Spatter Pattern Analysis

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Abstract

My experiment is spatter pattern analysis. I have chosen this topic because it both greatly interests me and has significant impacts on our world. I like that the topic has real-world impacts- I think that doing this experiment will allow me to learn about a topic that has a real use. Because the main use of Spatter Pattern Analysis is in crime, I want to think of the topic as being used in a crime sense rather than arbitrary drops of liquid.

Bloodstain Pattern Analysis is the study of how blood drops fall in relation to how they hit a flat surface. This analysis can be used to reveal information such as the path of the droplet, the direction of travel, the weapon used and even the time since the droplets fell. Being significant to solving crime, it has been widely researched, but the generally used method for finding the path of a droplet is by drawing lines out from the spatter pattern to indicate the original position of the blood.

To do this experiment, I tested the ratio of a spatter pattern's height and length in relation to the angle it hit the flat surface. I was able to find conclusive results, which I then graphed to find a relationship between the two. This relationship formed a line that matched up nearly perfectly with my data.

Aim

My aim for this experiment is to find an accurate formula or graph that can be used to predict the size and shape of spatter patterns for different angles and heights of a spatter pattern.

Background Information

Spatter patterns are the marks left by falling droplets on liquid onto a solid object. The type of spatter patterns that were investigated in this experiment are called *passive patterns*, patterns formed by droplets of a liquid falling in a predicable line, rather than a spray such as that seen in a spray can of paint. Different spatter patterns are formed by droplets hitting a solid object at different angles and speeds. There are a number of other variables- the surface of the object, the liquid used, the size of the droplet. In my experiment, I focused on the angle of the droplet, in order to find the length of the droplet in comparison to the height.

Spatter patterns are generally elliptical, with a tail on the end referred to as *elongation*. Often the spatter patterns also have *spines*, spine-like lines radiating from the droplet. Elongation is caused by the angle of the spatter, whilst spines are created in accordance to the speed and distance. Different shapes are made as a droplet's angle of elevation from the solid surface changed.

So when is spatter pattern analysis used? The main use is in crime. In violent crimes, bloodstains often hold important information. Bloodstain Pattern Analysts specialise in this. We classify bloodstains as either impact spatter or projection spatter, spatter created by force applied to a person's body or spatter created by second hand force, such as blood spurting from an artery. In my experiment, the bloodstains formed would be considered as *passive projection spatter*, spatter patterns formed by singular drops of blood such as that dripping from an open wound.

These patterns are analysed using the shape and size of the droplet. This can accurately predict the angle and distance of the droplet's path, thus showing what position the spatter came from. This is often done with string. This can be done by investigating the ratio of the spatter's height to its length- the smaller the angle, the longer the spatter. For my experiment, this ratio will be measured as the $\frac{\text{height}}{\text{length}}$ The length of a spatter pattern will never exceed its height, and the ratio of the height-to-length will always fall between 0 and 1- but it will never be 0.

Other factors affecting the shape and size of a spatter are the size of the drop, the viscosity of the liquid and the distance/speed of the drop's path. All of these factors however, affect the size of the spatter and thus have little meaning for my experiment (but were still kept controlled). This is because the force from which the drop moves changes according to these factors. A higher force causes the droplet to hit the surface and spread out, making the droplet bigger.

Variables

- The independent variable is the angle of the droplet's path to the paper
- The dependent variable is the shape of the spatter (the ratio)
- Controlled variables include:
    - the liquid used
    - the temperature of the room
    - the surface the drop falls on
    - the size of the drop
    - the distance of the dropper from the paper
    - the outside conditions (wind, humidity, etc.)

Hypothesis

I hypothesise that the graph for the spatter patterns will be a curve, starting above 0. The ratio of the height to length of the droplet will never surpass 1 (which occurs at a 90° angle), and the larger than angle, the smaller the ratio. This is because as a droplet travels at a larger angle, it spends more time touching the paper- imagine a droplet traveling at 0° to the paper. It will create a line across the paper- so the ratio will never be 0, but will come extremely close to it (ratio>0).

Risk Assessment

If you are working with real blood, you must wear gloves to reduce contamination. Also wear goggles and a face mask so you do not ingest any of the blood. Be extremely careful when using the blood and make sure it is bought from a qualified butcher. If the blood is contaminated, you will be safe if you wear gloves, a surgical mask, and goggles.

If you are using stage blood, do not ingest the blood and make sure the blood is non-toxic before touching it with your bare hands.

Materials

- blood from a cow/pig

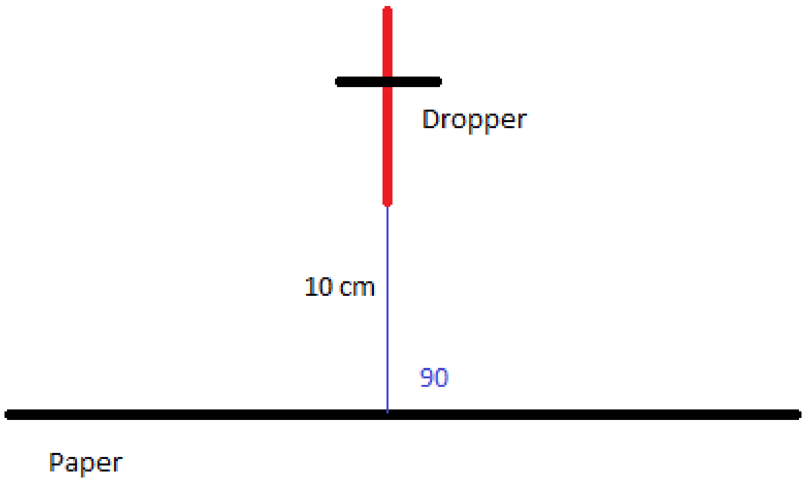
or

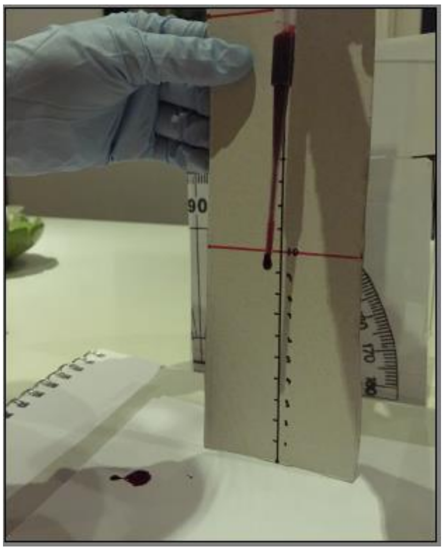
- fake prop blood
- dropper/pippete
- ruler
- protractor

- paper
- camera
- rubber gloves
- safety goggles
- surgical mask

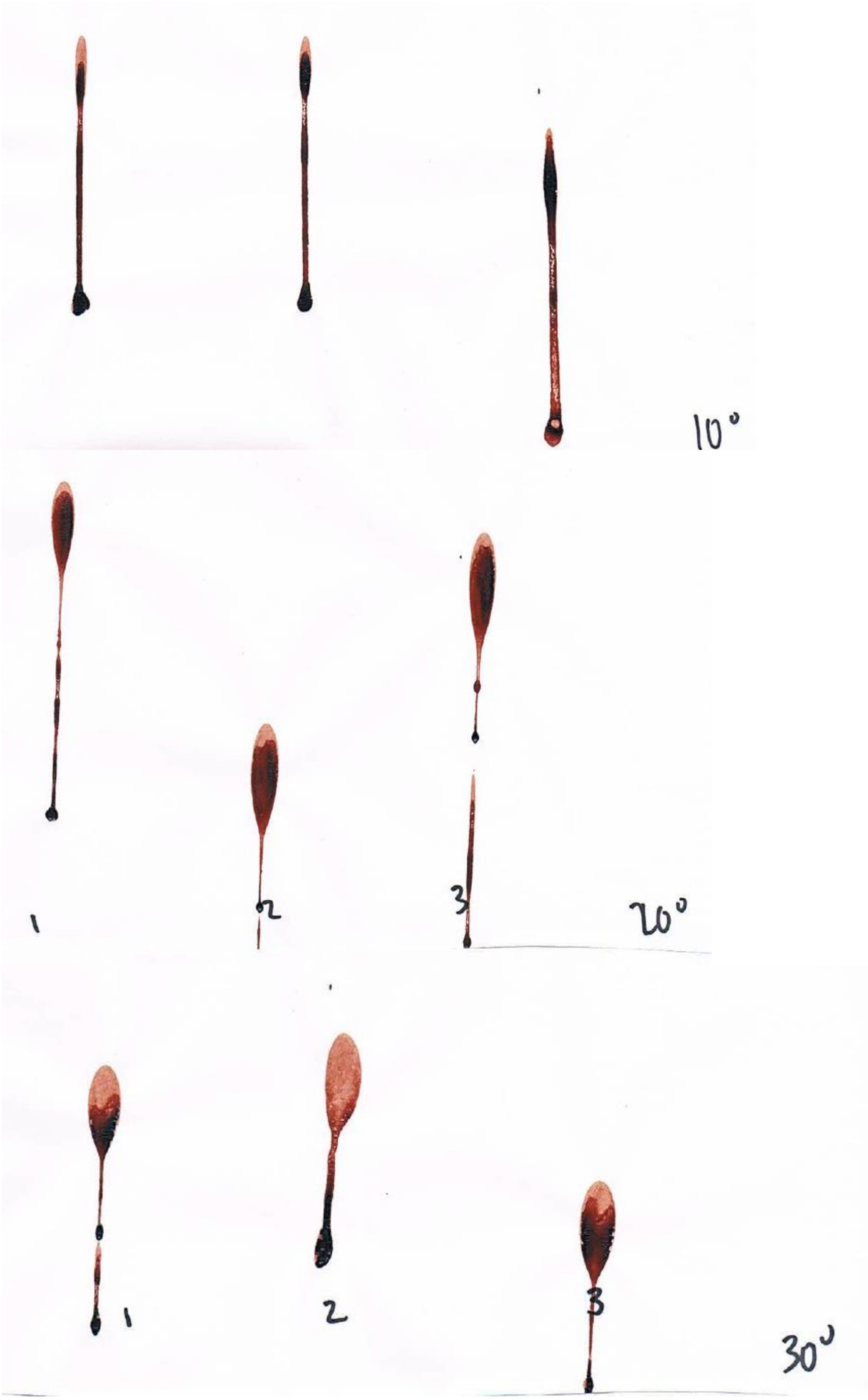
Method

1. Collect the blood in a dropper or pippete
2. With the dropper at a 90° angle to the paper, drop a single drop of the mixture onto the paper, 10 cm above the paper
3. Photograph the drop, making sure to photograph it from above the paper
4. Repeat steps 1-3 with angles 80°, 70°, 60°, 50°, 40°, 30°, 20°, and 10°
5. Complete the experiment 3 times for reliability
6. Using the photos, record the ratio of the spatter, height to length
7. Graph results





Results




1
2
3
40°

1
2
50°

1
2
3
60°

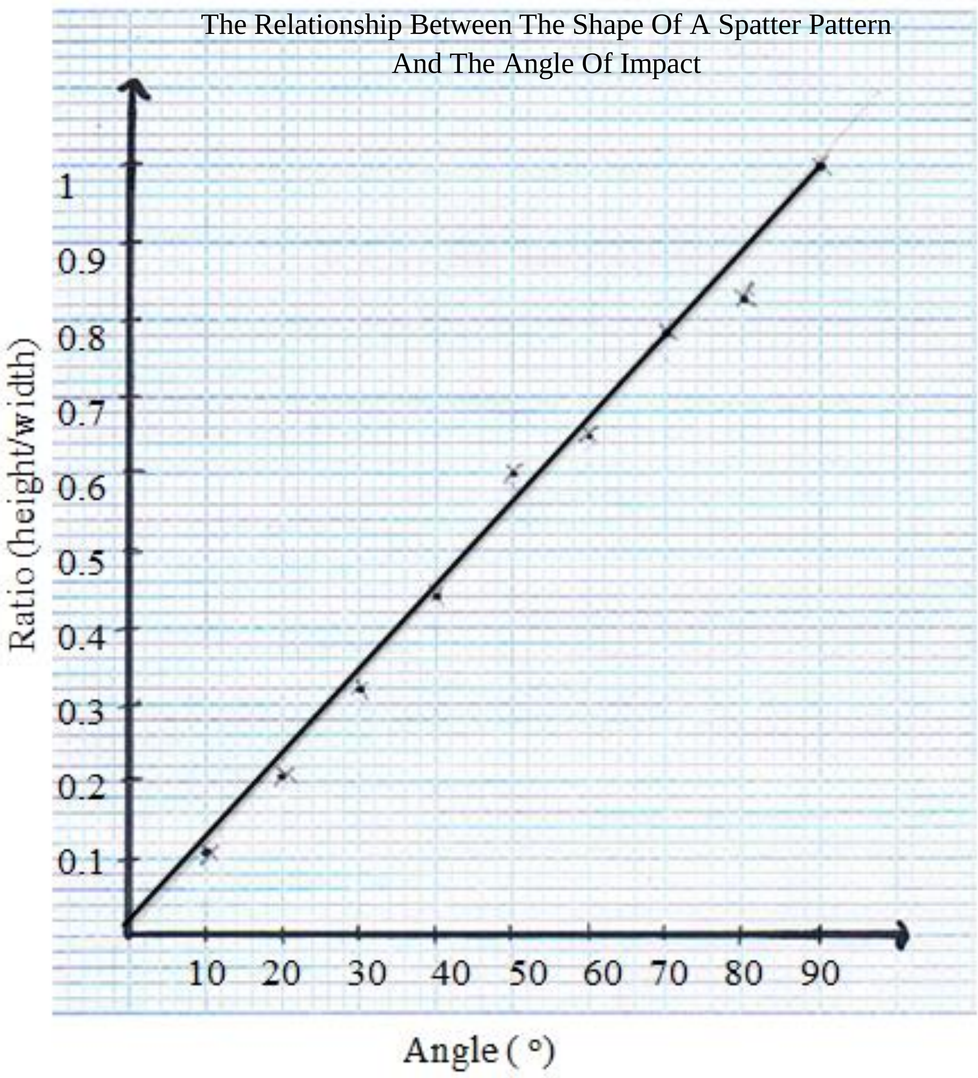

1
2
3
70°


1
2
3
80°


1
2
3
90°

Angle	Test 1		Test 2		Test 3		Average	
(°)	Length	Height	Length	Height	Length	Height	Length	Height
90	10	10	10	10	10	10	10	10
80	12	10	12	10	12	10	12	10
70	14	12	13	10	13	10	13.3	10.6
60	14	9	14	10	15	9	14.3	9.3
50	17	10	17	10	16	10	16.6	10
40	18	8	19	8	19	9	18.6	8.3
30	22	7	23	8	24	7	23	7.3
20	24	5	30	7	31	6	28.8	6
10	20	2	18	2	30	3	22.6	2.3

Angle	Ratio
90	1
80	0.83
70	0.797
60	0.65
50	0.60
40	0.45
30	0.32
20	0.21
10	0.11



Discussion

Validity: In my experiment, I worked hard to keep the variables controlled. Because the experiment was performed at one time and indoors I limited the amount of variables in the outside conditions. I also used the same batch of blood to keep the same viscosity of the liquid.

By keeping all variables controlled except the angle of impact, I was able to make my experiment valid as I knew that the changing height and length were a direct result of the changing angle of impact.

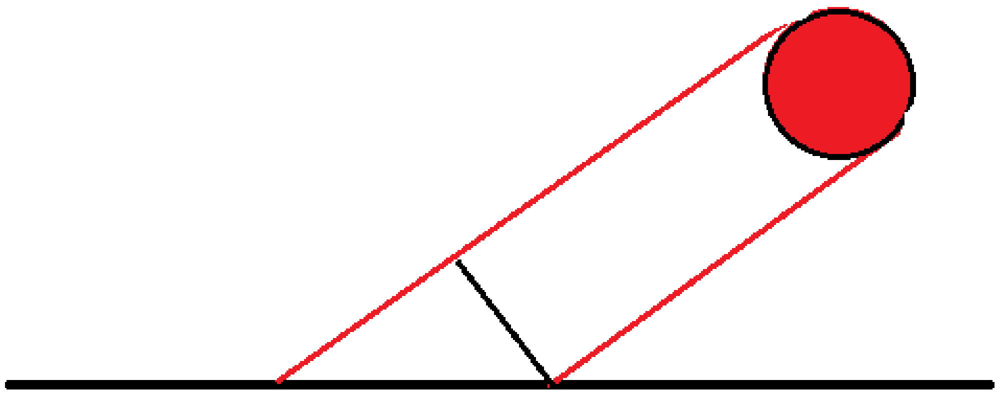
Reliability: In order to make my experiment more reliable, I completed the experiment 3 times over. I then took the ratios given from this and found the average score, which I then used to make my graph.

By doing so, I eliminated any astounding outliers in my data, thus making my experiment more reliable.

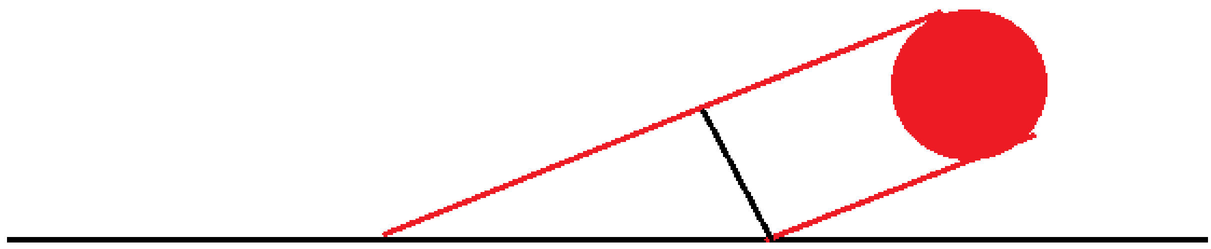
Accuracy: Because the spatter patterns were quite small, the accuracy of my experiment was not as high as it could have been. To make the patterns easier to measure, I photographed each pattern 10 cm directly above the pattern. I then zoomed into the pattern and used these measurements to make the ratio. This meant that my data was more accurate as I was able to measure the size of the pattern more closely.

The data I found formed a line of best fit that fit the data. To find my data, I found the averages of the 3 tests I performed. I then divided the height of the spatter by the length. These ratios were all between 0 and 1. Although I have not included it in my data, an angle of 0° would result in a single straight line. This line's ratio would be impossible to find- the length of the spatter would be infinite, and thus the ratio would simply be ratio>0. This proves my hypothesis incorrect- the data fell in a straight line, rather than a curved line as I expected.

For the first angle, 90°, the height and the length were the same- as the circular drop fell, it hit the ground from directly above, keeping the perfectly circular shape. When the angle becomes less than 90, however, the length becomes bigger than the height, so as the angle decreases, so does the ratio of height to length.

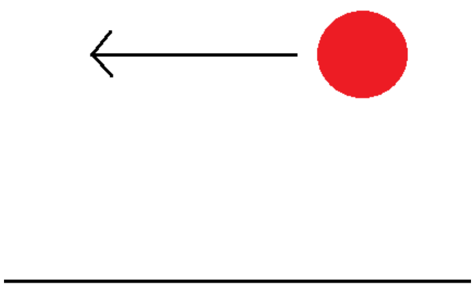


So as the angle decreases further, the length becomes bigger.



As I found in by graphing the changes, this increase in length was done at a steady rate. It must be noted however, that the graph is not entirely correct, for the angle should never reach 0.

To further the investigation, the tested angles of impacts could be extended to 100-180°, in which the results would mirror that of 0-90°. Another investigation could be on the effects of moving the dropper from left to right whilst the drop is falling. This would simulate blood dripping from a wound whilst the wounded is moving. The experiment could be done with the aid of the experiment I have already done.



In an experiment such as this, you could test the effects of changing speed on the shape of the spatter. Changing the speed of the dropper's movement would make the drop fall on an angle. You could test the effects of the speed on the angle of impact, by looking at the spatter to find the angle using results from this experiment.

There are a number of ways in which I could improve my experiment. To isolate a single spatter, I had to simulate a single blood drop falling directly down onto paper which was placed at an angle, rather than the blood move at an angle. Despite the blood still hitting the paper at an angle, in reality, the path of a blood droplet is not straight- it is curved.

This was the main difficulty I faced in designing this experiment- in order to create a stimulated singular spatter from a specific angle, I would need to accommodate for a number of variables, such as not being able to completely control the angle of the droplet's path, thus making the entire experiment invalid. I contemplated using a pellet like round object to simulate the drop, such as a paintball, but this would affect the spatter as the pellet needs to burst as it hits paper.

I was also unable to use human blood for the experiment- instead I used pig's blood. Although most mammals' blood is generally similar, human blood has a few notable differences, such as the lack of nuclei in the red blood cells. This does not generally affect the physical aspect of the blood however, so pig's blood is a suitable replacement.

A possible improvement is to use a syringe to create a constant stream of liquid, thus creating a path for the liquid to flow. This path would likely be curved from the weight of the blood, making it more accurate than my experiment. Instead of paper, I would use a surface that allows the excess liquid to pass through, leaving the outline of the pattern, such as thin mesh or fabric.

Conclusion

In conclusion, the graph used to find the relationship between the angle of impact and spatter pattern of a drop is a straight line, proving my hypothesis incorrect. I was correct, however, in assuming that the ratio between the height and length of the spatter pattern will never be 0. (see graph on page 7).

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