What Variables Affect the Speed of a Nerf Dart?

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Question

- **Question “Can you make a Nerf dart go faster by changing variables?”**
- It combines science with fun It lets us learn the concept of speed, energy, time, frame per second(fps.)
- Nerf guns are popular toys and using them in a experiment makes learning both exciting and practical.
- This project gives me the chance to apply scientific method to a real world object that we already enjoy.

Hypotheses

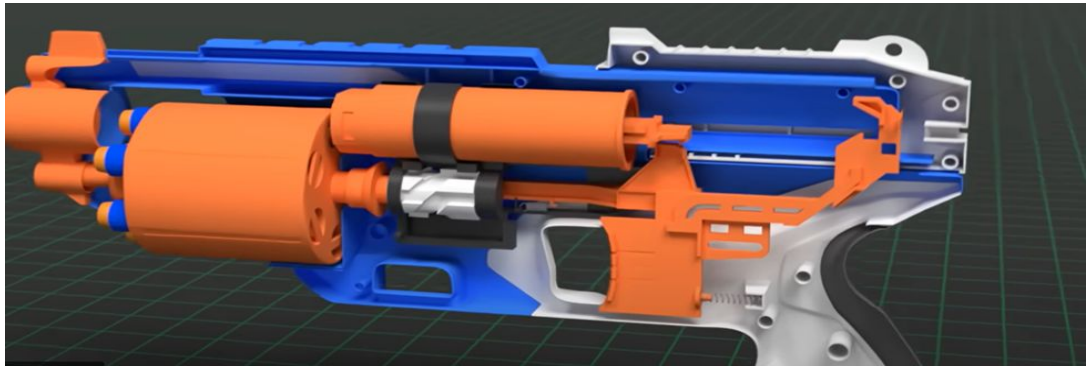
Test	Avyan Hypothesis	Everett Hypothesis
Control	We will compare all the variables against the control darts.	
Holes in Darts	If we drill holes into the dart then it might be **slower** because of the air going through it.	If we drill holes in the darts then they will go **faster** than control because there is less weight so it will go faster.
Heavy Darts	If we add weight to the dart then it might be **slower** because it is heavier and weighs down with gravity.	If we put weight in the darts then they will go the **slowest** because the extra weight is going to slow it down.
X-shot Darts	If we change the brand then it probably **won't make a change** from the normal dart because most darts are almost the same.	If we change the brand to X-shot then they will **go the same** speed as the control because they are about the same size and shape.
Short Darts	If we shorten the dart by a centimeter then it would most probably be **slower** because of aerodynamics.	If we shorten the darts then they will **go the same** speed because we only cut 1 cm off and 1cm isn't much.
Cold Darts	If we change the temperature then it **should not make any change** because it just changes hot or cold.	If we freeze the darts then they will **go slower** than the normal darts because cold is heavier than hot, and so there is more weight on the cold darts.

Background Research

How Nerf guns work

The **ELITE 2.0 COMMANDER** is a RD-6 (Rotating Drum 6 shot) blaster.

Before we started the tests we had to figure out “how does a Nerf gun work?” After some research, we learned that a Nerf gun works with the principle of air pressure. When you pull back the top slider of the Nerf gun, a spring connected to a piston is compressed. When the trigger is pulled, the spring decompresses rapidly and the piston moves forward with it. This sudden release of kinetic energy creates a burst of air pressure from the piston, which pushes the dart out of the barrel towards the target with high speed.



Background Research #2

Speed is a measurement of how fast an object is moving

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

- To measure the distance, we used a speed board
- To measure time, we used an iphone camera (slow-mo at 240 frames per second)

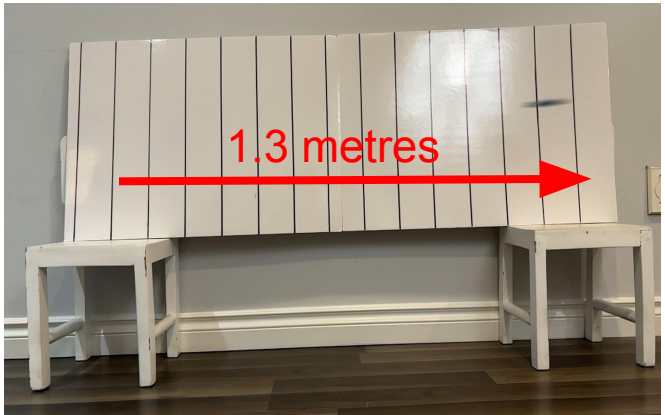
1 second / 240 frames = 0.004167 seconds/frame

15 frames = 0.004167 x 15 = 0.0625 seconds

Speed = 1.3 metres / 0.0625 seconds = 20.8 m/s

Frame 1

Frame 15



Variables

- **Controlled Variables**
  - ➢ Using the same Nerf gun for all tests
  - ➢ Testing in the same area where there is no wind
  - ➢ The distance between the Nerf gun & the speed board is the same
  - ➢ The room temperature stays the same
- **Manipulated Variables**
  - ➢ Holes in darts
  - ➢ Heavy Darts (putting things into the dart)
  - ➢ Different brands of darts (Nerf vs. Xshot darts)
  - ➢ Length (shorten the dart)
  - ➢ Cold dart
- **Responding Variable**
  - ➢ Speed of the Dart - How fast or slow the dart goes

Procedure

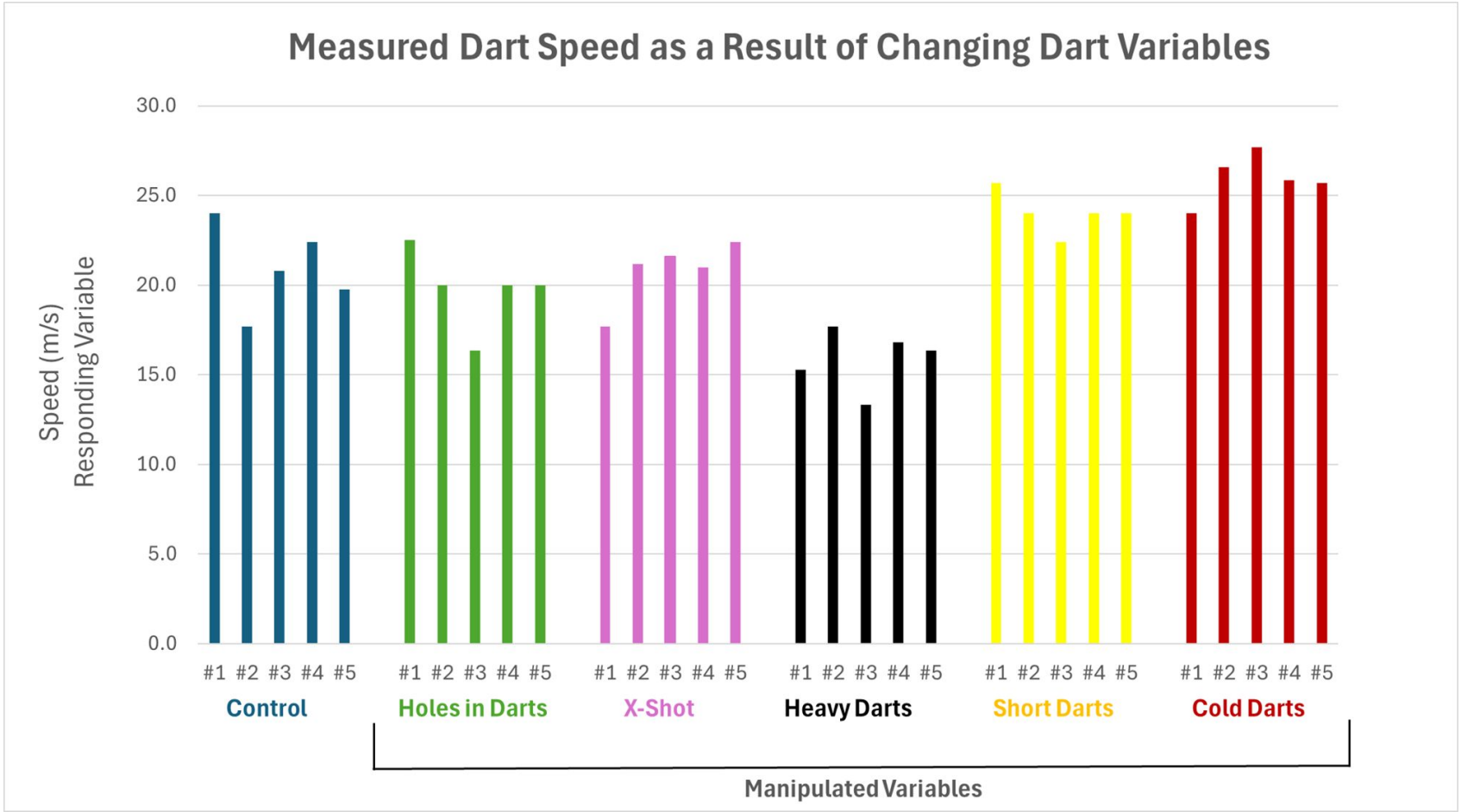
1. Prepare darts
    - label each of the 30 darts from 1-30 using a pen
    - put 5 darts into freezer
    - drill 4 holes in each of 5 darts
    - cut 5 darts each 1 cm shorter
    - put 2 magnetic balls and a small piece of plasticine in each of 5 darts
    - get 5 X-shot darts
    - put darts into zip lock bags to keep organized and name them each
2. Set up area
    - put speed board on two chairs
    - set up camera and lights
    - and put up a target
3. Shoot 5 darts for each variable with the camera recording in slow motion (at 240 fps)
4. Load videos into software (frame grabber app) and count how many frames it takes for the dart to get from the start of the speedboard to the end of the speedboard
5. Record results in log book
6. Complete calculations
7. Analyze results

Procedure: Testing Area Set Up

Materials

- Nerf gun (elite 2.0 commander)
- Different brands of darts (Xshot and elite 2.0 darts)
- Ruler/measuring tape
- Speed board (Sharpie, white cardboard, glue stick, tape)
- Camera
- Freezer
- Weighing scale (digital at a pharmacy)
- Plasticine
- Scissors
- Chopsticks
- Metallic balls
- Zip lock bags
- Drill
- Temp Gun
- Drill bits size is 7 / 64 inches

Observations



Analysis

- The controlled darts had a mean speed of 20.93 m/s.
- The holes in the darts made them slower.
- The X-shot was almost the same speed.
- The heavier darts went slowest.
- The shorter darts went faster.
- The colder darts went the fastest.

		Responding Variable (Speed)	
		Mean (m/s)	Median (m/s)
	Control	20.93	20.80
Manipulated Variables	Test#2 Holes In Bullets	19.77	20.00
	Test #3 X Shot Bullets	20.77	21.18
	Test #4 Heavy Bullets	15.89	16.36
	Test #5 Short Bullets	24.02	24.00
	Test #6 Cold Bullets	25.96	25.85

Conclusion

Making the darts shorter or colder made them go faster whereas making them heavier or drilling holes in them made them slower.

	Avyan Hypothesis	Everett Hypothesis
Control		
Test#2 Holes In Bullets	slower	faster
Test #3 X Shot Bullets	same	same
Test #4 Heavy Bullets	slower	slower
Test #5 Short Bullets	slower	same
Test #6 Cold Bullets	same	slower

Green=correct
Red=incorrect

Avyan was correct, Everett was not

Both hypotheses were correct

Both hypotheses were correct

Both of us were incorrect

Both of us were incorrect

Application and Extension

If you want to win a Nerf war with faster darts then

- Put your darts into a freezer
- Cut 1 cm off the dart
- Put the darts in the freezer and cut 1cm off the dart

Extension: Can you make these things go faster by making them colder **or** shorter?

- Balls like basketballs or soccer balls
- Real bullets or arrows
- Paper airplanes
- Drones

Sources of Error

Here are some potential sources of error in our experiment.

- The height and angle of the shot were hard to keep the same between tests.
- Our hand was too warm so it heated up the dart during cold tests when we were putting it in the Nerf gun.
- When looking at the video it was hard to find a frame where the dart was right at the beginning on a line to start counting.

Here are some things that we could have done better to improve this experiment, and to reduce the sources of error.

Improvements

- Place the gun in one locked position to control the height and angle of the shot.
- Use something other than your hand to put the cold darts in the gun like using tweezers.
- Shorten the distance between lines on the speed board or use a better camera with higher frame rate to improve precision and accuracy of the time.

Citations

1. https://www.facebook.com/jaredowenanimations/videos/nerf-guns-are-actually-quite-complex-on-the-inside-from-the-piston-all-the-way-t/570583970058471/ (how a nerf gun works, Jared Owen)
2. https://www.youtube.com/watch?v=P_6my53IlxY (the idea of a speedboard, Mark Rober)
3. https://www.topendsports.com/biomechanics/video-analysis-speed.htm (calculating speed using a video analysis, Topend sports)
4. https://www.amazon.ca (finding different bullets)
5. https://google.com (definition of speed)
6. https://www.youtube.com/watch?v=sgbKajHanoc (how to measure speed using an iphone, Zak's Lab)
7. Itunes app store (Frame Grab app to count frames in a video)
8. My uncle's friend Ishan gave us the weights for the darts

Acknowledgements

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Thank you

For listening to our presentation

Hope you enjoyed our presentation.
And the topic that we chose.

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