Brown’s Criterion WIP

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Meta Description

Brown’s Criterion is an application of a result in Mathematics which takes advantage of the fact that numbers can be uniquely written in base 2.

Learning Objectives

To learn about binary number systems.

To understand how binary is used in this problem.

Key Terms

Base
A base is a way how to represent numbers.

Binary
Number system of base 2.

Decimal
Number system of base 10.

Method

Step 1
Ask the participant to pick a number between 1 and 31, remember it, but not to disclose it to you.

Step 2
Show the participant the Brown’s Criterion cards and ask them to confirm or deny whether their number is on the card or not.

Step 3
Begin by showing the cards one by one each time looking at the card once it has been shown.

Step 4
After their last card has been shown, guess their number correctly.

Step 5
Ask them how they think you’ve done it.

Step 6
Let them observe the cards well and see if they can notice any trends.

Alternative Method

- If the participant is not convinced, usually by the fact that you are ‘looking where they’re looking’, you can repeat the above procedure by not looking at the participant, or closing your eyes. At the same time keeping sure that you either look at the card when you are not looking at the participant, or knowing the order of the cards when you have your eyes closed.
- If the participant is not convinced, usually by the fact that the cards are in the order you want them to be, you can repeat the above procedure by mixing up the cards

Narrative

Propose this experiment in the context of a magic trick and you as the demonstrator having the ability of reading the participant’s mind.

Questions

Did you guess the numbers because you know all the numbers on the cards by heart?
Not at all! Anyone is able to do this if they know how to.

What happens if you mix the cards up?
This still works if you or I mix up the cards!

Would it still work were you to not use all the cards?
No it wouldn’t, all the cards are important in this demonstration.

How does base 2 fit into this?
Base 2 is a type of way how to write numbers.

When you are telling me ‘Yes’ or ‘No’ you are identifying that number in base 2. How did you make the cards so that you can identify them in base 2?
The cards are built that way so that wherever the number appears, it has a ‘1’ in its binary form.

Brief Explanation

Every number can be uniquely written in any type of base. For example, 78 can only be written as 78 in decimal, but this can also be written in binary as 1001110. This is extremely handy for our cause since binary uses only 2 digits, 0 or 1, then something can either be ON the card or NOT ON the card. So the way the cards are created is by purposefully putting every number where ‘1’ appears in its binary representation, so that when the participant confirms that his number is on the card, he is actually identifying his number in binary.

For example, if he says Yes to the 1st card, No the 2nd card and Yes to the 3rd card then his number is 101 which is $(1 \text{ x } 2^2)+(0 \text{ x } 2^1)+(1 \text{ x } 2^0) = 4 + 0 + 1 = 5$

Detailed Explanation

In primary school, everyone is taught that numbers are written down using 10 digits, 0 up to 9 in a unit place, tenth place, hundredth place etc. Numerically, the hundredth place is 10^2 = 100, the tenth place is 10^1 =10 and the unit place is $10^0 = 1$ and any number is written as a sum of these parts. For example, 321 is $(3 \text{ x } 10^2) + (2 \text{ x } 10^1) + (2 \text{ x } 10^0)$

In Binary, only 2 numbers are used, 0 and 1.But the system is the same. Numerically, the first place is $2^2 = 4$, the second place is 2^1 =2 and the unit place is $2^0 = 1$ and any number is written as a sum of these parts too. For example, 5 written in the decimal way, can be converted to the binary since $(1 \text{ x } 2^2) + (0 \text{ x } 2^1) + (1 \text{ x } 2^0)$ or 101 in binary.

To create the cards, write any number where ‘1’ appears in its binary representation. Since 1, 2, 4, 8 are only powers of 2, then they easily are identifiable because they have one ‘1’ in their binary representations 0001,0010,0100,1000. This means that they only appear on 1 card, and they are usually written first on the top left corner of the card. 9 for example is 1001 and thus appears twice on the cards, once in the first and once in the last card.

Obviously to make things easier for the demonstrator, all that needs to be done to guess the number of the participant, is to look on the top left corner of the cards, which contain the powers of 2, and whenever the participant says ‘Yes’, add the number on the top left side and keep a record of their sum in your mind until all the cards have been gone through.

Applications and Research

Applications
Binary systems has been used mainly to develop the revolution that is Digital computing. The use of binary in the components which make up electronic has several advantages which make it very applicable.

- It is very easy to build
- There is very little room for ambiguity in its output interpretations

Applications of this idea to the modern world can be found in most electronicsin use today. Any device which is able to hold memory, work out numerical calculations, display an image or process any form of information uses binary to encode and decode that data.

Nowadays, we are fast approaching the ceiling for how much computing powerwe can pack in a small chip. Advances in Computer Science and Physics has given rise to a possible revolution through Quantum Computing.

Research
The method by which a machine uses its components and the binary systems within them to carry out operations which enable it to save memory or workout calculations uses a field of Mathematics called Boolean Algebra.

While the Mathematics of base 2 is not researched directly, it is being used to convert data into a language which computers can read everyday. Research is being done on trying to create low-cost method of DNA sequencing by converting it into binary format to enable readability on several platforms.

Investigation

1. Will it be possible for me to guess the number you are thinking if I changed the initial conditions? What happens if I mix up the cards for example?
2. Is it possible for this to be done with other numbers? i.e. greater than 31?

Brown's Criterion (steamexperiments.com)

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Subject

Maths & Stats

Education

Primary
Secondary
Post Secondary
University
Informal

Time Required

~10 minutes
Preparation: 1 minute
Conducting: 10 minutes
Clean Up: 1 minute

Cost

0 – 10 €

Recommended Age

6 – 9
10 – 12
13 – 16
>16

Number of People

1 participant

Supervision

Not Required

Location

Indoors
Outdoors
Festivals
Laboratory

Materials

Pen or Marker

Printed Paper

Contributors

Malcolm Muscat Rodo
Author
Darlene Sammut
Editor

Sources

Number Bases

Number Bases: Introduction & Binary Numbers

Additional Content

Abacus (Beginner)

Binary Count Fingers(Beginner)

Finger Binary(Beginner)

Gray code basics(Intermediate)

Quantum Computing Explained (Intermediate)

Digital Sequencing(Advanced)

Will the future quantum computers use the binary, ternary or quaternary numeral system? (Advanced)

Cite this Experiment

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