentiate two stains better than an "eye ball" examination?

Sub-problem 1: What areas of discrimination offer valid information?

Sub-problem 2: Will the estimated volumes of stains present in impact spatters show specific deviation between stains created by different events?

Sub-problem 3: What level of discrimination is possible using such data?

Hypothesis:

As we increase the energy involved in a bloodstain incident, we generally see a corresponding decrease in individual spatter size. As there is a correlation between spatter size and volume, either characteristic should reflect similar data.

Mere observations of size provide little demarcation by which to distinguish spatter patterns. A more detailed examination of the stains based on volume should present similar data as size, but in greater detail.

If sufficient demarcation exists between the energy levels which created two stains, then mean volume of the stains should allow us to differentiate the stains to some degree. Given such detail, stains which might otherwise be categorized together (e.g. two high velocity stains) may hold sufficient differences as to distinguish them from one another.

Delimitations:

This paper will not attempt to isolate the factors which define whether impact spatter will or will not be deposited.

No attempt will be made to prove the working models of volume estimation.

No attempt will be made to define the specific instances in which spatter dispersion itself can or cannot be used.

Definitions:

Impact Spatter Pattern - A stain pattern which results from the application of force or energy to blood.

Mean Volume - The estimated volume in micro-liters of a given pattern's individual stains. Expressed as the mean or average.

Assumptions:

Blood as a fluid, is acted on by energy and the forces of nature in a relatively uniform fashion.

When differentiated solely on stain size, overlap exists between patterns created under diverse conditions (e.g. hand slap and gunshot). This overlap limits the ability of the analyst to eliminate any particular set of events as having produced the pattern.

Importance:

The ability of the analyst to derive information from blood stains assists in the overall process of crime scene recreation.

Finding the point, at which the analyst is scientifically accurate in discriminating patterns is a fundamental issue of bloodstain analysis. If true observable relationships exist in stains, such information may assist the analyst in defining the forces at work. "Eye-balling" stains provides a method of differentiating stain patterns, but may not be the limiting boundary for the discipline.

Review of Related Literature:

Herbert MacDonell in **Bloodstain Pattern Interpretation** asked: What properties of bloodstains might provide information relevant to determining the events associated with a pattern? In answering, MacDonell said: "The second question could be rephrased to ask what is there about bloodstains that can be observed and/or measured? The answer to this is quite simple: the number of spots, their location, size, and shape, and the surface characteristics of the material upon which the stains are deposited." [1] MacDonell went on to describe the characteristics of medium velocity spatter as being "small droplets of 1/8th inch diameter or smaller." MacDonell felt high velocity spatters would show the same characteristics as those found in medium velocity spatter, with the addition of a "high percentage of very fine specks of blood." [2] In conclusion MacDonell stated: " The smaller the diameter of the drops , the higher the velocity of impact. The difference between medium velocity impact, such as an axe or hammer blow, and high velocity impact, such as a gunshot, is sufficient for differentiating the two provided adequate sample is observed by someone thoroughly familiar with evidence of this type." [3]

Laber and Epstein discussed impact spatter indicating several factors such as force of impact, nature of the impacting object and the amount of blood available would affect the resulting number, size and shapes of bloodstains found. They cautioned however " Care must be exercised in attempting to relate the size of the stain to the amount of force because several other factors significantly affect the stain size." [4] They did not expound on what they considered the "significant factors" effects to be. In discussing gunshot spatter patterns they stated: " Bloodspatters resulting from gunshots can be identified by certain characteristics. The most noticeable of these is the formation of a fine "mist like" spray of blood. This mist is produced by the high energy of the projectile breaking the blood into small drops. ..... Beyond this, the size of spatter produced by gunshots overlaps many other impact spatter patterns. Therefore great care must be taken when interpreting this type of bloodspatter pattern." [5]

Eckert and James identified the range of medium velocity spatter as being "... usually within the range of 1-4 mm in diameter although smaller and larger bloodstains are not uncommon." They placed the identifying characteristic of high velocity spatter as being .1 mm or smaller spatter with the associated medium velocity spatter also being present. This distinction apparently being to define the "mist-like" spatter. [11]

Tom Bevel and I in **Bloodstain Pattern Analysis - Theory and Practice: A Laboratory Manual,** indicated differences were evident between the various velocities. A caveat to this statement was no specific demarcation existed and overlap could be found in the various velocities. Size ranges were stated as 1-4 mm for medium velocity spatter and 1 mm or less for high velocity spatter. [6]

Volume estimation has been considered for numerous years by various authors. The nature of this estimation has typically dealt with large pools or stains. The end purpose of this analysis being to determine the amount of **bleeding** which occurred.

MacDonell discussed the nature and volume of a single drop of blood, placing the volume at "approximately 0.05 ml or 50 lambda." This volume was for a droplet that might be referred to as a low velocity droplet, created under natural pooling and bleeding actions. MacDonell stated "if the rate of bleeding is very rapid blood drop volume may increase slightly, but bleeding does not result in smaller drops." [7]

Laber and Epstein stated "As the volume of a single drop of blood increases, the diameter of the resultant bloodstains increases, providing the drops of different volumes fall from the same height to the same surface." They recognized the issue of falling height for low velocity stains as being an added factor in the resulting stain size, but felt "the volume of a blood drop cannot be determined from the diameter of the stain unless the distance from which it fell is known." This limitation appeared to be applied only to low velocity stains, apparently in recognition of the underlying terminal velocity issue. [8]

MacDonell and Lige later developed a model for correlating diameter to stain volume. In "On Measuring the Volume of Very Small Drops of Fluid Blood and Correlation of This Relationship to Bloodstain Diameter" they concluded " if the diameter of a bloodstain is known, it is possible to estimate the volume of blood required to produce the stain with an accuracy of plus or minus ten percent ...". The working model developed from these efforts was based on a wet blood volume determination. [9]

Carter and Podworny in developing computer modeling procedures, discussed a volume estimation model. The Carter/Podworny model was developed using a dry weight methodology. They too, felt a correlation existed between size of a resulting spatter and the volume present. [10]

When the demonstration software of BACKTRACK was shipped in 1991, the program included a function which adjusted the droplet volume based on the resulting length/width measurements. The express manner for the development of this model was not specifically indicated. Based on a previous paper presented to the IABPA it appeared to be the dry weight methodology.

In discussing Backtrack, Dr. Carter reported that the dry weight methodology was the basis of the volume modelling. Dr . Carter had reservations however in correlating the MacDonell/Lige data with that created by himself and E. Podworny. Subsequent queries to Dr. Carter concerning his specific reservations were not available at the time of printing this paper. [12]

Interestingly the BACKTRACK and MacDonell/Lige models, although based on opposite methodologies, agree to a great extent. Differences were noted when discussing extremely small droplets (< .5 mm). In this instance the MacDonell/Lige model results in higher volumes than BACKTRACK. This may be explained as the M/L model was developed directly from empirical data and the .8 - 1 mm diameters appear to be the low end of the M/L data.

A problem associated with evaluating spatter based solely on size is whether categorizing (e.g. low, medium, high velocity) impact spatters is appropriate.

The negative argument relies heavily on the issue there is overlap between those events typically associated as high or medium velocity. Added to this is a tendency by analysts to associate a particular velocity with a specific group of events. An example is associating high velocity spatter and gunshots excluding other possibilities.

The positive argument calls for categorizing stains without assuming an underlying event. Categorization serves the function of documenting the stains **appearance,** not in analyzing the event which created it.

In summary, discriminating impact spatter has been based on size evaluations. Authors tend to agree that as we increase energy we will see a decrease in the size of spatter. Unfortunately they also agree that overlap can exist between spatter patterns created under very different conditions. No universally accepted demarcation point has yet to be defined.

Previous attempts to differentiate stain volumes were limited to large volumes. Until the development of the two volume estimation models, it was considered unlikely by some authors that volume could be estimated based on stain size. No attempts have been noted, in which volume estimation has been included as a means to discriminate between two stains.

Treatment of the Data

The modelling process applied to the data deals with three criteria: the number of spatter below .5 mm , the mean volume per individual spatter, and mean spatter dispersion per pattern.

For each stain pattern within a group the total number of stains present were counted. The spatter diameters were then measured and assigned to ranges.

Using BACKTRACK, volume estimations were made for the stains, with mean volumes determined for each pattern.

The total number of stains were divided by the area defined in the pattern to produce a spatter per square inch figure.

The Data

The original issue related to this work was whether the questioned stain was created as a result of backspatter or some other form of impact. An opposing analyst offered a theory that a single drop of blood present on an arm, was slapped by a hand, resulting in the observed pattern.

Questioned (Q) - The questioned stain was found at the scene of a shooting. The overall pattern measured about 4.5 X 5 inches. No discernible cone was evident in the pattern. All spatter were generally circular. A total of 161 individual stains were present, which ranged as follows:

Size	Number	% of Pattern
2 mm or greater	1	0.6%
1 - 2 mm	20	12.4%
.5 - .99 mm	71	44.0%
.49 or smaller	69	42.0%

A total of 68.2 % of the spatter were .5 mm in size or less. The mean volume of the stain was .058 mml. The mean dispersion was 8.2 spatter per square inch.

Back Spatter Standard (BS-1) - This stain group consisted of nine standards, created using .22 caliber pistol. Five were taken from an area 4.5 X 3.5 inches in size. Four came from an area measuring 3 X 3.5 inches.

A mean of 86.5 % of the spatter were .5 mm in size or less. The mean volume of the stain was .029 mml. The mean dispersion was 9.8 spatter per square inch.

Single Drop - 1 (SD-1) - Using a technique described and demonstrated by the opposing analyst a total of seventeen standards were created on both paper and cotton sheets. In the SD-1 group, the blood was placed on the hand (weapon) in motion.

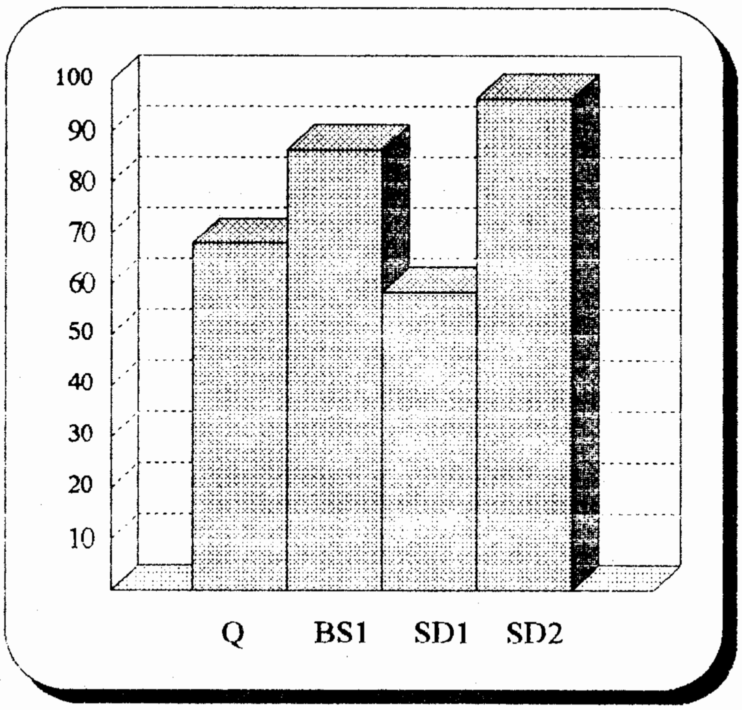
A mean of 58.4 % of the spatter were .5 mm in size or less. The mean volume of the stain was .113 mml. The mean dispersion was 2.23 spatter per square inch.

Single Drop - 2 (SD-2) - Using a similar technique as described for SD-1 a total of eight standards were created. In SD-2 the blood is on the arm (target) being struck by the hand in motion.

A mean of 96.49 % of the spatter were .5 mm in size or less. The mean volume of the stain was .0108 mml. The mean dispersion was 18.8 spatter per square inch.

COMPARISONS

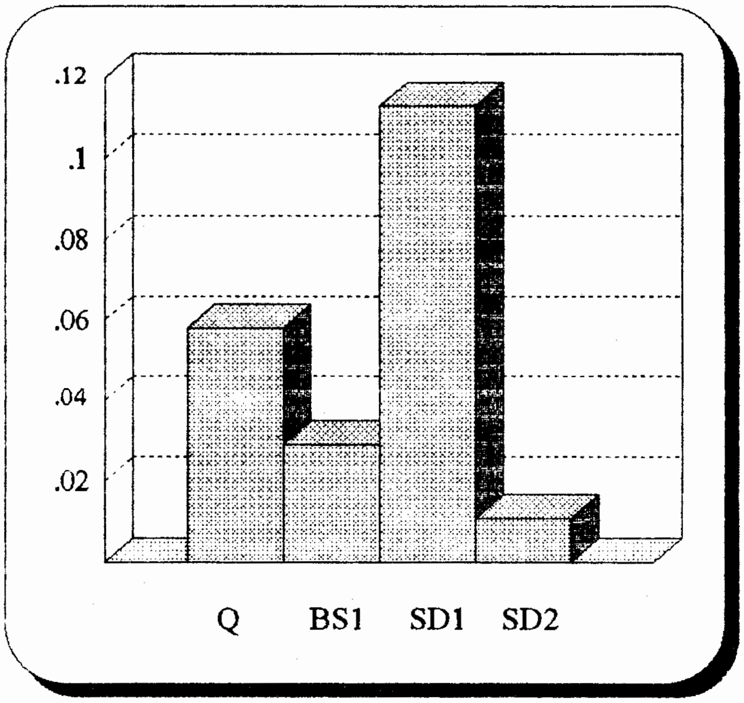
% Below .5mm Comparison



Stain Pattern	**% < .5 mm**
Q	68%
BS-1	86.5%
SD-1	58.4%
SD-2	96.5%

The data fails to establish any great demarcation between the questioned and BS-1 or SD-1. Based on this data alone, SD-1 appears to model Q.

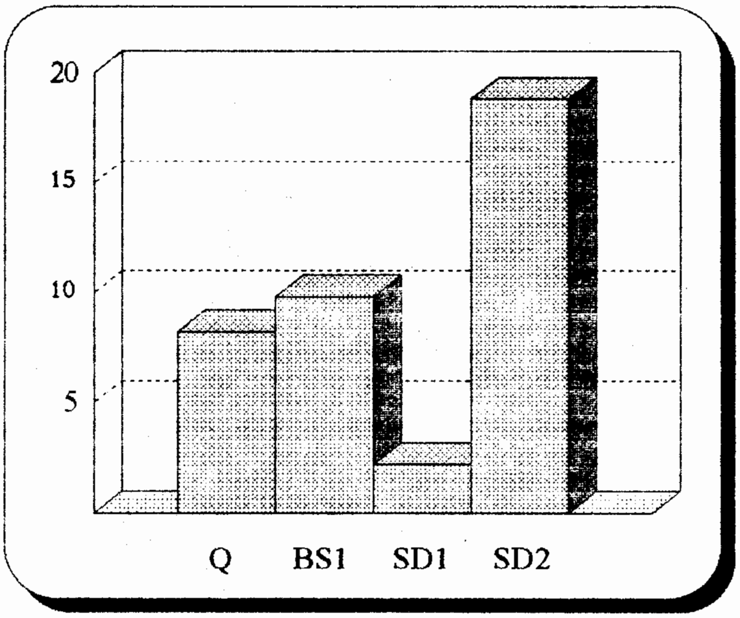
Volume Comparison



Stain Pattern	**Mean Volume**
Q	.058 mml
BS-1	.029 mml
SD-1	.113 mml
SD-2	.0108 mml

This data presents a more evident demarcation. Group Q and BS-1 differ by .029 mml. SD-1 which did not reflect great demarcation using size, does evidence demarcation using the volume (+.055). SD-2 stands out with a far lower mml volume.

Dispersion Comparison



Stain	**Spatter per Square Inch**
Q	8.2
BS-1	9.8
SD-1	2.2
SD-2	18.8

Q models best the BS-1 group. SD-1 as a group showed a distinctive low number of stains, which in this instance is quite important. Obviously SD-2 shows a much higher figure. **This type of data must be considered cautiously.** Only groups SD-1 and SD-2 are based on a **known** "total stain" count. We accept that we are only seeing a sample of BS-1. Yet based on the size of the sample group we may feel confident this number is representative for the stain as a minimum level.

Our confidence in the true level of spatter per square inch for Q is not as high. If we believe Q to be the result of a single incident and that we are looking at a representative sample of the stain, we may then assume that 8.2 is also a **minimum figure.** Higher figures are entirely possible. Had our sample (Q) come from the periphery of an area effected by some event, this number would probably be lower than if found nearest the center of such an area. The acceptance of the minimum level offers us some flexibility for comparison.

Related Issues:

In beginning this work, there were several thoughts I considered probable, which eventually were not supported by the data. These were:

- Volume alone would prove to be a singularly distinctive discriminator.

- Backspatter would stand out as a group from all other events, without distinction as to the method of creation (e.g. type of weapon).

First, volume proved not to be as distinctive, at least when considering the range of values present pattern to pattern in the groups.

Regarding the second, my acceptance of a non-matching backspatter creation method led to biased evaluation on my part. When looking at the data, I recognized that it was very likely spatter created from different weapons would result in different mean volume estimations. As a result I started to allow favorable preference to the BS-1 group, based on unproved assumptions. This became evident when I first wrote the "Summary of Comparisons" section, resulting in a rewrite. Not matching the backspatter to the specific suspect weapon, proved to be a major oversight.

Summary of Comparisons :

Size: When considering the size comparisons, the data was viewed based on percentage below .5mm. There was no particular reason for choosing .5 as the demarcation point ; however, there was for choosing a percentage comparison. The central tendency being evaluated on page 7 is this "preponderance of the stain" view, often taught to budding analysts. This information is limited in it's usefulness. In viewing distinctly different events, it may be functional, but not in instances where the spatter are not so distinctive. The actual ranges of spatter present in the <u>individual patterns</u> making up the three groups overlap each other. Each group has a distinctive central tendency, and based on that tendency Q best fits the SD-1 ranges and mean.

Volume: Mean volume estimation provides a starting point on how to view a particular events spatter. Yet the ranges of the mean, in the individual patterns of each group, must also be considered. In evaluating Appendix II, it becomes apparent the groups when taken individually show evident deviation . The data does not present tight specific ranges. But no less evident is the fact that the ranges in the groups, do not show distinctive encroachment on other group ranges.

In considering the issue of volume, we must always remember we are dealing with an estimation! Professor MacDonell felt these ranges would vary plus or minus ten percent. Dr. Carter felt there might be "considerable variance in the stain size versus drop volume" estimation.[13] We are still clearly dealing with a parameter decision.

Viewing the mean and the range of means present in the volume data, the following comparisons are possible:

Group	Consistent	Inconsistent
BS-1	X	
SD-1	X	
SD-2		X

Dispersion: It is important to state that the nature of the Questioned stain is what allows this evaluation to occur. In this instance Q had only one side which appeared voided. The remainder of the stain contains obvious peripheral edges on three sides.

If our sample of <u>any</u> Q is either: the entire stain or a representative sample (including a peripheral edge) we should be able to determine a minimum dispersion figure. These figures could only increase were our sample to include more of the central section of the stain.

The mean and ranges for the standards however, cannot increase. They are based on a total stain count. Because of this we can conduct a minimum versus maximum value comparison. Even if Q were created at a greater distance than the standards, if it's minimum number is higher than the standards maximum dispersion it still lends itself to comparison. In this instance:

Group	Consistent	Inconsistent
BS-1	X	
SD-1		X
SD-2	X	

Final Conclusions:

The comparison of Q, proves to be a poor illustration. This because it does not provide immediate and apparent distinction to any single suspect event, excluding all others based on volume. Yet exclusions can be made.

This does not indicate the modelling method has no function. The bottom line is if I am to exclude or include a stain as consistent to some other stain, I should point to some specific data, which has it's basis in the actual physical characteristics of the stains in question. These are still only "range of value" or parameter decisions, but they rate higher than a "it looks like" decision.

The failure of Q to fall conveniently into a single group of standards may well be a result of my "generic" backspatter thinking. This leads to the obvious decision to further evaluate spatter created from various types and calibers of weapons.

Beyond the evaluation of spatter size by visual means, comparisons of volume and dispersion appear to offer valid information for discriminating stains. The nature of this discrimination is best suited for excluding some particular event, not for **identification.** This process is not a necessity in every single spatter evaluation instance. But given two or more possible suspect events it may well lead to the exclusion of one or more as the likely origin of the spatter.

References

1. MacDonell,H., **Bloodstain Pattern Interpretation,** Laboratory of Forensic Science, NY, 1982, pg 2.

2. ibid pp 15-16

3. ibid pg 25

4. Epstein, Barton P.,& Laber, Terry, L., **Experiments and Practical Exercises in Bloodstain Pattern Analysis**, 1983, pg 31.

5. ibid pg 38

6. Bevel, Tom and Gardner, Ross M., **Bloodstain Pattern Analysis - Theory and Practice: A Laboratory Manual** , pp 17-18.

7. MacDonell, H., **Bloodstain Pattern Interpretation,** Laboratory of Forensic Science, NY, 1982, pg 3.

8. Epstein, Barton P.,& Laber, Terry, L., **Experiments and Practical Exercises in Bloodstain Pattern Analysis**, 1983, pg 6.

9. MacDonell, Herbert L. and Lige, Kiyomi De, "**On Measuring the Volume of Very Small Drops of Fluid Blood and Correlation of This Relationship To Bloodstain Diameter**", IABPA News, March 1990.

10. Carter, A. L., Podworny, E. J., "**Computer Modeling of Blood Droplet Trajectories**", presentation to the International Association of Bloodstain Pattern Analysts, November 1989, Dallas Tx.

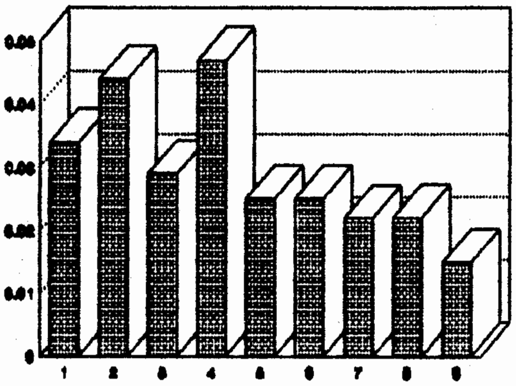
11. Eckert, William, & James, Stuart, **Interpretation of Bloodstain Evidence at Crime Scenes,** Elsevier Press , 1989, pp 53-59.

12. Carter, A. L., personal communications, June 1992.

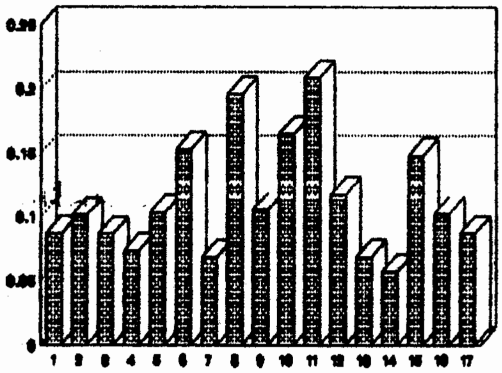
13. ibid.

Low	High
.015	.047
.057	.209
.006	.02

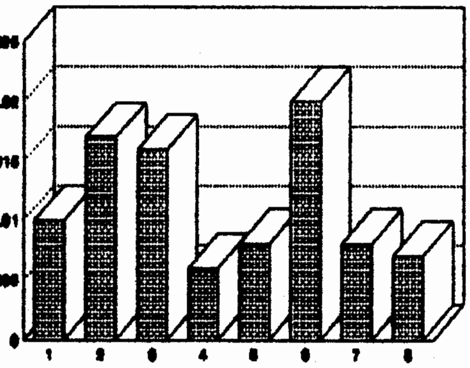
BS-1 Group Statistics
Volume



SD-1 Group Statistics
Volume

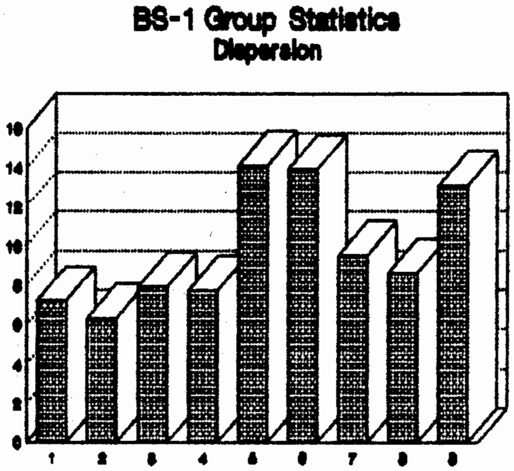


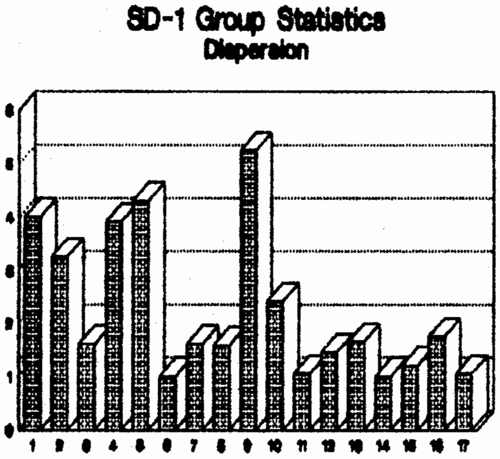
SD-2 Group Statistics
Volume

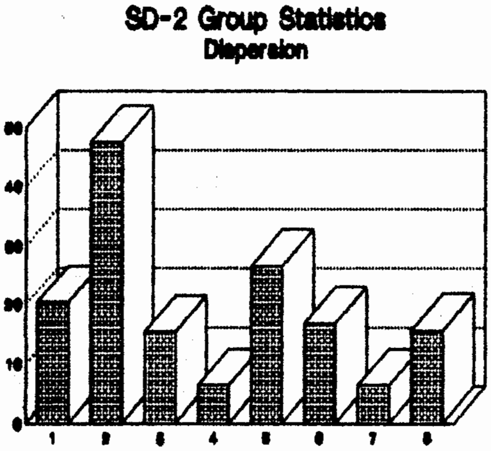


VOLUME

Low	High
6.3	14.1
1	5.25
6.34	47.5







DISPERSION