

Do androids read about electric sheep?

Machine reading comprehension algorithms

Marek Grzenkowicz
Roche Global IT Solution Centre

About me



Marek Grzenkiewicz

C64 BASIC → ... → ETL → Hadoop → **Python / Data analytics**

 marek.grzenkiewicz@roche.com  [@chopeen](https://twitter.com/chopeen)



Roche Global IT Solution Centre (RGITSC)

Offices in Warsaw and Poznan

 it.roche.pl  instagram.com/it.roche.pl

Agenda



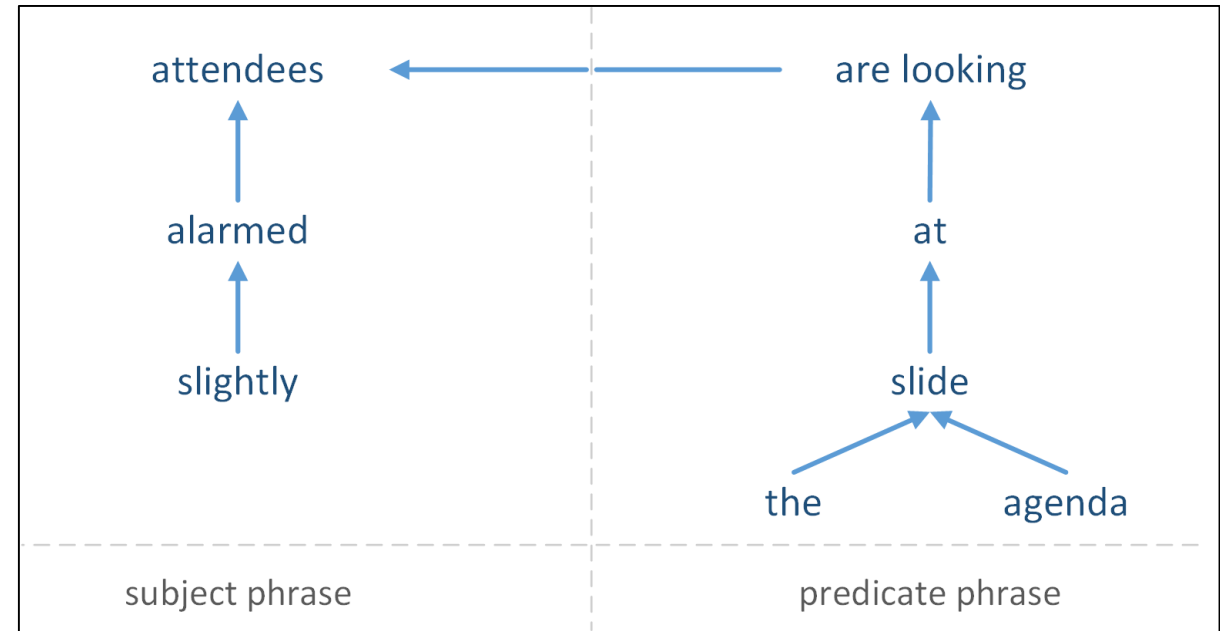
1. Natural language processing

- What is it?
- Why is it important?
- Basic NLP operations [demo] 🙌
- Basic NLP vs. reality

2. Do androids read?

- Fundamental skills
- The state of research

3. Summary



Reading between the lines

Reading between the lines

How does it work?



A sentence or a short paragraph of text.

Option 1

(raise your **left hand**)

Option 2

(raise your **right hand**)

Reading between the lines



Bob? Who's Bob?

My friend Alice is a great Java developer.
Unfortunately, Bob isn't.



Bob is not my friend

A blue speech bubble with a tail pointing towards the bottom left.

Bob is not a great
developer

An orange speech bubble with a tail pointing towards the bottom right.

Reading between the lines

Charlie is 6

Roche

Charlie can already write, so he must be at least 6!

6 six years old

6 feet tall

Reading between the lines

Charlie is 6

Roche

Charlie plays basketball, so he must be at least 6!

6 six years old

6 feet tall

Reading between the lines

How's the water?

Roche

Chuck: How did you like the Canary Islands?

Frank: It was nice – sunny, not too humid.
The water was a bit cold though.

Water in the ocean
was cold

Water in the shower
was cold

Reading between the lines

Nothing is certain



Let me tell you how it will be
There's one for you, nineteen for me
'Cause I'm the taxman, yeah, I'm the taxman
The Beatles - Taxman

The Beatles were
required to pay a
95% tax

Before 1971, 1 pound = 20 shillings
(and 1 shilling = 12 pence)

Altogether there
were 20 forms to be
filled

Reading between the lines

Album 1, side 1, track 1



She was born in November 1963

The day Aldous Huxley died

Sheryl Crow – Run Baby Run

Aldous Huxley

From Wikipedia, the free encyclopedia

Aldous Leonard Huxley (26 July 1894 – 22 November 1963) was an English writer and philosopher.^{[1][2][3][4]} He wrote nearly fifty books^{[5][6]}—both novels and non-fiction works—as well as wide-ranging essays, narratives, and poems.

John F. Kennedy

From Wikipedia, the free encyclopedia

(Redirected from [John Fitzgerald Kennedy](#))

"*JFK*", "*John Kennedy*", and "*Jack Kennedy*" redirect here. For other uses, see *JFK (disambiguation)*, *John Kennedy (disambiguation)*.

John Fitzgerald Kennedy (May 29, 1917 – November 22, 1963), often referred to by initials **JFK** and **Jack**, was an American politician who served as the 35th [president of the United States](#) from January 1961 until his

Natural language processing

Natural language processing

Selected areas and tasks



Speech

Speech-to-text
(recognition)

Text-to-speech
(generation)

Discourse

Coreference
resolution
Discourse analysis

Summarization

Syntax

Lemmatization
Stemming

POS tagging
Text
segmentation

Semantics

Machine translation
Optical character recognition (OCR)

Named entity recognition (NER)
Sentiment analysis

Natural language understanding (NLU)
Natural language generation (NLG)

Topic modelling
Word sense disambiguation

Natural language processing

Publication overload



Stud Health Technol Inform. 2019 Aug 21;264:1586-1587. doi: 10.3233/SHTI190547.

Named Entity Recognition in Prehospital Trauma Care.

Silverman GM^{1,2}, Lindemann EA³, Rajamani G⁴, Finzel RL⁵, McEwan R¹, Knoll BC², Pakhomov S⁵, Melton GB^{2,3}, Tignanelli CJ^{2,3,6}.

– Author information

- 1 Academic Health Center - Information Systems, University of Minnesota, Minneapolis, Minnesota, USA.
- 2 Institute for Health Informatics, University of Minnesota, Minneapolis, Minnesota, USA.
- 3 Department of Surgery, University of Minnesota, Minneapolis, Minnesota, USA.
- 4 Stanford University, Stanford, CA, USA.
- 5 College of Pharmacy, University of Minnesota, Minneapolis, Minnesota, USA.
- 6 Department of Surgery, North Memorial Health Hospital, Robbinsdale, Minnesota, USA.

Abstract

Natural language processing (NLP) methods would improve outcomes in the area of prehospital Emergency Medical Services (EMS) data collection and abstraction. This study evaluated off-the-shelf solutions for automating labelling of clinically relevant data from EMS reports. A qualitative approach for choosing the best possible ensemble of pretrained NLP systems was developed and validated along with a feature using word embeddings to test phrase synonymy. The ensemble showed increased performance over individual systems.

KEYWORDS: Emergency medical services; Labeling; Natural language processing

PMID: 31438244 DOI: [10.3233/SHTI190547](https://doi.org/10.3233/SHTI190547)

[Indexed for MEDLINE]

Source: <https://www.ncbi.nlm.nih.gov/pubmed/31438244>

Natural language processing


Publication overload



5 000+ life sciences and biomedical journals

813 598 citations in FY 2017

2 000+ articles daily



Only a fraction
of available
knowledge and
data is used

Sub-optimal results

- Research
- Drug development
- Patient treatment
- Software development

Source: https://www.nlm.nih.gov/bsd/index_stats_comp.html

Natural language processing

Basic NLP operations [demo]



spaCy

Natural language processing

Text analytics (Pharma)



Extracting **potential issues and risks** described in audit protocols and observation notes.

On 08/29/2017, during the receipt step of the product 123456: XYZ, batch: M0000M0, it was identified 01 pallet with 3 **damaged shipping boxes** at the top.

When opening them, it was observed that at the 1st shipping box with all 40 damaged units (dented and torn), the 2nd shipping box with 5 damaged units (dented and torn) and the 3rd shipping box with 02 damaged units (dented and torn), according to TW#123456 - attached 01 - Photographic Report.

Delivery Note: 123456.

HAWB 123456

QC Stability: PAT X-Y-ZZ-1234
(HPLC-unit 17) **Qualification** of
the **fluorescence detector failed**



Natural language processing

Decision support system for complaint handling (Diagnostics)

Suggesting ticket classification (flagging potential incidents) to increase the efficiency of **complaint handling**.

The hospital reported an **erroneously low result** for <product> using <test>. **No adverse event** was reported regarding this case. The hospital results for <product> using <test>:

First run <5 pg/mL (**not reported out** from the lab)

Repeated run 900 pg/mL

The analyzer had maintenance check in December 2015 and its pinch have been replaced. The caller was not the operator of this analyzer so detailed information was not provided.

<affiliate> is going to visit the customer on 06-Jan-2016.

Do androids read?

Reading comprehension

Definition

Reading comprehension is the ability to:

1. process text,
2. understand its meaning,
3. integrate with what the reader already knows.

Reading comprehension

Fundamental skills



Knowing **meaning of words**

Understanding meaning of words from discourse context

Ability to identify the main thought of a passage

Ability to **answer questions** answered in a passage

Ability to recognize the **literary devices** used in a passage and determine its tone

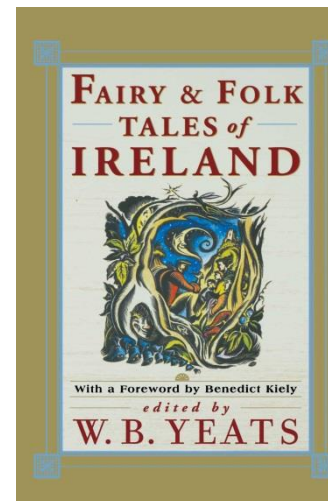
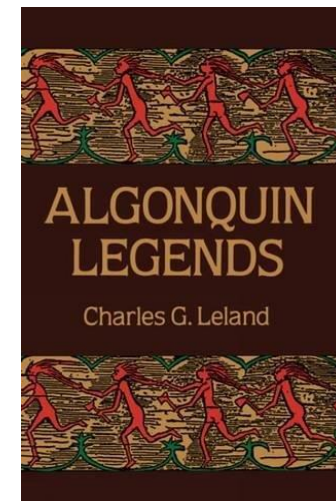
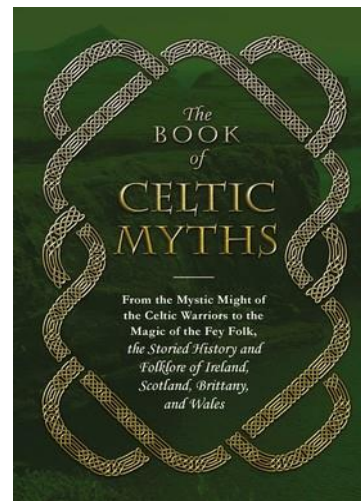
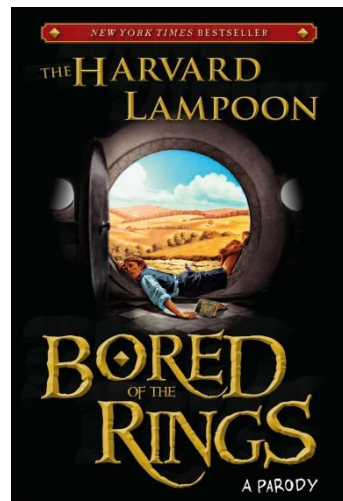
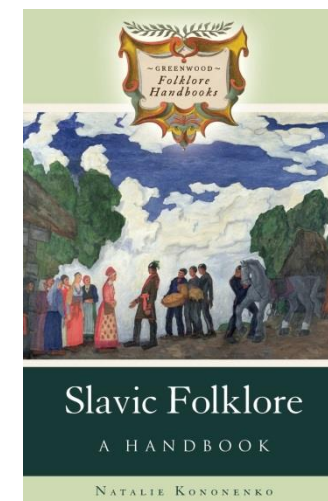
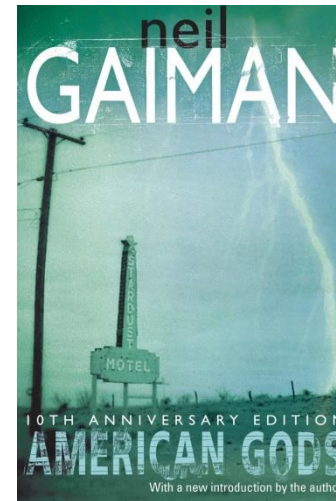
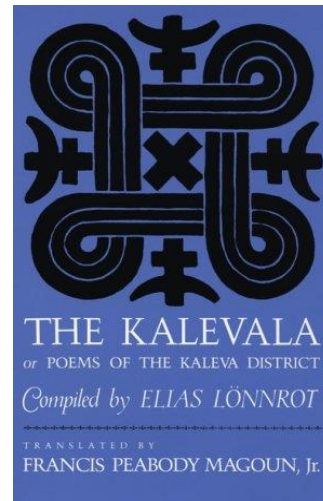
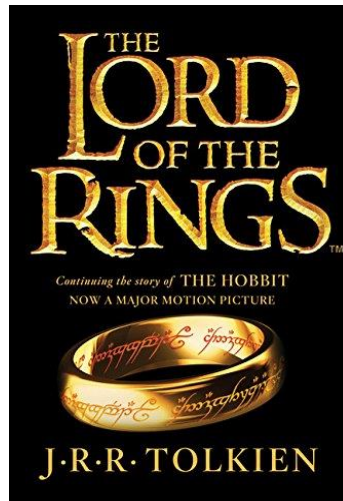
Information integration

- real-world knowledge
- common sense
- pragmatic understanding

Reading comprehension

My vision

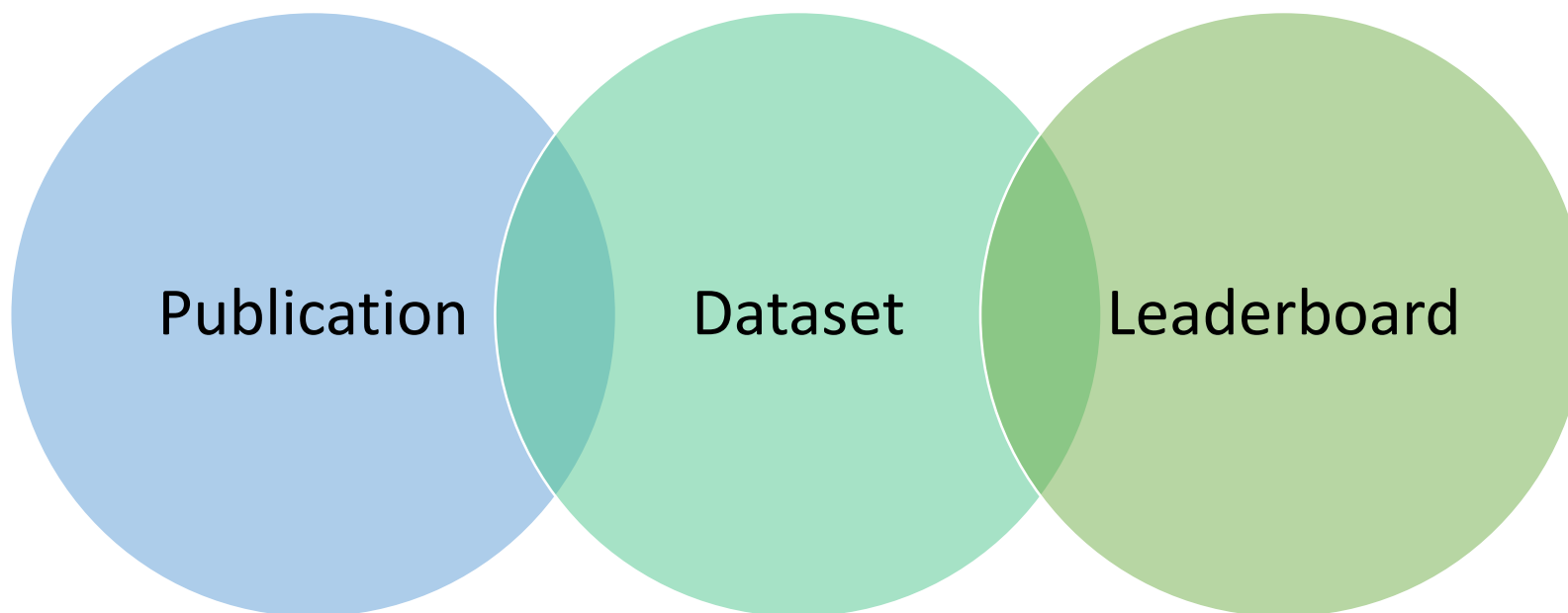
Roche



Reading comprehension

Current research

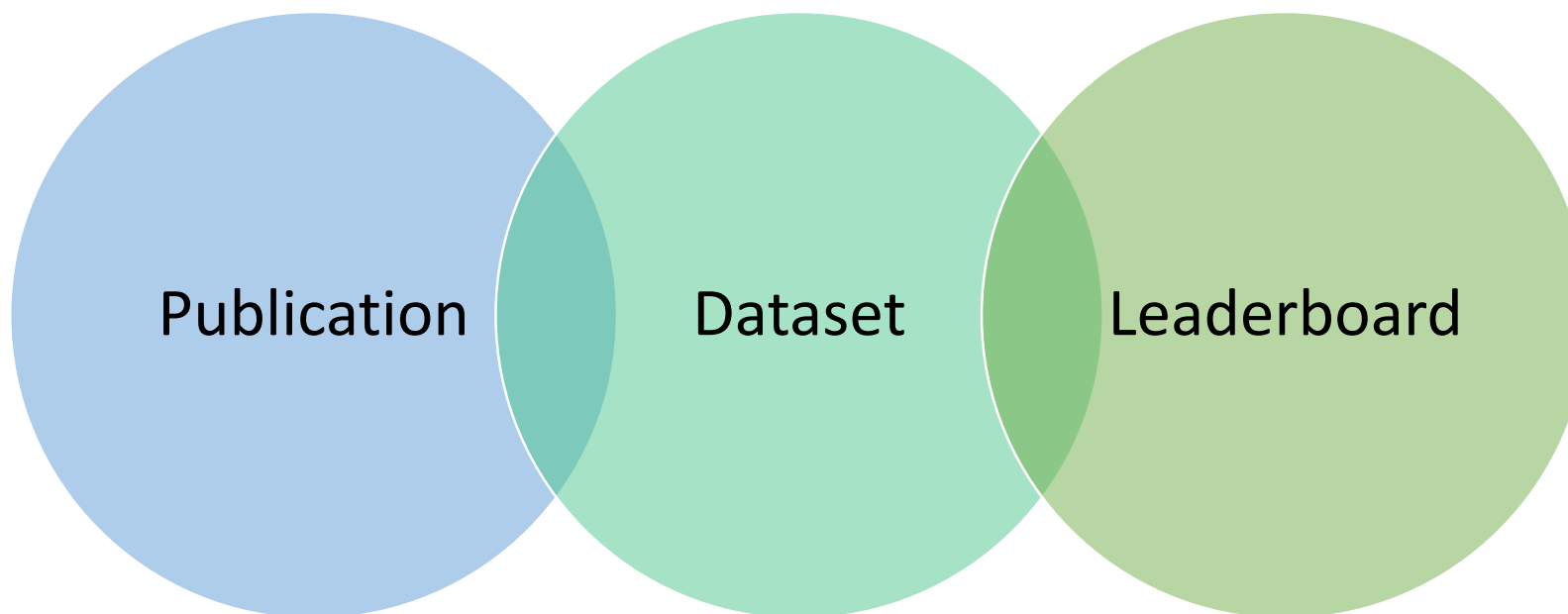
1. Stanford Question Answering Dataset (SQuAD)
2. Reading Comprehension with Multiple Hops (QAngaroo)
3. NarrativeQA Reading Comprehension Challenge



Reading comprehension

Current research

1. **Stanford Question Answering Dataset (SQuAD)**
2. Reading Comprehension with Multiple Hops (QAngaroo)
3. **NarrativeQA Reading Comprehension Challenge**



SQuAD dataset



SQuAD v1.1

- 100,000+ question-answer pairs
- extracted from 500+ Wikipedia articles

SQuAD v2.0

- v1.1 combined with 50,000+ new, unanswerable questions

Example

Document: The heat required for boiling the water and supplying the steam can be derived from various sources, most commonly from burning combustible materials with an appropriate supply of air in a closed space (called variously combustion chamber, firebox). In some cases the heat source is a nuclear reactor, geothermal energy, solar energy or waste heat from an internal combustion engine or industrial process. In the case of model or toy steam engines, the heat source can be an electric heating element.

Question: What is the usual source of heat for boiling water in the steam engine?

Example

Document: The heat required for boiling the water and supplying the steam can be derived from various sources, most commonly from **burning combustible materials** with an appropriate supply of air in a closed space (called variously combustion chamber, firebox). In some cases the heat source is a nuclear reactor, geothermal energy, solar energy or waste heat from an internal combustion engine or industrial process. In the case of model or toy steam engines, the heat source can be an electric heating element.

Question: What is the usual source of heat for boiling water in the steam engine?

Answer: burning combustible materials



	Exact match	F1 score
Human performance	86.831	89.452
Best model (Sep 2019)	89.731	92.215

Results for SQuAD v2.0

SQuAD dataset



Limitations

- ❌ Limited lexical and topical diversity
- ❌ The documents are short (i.e. paragraphs of text)
- ❌ Each answer is a span of text from a single document (→ QAngaroo)
- ❌ Shallow pattern matching may suffice to produce correct answers (→ NarrativeQA)

NarrativeQA dataset



- 1,500+ documents
 - books (Project Gutenberg)
 - movie scripts (Internet Movie Script Database and other websites)
- 45,000+ question-answer pairs

NarrativeQA dataset



Example

Full story snippet:

As he spins around one of the attackers jams all eight inches of his bayonet blade into Jacob's stomach. Jacob screams. It is a loud and piercing wail.

...

A doctor leans his head in front of the lamp and removes his mask. His expression is somber. He shakes his head. His words are simple and final.

DOCTOR: He's gone.

The doctor steps away. A nurse rudely pulls a green sheet over his head. The doctor turns to one of the aides and throws up his hands in defeat.

Question: What is the fatal injury that Jacob sustains which ultimately leads to his death?

NarrativeQA dataset



Example

Full story snippet:

As he spins around one of the attackers **jams all eight inches of his bayonet blade into Jacob's stomach**. Jacob screams. It is a loud and piercing wail.

...

A doctor leans his head in front of the lamp and removes his mask. His expression is somber. He shakes his head. His words are simple and final.

DOCTOR: **He's gone.**

The doctor steps away. A nurse rudely pulls a green sheet over his head. The doctor turns to one of the aides and throws up his hands in defeat.

Question: What is the fatal injury that Jacob sustains which ultimately leads to his death?

Answer: a bayonet wound

NarrativeQA dataset



Results



	BLEU-1	BLEU-4	METEOR	ROUGE-L
Human performance	44.43	19.65	24.14	57.02
Best model (Dec 2017)	19.09	2.11	4.37	14.03

Results for models processing full stories

NarrativeQA dataset



Results

		BLEU-1	BLEU-4	METEOR	ROUGE-L
✓ ★	Human performance	44.43	19.65	24.14	57.02
	Best model (Dec 2017)	19.09	2.11	4.37	14.03
✓ ★	Best model (Jan 2019)	48.70	20.98	21.95	54.74

Results for models processing full stories

NarrativeQA dataset



Summary

- ☒ No integration of external information required (every question can be answered using a single document)
- ☐ High computational complexity when processing the full dataset
- ☒ Decreasing performance gap between humans and machines – impressive progress made in less than two years

Summary

Reading comprehension

Why is it hard?



He reached for the **mouse** on his desk and **froze**.

Reading comprehension



Why is it hard?

He reached for the mouse on his desk and froze. It was **gone** and so was everything else.

Reading comprehension



Why is it hard?

He reached for the mouse on his desk and froze. It was gone and so was everything else. He was standing on a mountain top, it was **freezing** and he saw nothing but **whiteness**.

Reading comprehension

Why is it hard?

He reached for the mouse on his desk and froze. It was gone and so was everything else. He was standing on a mountain top, it was freezing and he saw nothing but whiteness.

A while ago the professor said that dreams might interfere with the **teleportation device**, ...

Reading comprehension



Why is it hard?

He reached for the mouse on his desk and froze. It was gone and so was everything else. He was standing on a mountain top, it was freezing and he saw nothing but whiteness.

A while ago the professor said that dreams might interfere with the teleportation device, and just last night he had a weird dream – barefoot and wearing only his pajamas, he was climbing the **highest mountain in the Alps** and, for the world, he could not remember its name.

Reading comprehension



Why is it hard?

He reached for the mouse on his desk and froze. It was gone and so was everything else. He was standing on a mountain top, it was freezing and he saw nothing but whiteness.

A while ago the professor said that dreams might interfere with the teleportation device, and just last night he had a weird dream – barefoot and wearing only his pajamas, he was climbing the highest mountain in the Alps and, for the world, he could not remember its name.

And then it **clicked in his head** - he knew where he was and it bad news!

Reading comprehension



Why is it hard?

He reached for the mouse on his desk and froze. It was gone and so was everything else. He was standing on a mountain top, it was freezing and he saw nothing but whiteness.

A while ago the professor said that dreams might interfere with the teleportation device, and just last night he had a weird dream – barefoot and wearing only his pajamas, he was climbing the **highest mountain in the Alps** and, for the world, he could not remember its name.

And then it clicked in his head - he knew where he was and it bad news! The icy darkness around was the summit of .

Reading comprehension

Do androids read about electric sheep?

~~No.~~

Not yet.

Doing now what patients need next