Bayesian Thinking for Toddlers

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illustrations by Viktor Beekman

Once upon a time,
in a land far, far away,
Kate and Miruna were
debating who knows the
most about dinosaurs...

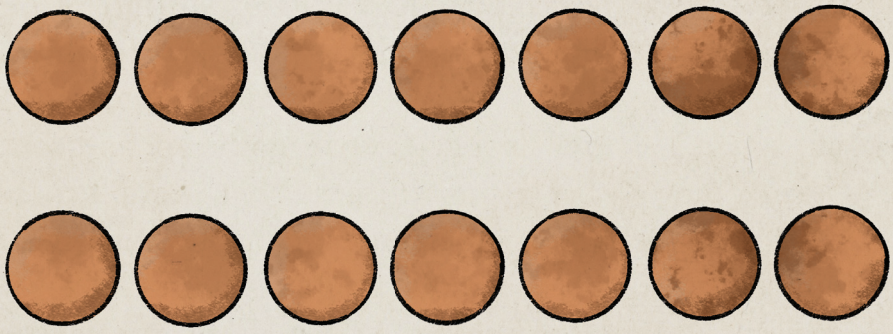
'I CAN NAME EACH AND EVERY DINOSAUR!
AND I CAN SAY "*HUEHUETHTLUS*" REALLY FAST.'

Kate

Miruna

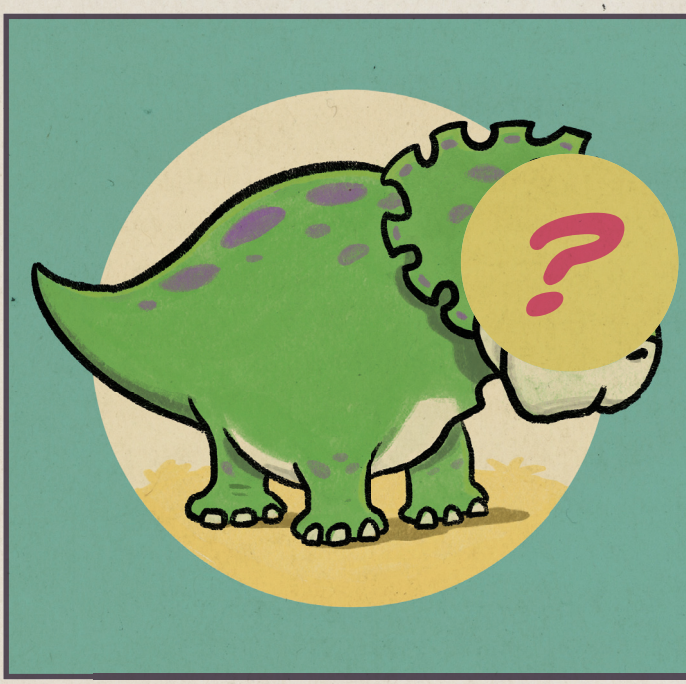
'*LOOK AT MY CROWN!* ALSO, I HAVE WATCHED
A LOT OF TELEVISION. AND MY DAD CAN BUY ME
AS MANY DINOSAURS AS I LIKE.'

Whoever knows the most about dinosaurs gets **14 homemade cookies** from aunt Agatha



AUNT AGATHA CANNOT TELL WHETHER KATE OR MIRUNA KNOWS THE MOST ABOUT DINOSAURS, SO SHE CONSIDERS TO DIVIDE THE COOKIES EVENLY:

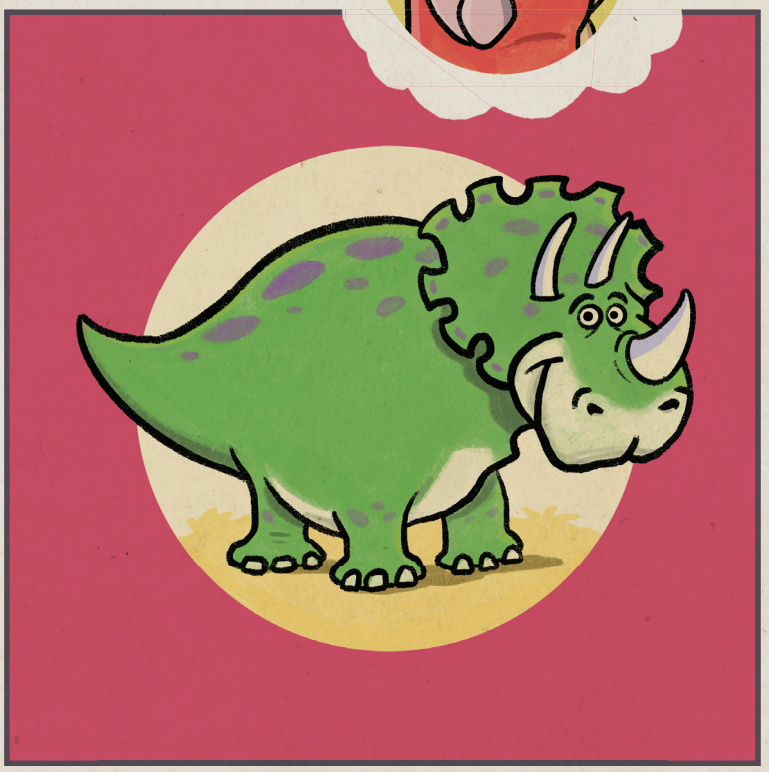
But wait! Aunt Agatha has an idea. She will ask a question to help her determine who knows the most about dinosaurs.

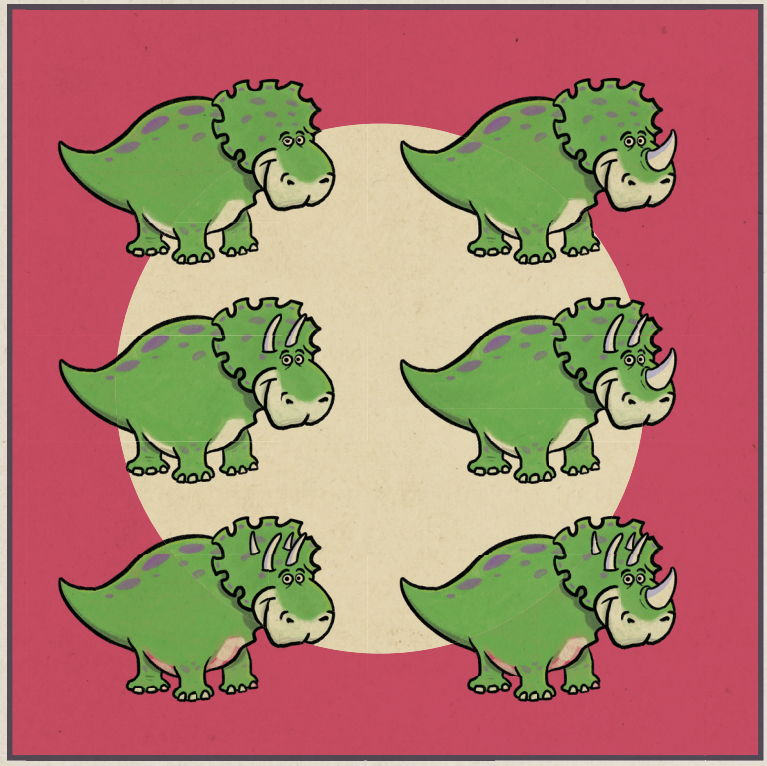


The question is:

'HOW MANY HORNS DOES A TRICERATOPS HAVE ON ITS HEAD?'

"THREE! I AM ABSOLUTELY SURE!"

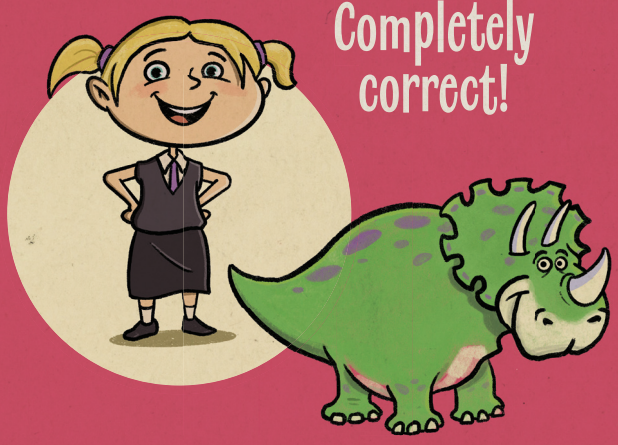




"OH, THIS IS DIFFICULT!
I AM NOT SURE.
IT COULD BE NONE, OR ONE,
OR TWO, OR THREE, OR FOUR,
OR FIVE -- *ALL OF THESE ARE EQUALLY LIKELY TO ME!*"

The answer is **three.**
A Triceratops has **three** horns on its head.

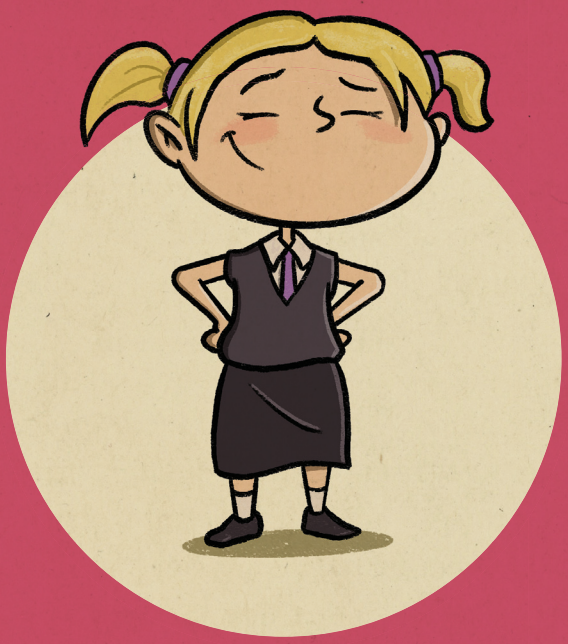
HOW WELL DID KATE AND MIRUNA PREDICT THE CORRECT ANSWER?

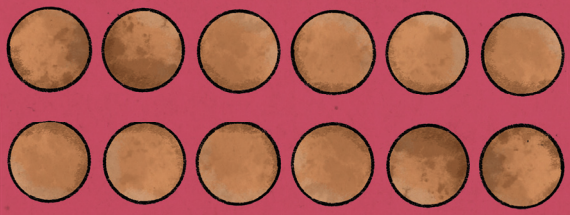


Completely correct!

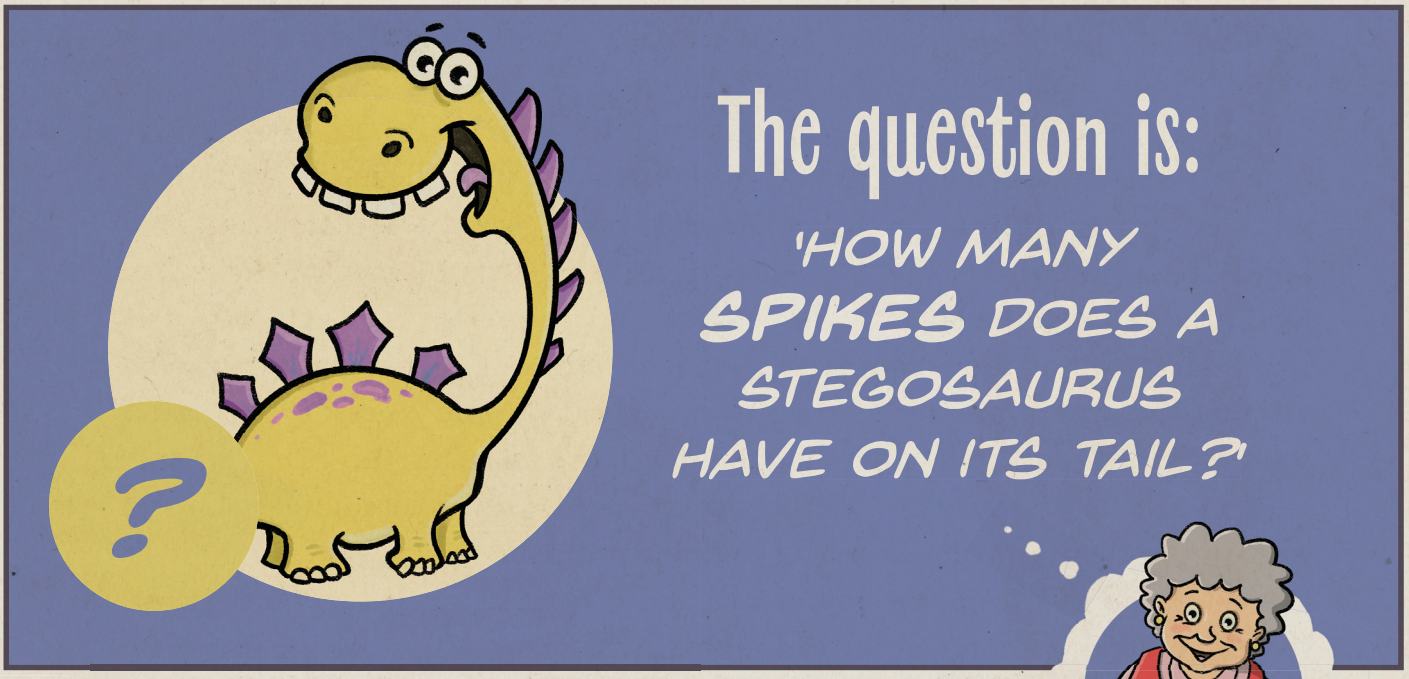
Correct for one out of six of her predictions!

Kate **outpredicted** Miruna
by a factor of six.
So now aunt Agatha considers
giving Kate **six times** as many
cookies as Miruna.

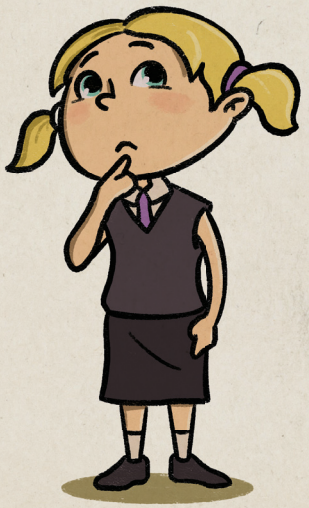


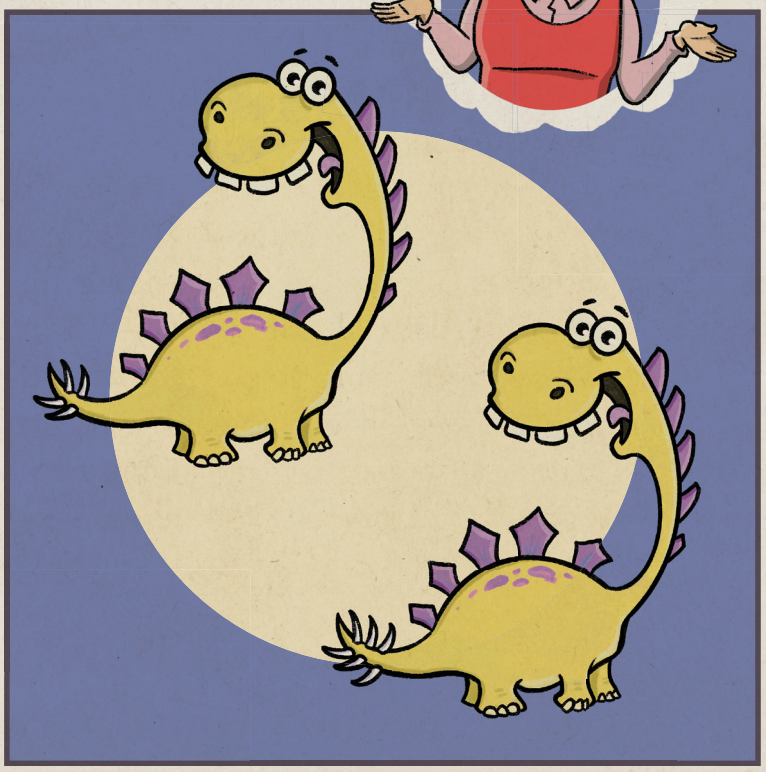


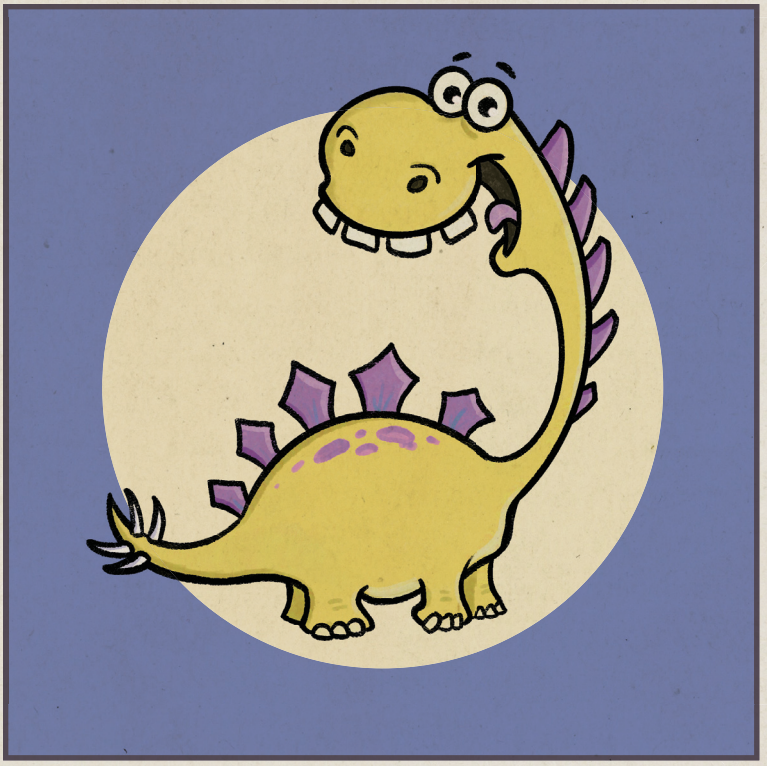
But wait! Aunt Agatha has another idea. She will ask a second question about dinosaurs! Are you ready?



'HMMM. I AM NOT SURE. FOUR OR SIX SPIKES -- BOTH OPTIONS SEEM EQUALLY PLAUSIBLE TO ME.'





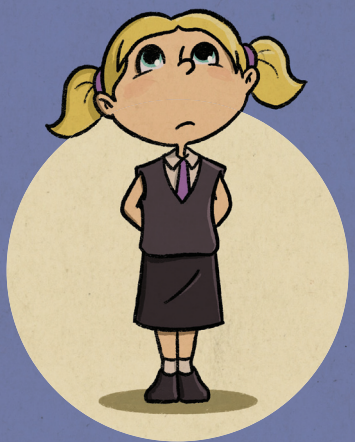


'FOUR! NO DOUBT ABOUT IT!'

The answer is four. A Stegosaurus has four spikes on its tail.

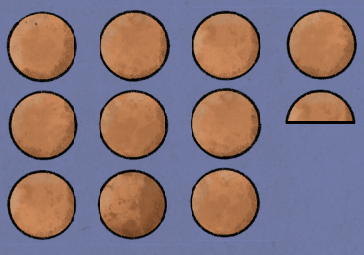
HOW WELL DID KATE AND MIRUNA PREDICT THE CORRECT ANSWER?

Completely correct!



Correct for one out of two of her predictions!

Overall then, Kate outpredicted Miruna by a **factor of 6/2 = 3.** Based on what she now knows, aunt Agatha feels that Kate should get **three times** as many cookies as Miruna:



Toddlers, what have we learned?

1

A TRICERATOPS HAS THREE HORNS ON ITS HEAD.

2

A STEGOSAURUS HAS FOUR SPIKES ON ITS TAIL.

3

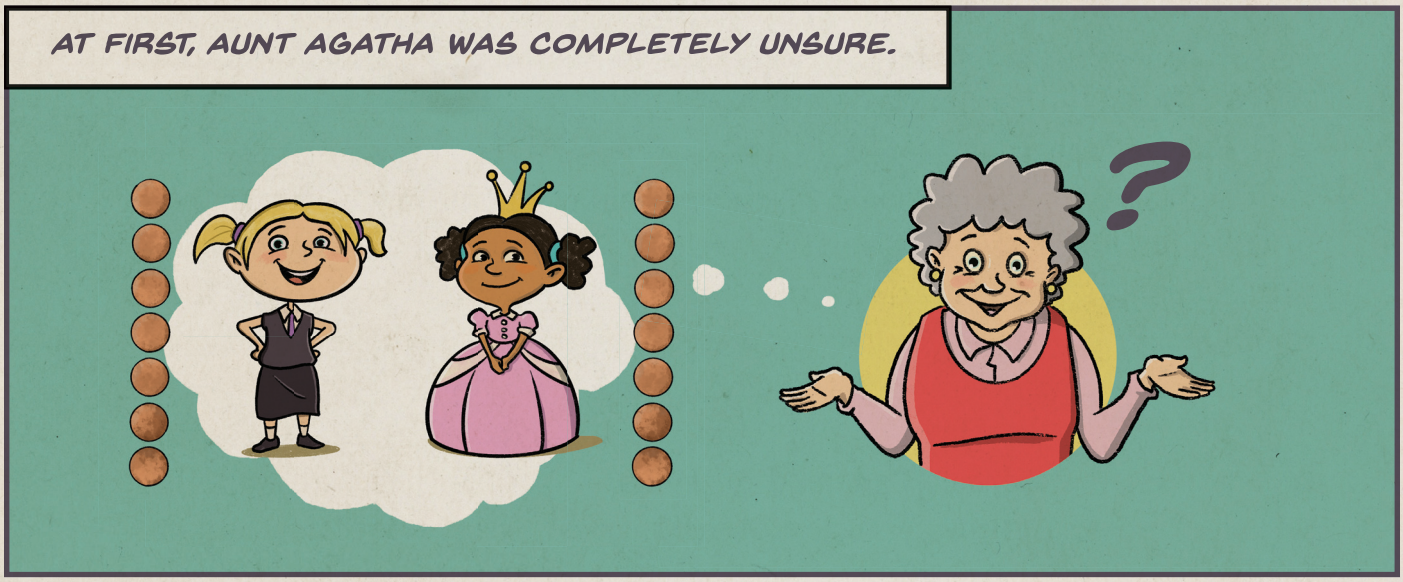
COOKIES MEASURE CONFIDENCE.

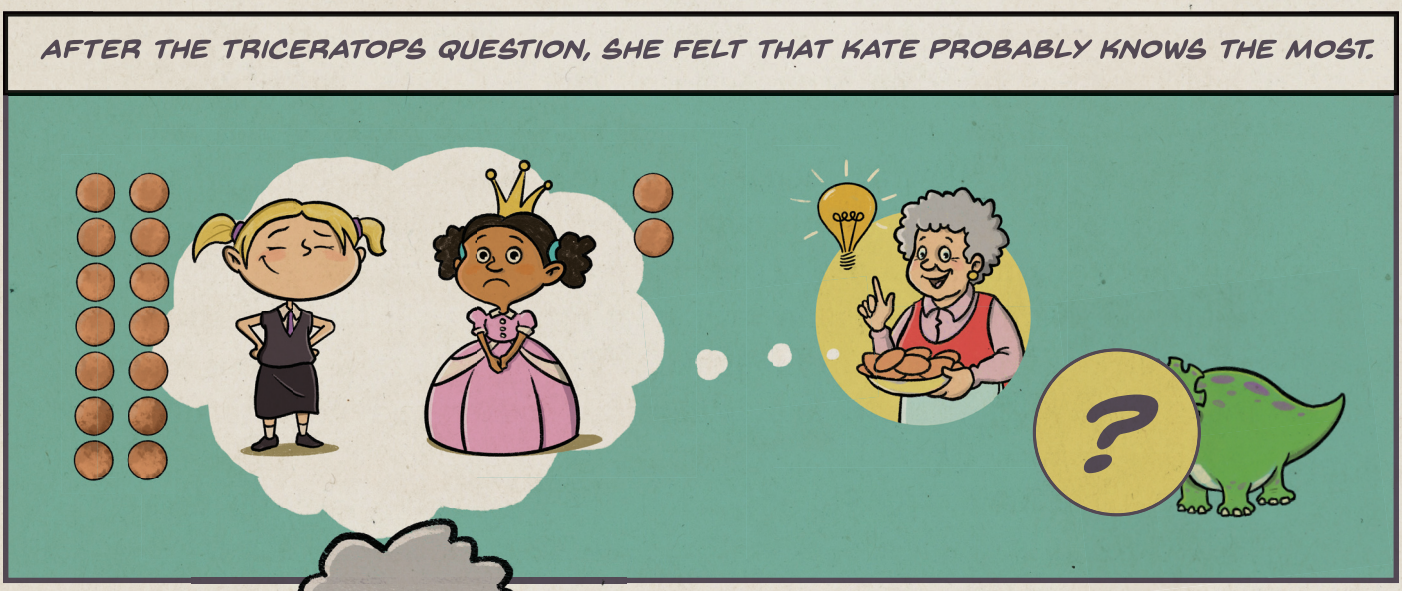
KATE OUTPREDICTED MIRUNA ON THE DINOSAUR TEST, AND THAT'S WHY AUNT AGATHA BELIEVES THAT KATE KNOWS THE MOST ABOUT DINOSAURS --

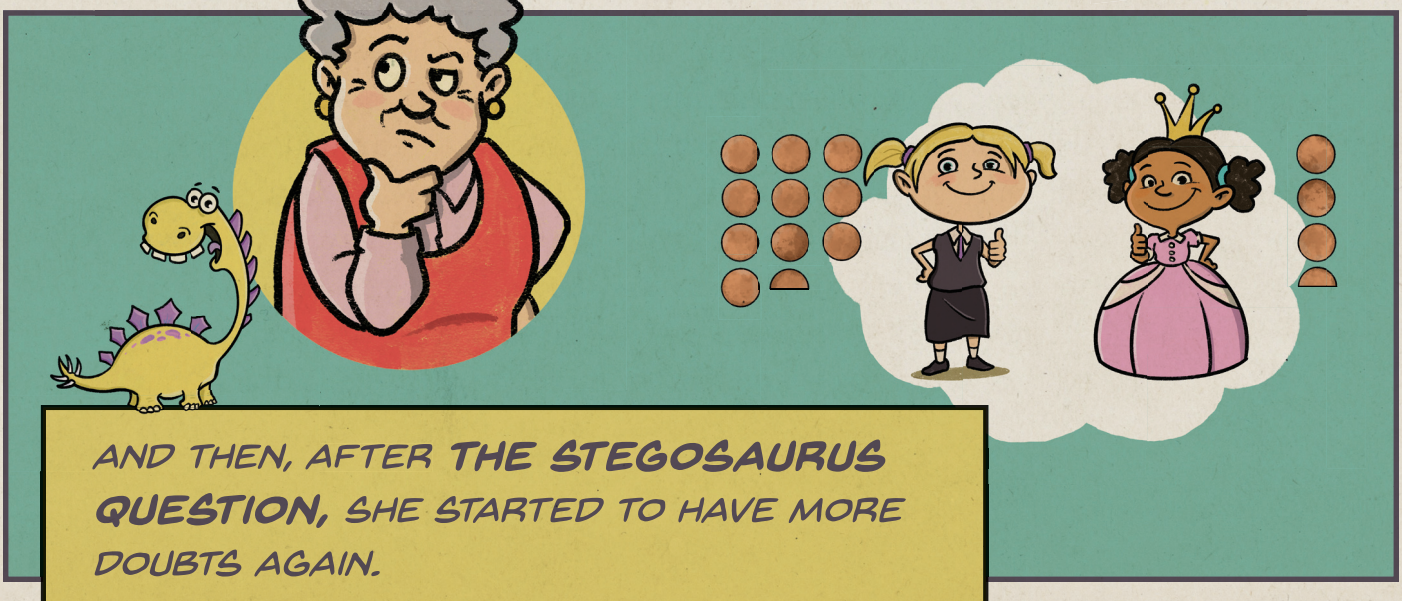
BUT AUNT AGATHA IS ***NOT*** COMPLETELY SURE.

THIS IS WHY MIRUNA STILL GETS ***SOME COOKIES***, EVEN THOUGH SHE DID WORSE ON THE TEST THAN KATE.

4 Over time, aunt Agatha adjusted her confidence that Kate knows the most about dinosaurs.



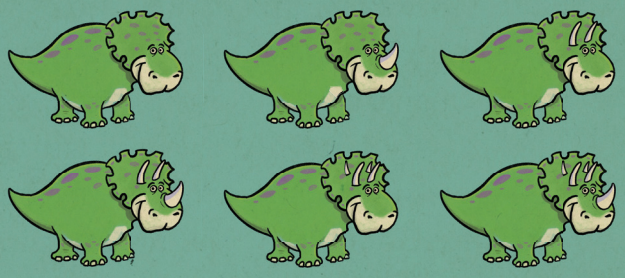




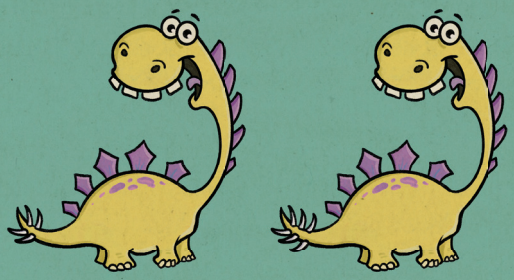
5

Kate did better than Miruna on the Triceratops question;
Miruna did better than Kate on the Stegosaurus question.

Knowing it precisely



Knowing it vaguely



EACH DID BETTER BECAUSE KNOWING THE ANSWER EXACTLY IS MORE IMPRESSIVE THAN KNOWING IT VAGUELY.

Toddlers, students, and researchers can use
JASP for more realistic Bayesian analyses.
Download JASP for free at jasp-stats.org.

JASP

JASP-STATS.ORG.

BAYESIAN THINKING IS EASY, AND TODDLERS DO IT ALL THE TIME. THE FUNDAMENTAL PRINCIPLE IS LEARNING FROM EXPERIENCE: HYPOTHESES THAT PREDICT THE DATA WELL RECEIVE A BOOST IN PLAUSIBILITY, WHEREAS HYPOTHESES THAT PREDICT THE DATA POORLY SUFFER A DECLINE.
FOR EXAMPLE, ***HYPOTHESIS A*** COULD STATE *"AT 6 AM MY PARENTS WILL GENERALLY BE ASLEEP"* AND ***HYPOTHESIS B*** COULD STATE *"AT 6 AM MY PARENTS WILL GENERALLY BE AWAKE"*.

WHEN A TODDLER THEN WAKES UP AT 6 AM AND NOTICES THAT BOTH PARENTS ARE STILL SOUND ASLEEP, THIS OBSERVATION ***INCREASES*** THE PLAUSIBILITY OF HYPOTHESIS A AND ***DECREASES*** THAT OF HYPOTHESIS B.

EASY!

KNOWLEDGEABLE READERS WILL DISCOVER THAT THE DINOSAUR COVER STORY HINTS AT CONCEPTS SUCH AS ***OCKHAM'S RAZOR***, COHERENT KNOWLEDGE UPDATING, AND PROBABILITY AS DEGREE OF REASONABLE BELIEF. STATISTICIANS MAY RECOGNIZE *PHIL DAWID'S* ***PREQUENTIAL PRINCIPLE*** IN ACTION.
TODDLERS MAY JUST WANT TO LOOK AT THE DINOSAURS.

JASP
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