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Searching to Speak

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Locked-in Syndrome

- A person with locked-in syndrome is totally paralysed except perhaps being able to move an eyelid.
- They can see, hear and think but they cannot move
  - including talk.
- They are just as intelligent as ever.

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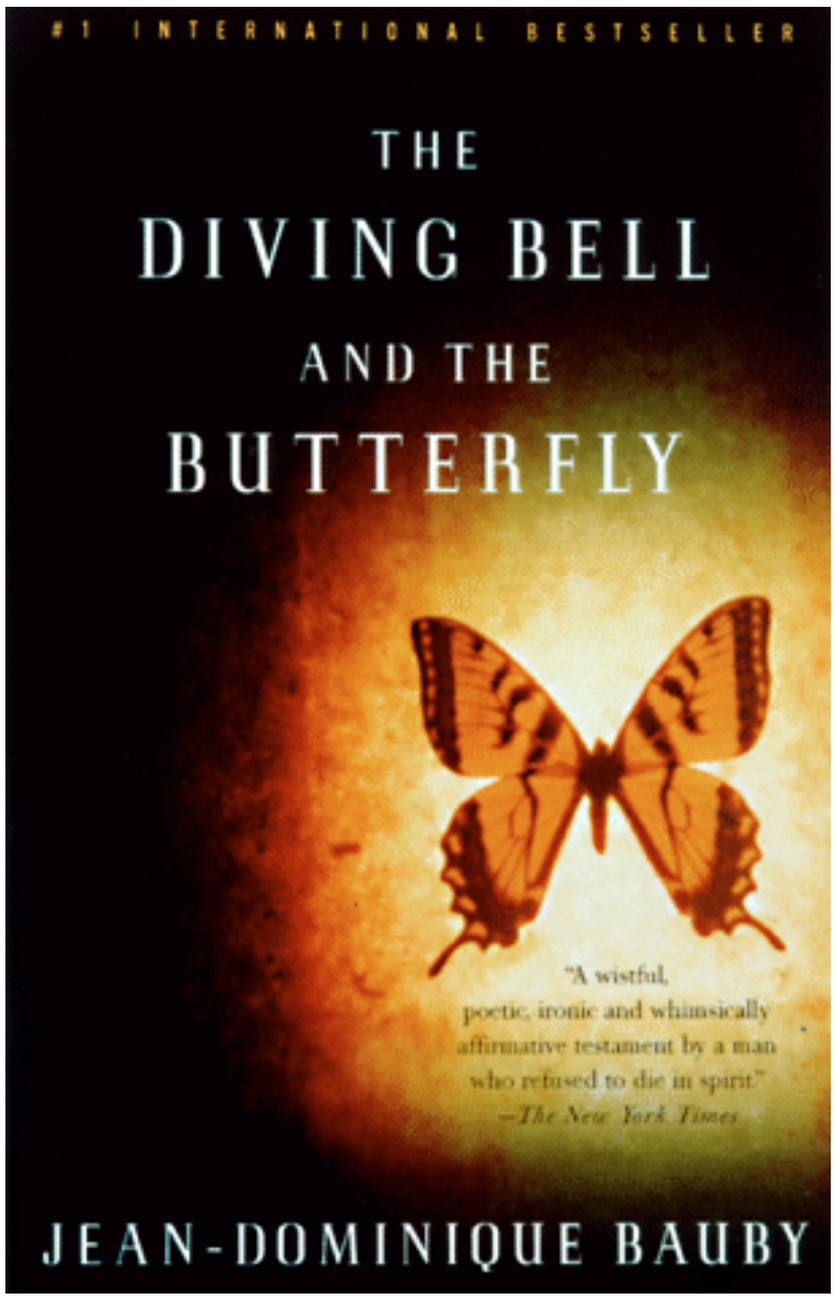
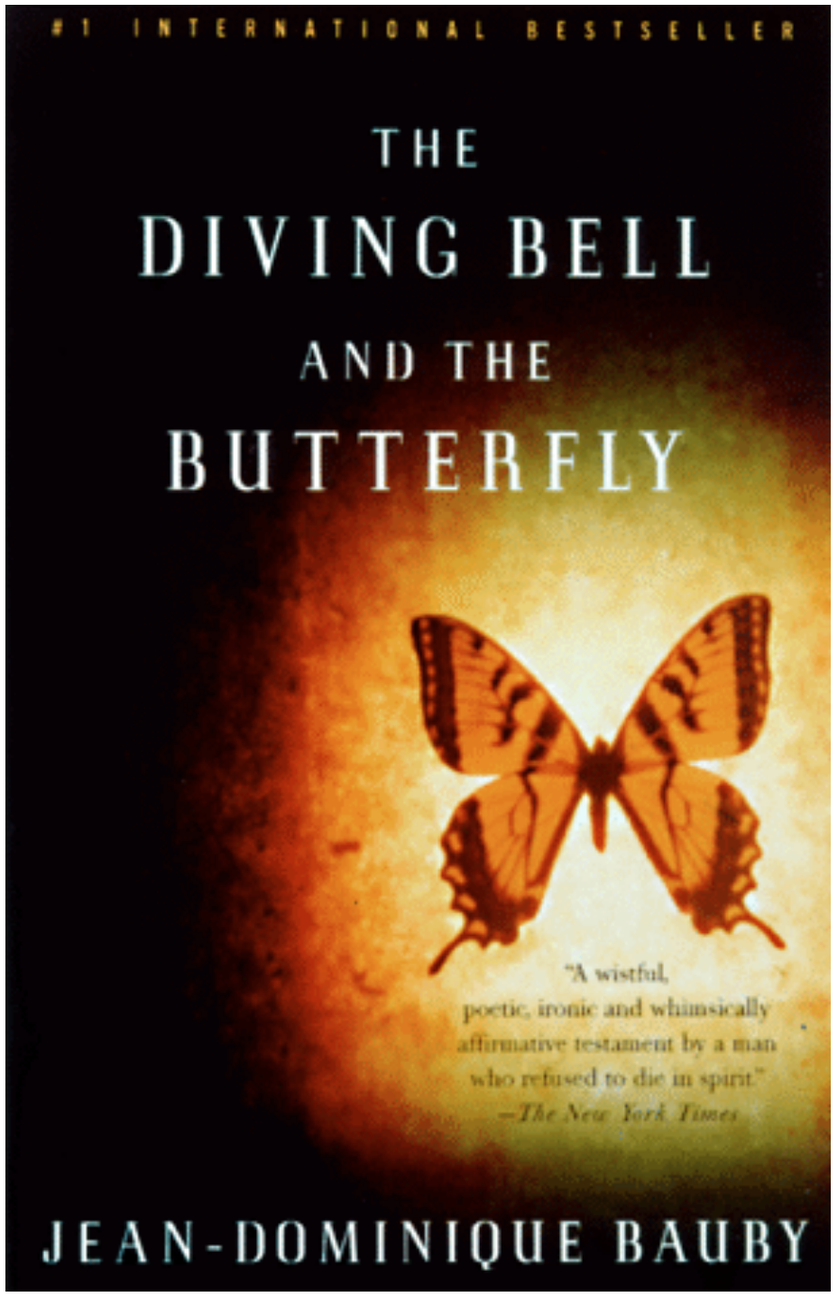
Could you write a book if you had locked-in syndrome?

- Jean-Dominique Bauby did…
  - "one of the greatest books of the century".
- Describing his life with locked-in syndrome.
- How did he do it?
  - With a helper
  - No technology



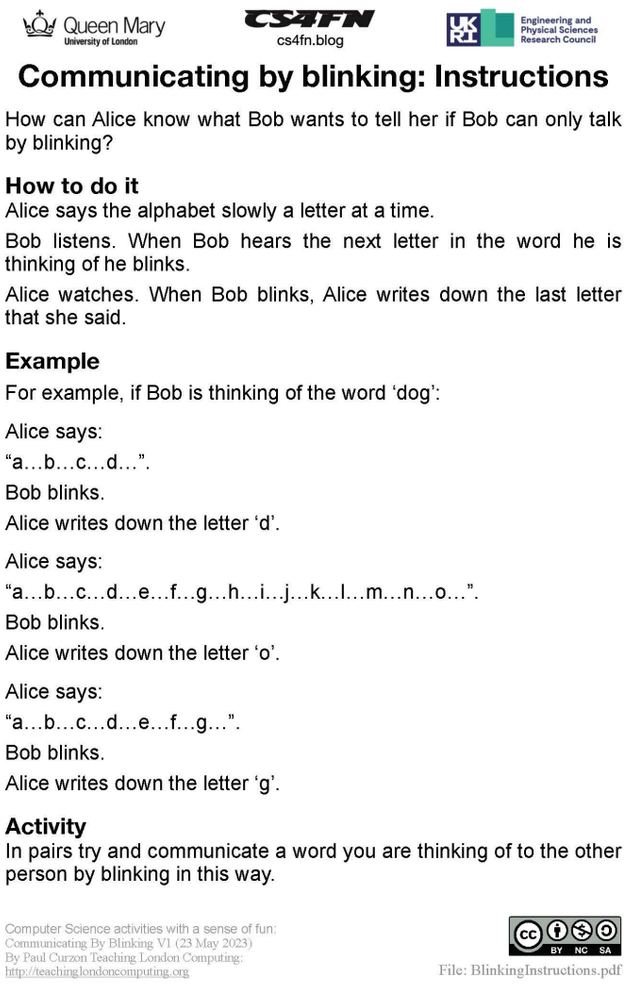
How?

- The helper says:
  - “A B C … “
  - He blinks at the right letter.
  - The helper writes it down.



Activity: Communicate by blinking

- Get into pairs.
- Each take a word card and (keep it hidden)
- One person try and communicate the word just by blinking with the helper talking through the alphabet.
  - Then swap over.
- What goes wrong?
- Can it be improved?



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Communicating by blinking: Instructions

How can Alice know what Bob wants to tell her if Bob can only talk by blinking?

How to do it

Alice says the alphabet slowly a letter at a time.

Bob listens. When Bob hears the next letter in the word he is thinking of he blinks.

Alice watches. When Bob blinks, Alice writes down the last letter that she said.

Example

For example, if Bob is thinking of the word 'dog':

Alice says:

"a…b…c…d…".

Bob blinks.

Alice writes down the letter 'd'.

Alice says:

"a…b…c…d…e…f…g…h…i…j…k…l…m…n…o…".

Bob blinks.

Alice writes down the letter 'o'.

Alice says:

"a…b…c…d…e…f…g…".

Bob blinks.

Alice writes down the letter 'g'.

Activity

In pairs try and communicate a word you are thinking of to the other person by blinking in this way.

File: BlinkingInstructions.pdf

- You need
  - Communicating by blinking instructions
  - a word from the word sheet

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How well does it work?

- What problems need to be solved?
  - to make it really work
- Can it be improved?

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Frequency Analysis

- A way to improve our blinking algorithm is to use frequency analysis.
- It was invented by a Muslim scholar, Al-Kindi, over a thousand years ago.
- He used it to crack secret messages (ciphers) where each letter is replaced by a new symbol.

Image of Al Kindi by Michel Bank CC BY-SA 4.0

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Frequency Analysis

- You work out how often each letter appears in writing
  - eg count the letters in books, papers, comics etc
  - how many times does ‘a’ appear?
  - how many times does ‘b’ appear?
  - …

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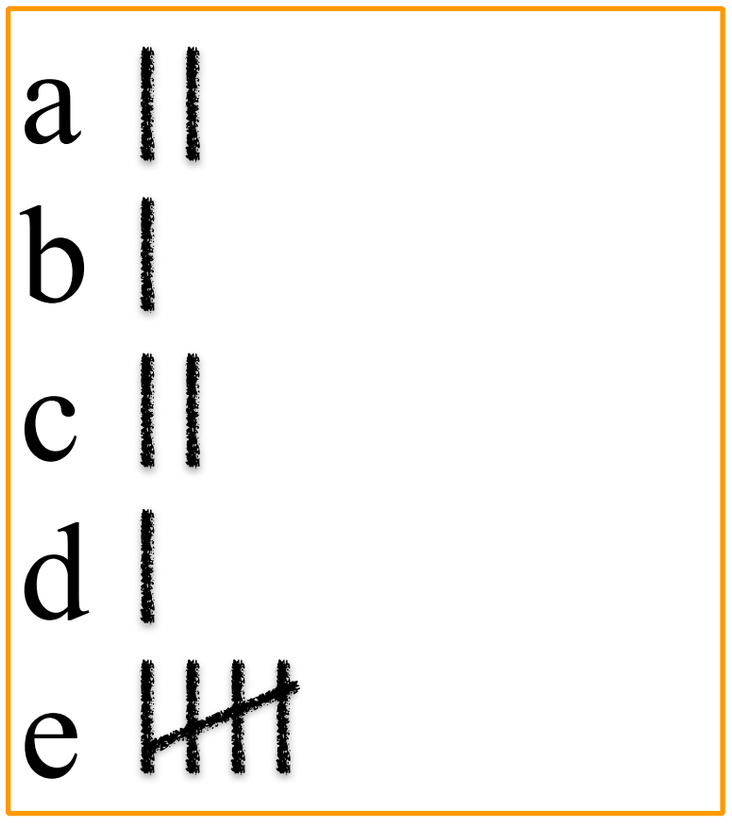
Activity: Frequency Analysis by tallying

- Fill in the tally sheet to count how many times each letter appears in the handout.
  - To tally check each letter and add a tally mark (a line) against that letter in the table.
- Add a bar when you get to 5.
- What is the most common letter in English?



- You need
  - Tally Sheet
  - frequency analysis sheet

Activity: Frequency Analysis by tallying

Frequency Analysis:
Finding out which letters are most common

Activity

Count how many of each letter there are in the passage below by keeping a tally for each letter on the Tally Sheet. Ignore punctuation like full stops and commas.

> **Here is Edward Bear, coming downstairs now, bump, bump, bump, on the back of his head, behind Christopher Robin.**
>
> **It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there really is another way, if only he could stop bumping for a moment and think of it.**
>
> **And then he feels that perhaps there isn't. Anyhow, here he is at the bottom, and ready to be introduced to you. Winnie-the-Pooh.**

Which are the three most common letters in the above passage?

Extension Activities

The following are extra activities you could do.

1. Draw a histogram of your tally data. The x-axis should show the letters of the alphabet. The y-axis should show the frequency of each letter.

2. Do a new frequency analysis but this time by tallying several pages from your favourite book. Draw a histogram of the results.

Are the results exactly the same as your original version? If not, can you explain why not?

Tally Sheet: Tally the number of letters in a passage

LETTER	TALLY	TOTAL
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		

Tally Results

- For this passage the most common letters are:
  - e: 37
  - t: 29
  - o: 29
  - h: 26
  - n: 24
  - a: 23
- The least common letters are
  - j: 0
  - q: 0
  - v: 0
  - x: 0
  - z: 0

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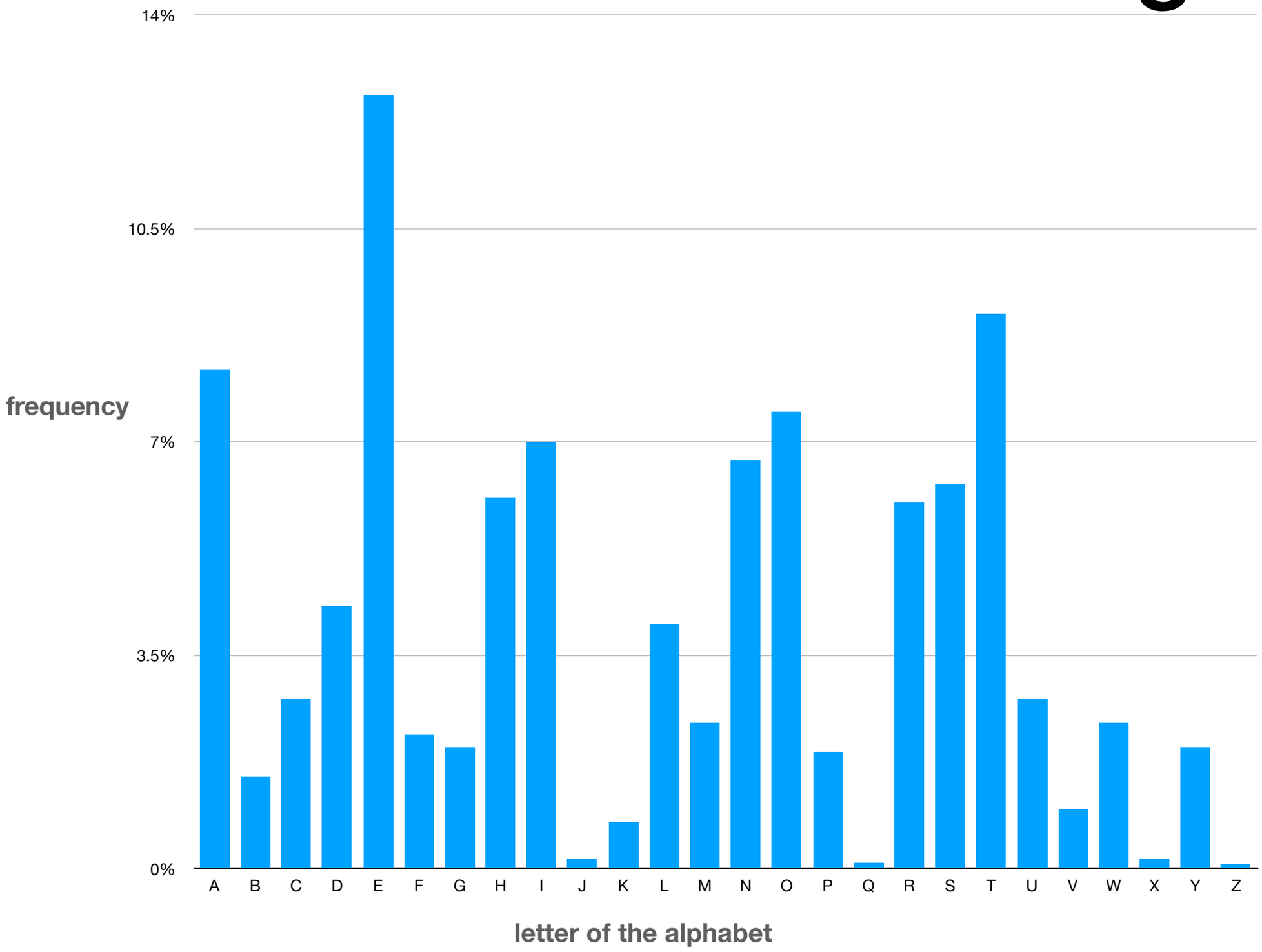
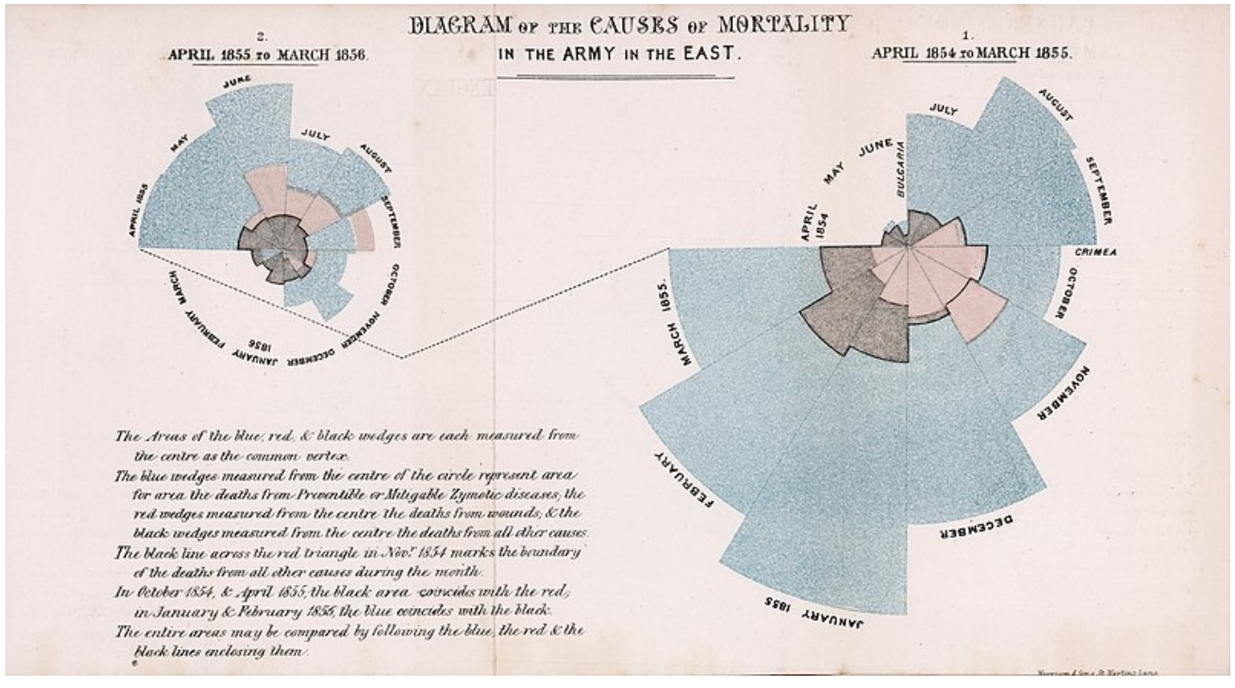
Over LARGE amounts of English



Visualising data well

- Florence Nightingale is the first person to combine lots of numbers with good ways of presenting them so the patterns can be seen.
- She convinces politicians to do something about deaths in hospital due to them not being clean.



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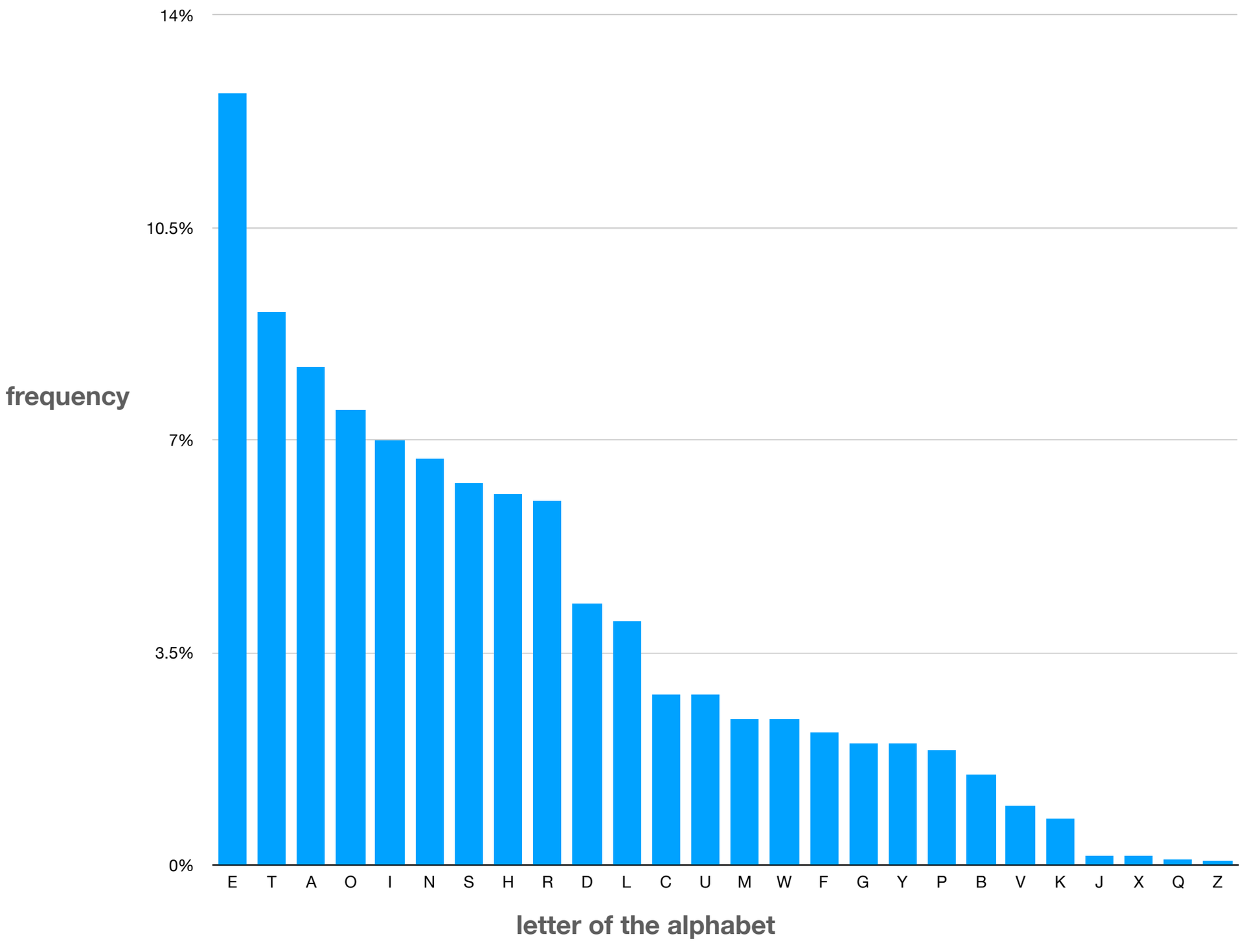
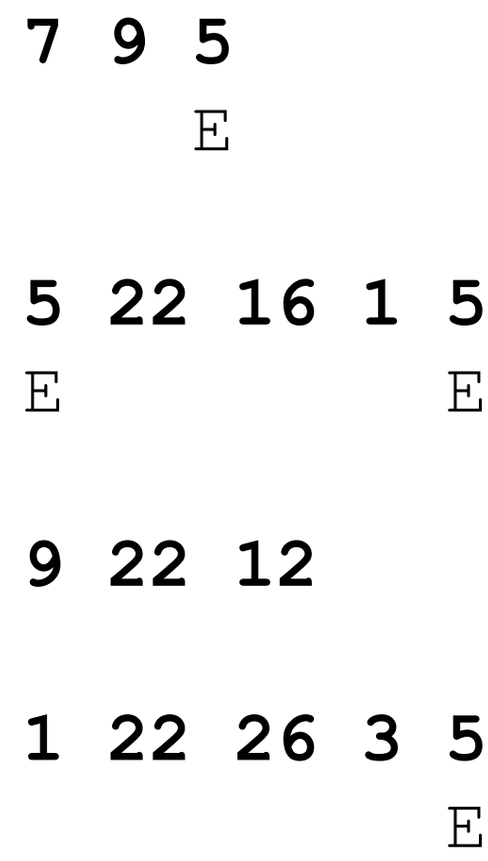
A better data visualisation



Code cracking

- The frequency of characters in a secret message is likely similar to our tally
- So if E is most common in English and 5 is most common in the message then guess that 5 is E,
- … and so on.
  - Remember most common are then likely: t, a, o, i, h, n



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```
7  9  5
      E

5  22  16  1  5
E              E

9  22  12

1  22  26  3  5  3
                E
```

THE
EAGLE
HAS
LANDED

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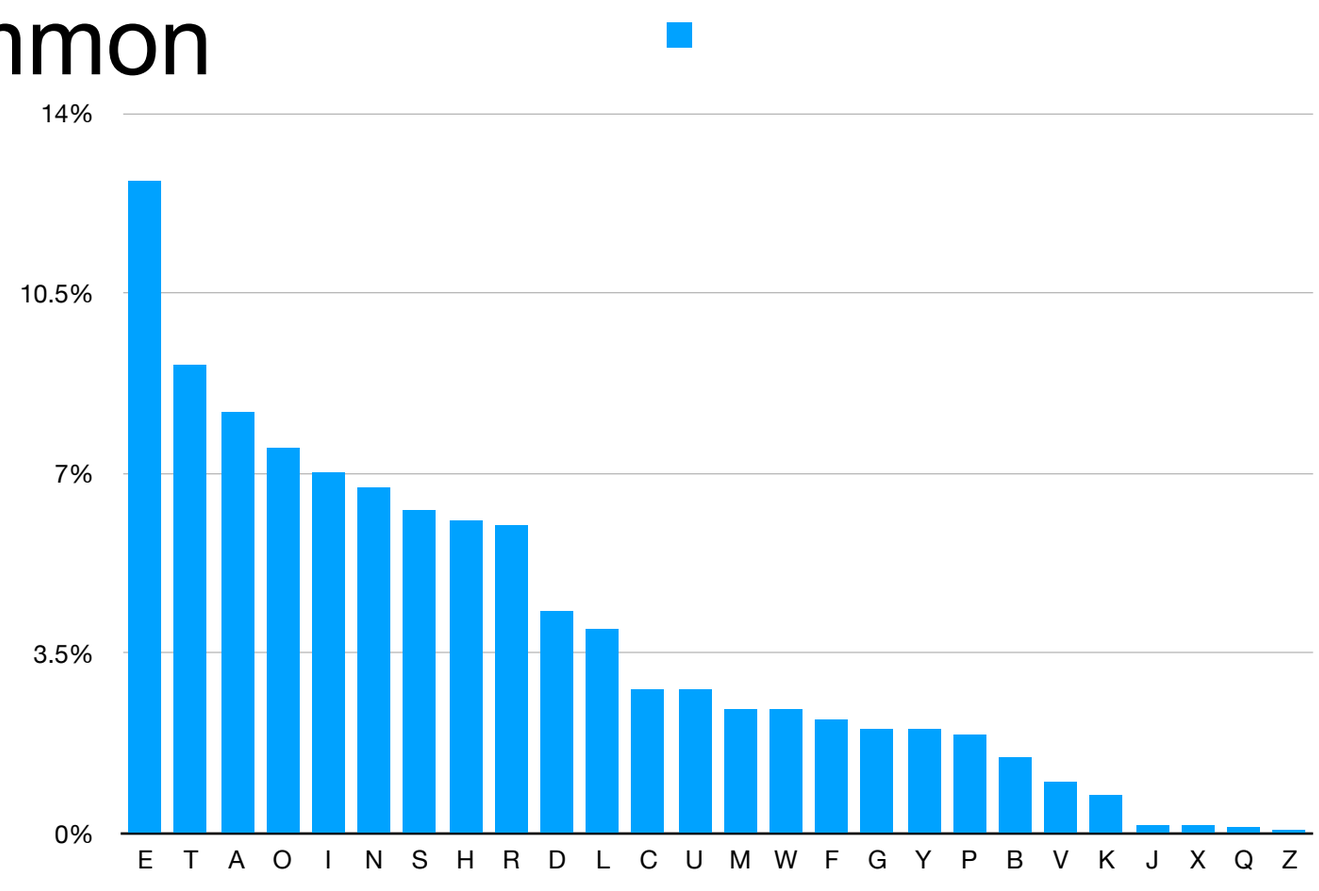
Back to our blinking algorithm

- Do not go through the alphabet A, B, C …
- Start with the most common letters. Use the order
- E, T, A, O, I, N, S, …



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How fast is it?

- How fast is it?
  - How long would it take to write a book?

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How fast is it?

- It is very slow
  - It takes on average 13 questions for *every* letter
  - At worst it takes 26 questions
- Frequency analysis speeds things up to about 10 questions on average

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Computer Scientists do it better

- Any Computer Scientist knows it can be done in…

5 questions per letter at worst

How?

Activity: Let's play a game

- 20 Questions…

- I think of a famous person.
- You have to guess who I am thinking of by asking questions.
- I can only answer yes or no.

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Winning at 20 Questions

- Do you ask questions like
  - Is it Adele?
  - Is it Usain Bolt?
  - Is it Churchill?
- That takes millions of questions
  - you have only 20!
- Instead you try to ask halving questions.
  - Are they female?
- Apply that to blinking

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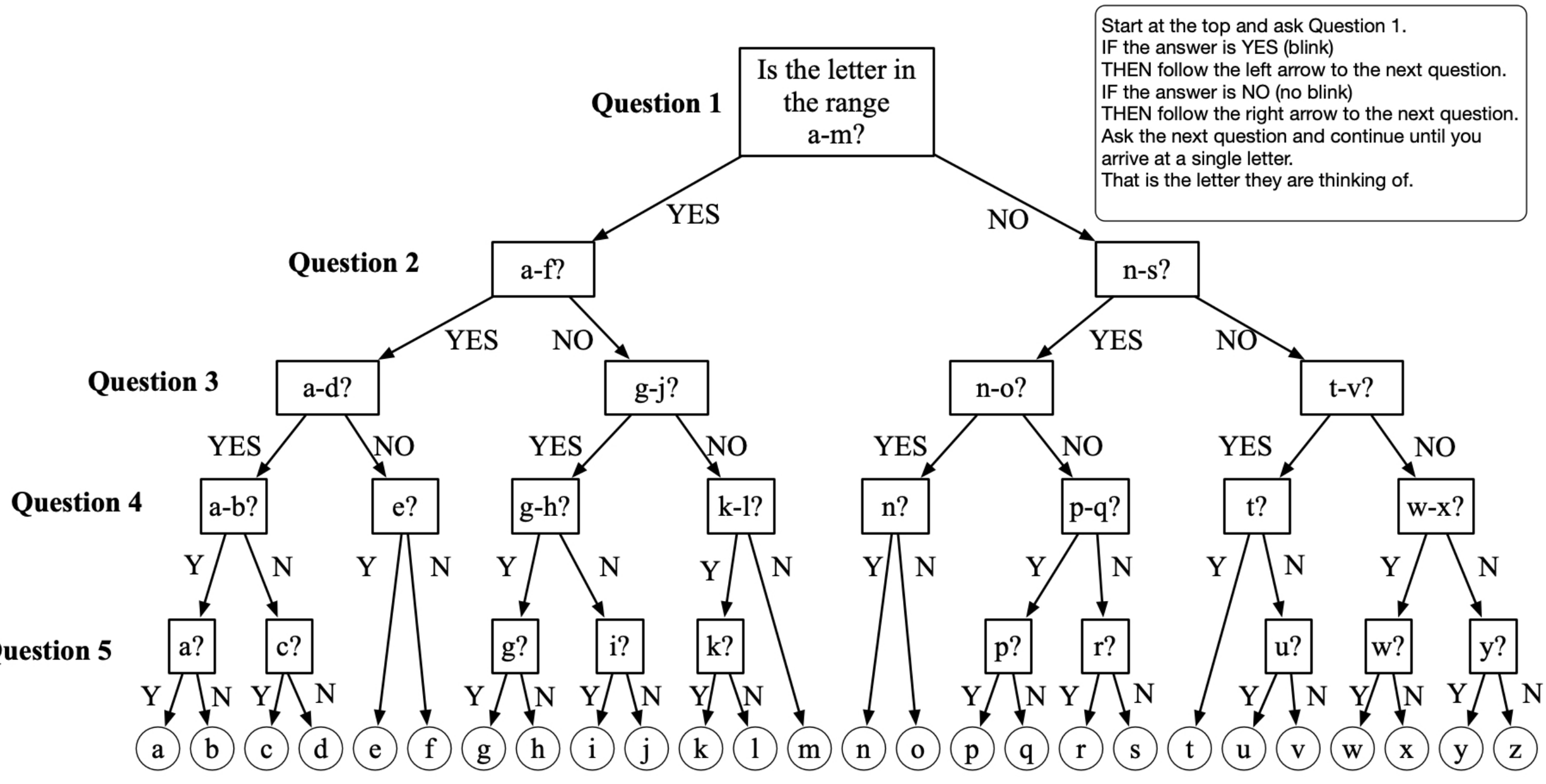
A decision tree



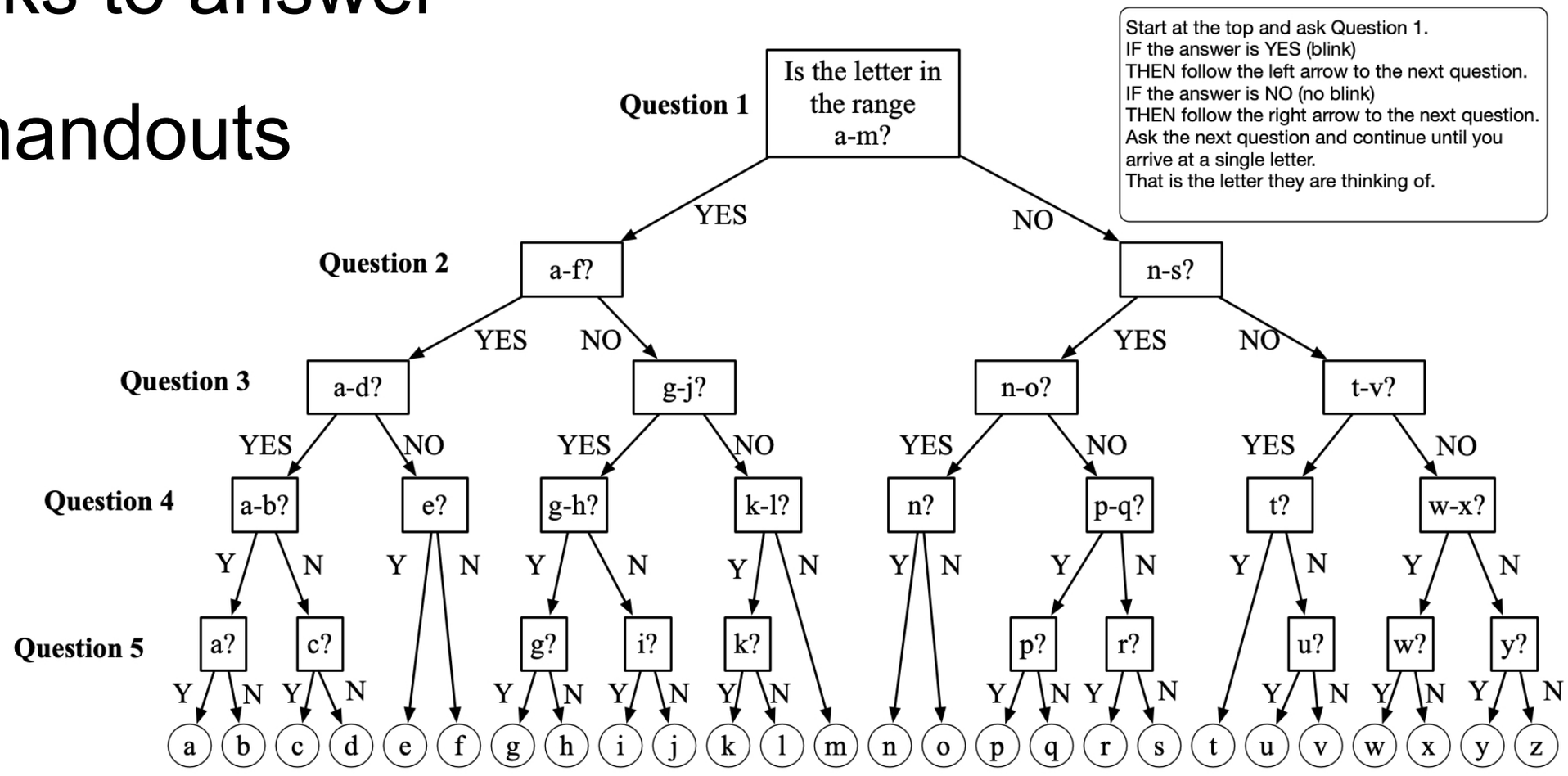
Activity: decision tree blinking

- You need
  - Decision tree sheet

– Try it to communicate a word by blinking

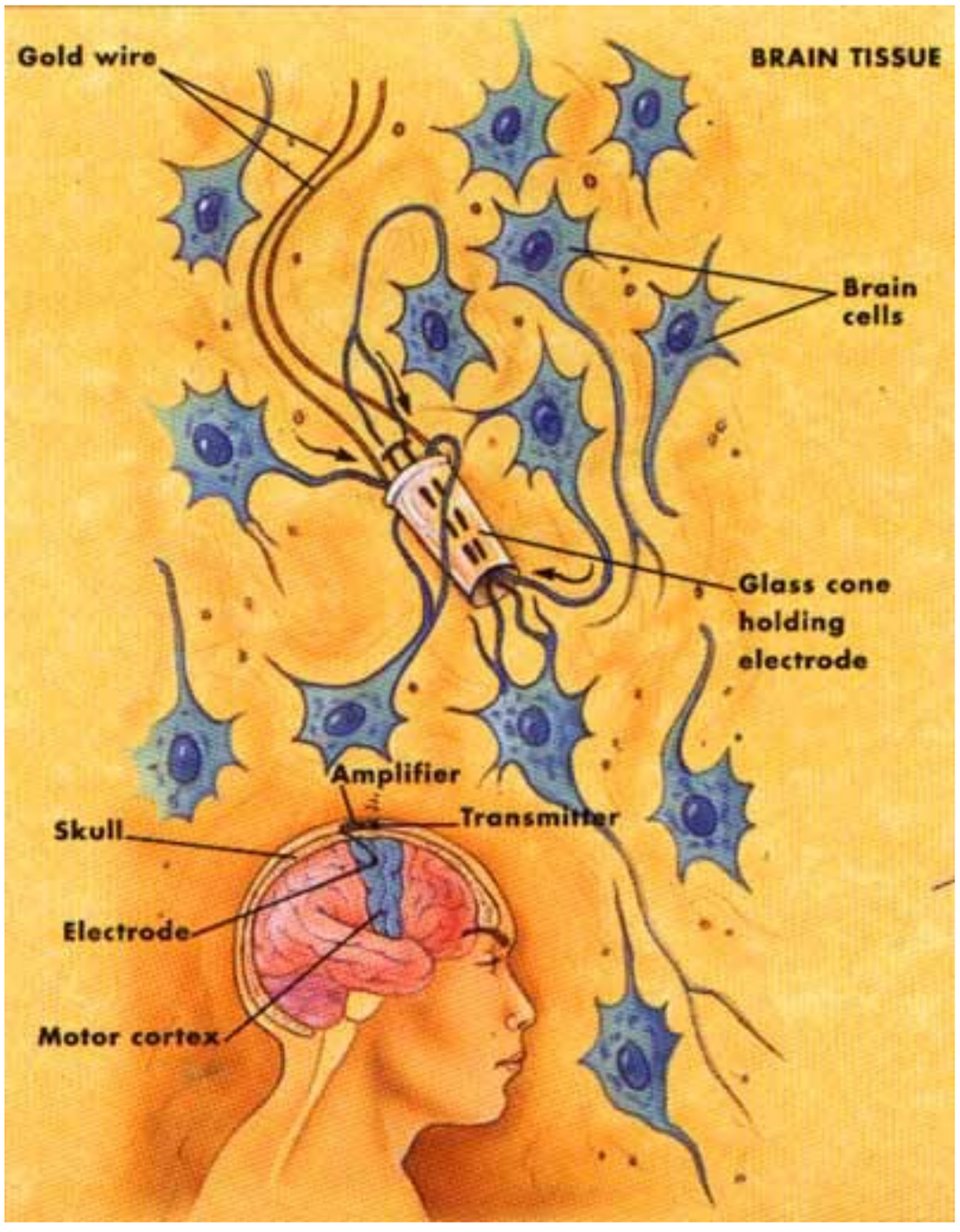
– One person asks the questions, the other blinks to answer

– Use the handouts



Algorithms first

- Now we have a good solution
- we can think about using a particular technology to replace the human helper.
- For example,
  - computer detecting blinks
  - brain implants or scalp electrodes to read thoughts



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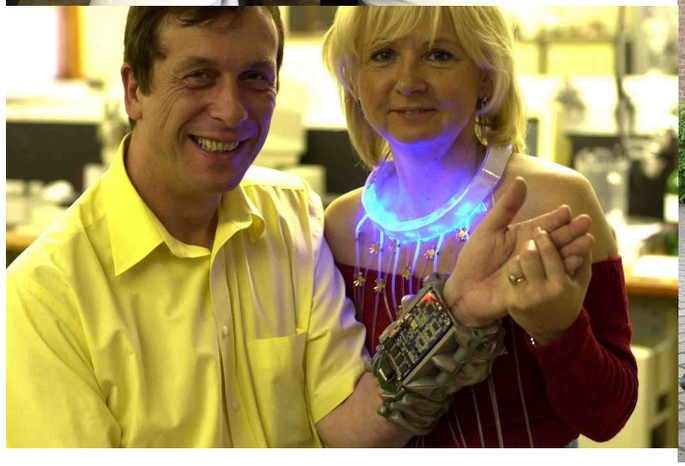
The first cyborg

- Prof Warwick of Reading University had a chip implanted in the nerves of his arm
  - A computer read the signals between his brain and hand…
  - and sent them over the Internet.
  - The technology that helps the disabled could give “super-human powers”.



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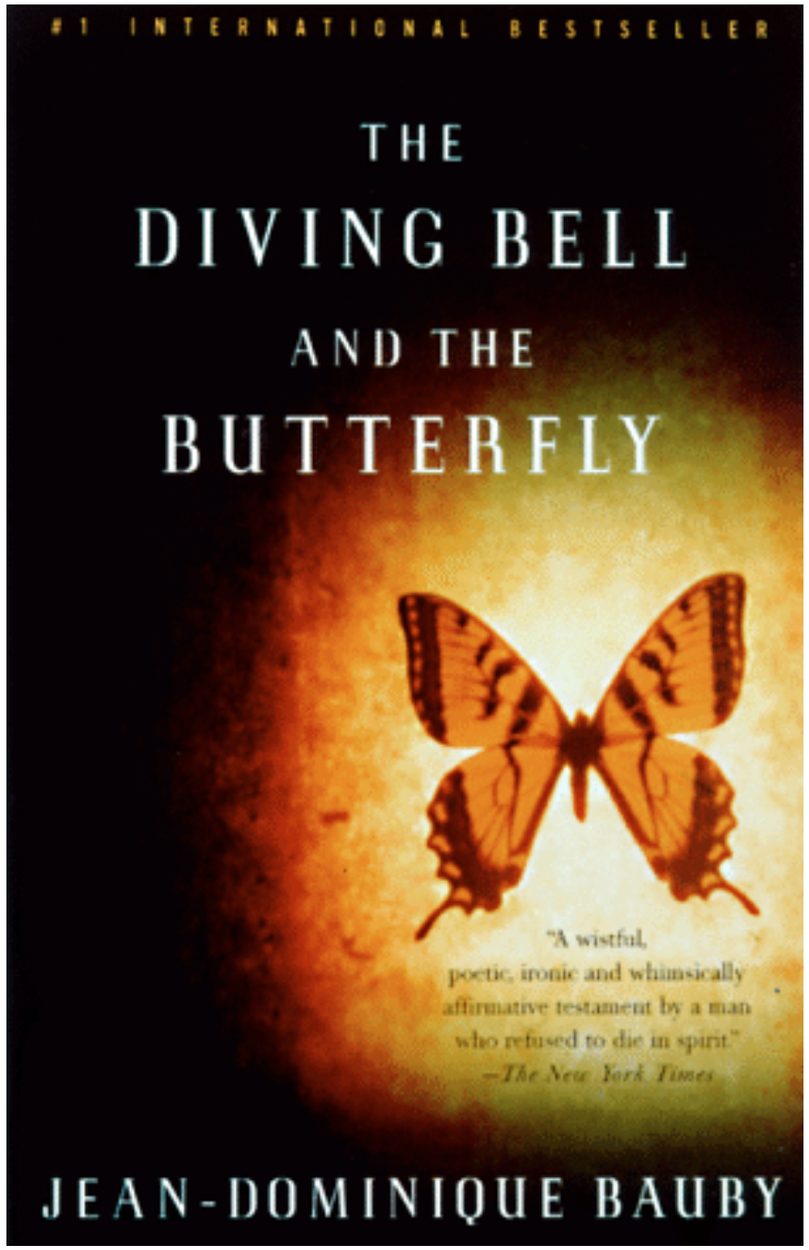
Does everyone agree we would have made things better for Bauby?



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Did we get it right?

- Did we count the right thing?
- What if blinking is hard work for Bauby?
  - He now has to blink 5 times per letter!
  - We should have found out first.
- Have we made his life better or worse?

Computing is about understanding people too.

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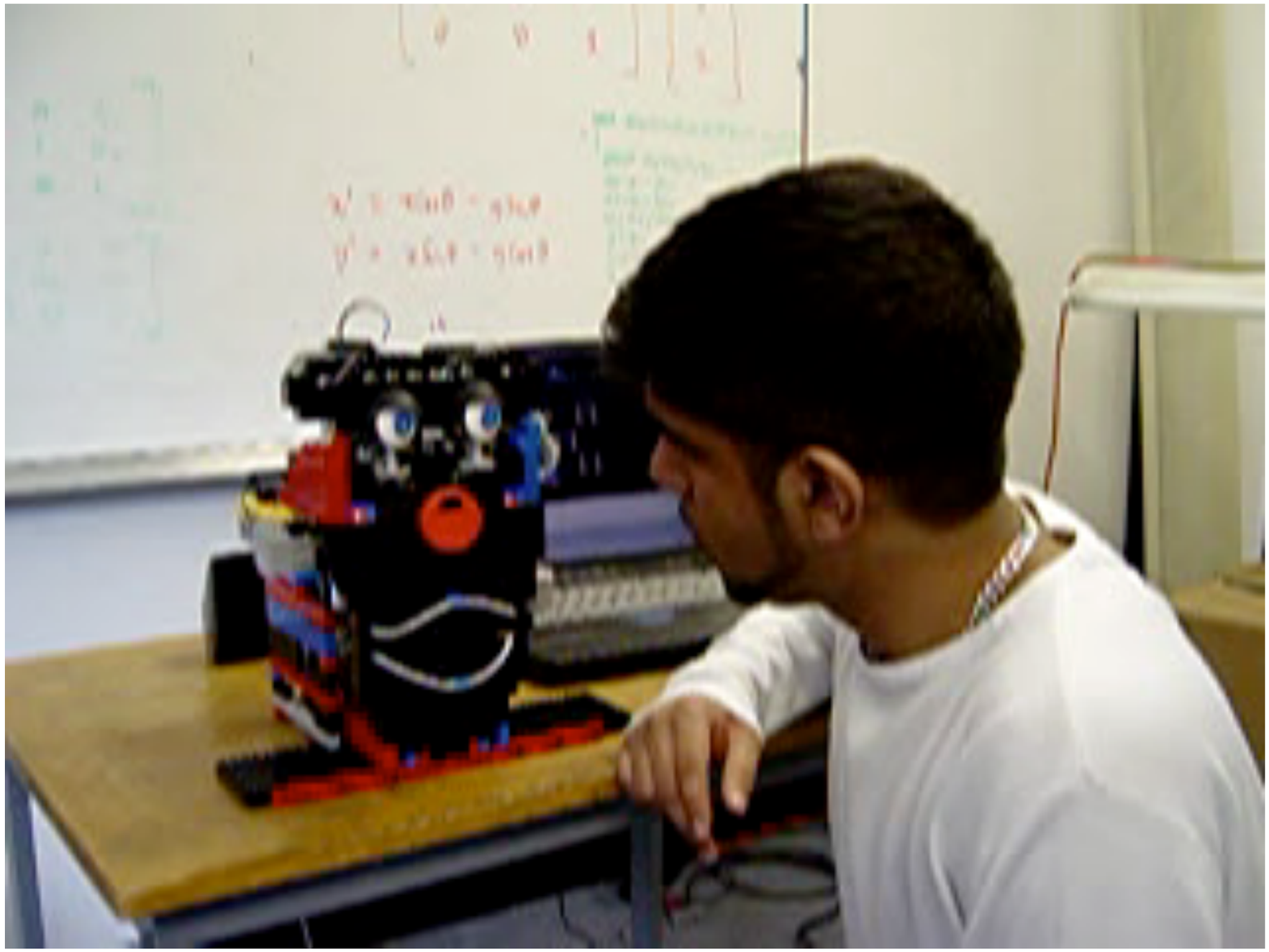
We communicate with more than words



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Activity: What maths have we used?

- Write down the different maths we have come across to help people with locked in syndrome.

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What maths have we used?

- Computation and Algorithms
- Logical thinking
- Counting and Tallying
- Frequency and Histograms
- Doubling and halving
- Divide and conquer
- Decision trees, data visualisation … and more

All to help us work out how to help a disabled person

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Maths and computation are everywhere

- Maths and Computational thinking are about
  - thinking skills and
  - solving problems
- Computer Science is not just about computers!
  - – Solutions for people
  - – Understanding people

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