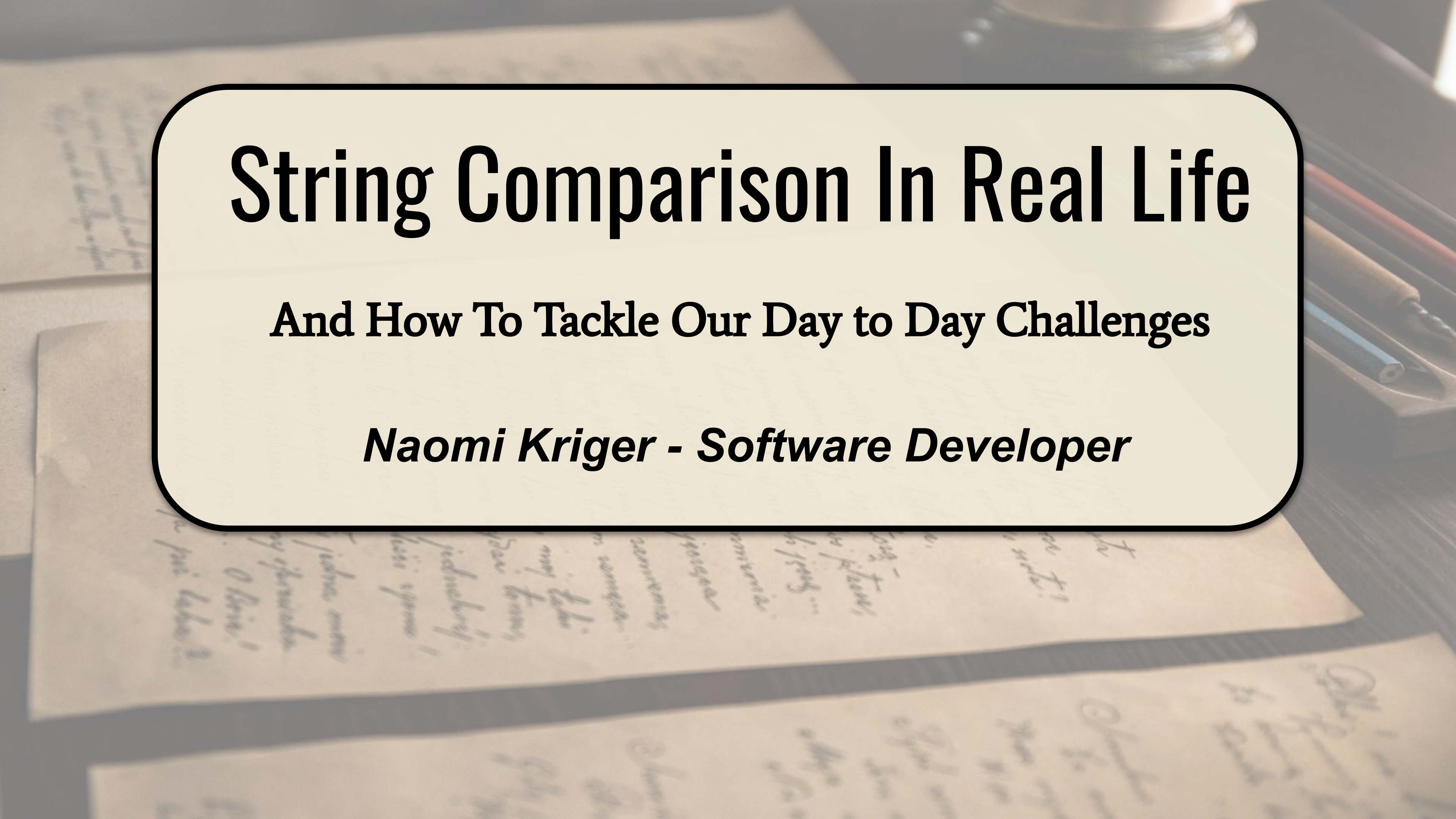


String Comparison In Real Life

And How To Tackle Our Day to Day Challenges

Naomi Kriger - Software Developer

Table A

Hey hi	sin
name	me

Table B

hey	sing
name!	ME!

Table A

Hey hi	sin
name	me

Table B

hey	sing
name!	ME!

Similarity(“name”, “name!”) = 9/10

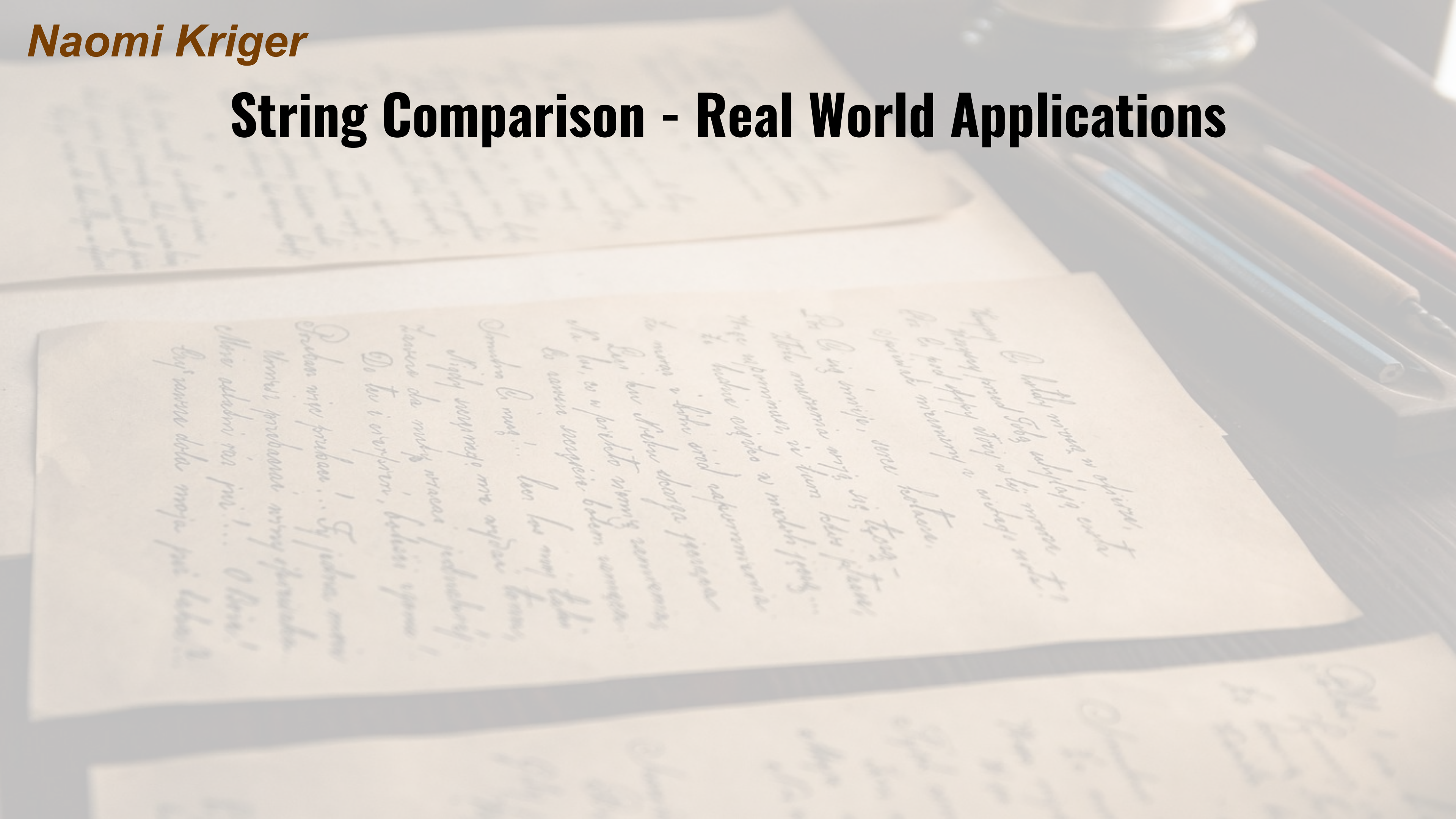
String Comparison - What Could Go Wrong?

- Typos
- Abbreviations
- Reordering of words in a sentence
- Repetitions of words
- Punctuation

There is no single definition for similarity or difference of strings

Naomi Kriger

String Comparison - Real World Applications



String Comparison - Real World Applications

- Fraud detection

String Comparison - Real World Applications

- Fraud detection

Identities Commonly Used By Fraudsters

- George Forge
- Billy Stealy
- Jerry Robbery
- ...

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String Comparison - Real World Applications

- Fraud detection

ORIGINAL PERSON

Full name: George Forge
Address: 123 Made Up Lane, Central State, US 45476

STOLEN IDENTITY

Full name: Mr. Georgie Forge
Address: 123 Made-Up ln., Central State, US 0045476

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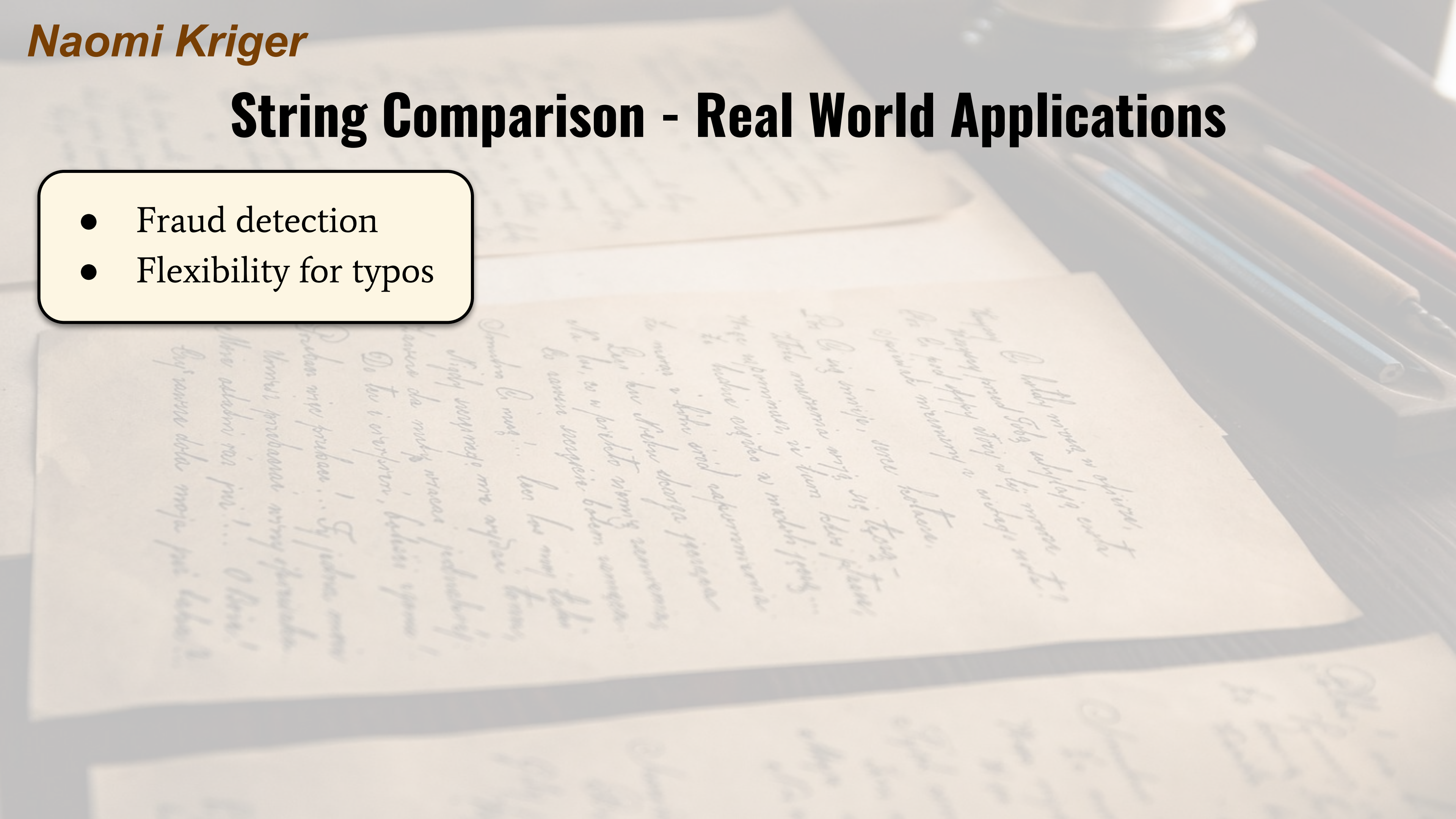
String Comparison - Real World Applications



- Fraud detection
- Flexibility for typos

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String Comparison - Real World Applications

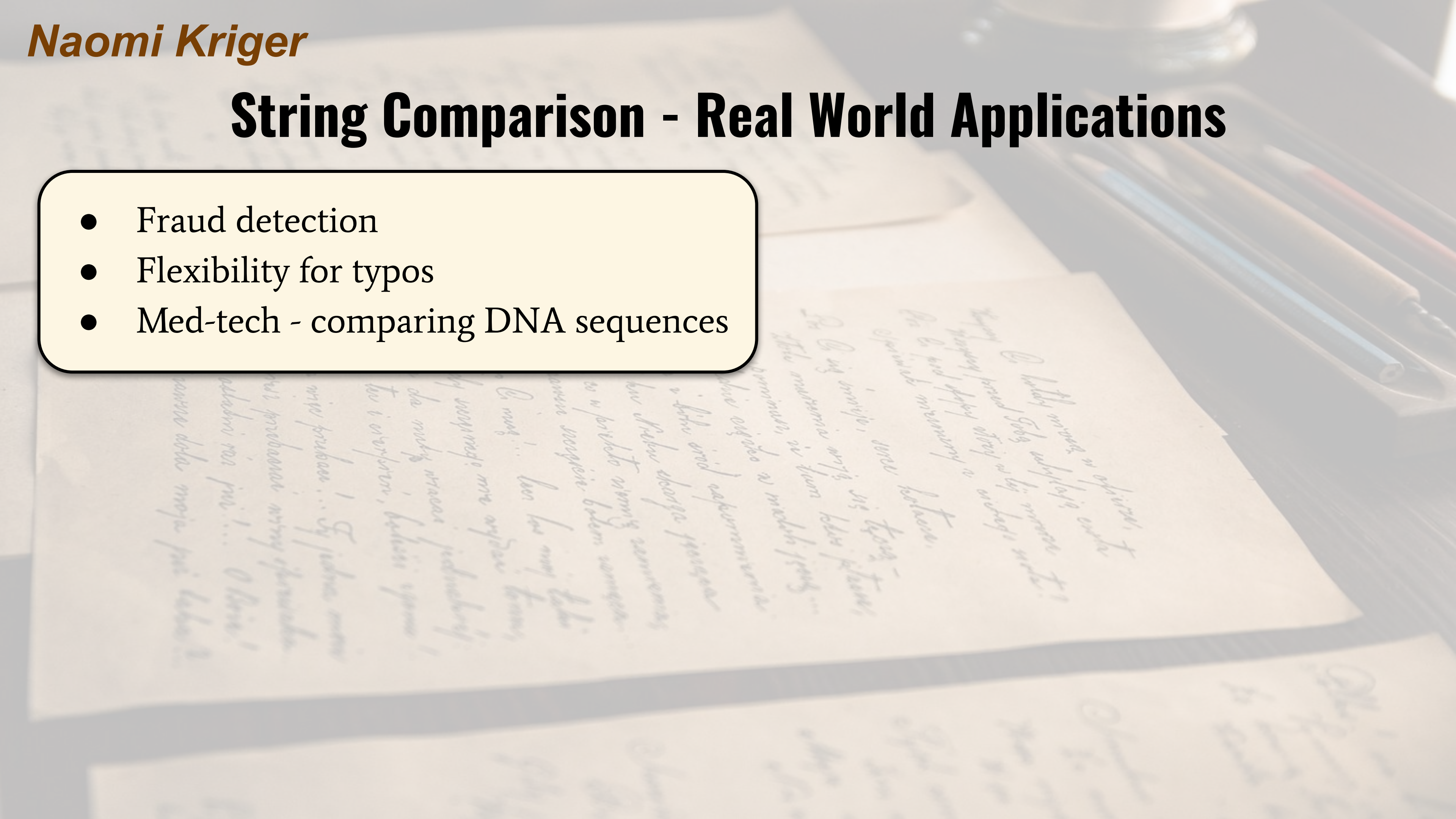
- Fraud detection
- Flexibility for typos

assessment / asessment

hazardous / hazrdus

responsibility / responsability

String Comparison - Real World Applications



- Fraud detection
- Flexibility for typos
- Med-tech - comparing DNA sequences

String Comparison - Real World Applications

- Fraud detection
- Flexibility for typos
- Med-tech - comparing DNA sequences

ATGACGTGGGAA
ATAACGTGGGCA

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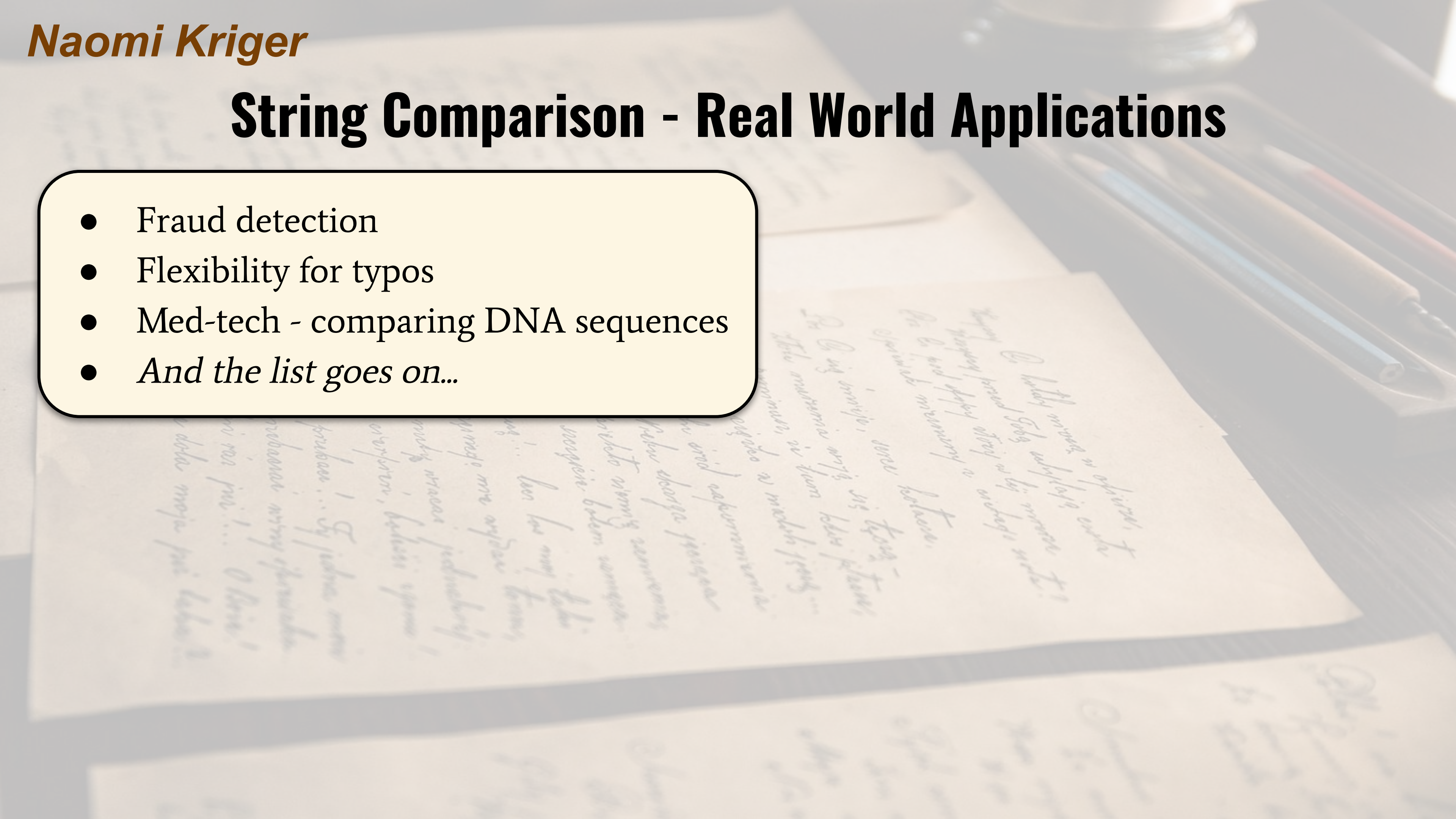
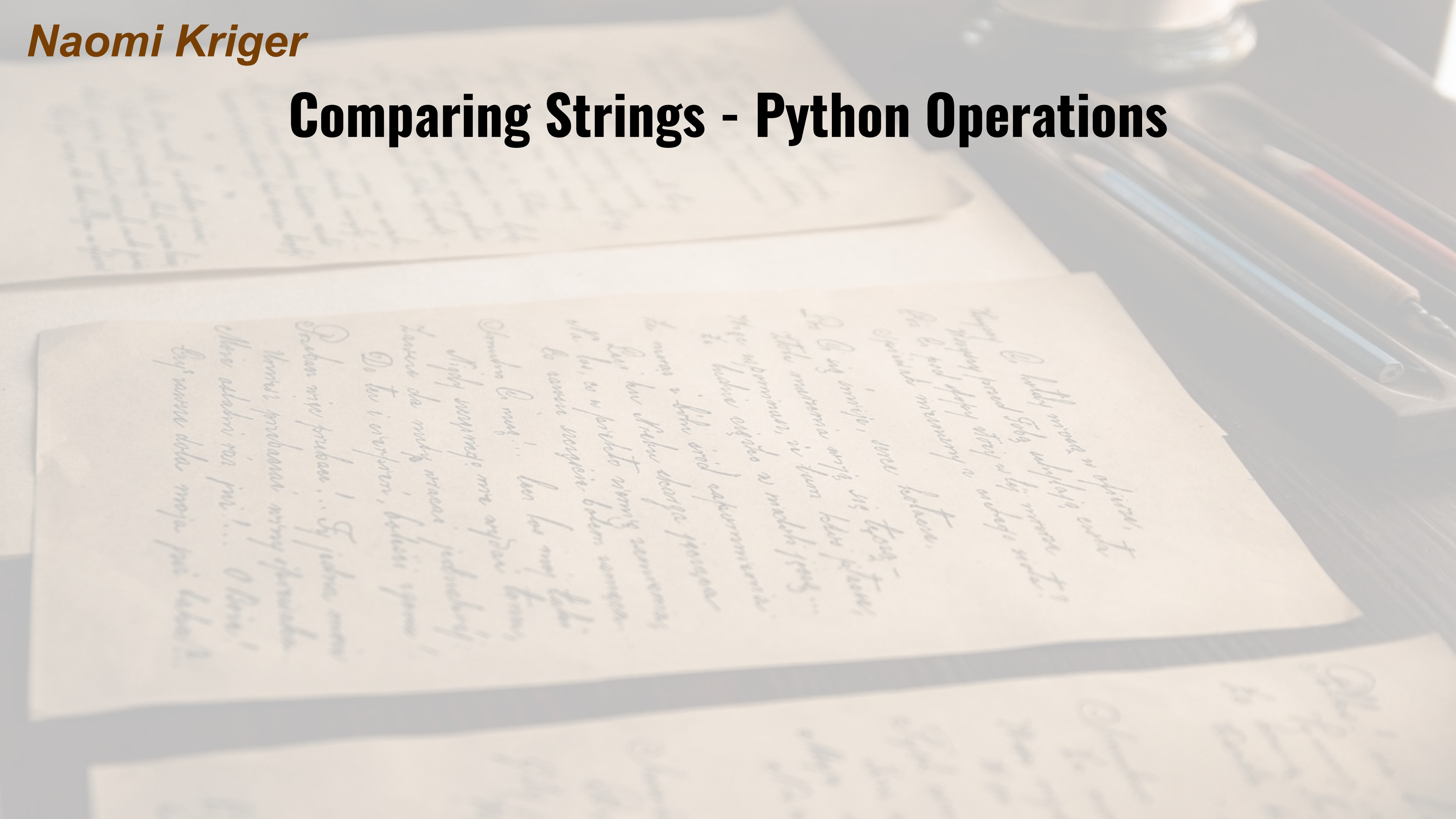
String Comparison - Real World Applications



- Fraud detection
- Flexibility for typos
- Med-tech - comparing DNA sequences
- *And the list goes on...*

Comparing Strings - Python Operations



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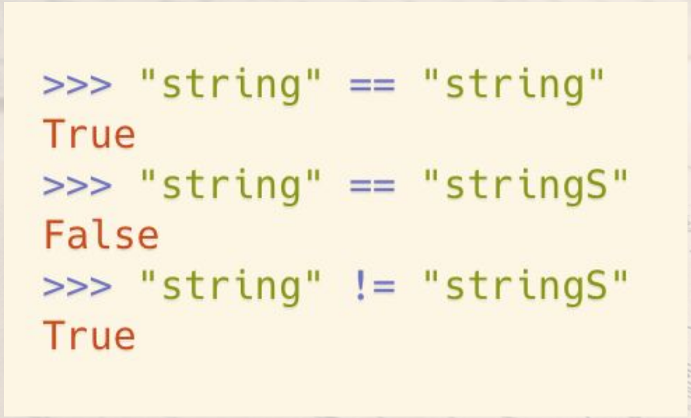
Comparing Strings - Python Operations



```
>>> "string" == "string"
True
>>> "string" == "stringS"
False
>>> "string" != "stringS"
True
```

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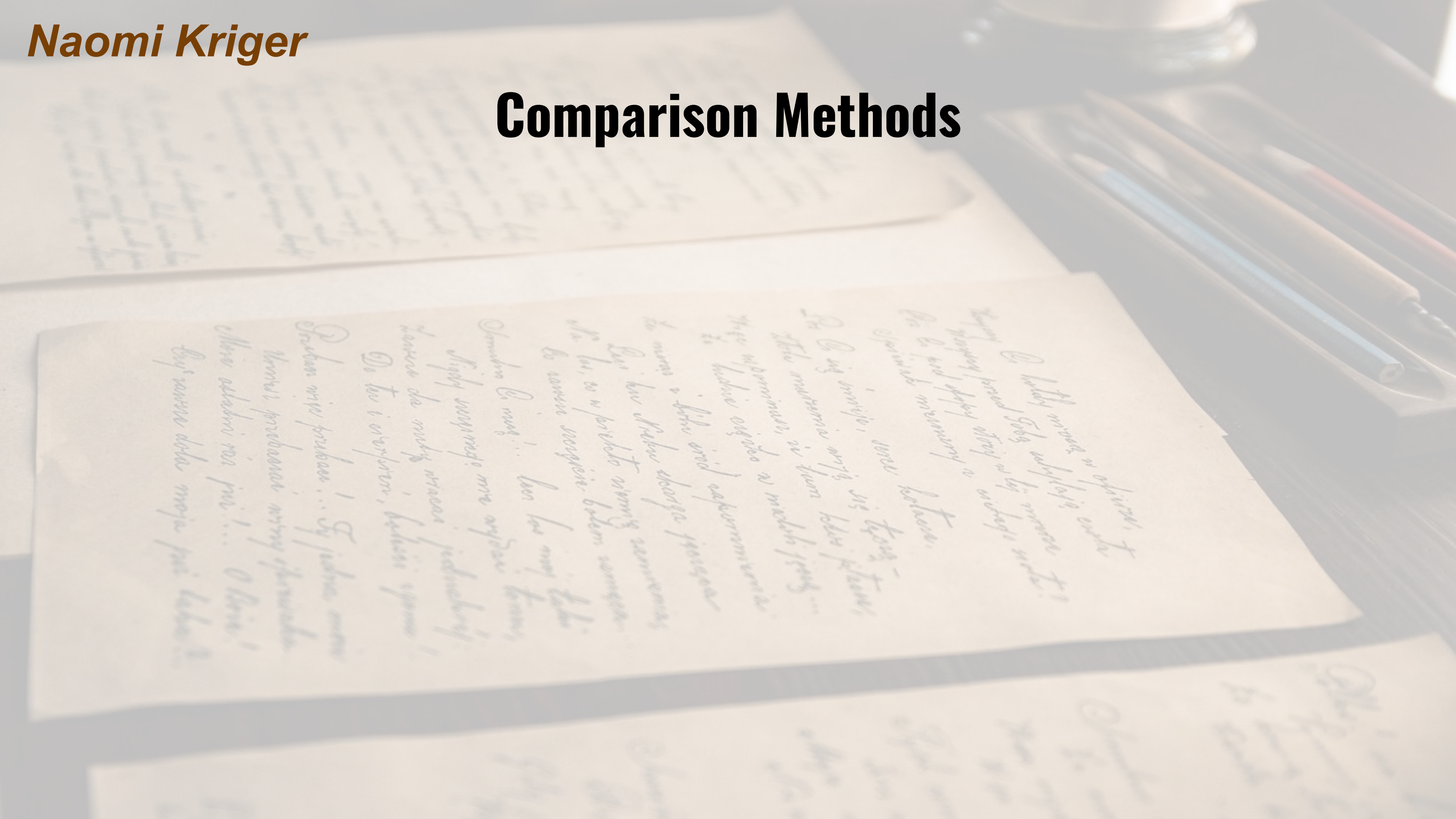
Comparing Strings - Python Operations

```
>>> "string" == "string"
True
>>> "string" == "stringS"
False
>>> "string" != "stringS"
True
```

```
>>> a = "my new string"
>>> b = "new"
>>> a in b
False
>>> b in a
True
```

Comparison Methods



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Comparison Methods

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Comparison Methods

Jellyfish

Edit distance

Phonetic encoding

Jellyfish

Edit distance

- *Levenshtein Distance*
- *Damerau-Levenshtein Distance*

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String Metric

String Metric

Receives two strings

	s	t	r	i	n	g
s						
t						
i						
n						
g						

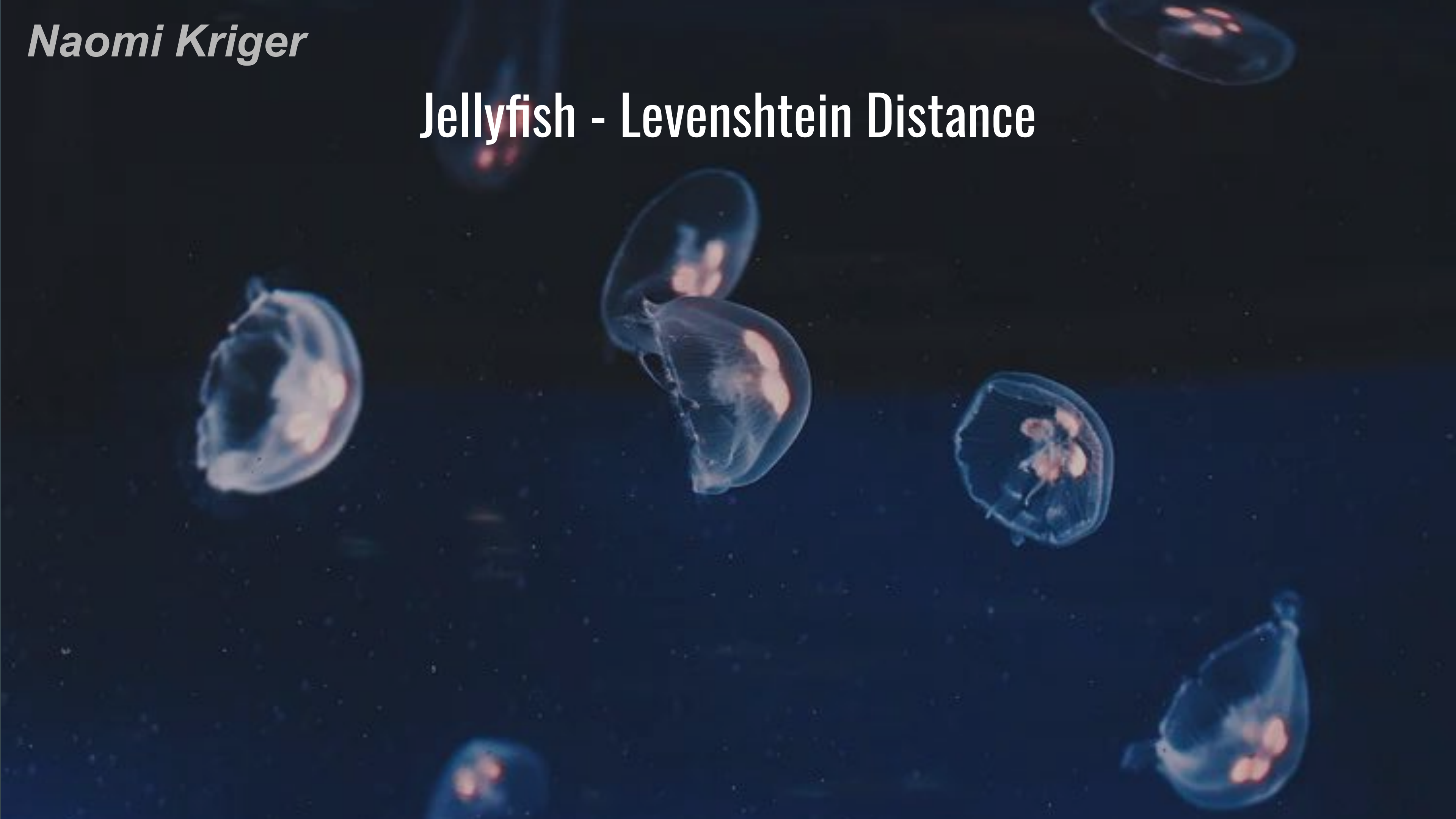
String Metric

Receives two strings
and produces a distance score

	s	t	r	i	n	g
s						
t						
i						
n						
g						

magic

distance("string", "sting") = 1



Jellyfish - Levenshtein Distance

Jellyfish - Levenshtein Distance

- Calculates the minimal steps required to convert string A to string B
- A step is one of the followings:
  - **Addition, deletion, replacement**
- Higher score → bigger difference

Jellyfish - Levenshtein Distance

```
>>> jellyfish.levenshtein_distance(“exit“, “exist“)
```

Jellyfish - Levenshtein Distance

```
>>> jellyfish.levenshtein_distance(“exit“, “exist“)
1
```

Jellyfish - Levenshtein Distance

```
>>> jellyfish.levenshtein_distance(“exit“, “exist“)
1
>>> jellyfish.levenshtein_distance(“great“, “grate“)
```

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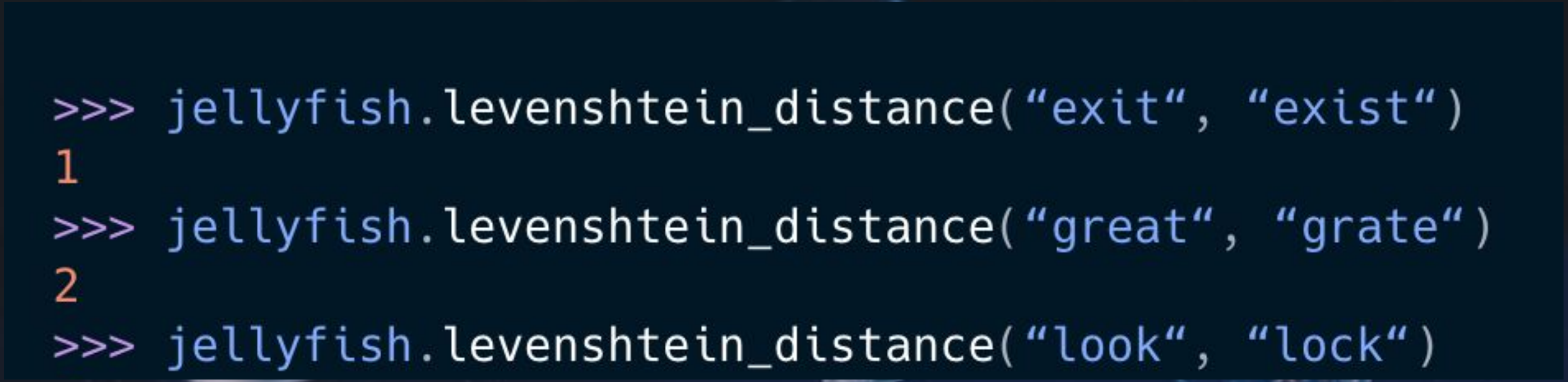
Jellyfish - Levenshtein Distance

```
>>> jellyfish.levenshtein_distance(“exit“, “exist“)
1
>>> jellyfish.levenshtein_distance(“great“, “grate“)
2
```

Jellyfish - Levenshtein Distance



```
>>> jellyfish.levenshtein_distance(“exit“, “exist“)
1
>>> jellyfish.levenshtein_distance(“great“, “grate“)
2
>>> jellyfish.levenshtein_distance(“look“, “lock“)
```

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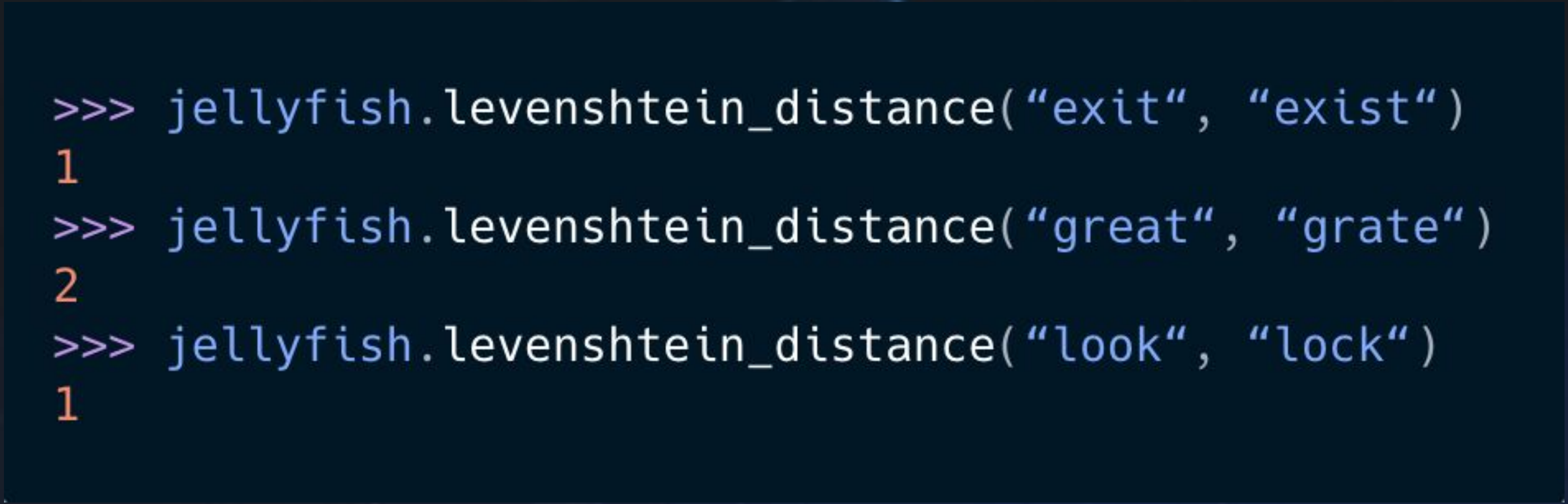
Jellyfish - Levenshtein Distance



```
>>> jellyfish.levenshtein_distance(“exit“, “exist“)
1
>>> jellyfish.levenshtein_distance(“great“, “grate“)
2
>>> jellyfish.levenshtein_distance(“look“, “lock“)
1
```

Jellyfish - Damerau-Levenshtein Distance

- Calculates the minimal steps required to convert string A to string B
- Higher score → bigger difference
- A step is one of the followings:
  - **Addition, deletion, replacement**

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Jellyfish - Damerau-Levenshtein Distance

- Calculates the minimal steps required to convert string A to string B
- Higher score → bigger difference
- A step is one of the followings:
  - **Addition, deletion, replacement**
- Counts a swap of two adjacent characters as a **single** step, unlike Levenshtein Distance which counts them as two steps

Jellyfish - Damerau-Levenshtein Distance

```
>>> jellyfish.damerau_levenshtein_distance("swap", "sawp")
1
>>> jellyfish.levenshtein_distance("swap", "sawp")
2
```

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Jellyfish - Distance - When Is It Useful?

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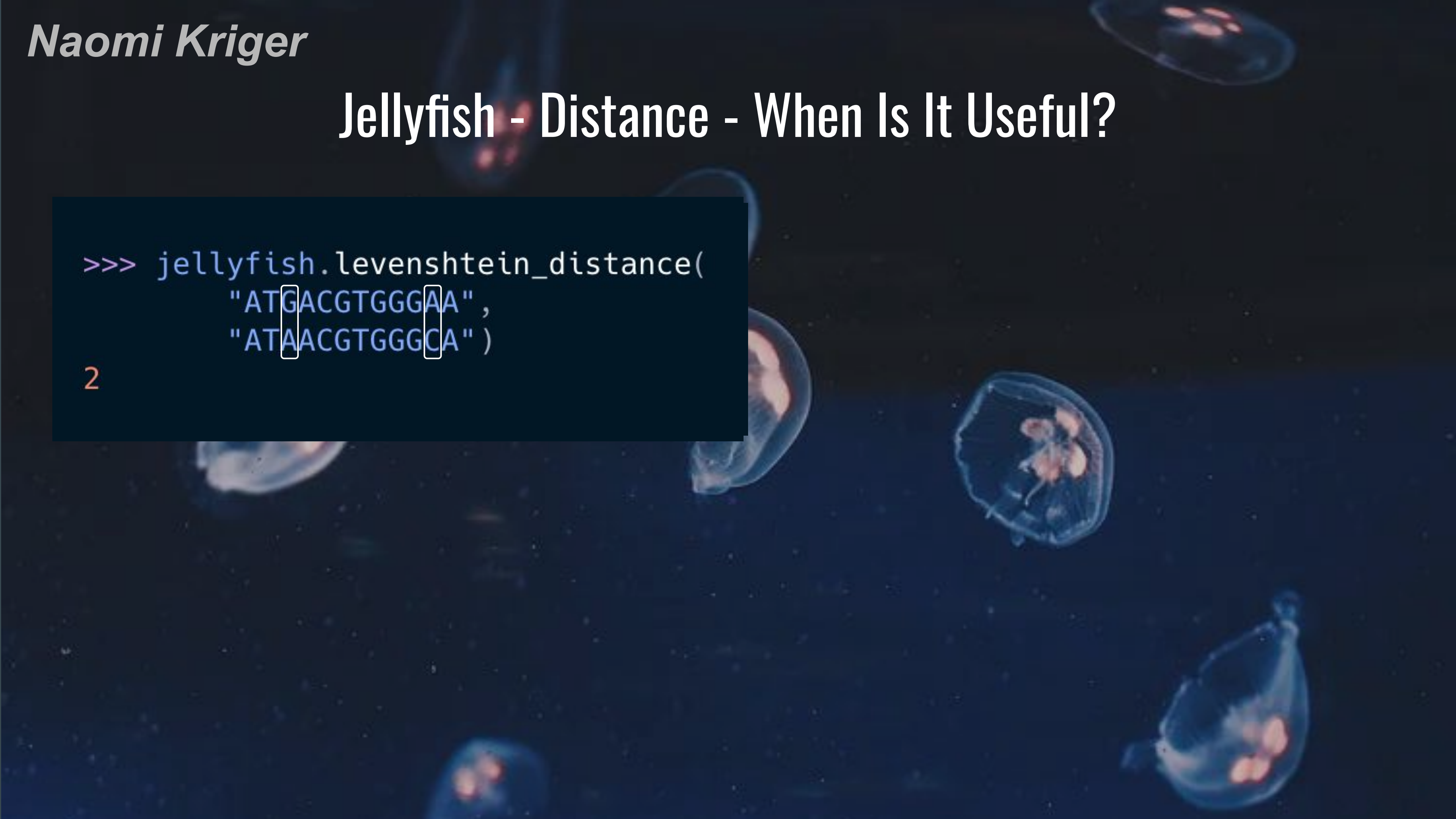
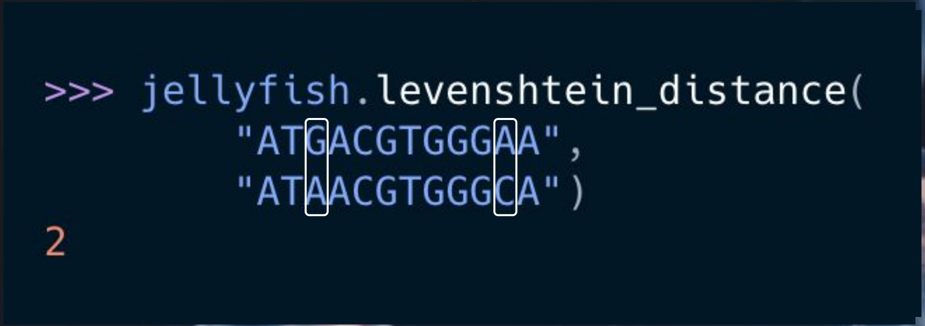
Jellyfish - Distance - When Is It Useful?





```
>>> jellyfish.levenshtein_distance(
        "ATGACGTGGGAA",
        "ATAACGTGGGCA")
2
```

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Jellyfish - Distance - When Is It Useful?

```
>>> jellyfish.levenshtein_distance("Mr. Bean", "Mr Bean")
1
>>> jellyfish.damerau_levenshtein_distance("Johnny Depp", "Jhonny Depp")
1
```

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Jellyfish - Distance - When Is It NOT Useful?

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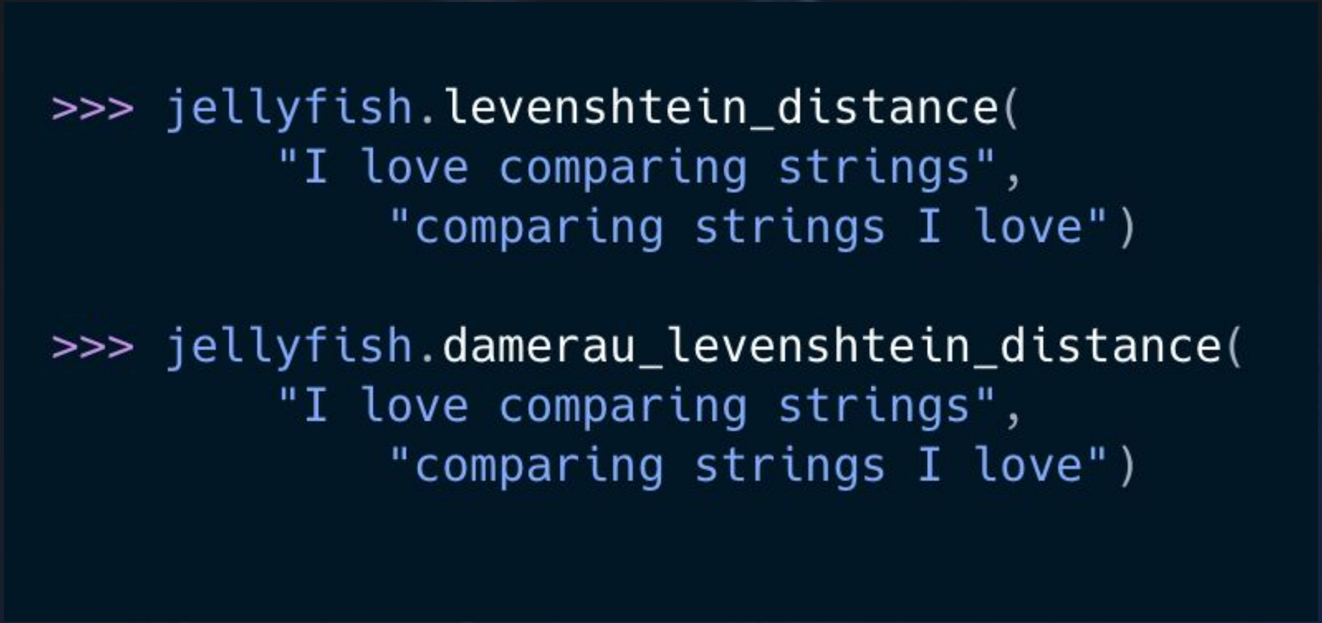
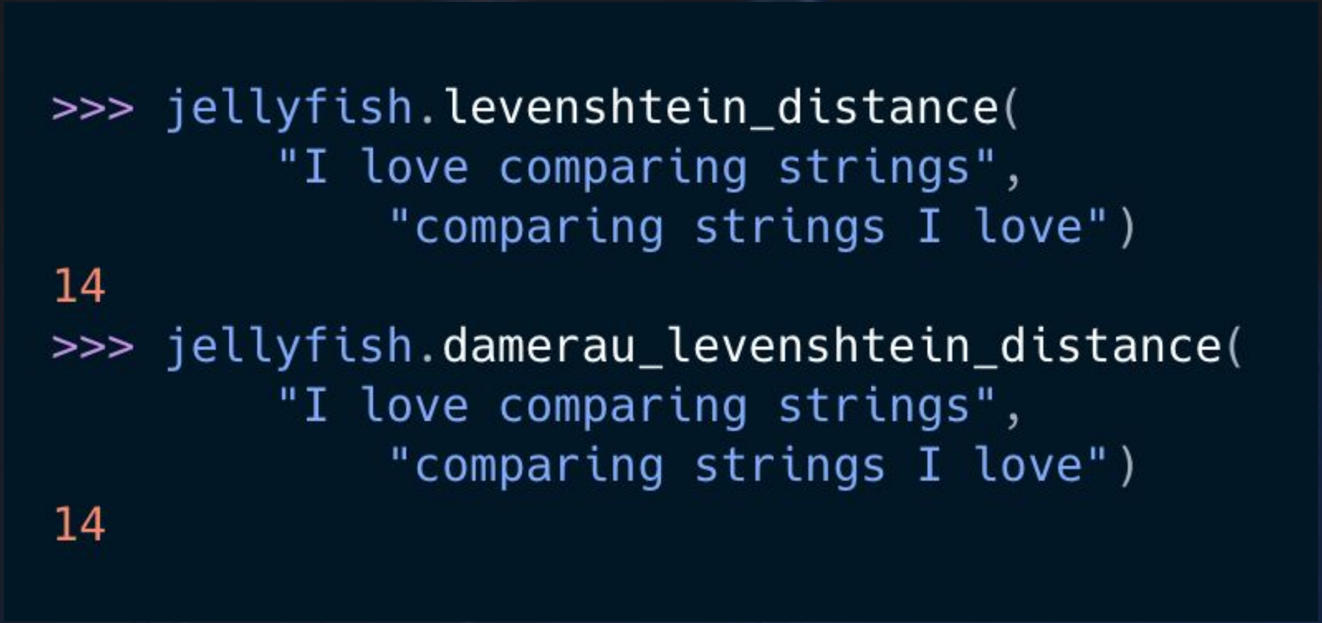
Jellyfish - Distance - When Is It NOT Useful?



```
>>> jellyfish.levenshtein_distance(
        "I love comparing strings",
            "comparing strings I love")

>>> jellyfish.damerau_levenshtein_distance(
        "I love comparing strings",
            "comparing strings I love")
```

Jellyfish - Distance - When Is It NOT Useful?



```
>>> jellyfish.levenshtein_distance(
        "I love comparing strings",
            "comparing strings I love")
14
>>> jellyfish.damerau_levenshtein_distance(
        "I love comparing strings",
            "comparing strings I love")
14
```

Naomi Kriger

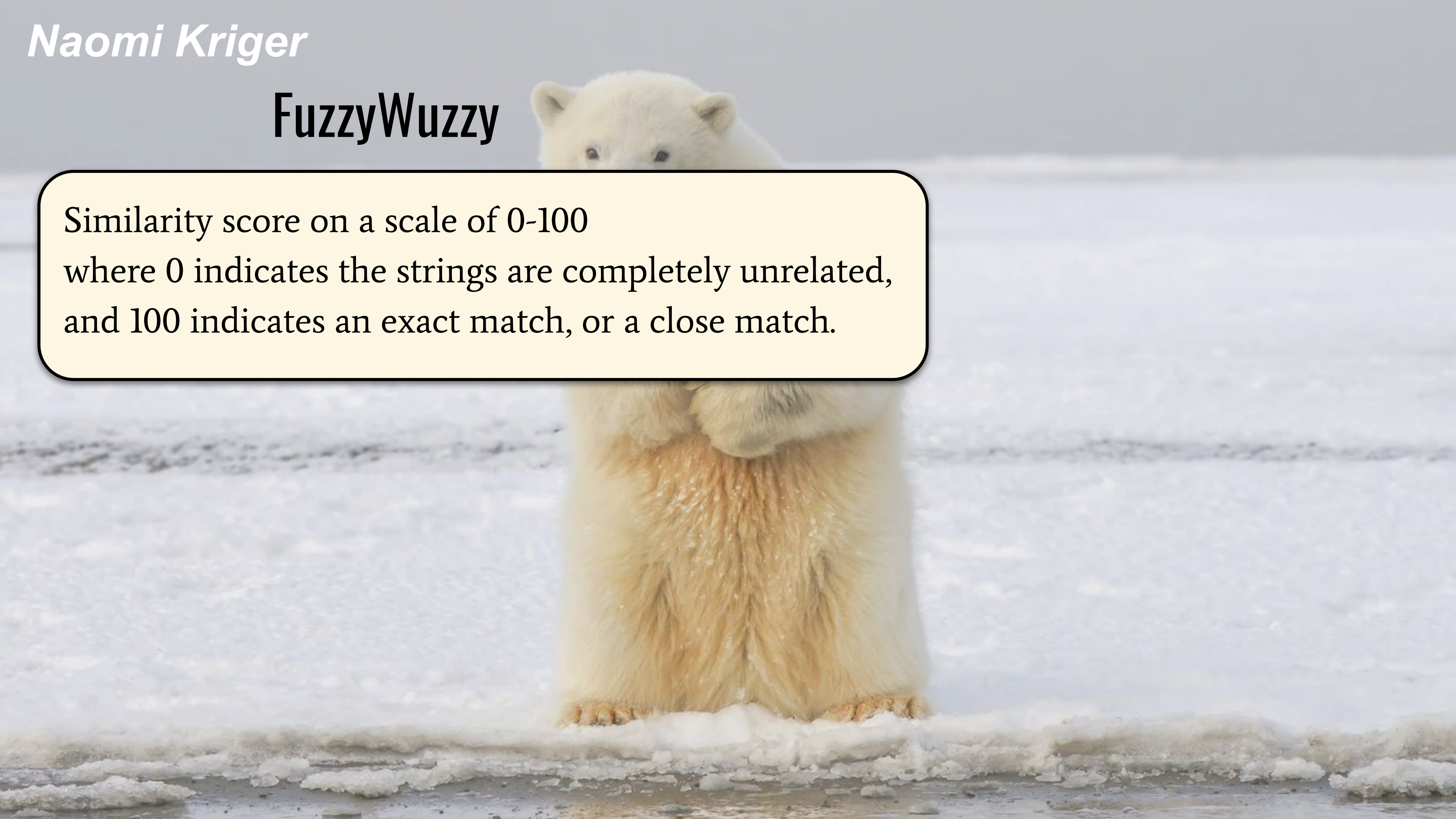
Fuzzy Wuzzy was a bear.
Fuzzy Wuzzy had no hair.
So Fuzzy Wuzzy
wasn't very fuzzy,
was he?

Naomi Kriger

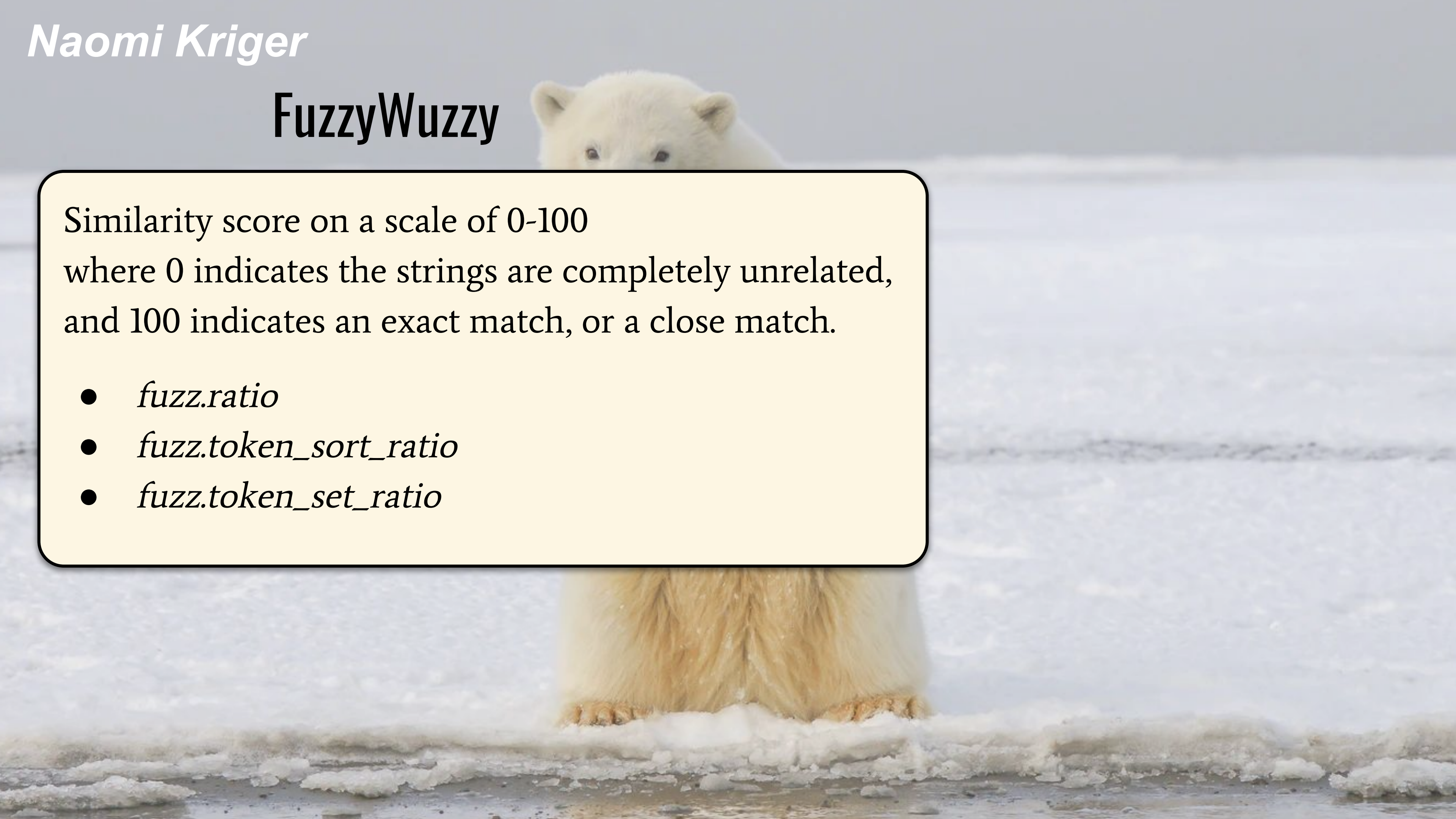
FuzzyWuzzy

Naomi Kriger

FuzzyWuzzy



Similarity score on a scale of 0-100
where 0 indicates the strings are completely unrelated,
and 100 indicates an exact match, or a close match.



FuzzyWuzzy

Similarity score on a scale of 0-100
where 0 indicates the strings are completely unrelated,
and 100 indicates an exact match, or a close match.

- *fuzz.ratio*
- *fuzz.token_sort_ratio*
- *fuzz.token_set_ratio*

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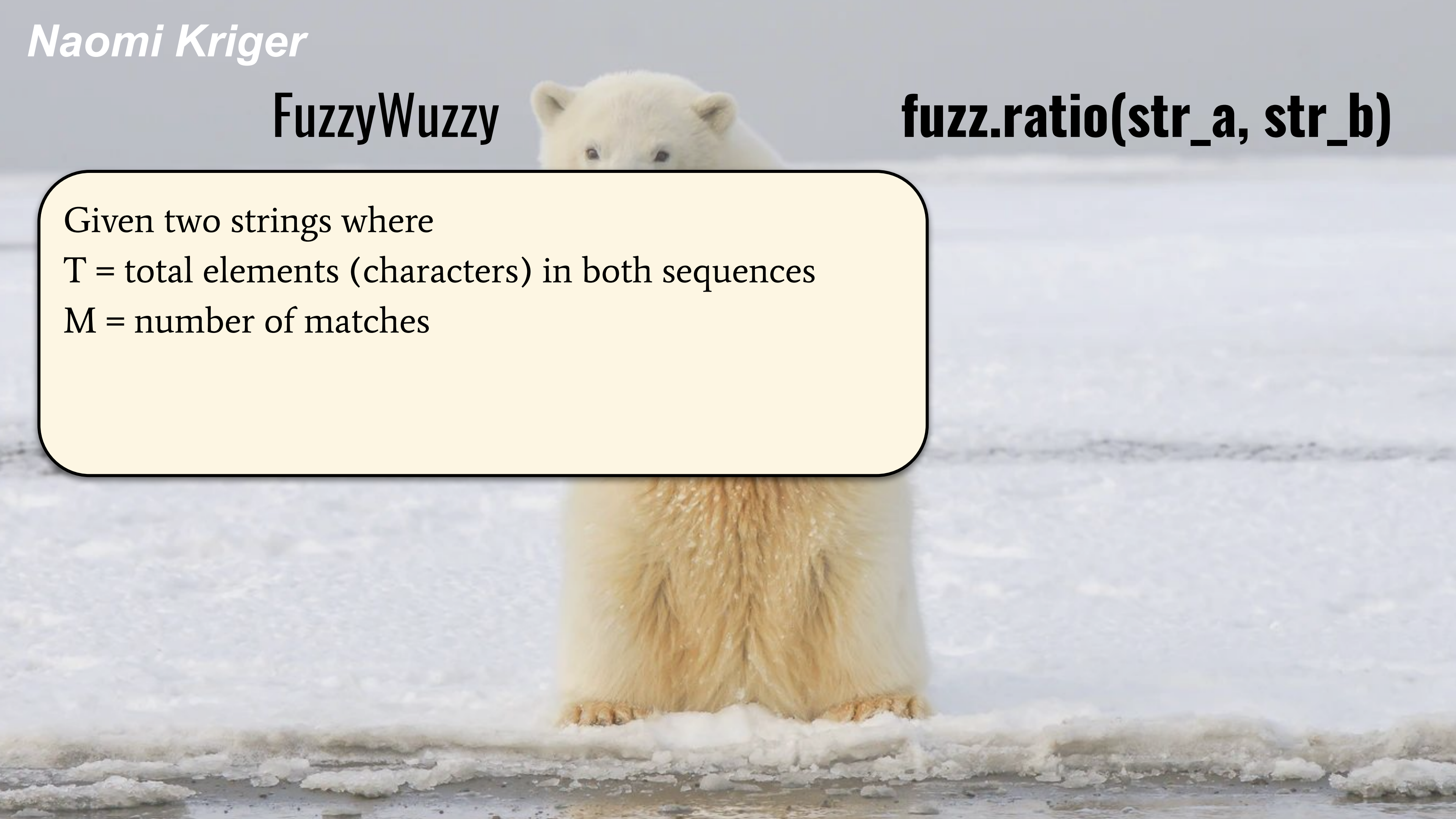
FuzzyWuzzy

`fuzz.ratio(str_a, str_b)`



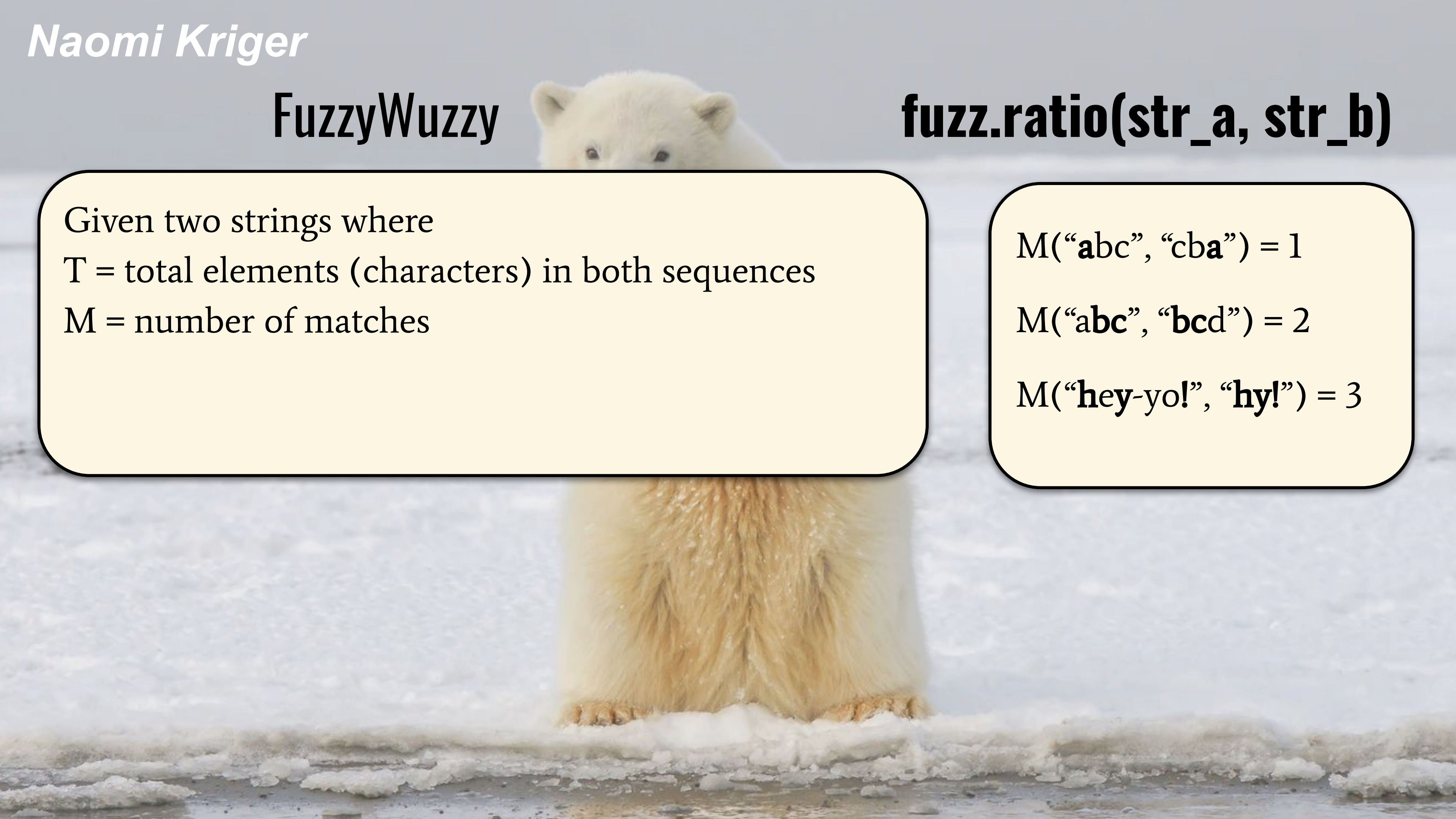
FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Given two strings where

T = total elements (characters) in both sequences

M = number of matches



FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Given two strings where

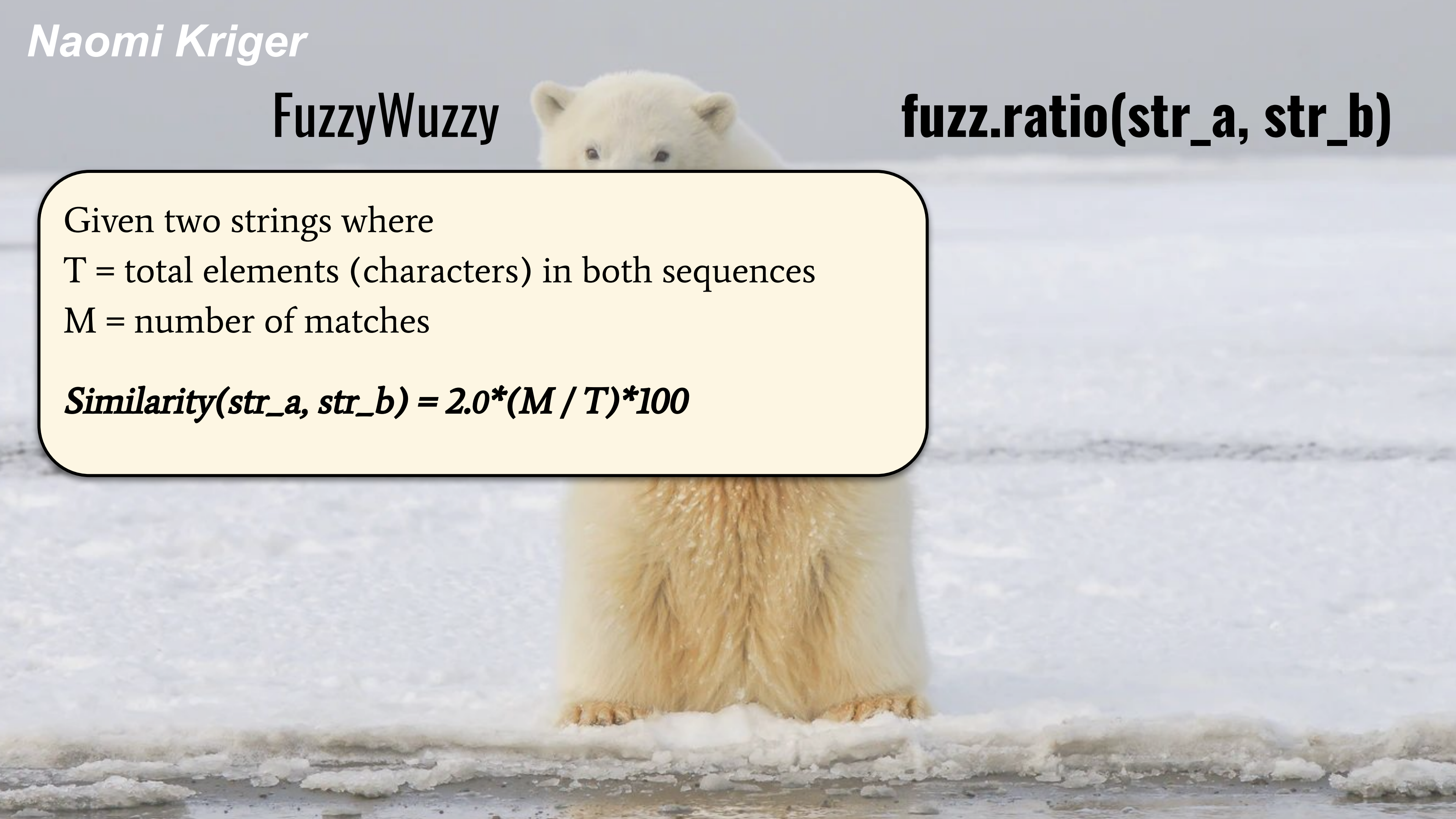
T = total elements (characters) in both sequences

M = number of matches

M(“**a**bc”, “cb**a**”) = 1

M(“a**bc**”, “**bc**d”) = 2

M(“**hey**-yo**!**”, “**hy!**”) = 3



FuzzyWuzzy

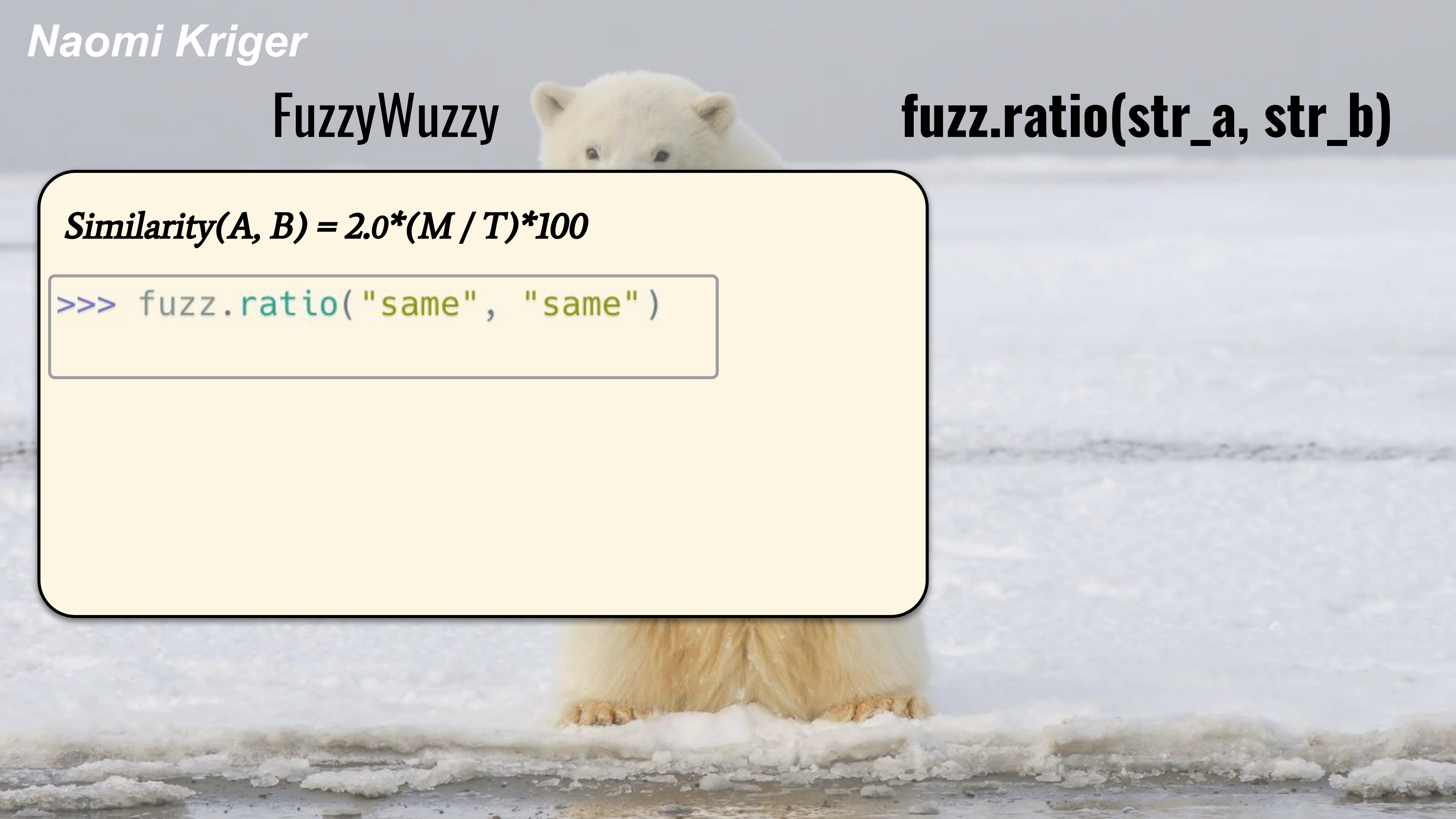
fuzz.ratio(str_a, str_b)

Given two strings where

T = total elements (characters) in both sequences

M = number of matches

Similarity(str_a, str_b) = 2.0*(M / T)*100



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FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0(M / T)*100*

```
>>> fuzz.ratio("same", "same")
```

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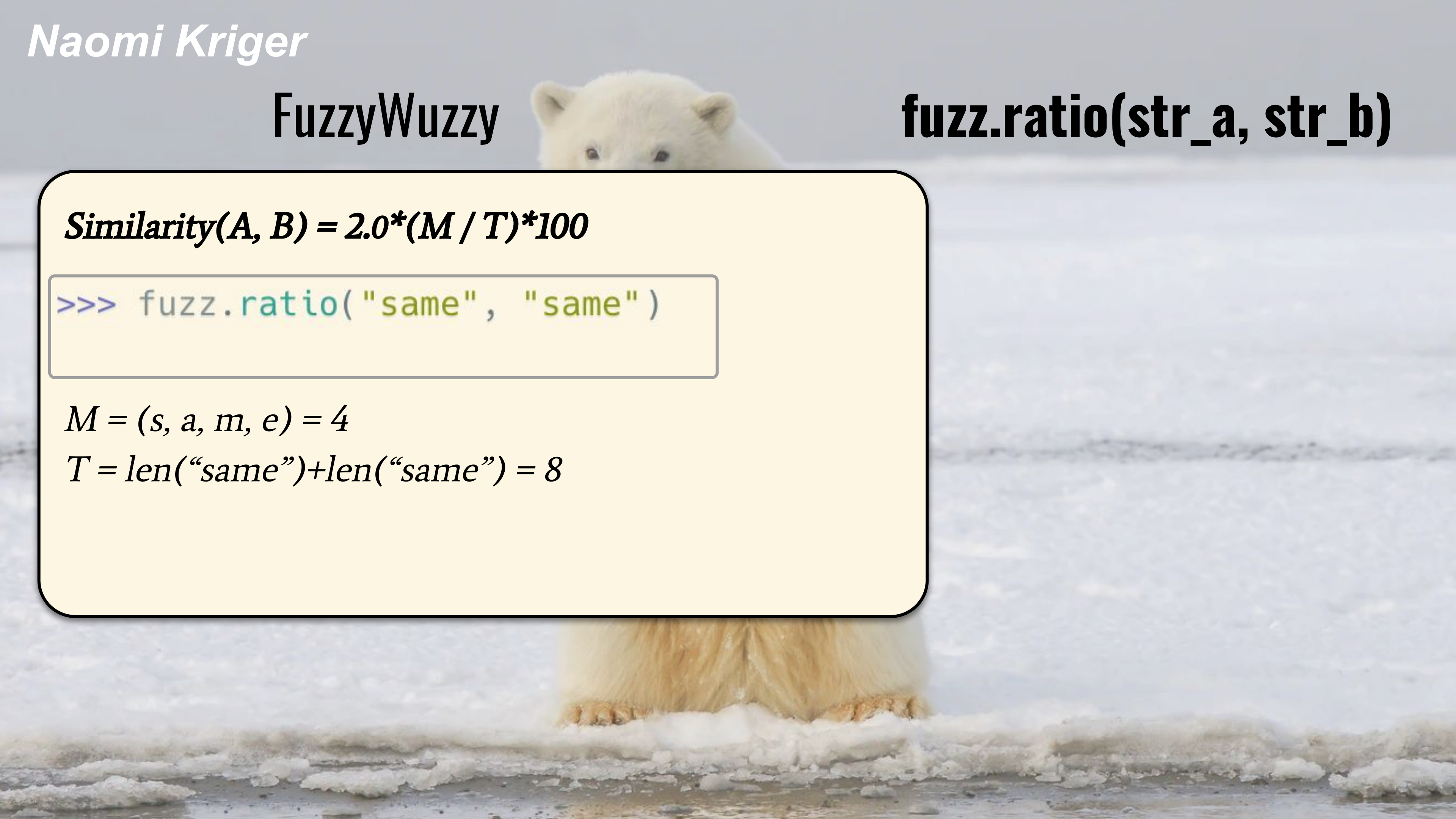


FuzzyWuzzy

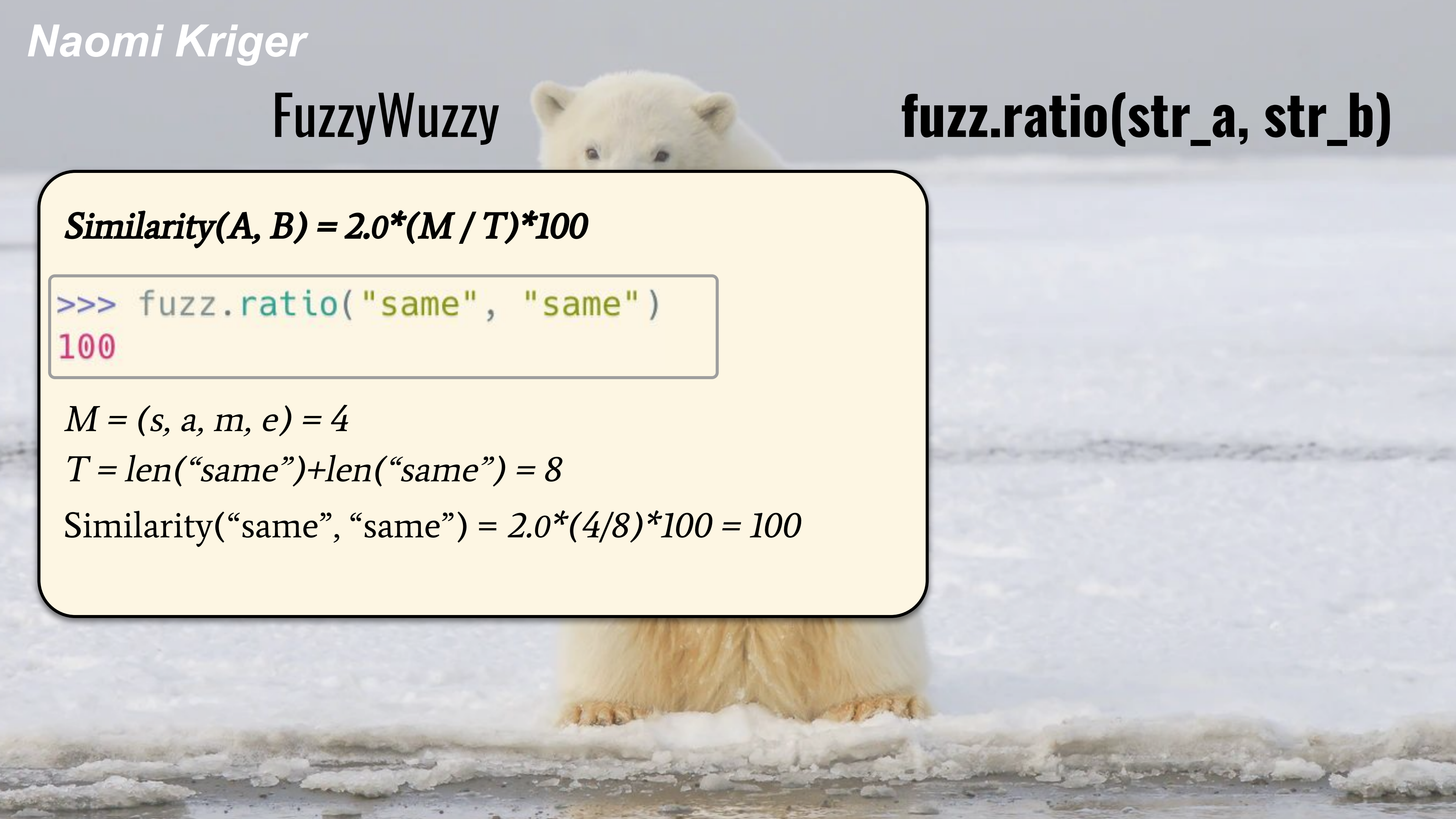
fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0*(M / T)*100

```
>>> fuzz.ratio("same", "same")
```

M = (s, a, m, e) = 4

T = len("same")+len("same") = 8



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FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0*(M / T)*100

```
>>> fuzz.ratio("same", "same")
100
```

M = (s, a, m, e) = 4

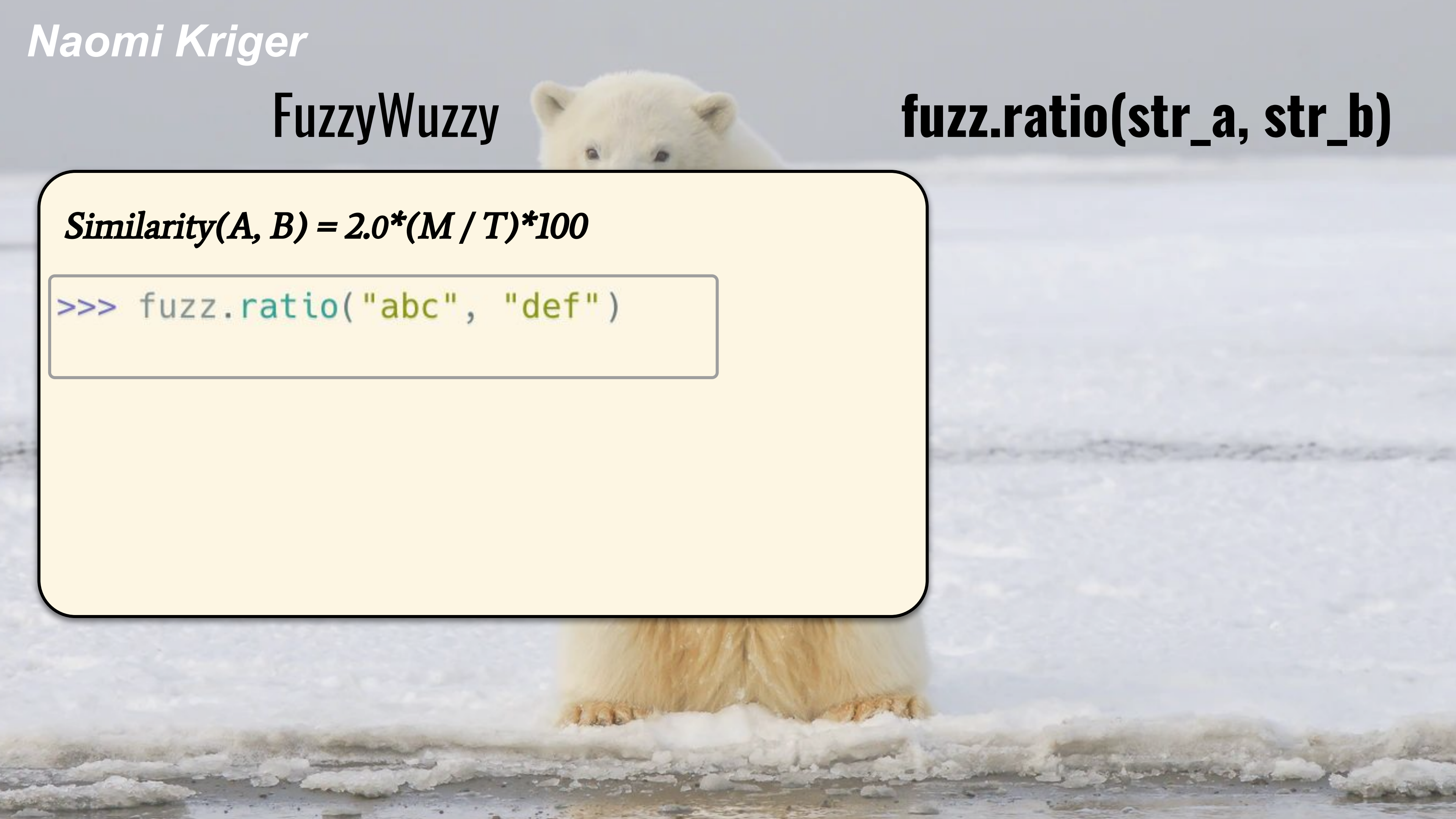
T = len("same")+len("same") = 8

Similarity("same", "same") = *2.0*(4/8)*100 = 100*

Naomi Kriger

FuzzyWuzzy

fuzz.ratio(str_a, str_b)

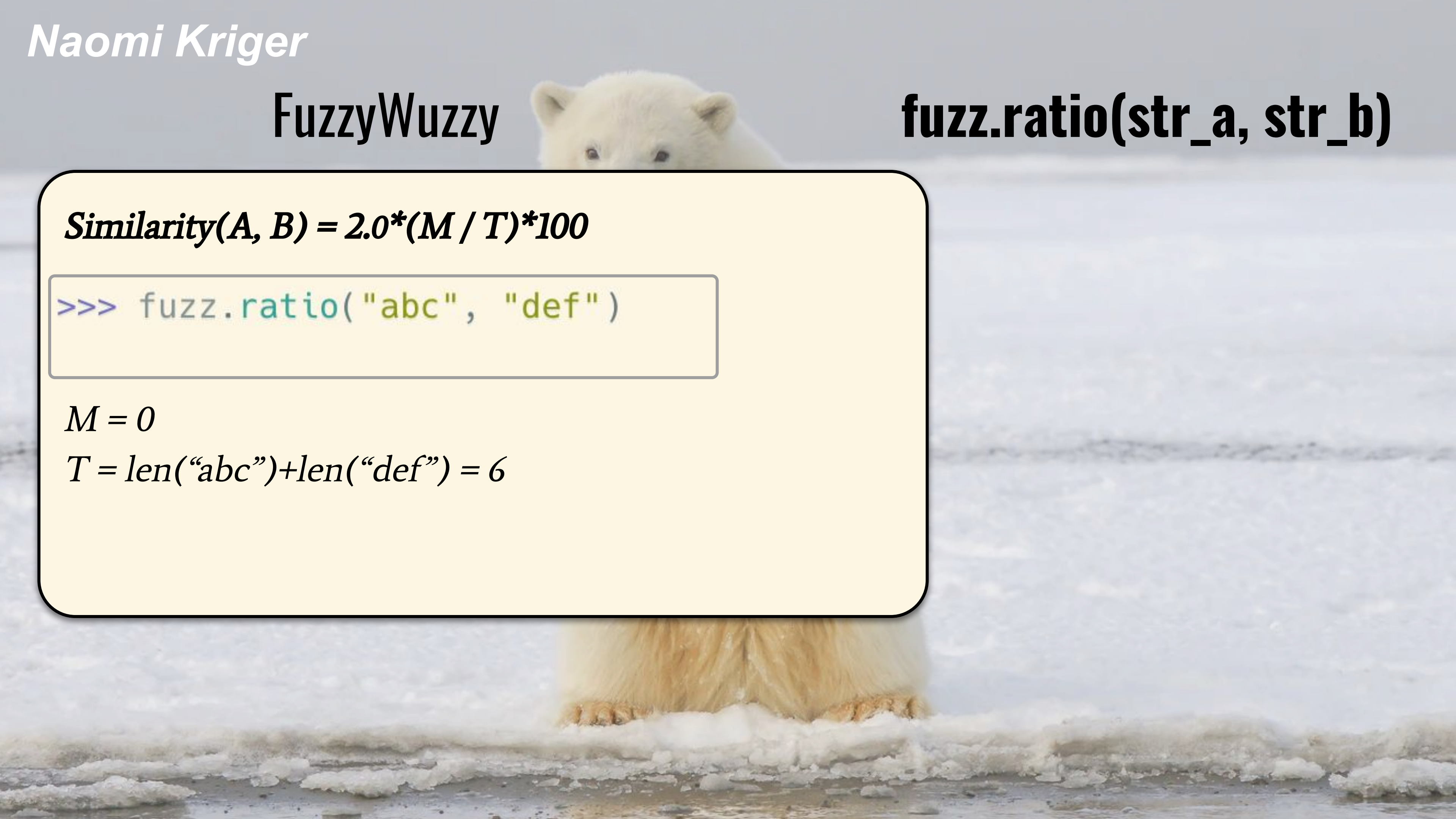


Similarity(A, B) = 2.0(M / T)*100*

```
>>> fuzz.ratio("abc", "def")
```

FuzzyWuzzy

fuzz.ratio(str_a, str_b)

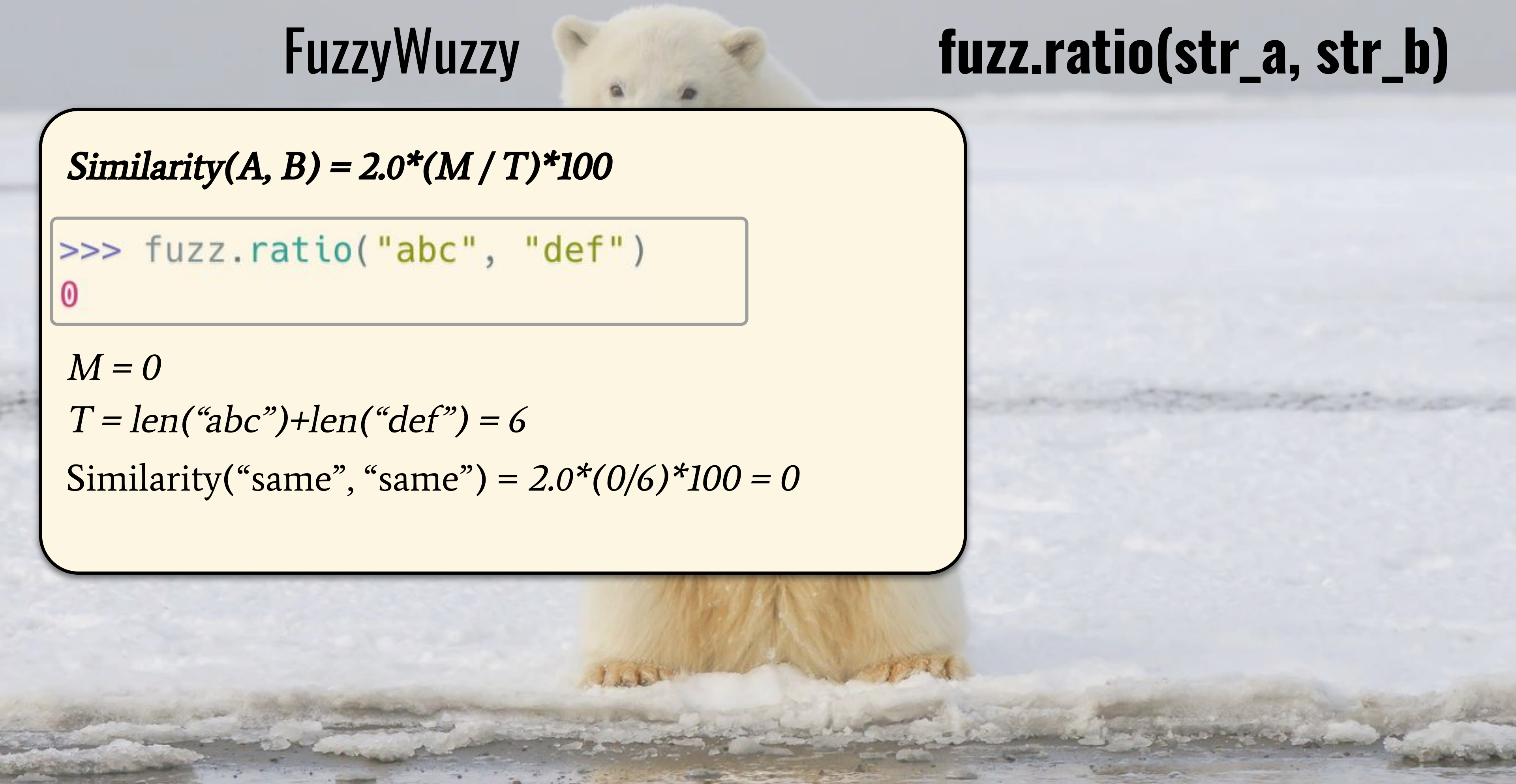


Similarity(A, B) = 2.0*(M / T)*100

```
>>> fuzz.ratio("abc", "def")
```

$M = 0$

$T = len(“abc”)+len(“def”) = 6$



FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0*(M / T)*100

```
>>> fuzz.ratio("abc", "def")
0
```

M = 0

T = len("abc")+len("def") = 6

Similarity("same", "same") = *2.0*(0/6)*100 = 0*

FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0(M / T)*100*

```
>>> fuzz.ratio("great", "green")
```

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FuzzyWuzzy

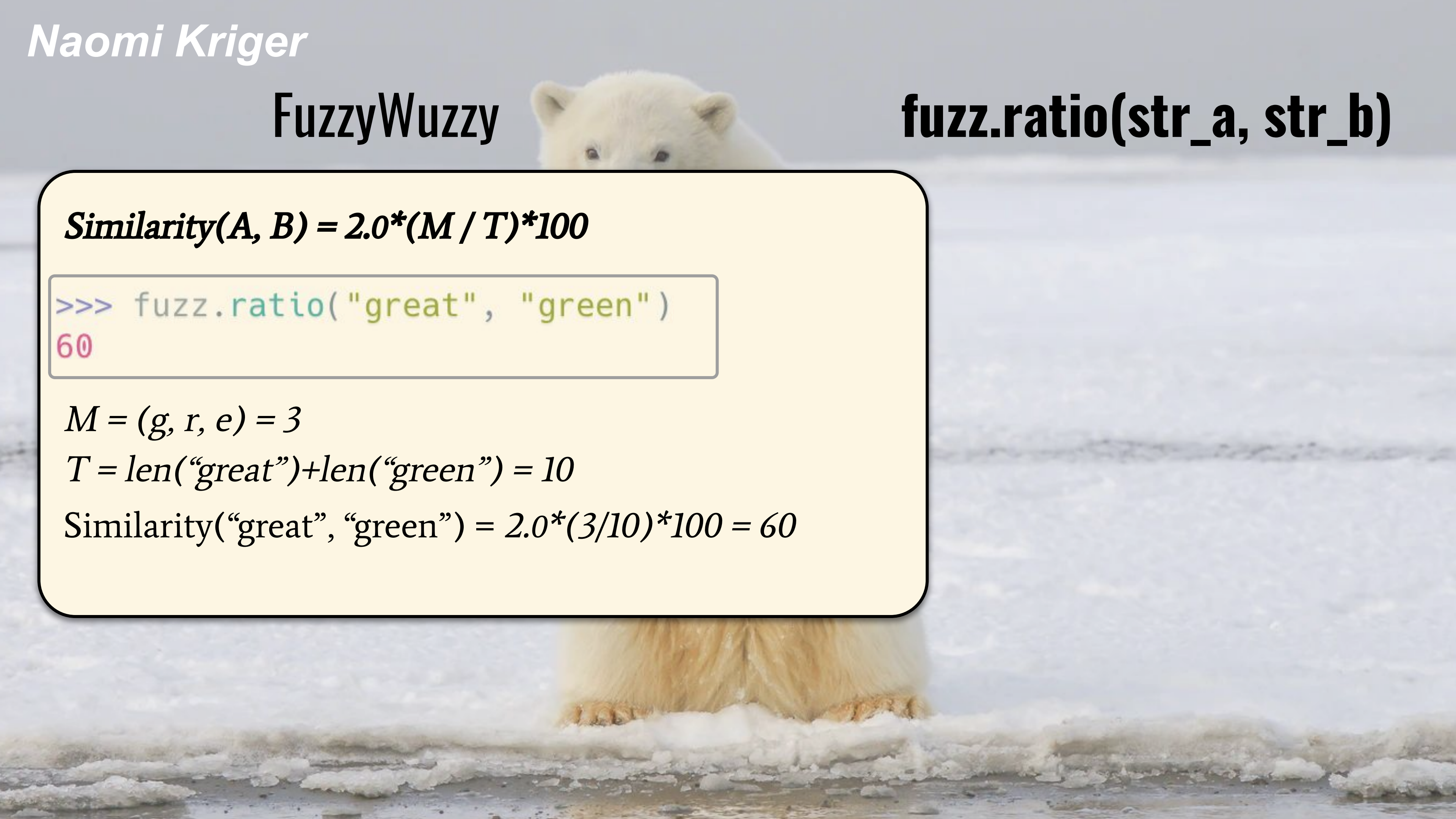
fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0*(M / T)*100

```
>>> fuzz.ratio("great", "green")
```

M = (g, r, e) = 3

T = len("great")+len("green") = 10



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FuzzyWuzzy

fuzz.ratio(str_a, str_b)

Similarity(A, B) = 2.0*(M / T)*100

```
>>> fuzz.ratio("great", "green")
60
```

M = (g, r, e) = 3

T = len("great")+len("green") = 10

Similarity("great", "green") = *2.0*(3/10)*100 = 60*

FuzzyWuzzy

fuzz.ratio(str_a, str_b)

```
>>> fuzz.ratio("1943 Evergreen Lane Gardena California 90247",
               "#1943 Evergreen Lane Gardena, California 0090247")

>>> fuzz.ratio("a", "abcde")
```

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FuzzyWuzzy

fuzz.ratio(str_a, str_b)

```
>>> fuzz.ratio("1943 Evergreen Lane Gardena California 90247",
               "#1943 Evergreen Lane Gardena, California 0090247")

>>> fuzz.ratio("a", "abcde")
```

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FuzzyWuzzy

fuzz.ratio(str_a, str_b)

```
>>> fuzz.ratio("1943 Evergreen Lane Gardena California 90247",
                    "#1943 Evergreen Lane Gardena, California 0090247")

>>> fuzz.ratio("a", "abcde")
```

```
>>> jellyfish.levenshtein_distance(
"1943 Evergreen Lane Gardena California 90247",
                "#1943 Evergreen Lane Gardena, California 0090247")
4

>>> jellyfish.levenshtein_distance("a", "abcde")
4
```

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FuzzyWuzzy

fuzz.ratio(str_a, str_b)

```
>>> fuzz.ratio("1943 Evergreen Lane Gardena California 90247",
               "#1943 Evergreen Lane Gardena, California 0090247")
96
>>> fuzz.ratio("a", "abcde")
33
```

FuzzyWuzzy

fuzz.ratio(str_a, str_b)

```
>>> fuzz.ratio("1943 Evergreen Lane Gardena California 90247",
                  "#1943 Evergreen Lane Gardena, California 0090247")
96
>>> fuzz.ratio("a", "abcde")
33
>>> fuzz.ratio("A", "a")
0
```

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FuzzyWuzzy

Threshold Score

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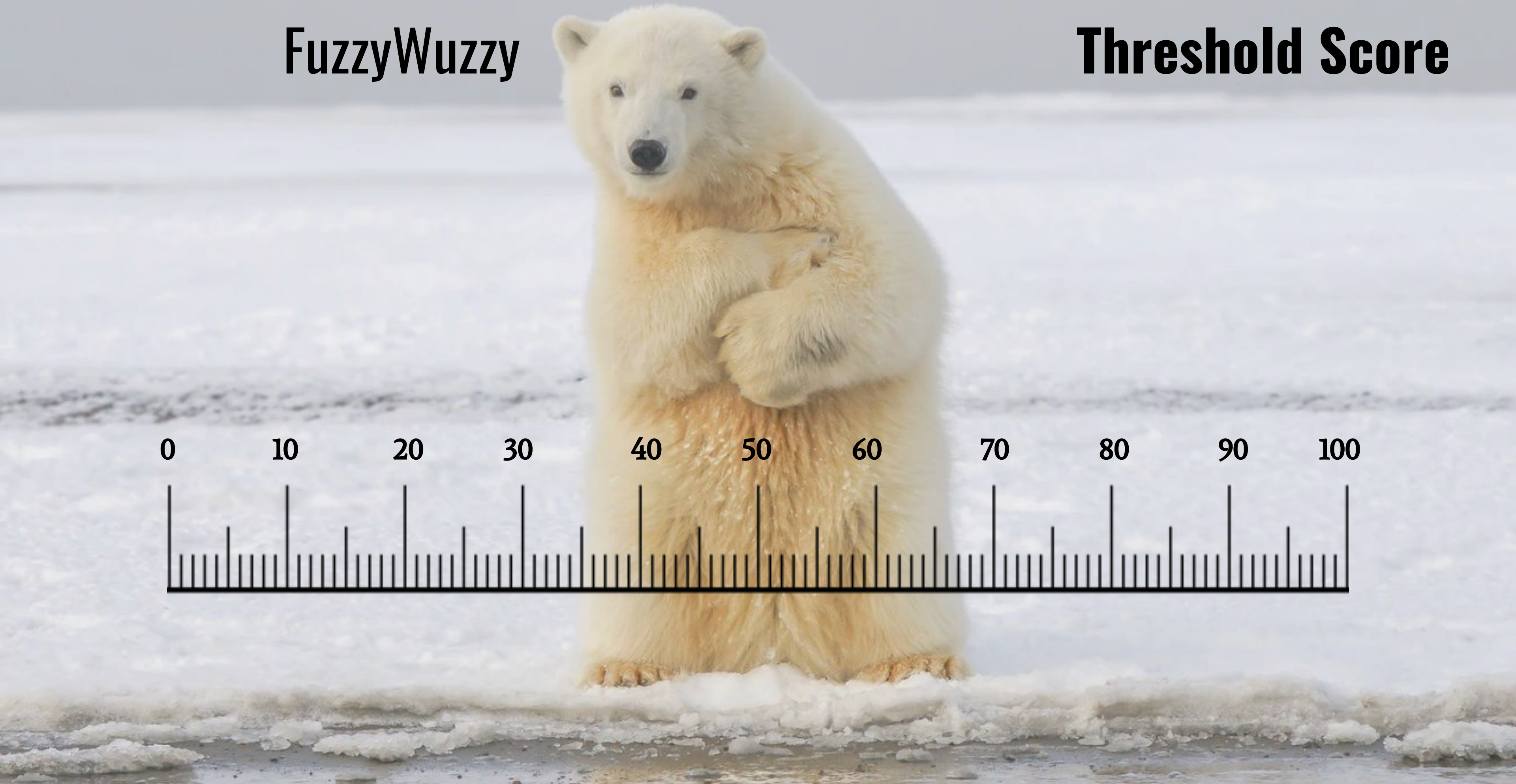
FuzzyWuzzy Threshold Score



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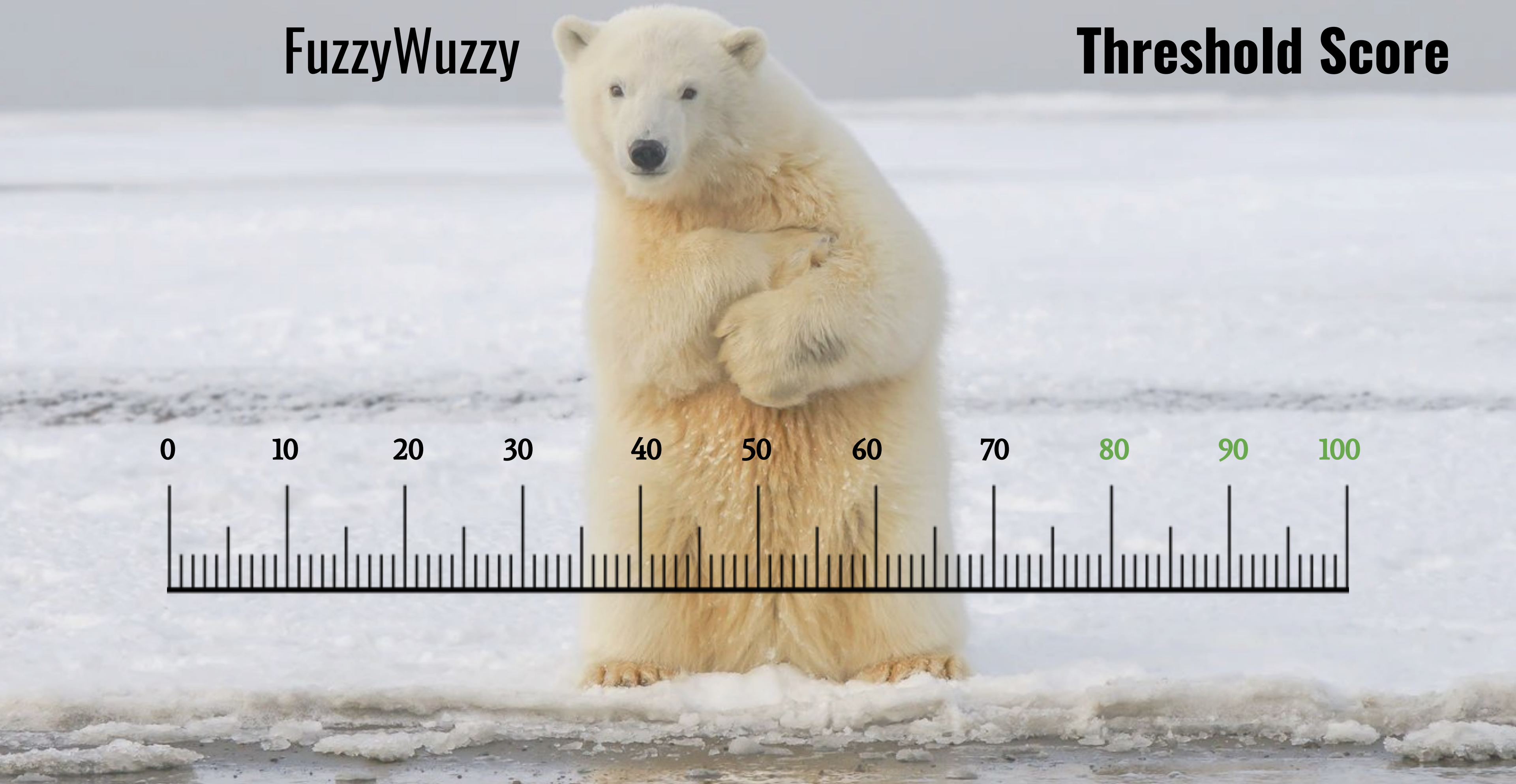
FuzzyWuzzy Threshold Score



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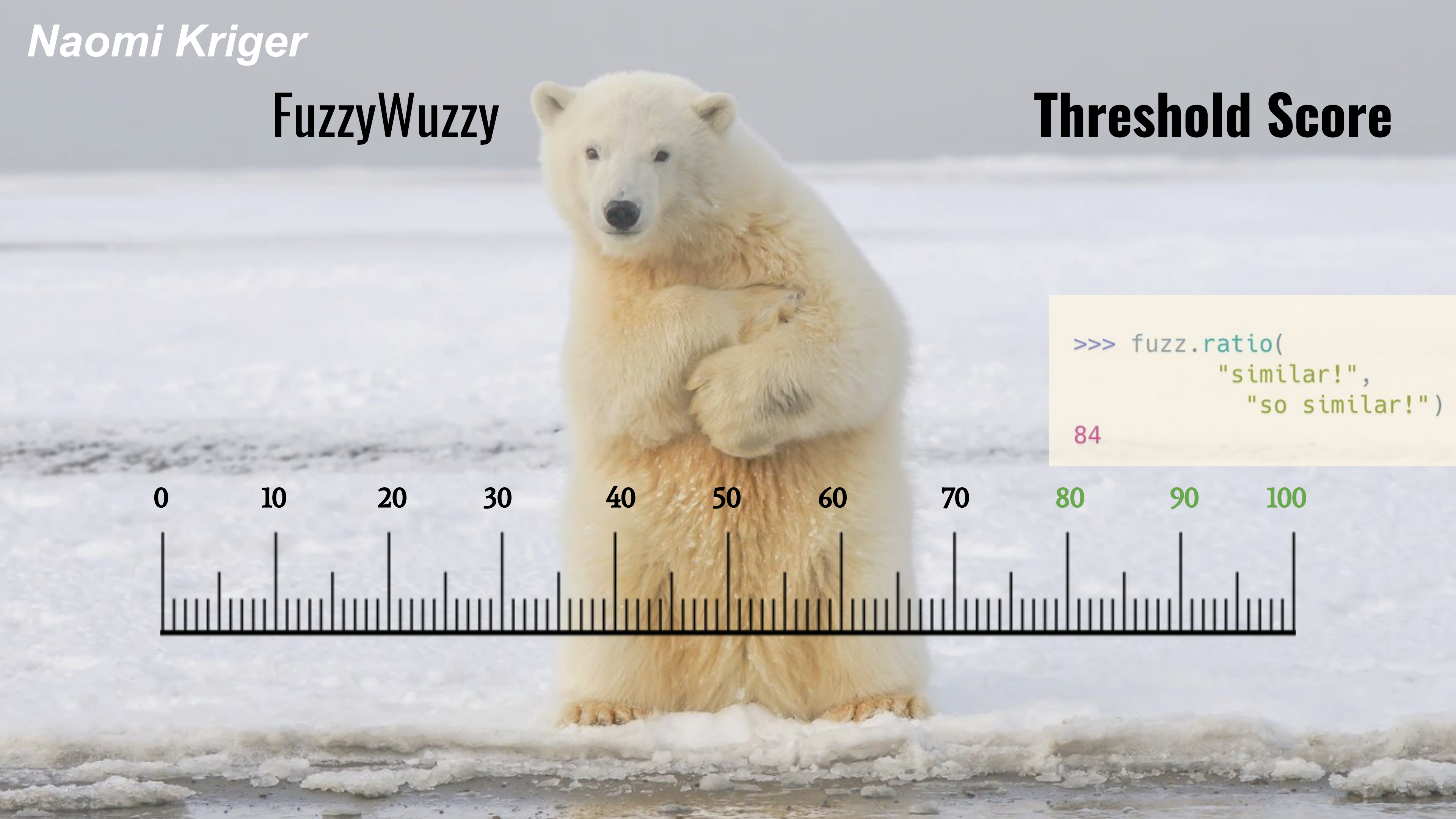
FuzzyWuzzy

Threshold Score



```
>>> fuzz.ratio(
            "similar!",
              "so similar!")
84
```

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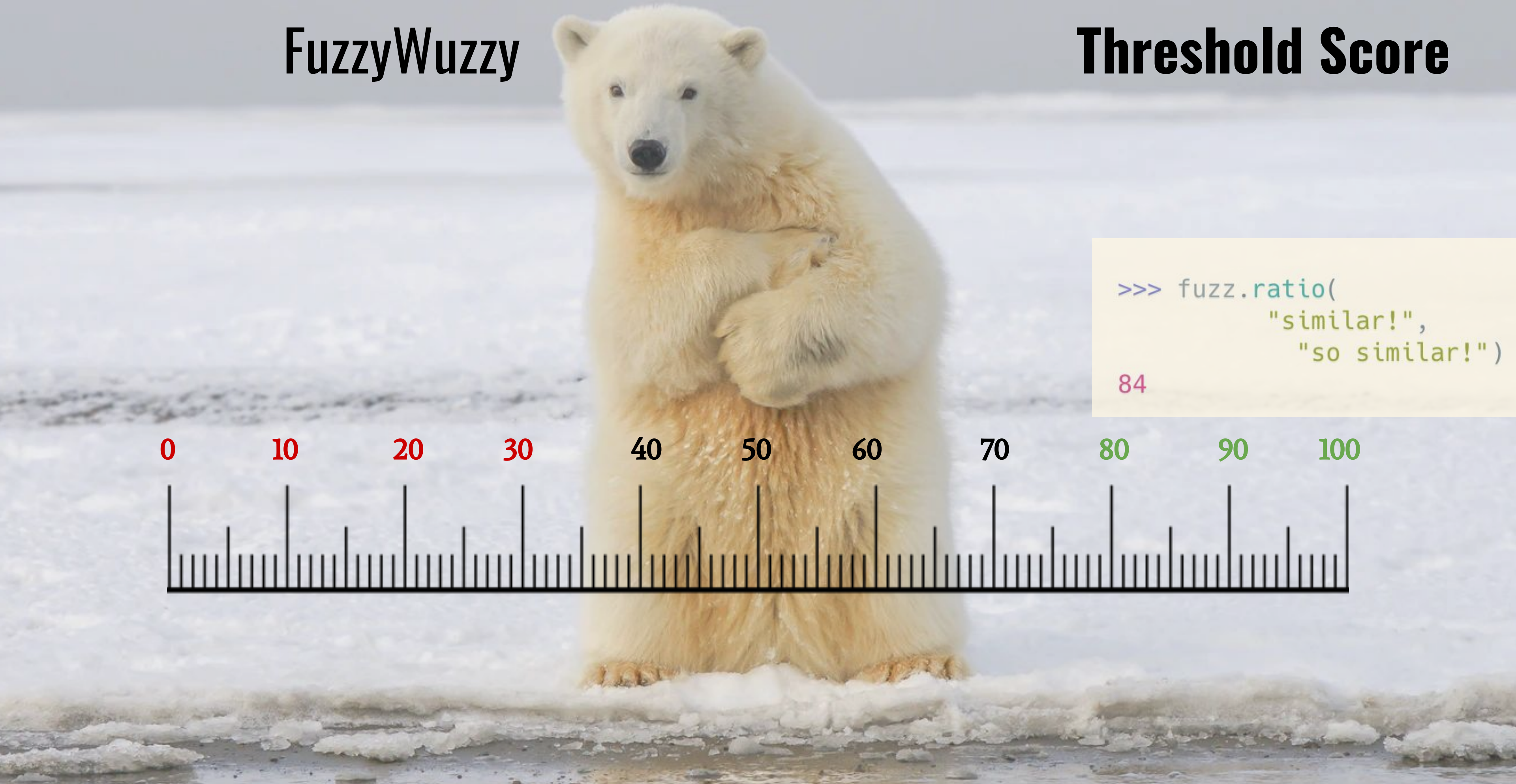
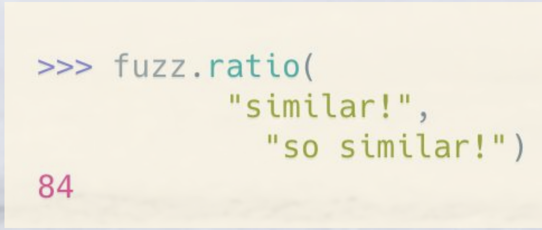
FuzzyWuzzy

Threshold Score





```
>>> fuzz.ratio(
          "similar!",
            "so similar!")
84
```

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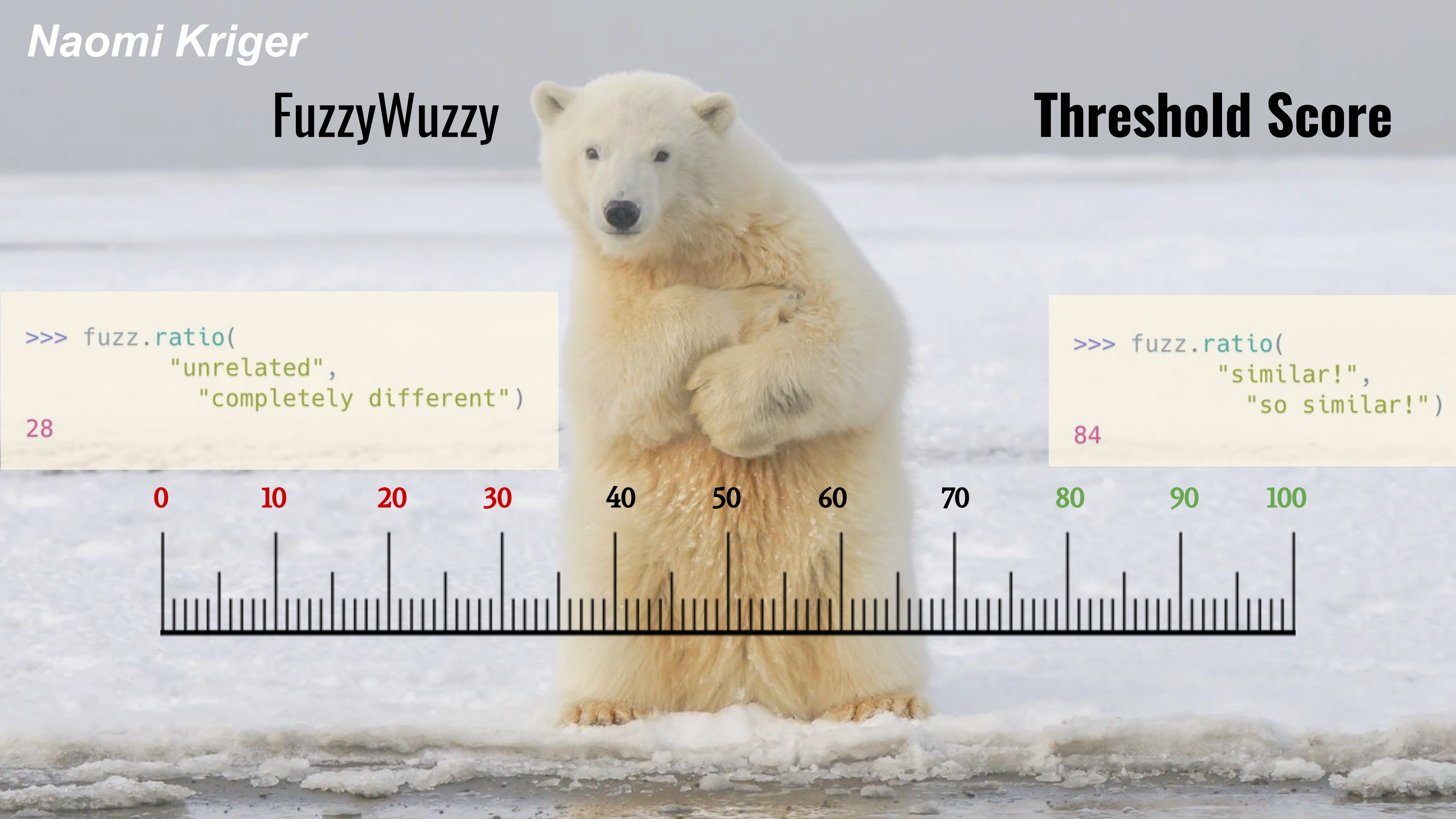
FuzzyWuzzy Threshold Score



```
>>> fuzz.ratio(
        "unrelated",
          "completely different")
28
```

```
>>> fuzz.ratio(
          "similar!",
            "so similar!")
84
```

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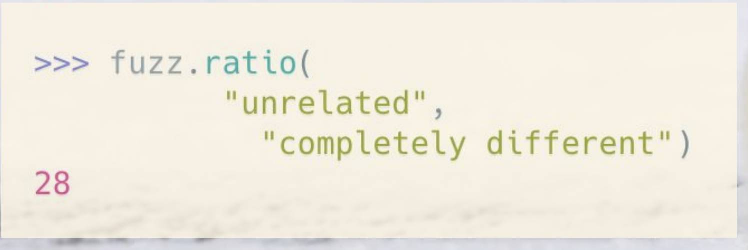
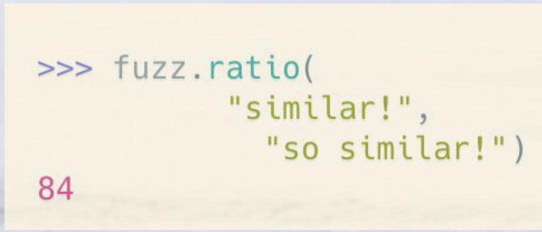
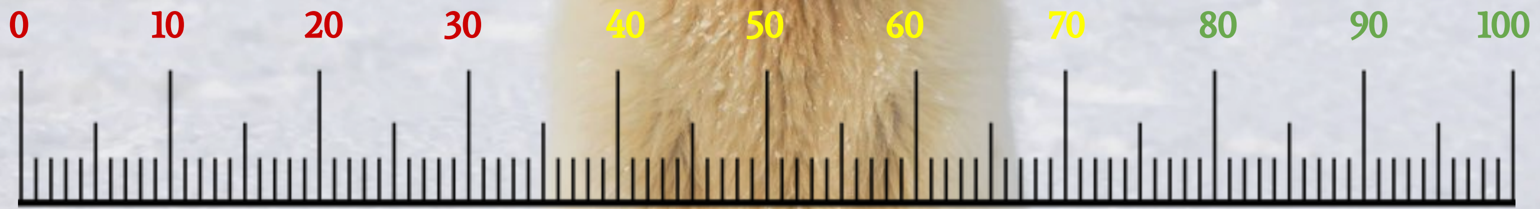
FuzzyWuzzy Threshold Score



```
>>> fuzz.ratio(
          "unrelated",
            "completely different")
28
```



```
>>> fuzz.ratio(
          "similar!",
            "so similar!")
84
```



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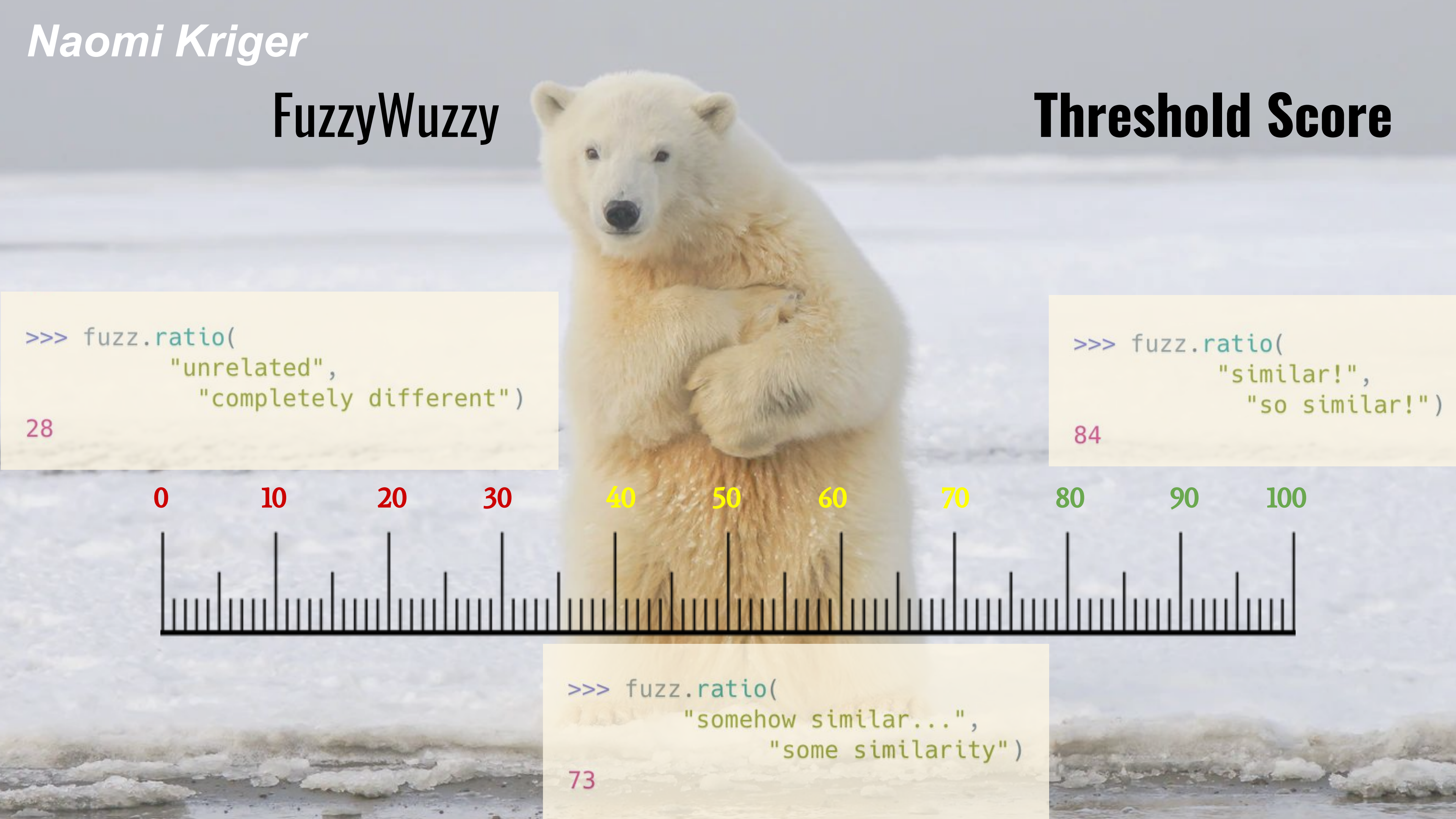
FuzzyWuzzy Threshold Score



```
>>> fuzz.ratio(
        "unrelated",
          "completely different")
28
```

```
>>> fuzz.ratio(
          "similar!",
            "so similar!")
84
```

```
>>> fuzz.ratio(
        "somehow similar...",
              "some similarity")
73
```

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FuzzyWuzzy Threshold Score

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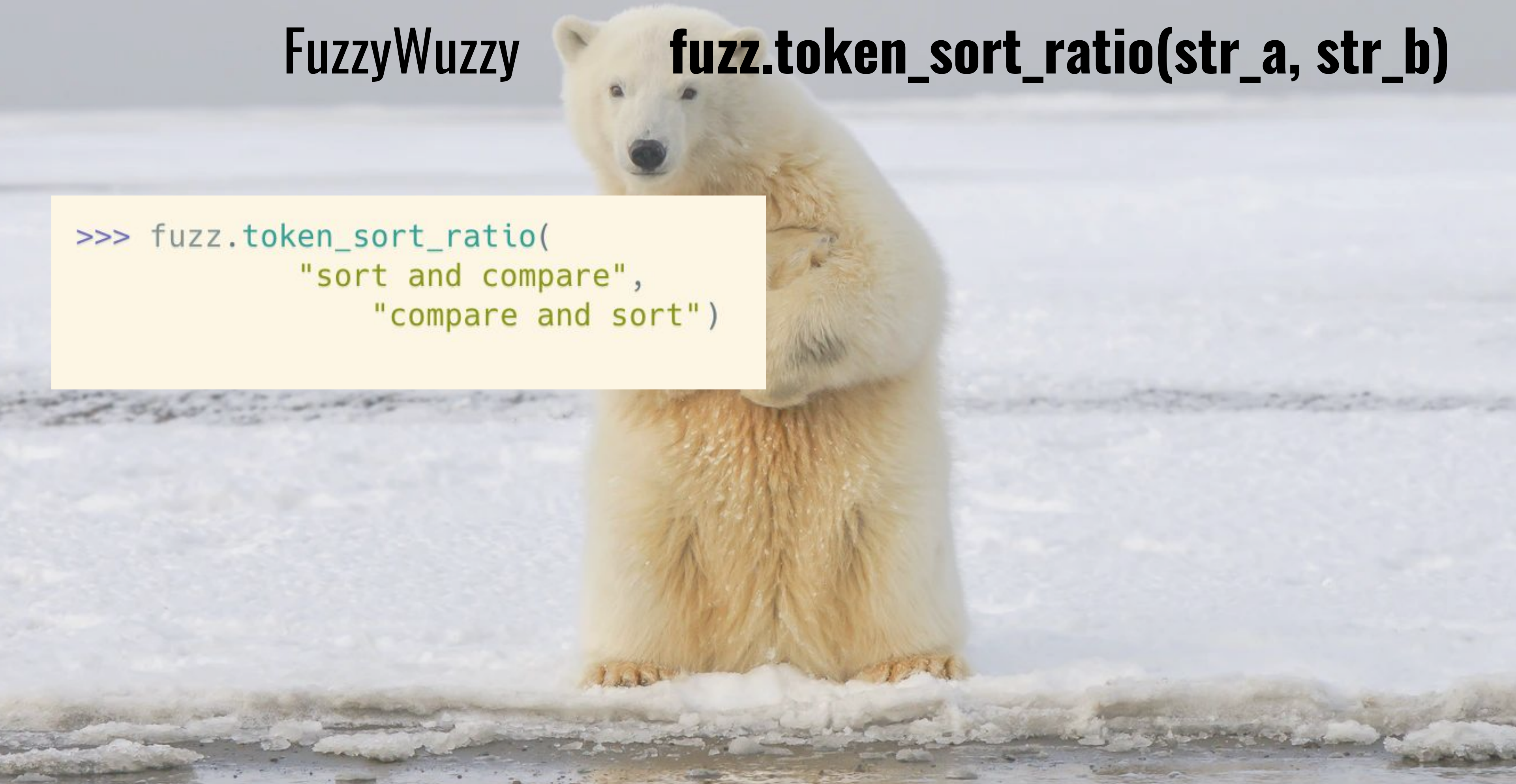
FuzzyWuzzy **fuzz.token_sort_ratio(str_a, str_b)**

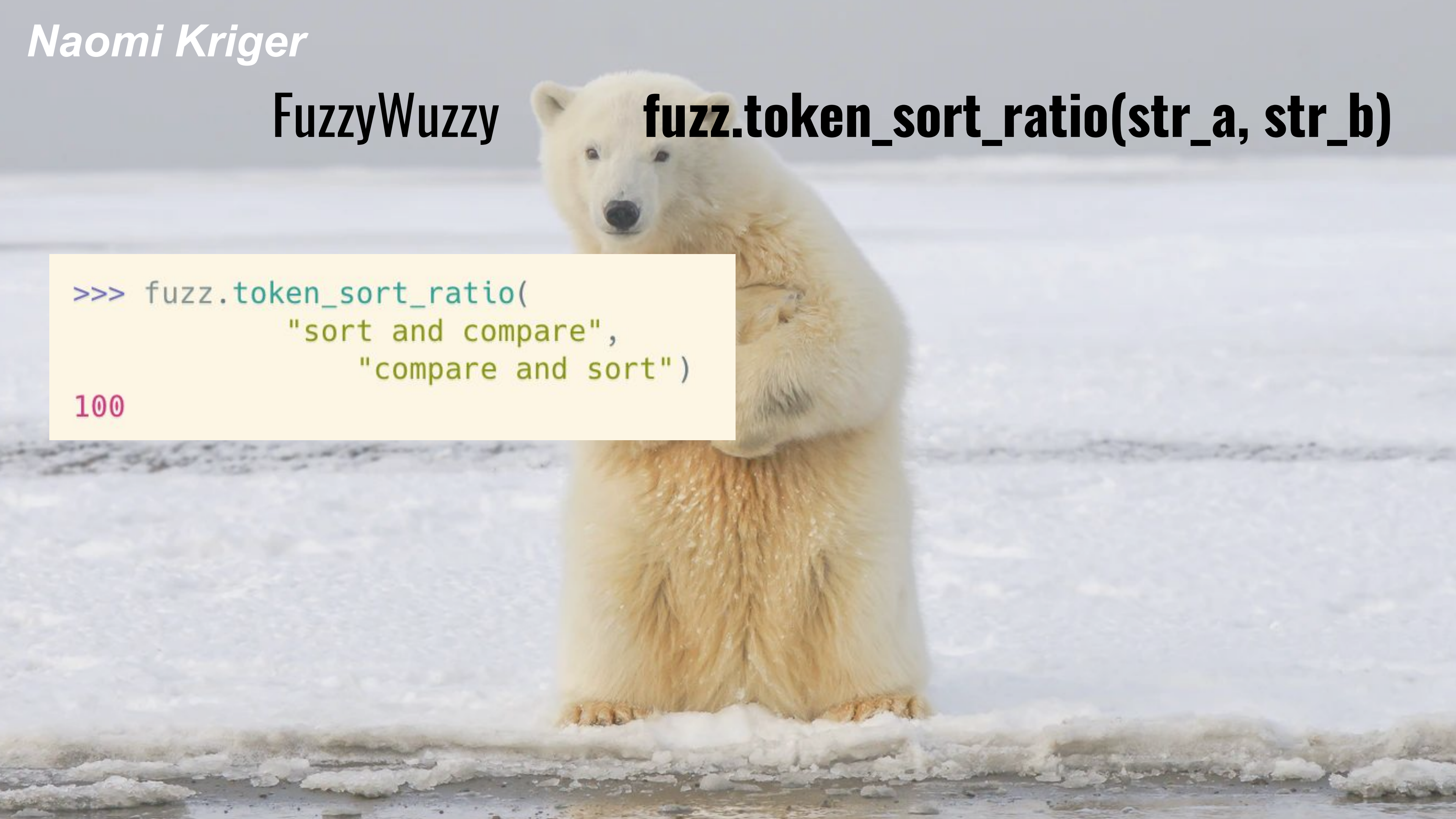
Naomi Kriger

FuzzyWuzzy fuzz.token_sort_ratio(str_a, str_b)



```
>>> fuzz.token_sort_ratio(
            "sort and compare",
                "compare and sort")
```

FuzzyWuzzy **fuzz.token_sort_ratio(str_a, str_b)**



```
>>> fuzz.token_sort_ratio(
            "sort and compare",
                "compare and sort")
100
```

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FuzzyWuzzy **fuzz.token_sort_ratio(str_a, str_b)**

```
>>> fuzz.token_sort_ratio(
                "Emma walked home with Liza",
                    "LIZA WALKED WITH EMMA HOME")
```

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FuzzyWuzzy **fuzz.token_sort_ratio(str_a, str_b)**

```
>>> fuzz.token_sort_ratio(
            "Emma walked home with Liza",
                "LIZA WALKED WITH EMMA HOME")
100
```

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FuzzyWuzzy

`fuzz.token_set_ratio(str_a, str_b)`

FuzzyWuzzy fuzz.token_set_ratio(str_a, str_b)

```
>>> fuzz.token_set_ratio(
            "sort, lower, and no-repeats",
                "LOWER, no-repeats, sort and sort")
```

FuzzyWuzzy fuzz.token_set_ratio(str_a, str_b)

```
>>> fuzz.token_set_ratio(
            "sort, lower, and no-repeats",
                "LOWER, no-repeats, sort and sort")
100
```

FuzzyWuzzy fuzz.token_set_ratio(str_a, str_b)

```
>>> fuzz.token_set_ratio(
              "sort, lower, and no-repeats",
                   "LOWER, no-repeats, sort and sort")
100

>>> fuzz.token_sort_ratio(
              "sort, lower, and no-repeats",
                   "LOWER, no-repeats, sort and sort")
```

FuzzyWuzzy

fuzz.token_set_ratio(str_a, str_b)

```
>>> fuzz.token_set_ratio(
            "sort, lower, and no-repeats",
                "LOWER, no-repeats, sort and sort")
100

>>> fuzz.token_sort_ratio(
            "sort, lower, and no-repeats",
                "LOWER, no-repeats, sort and sort")
91
```

FuzzyWuzzy **fuzz.token_set_ratio(str_a, str_b)**

```
>>> fuzz.token_set_ratio(
             "I love chocolate and ice cream",
                 "I LOVE ice cream AND I love chocolate!")
```

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FuzzyWuzzy fuzz.token_set_ratio(str_a, str_b)

```
>>> fuzz.token_set_ratio(
            "I love chocolate and ice cream",
                "I LOVE ice cream AND I love chocolate!")
100
```

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FuzzyWuzzy Usages & Advantages

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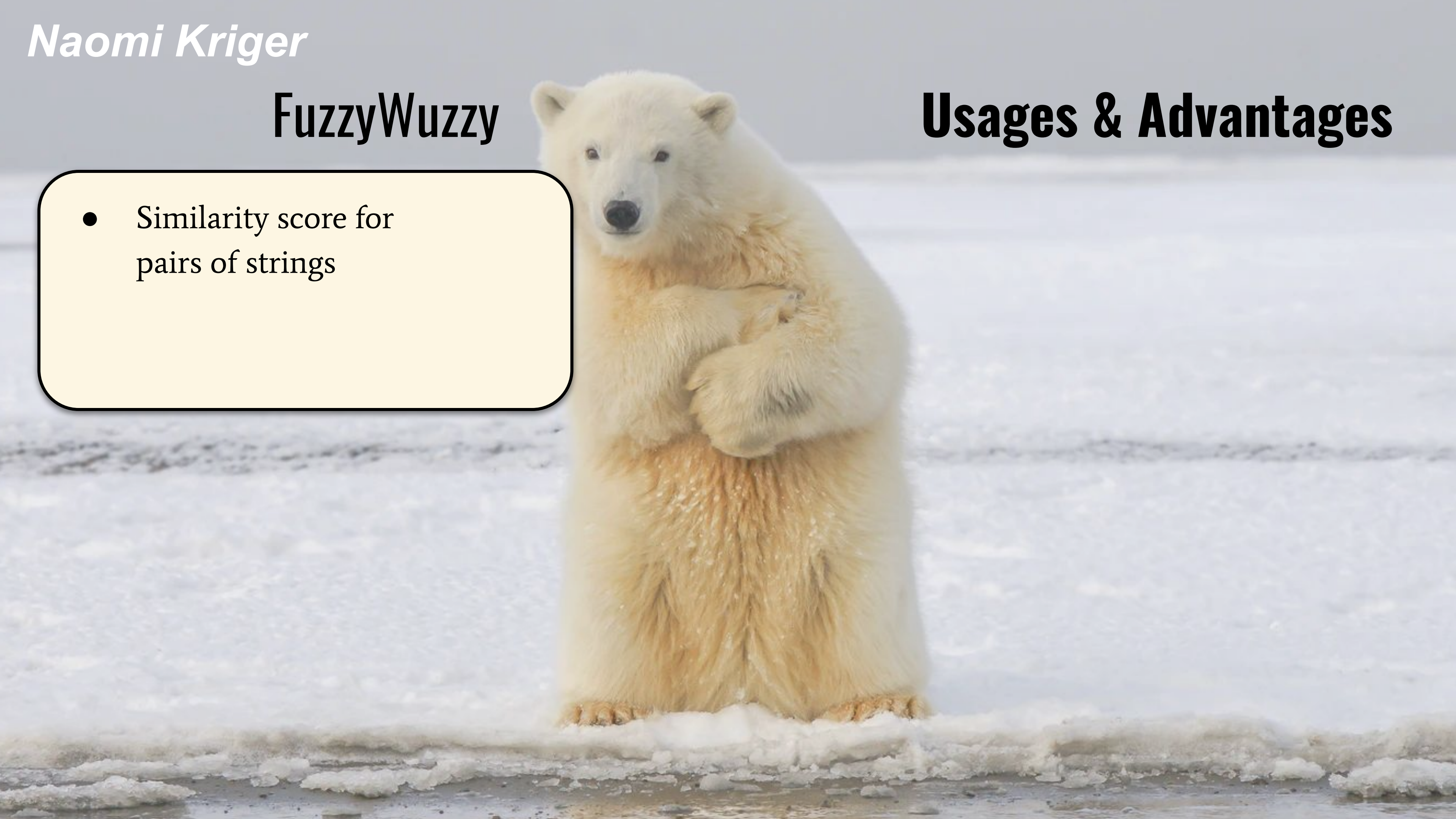
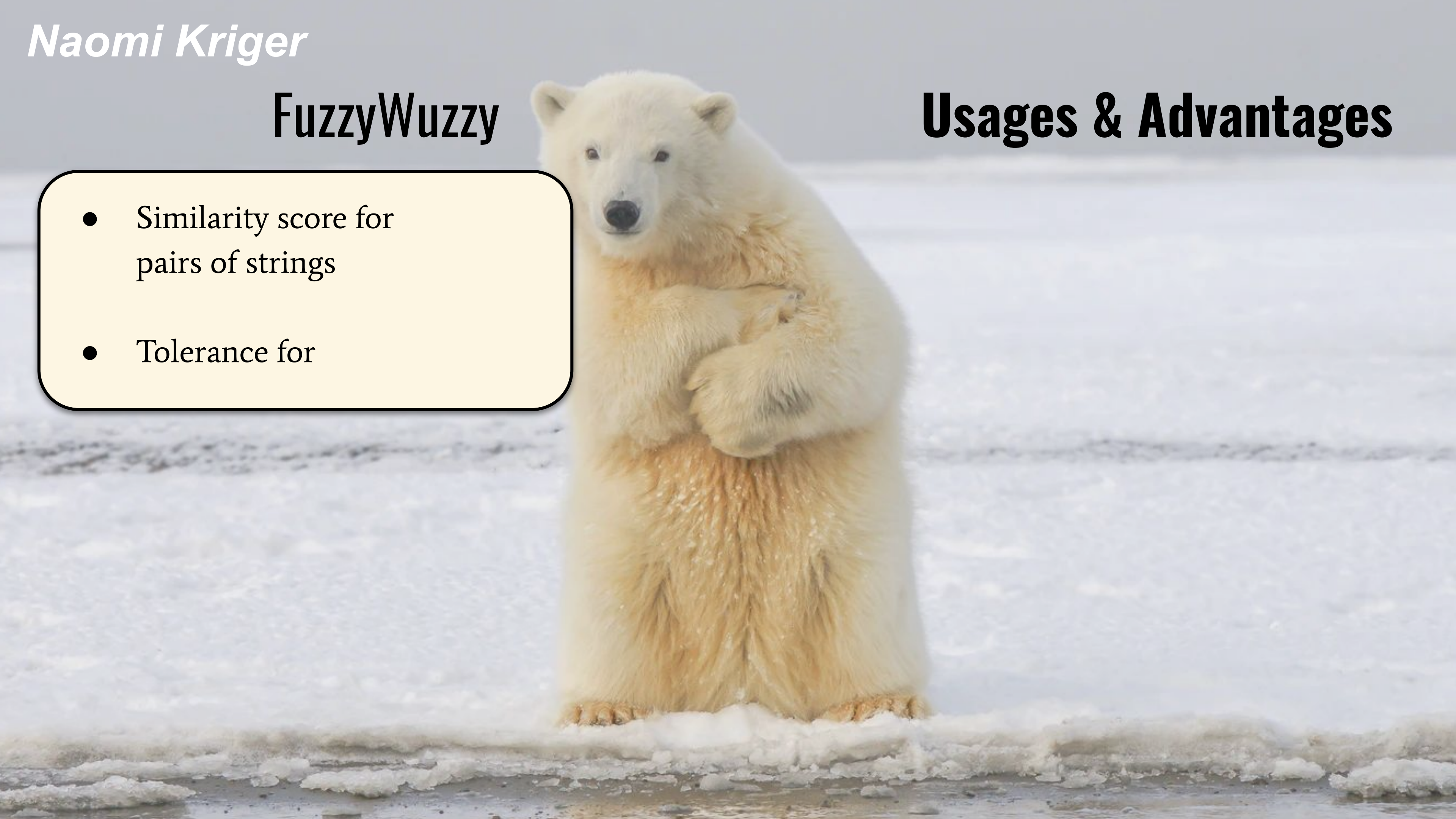
FuzzyWuzzy Usages & Advantages



- Similarity score for pairs of strings



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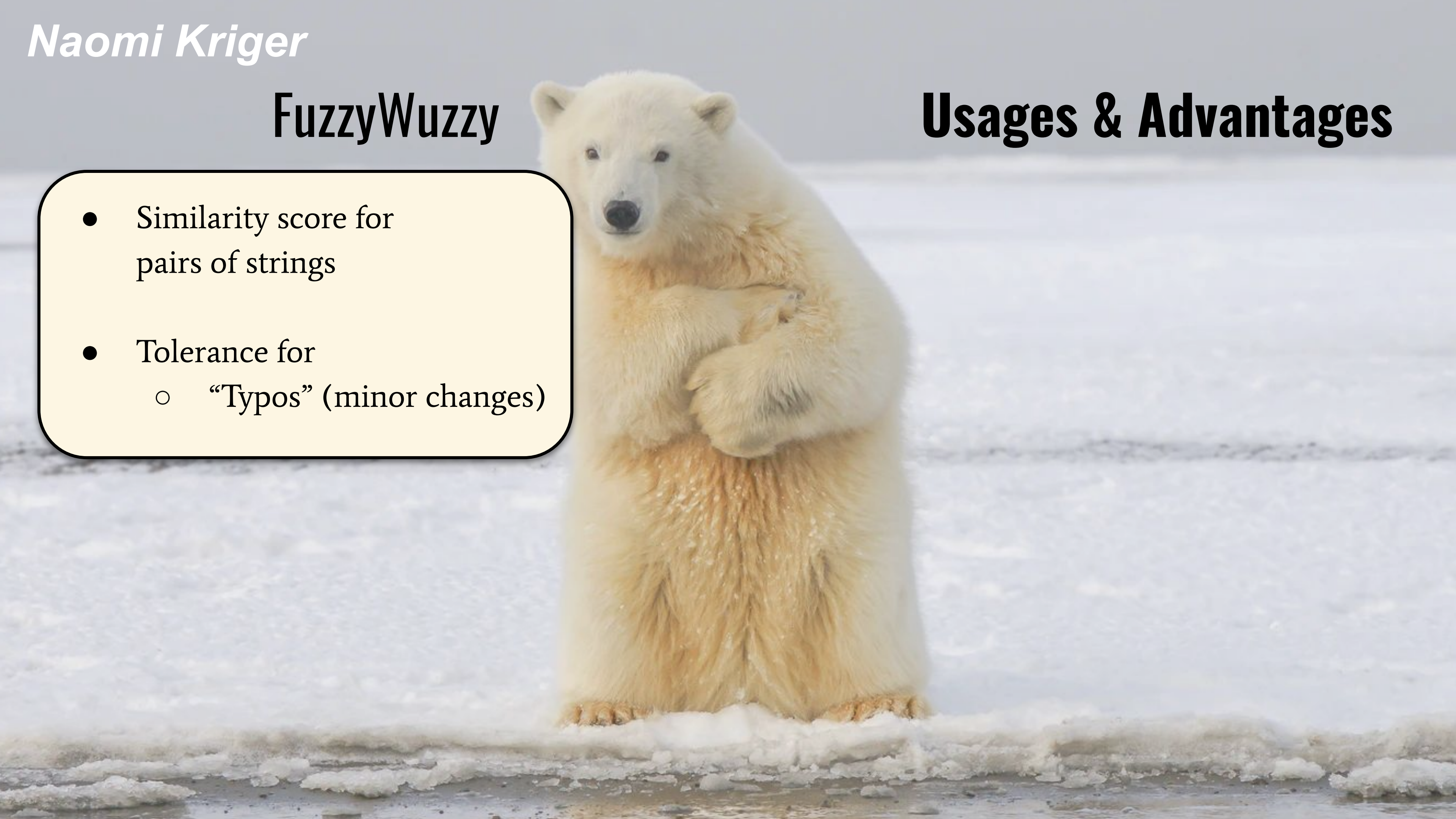
FuzzyWuzzy

Usages & Advantages

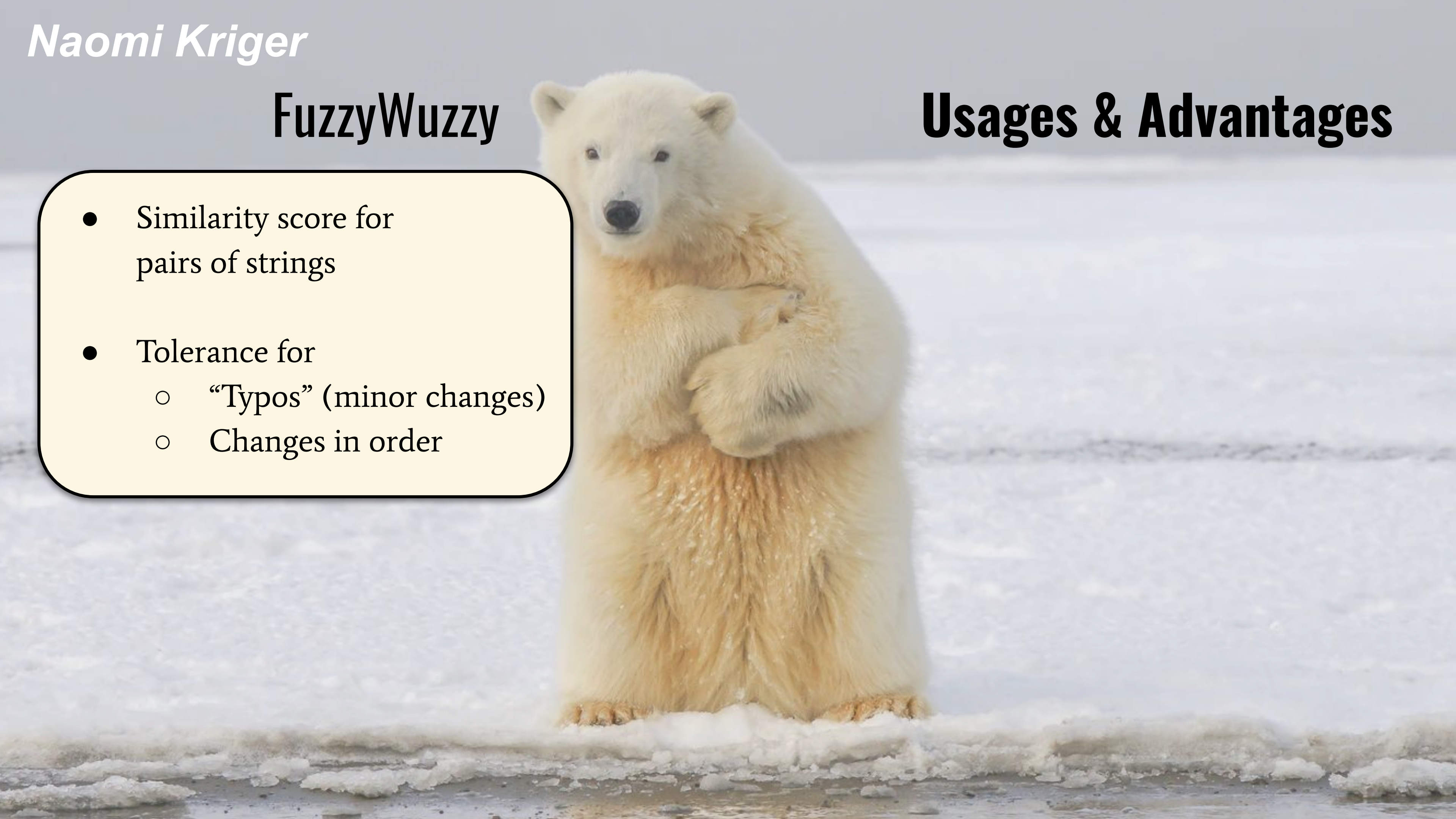
- Similarity score for pairs of strings
- Tolerance for



FuzzyWuzzy Usages & Advantages

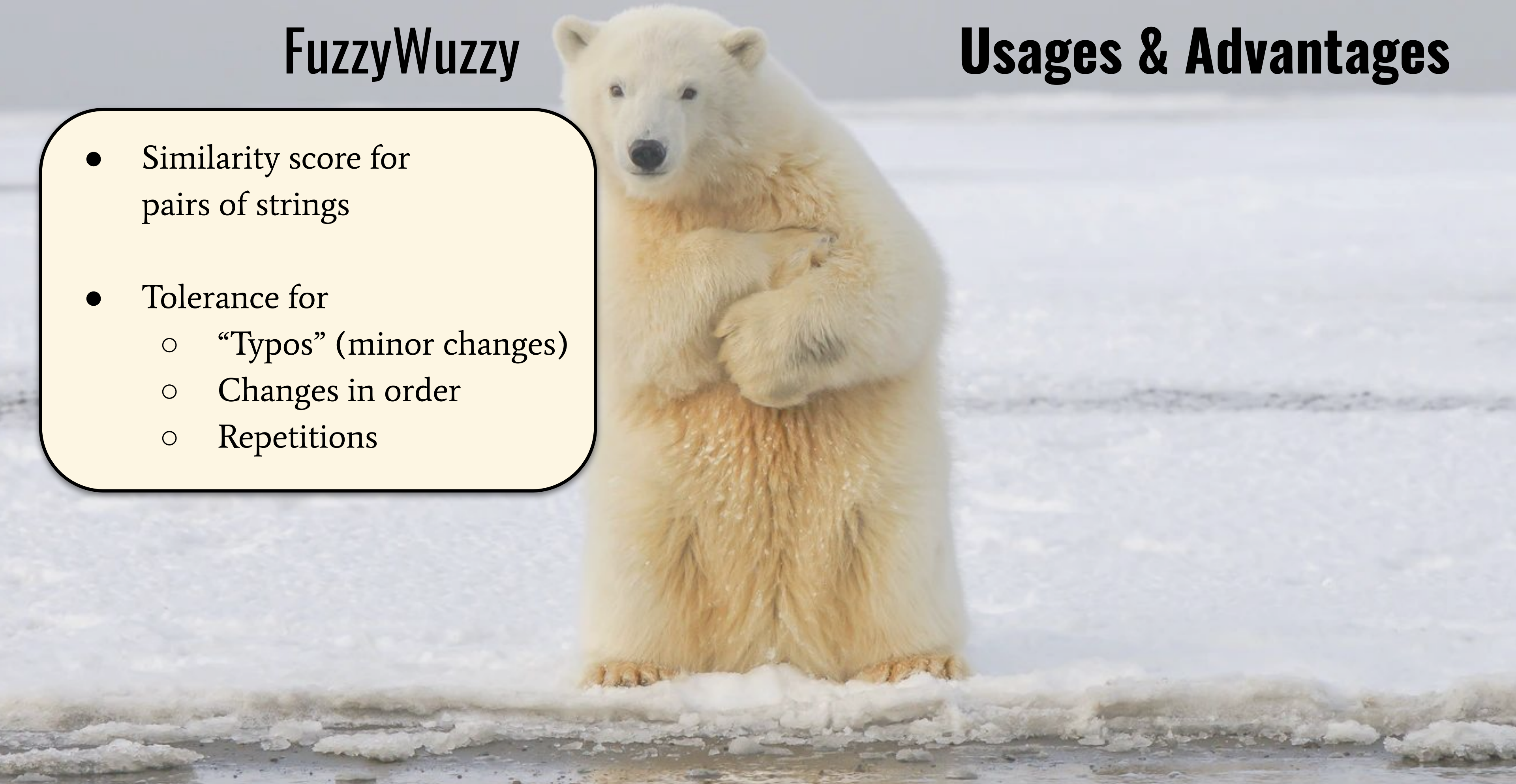
- Similarity score for pairs of strings
- Tolerance for
  - "Typos" (minor changes)

FuzzyWuzzy Usages & Advantages



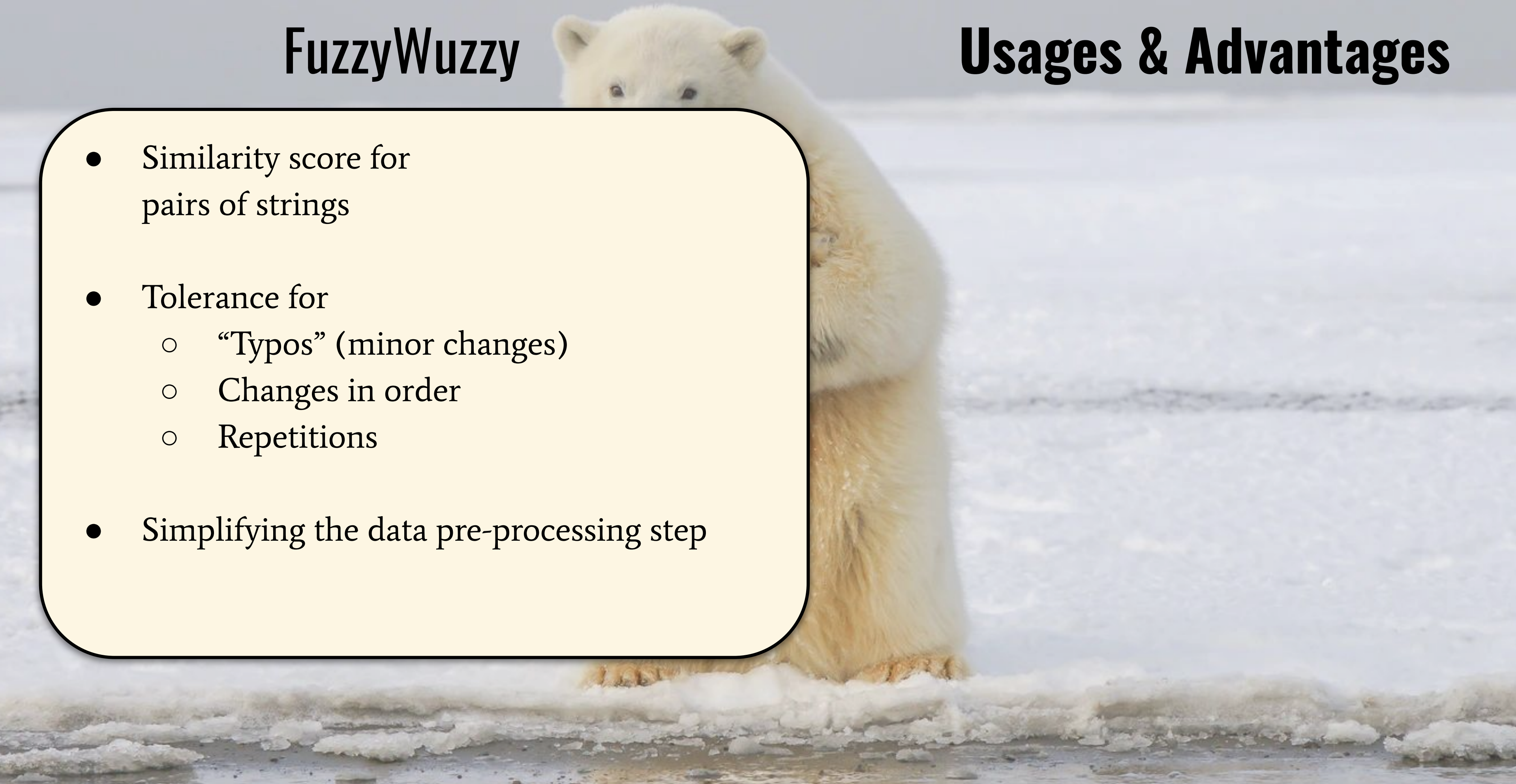
- Similarity score for pairs of strings
- Tolerance for
    - “Typos” (minor changes)
    - Changes in order

FuzzyWuzzy Usages & Advantages



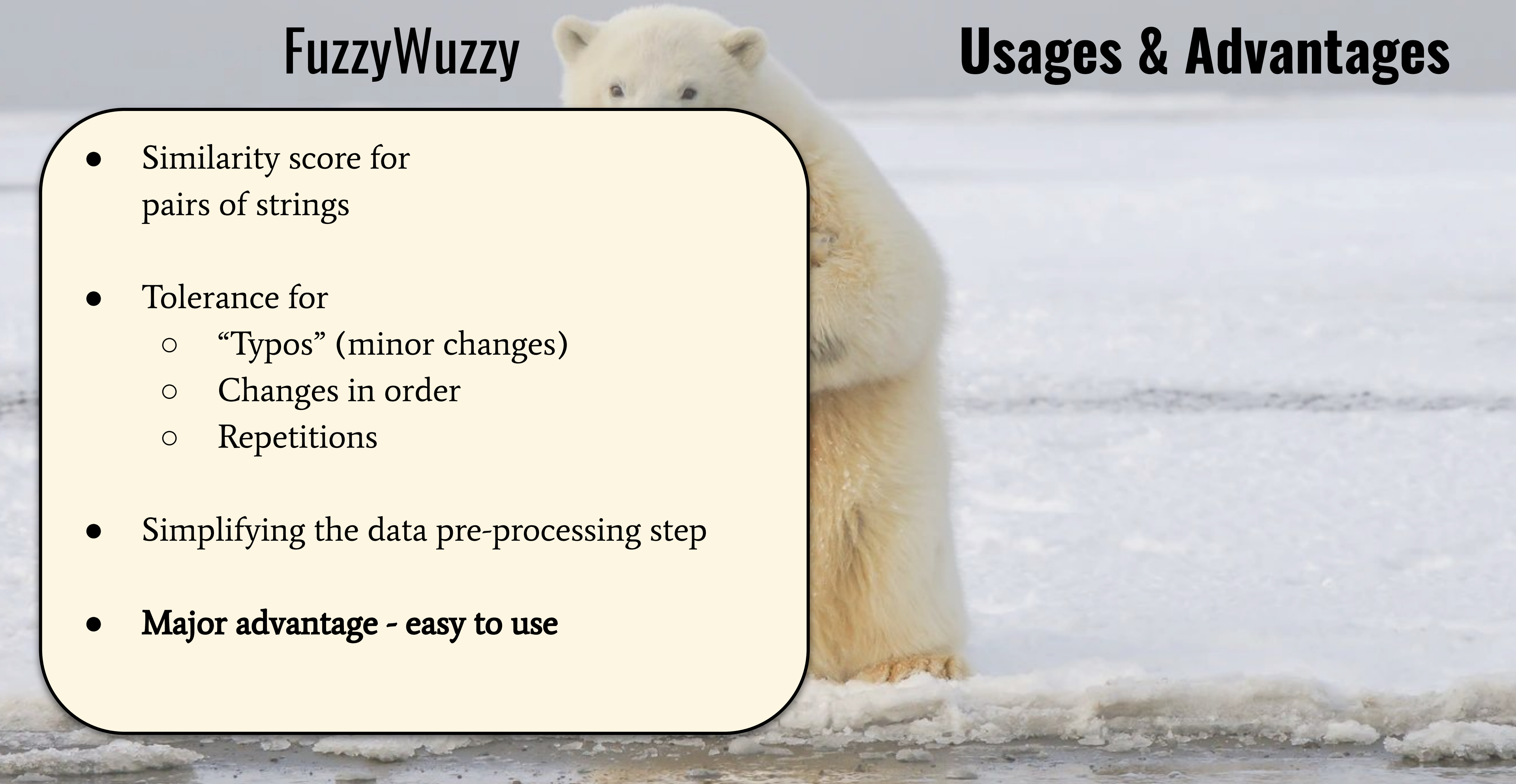
- Similarity score for pairs of strings
- Tolerance for
  - “Typos” (minor changes)
  - Changes in order
  - Repetitions

FuzzyWuzzy Usages & Advantages



- Similarity score for pairs of strings
- Tolerance for
  - “Typos” (minor changes)
  - Changes in order
  - Repetitions
- Simplifying the data pre-processing step

FuzzyWuzzy Usages & Advantages



- Similarity score for pairs of strings
- Tolerance for
  - “Typos” (minor changes)
  - Changes in order
  - Repetitions
- Simplifying the data pre-processing step
- **Major advantage - easy to use**

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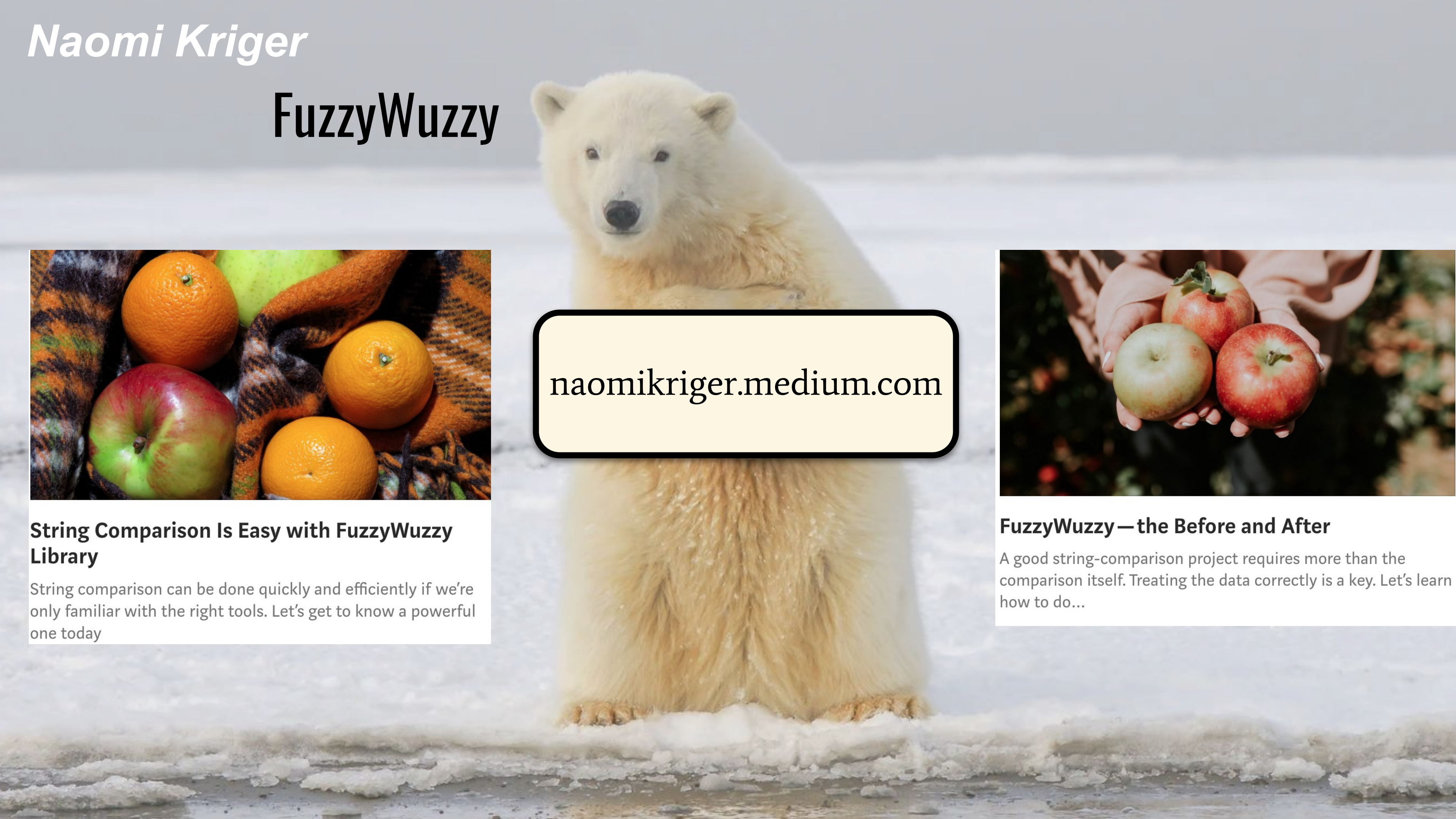
FuzzyWuzzy



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String Comparison Is Easy with FuzzyWuzzy Library

String comparison can be done quickly and efficiently if we're only familiar with the right tools. Let's get to know a powerful one today

FuzzyWuzzy — the Before and After

A good string-comparison project requires more than the comparison itself. Treating the data correctly is a key. Let's learn how to do...

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What did we learn?

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What did we learn?

Jellyfish

Naomi Kriger

What did we learn?

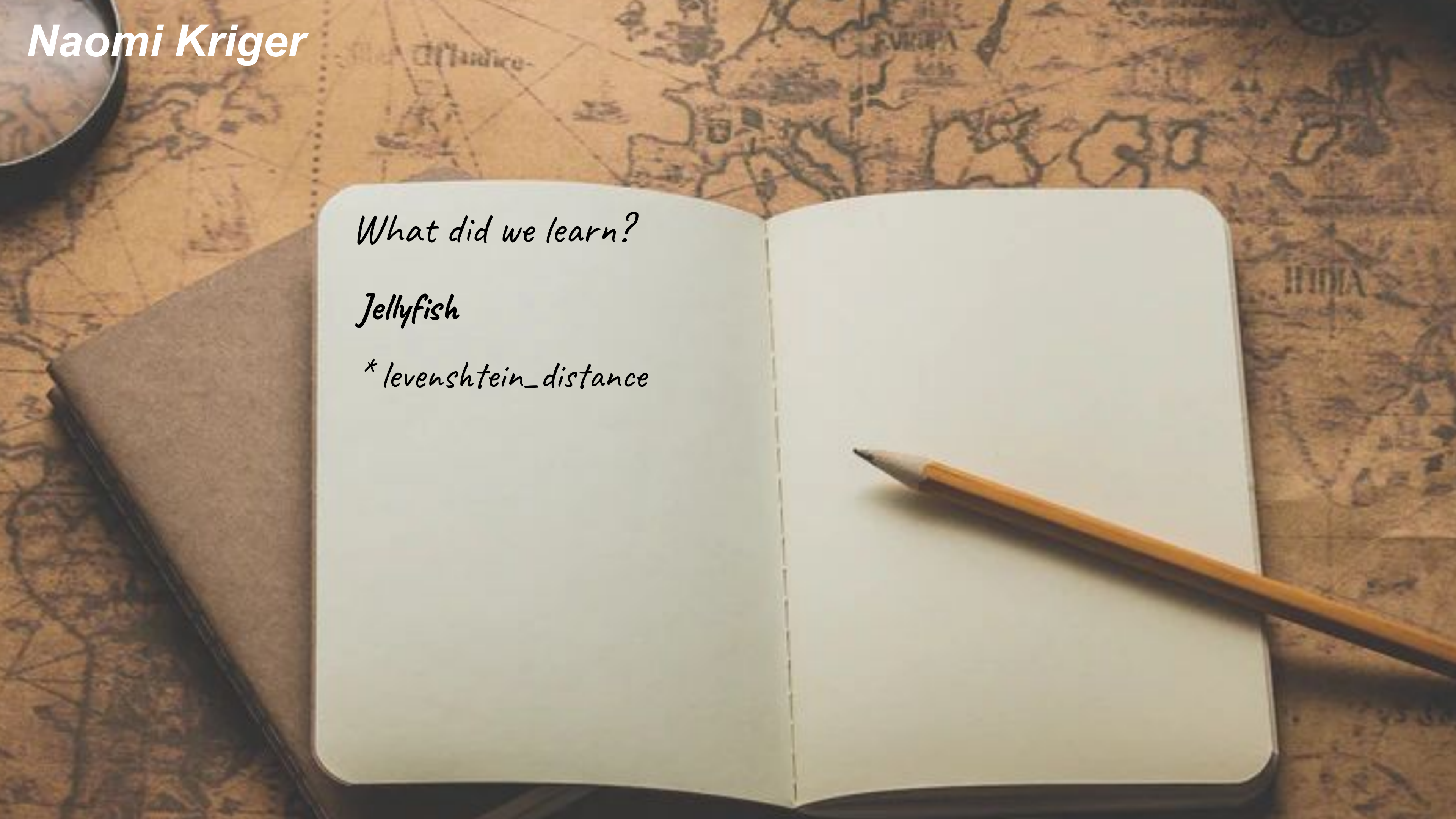
Jellyfish

FuzzyWuzzy

Naomi Kriger

What did we learn?

Jellyfish



What did we learn?

Jellyfish

* levenshtein_distance

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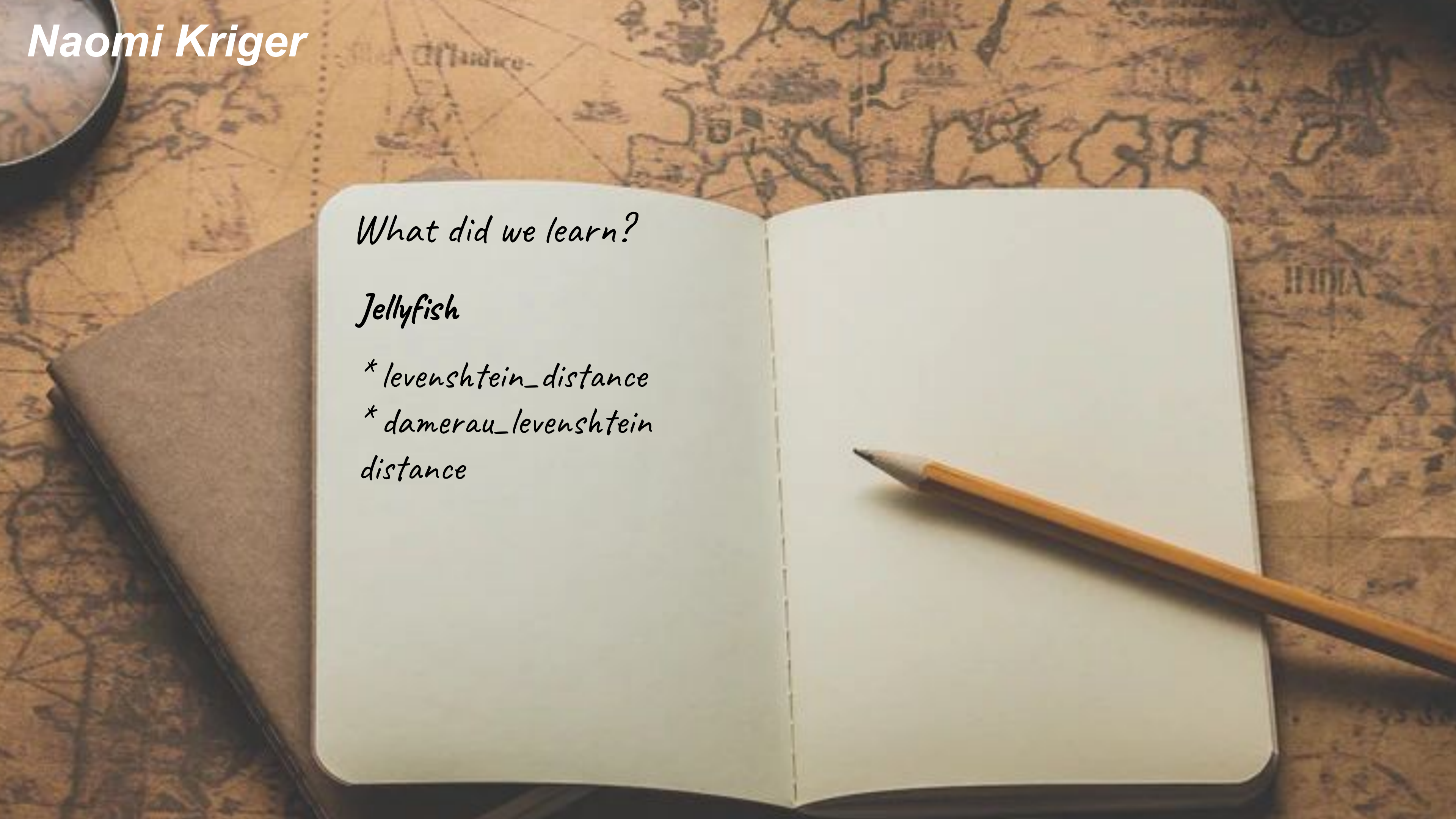

What did we learn?

Jellyfish

* levenshtein_distance
* damerau_levenshtein distance

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What did we learn?

Jellyfish

* levenshtein_distance
* damerau_levenshtein distance

FuzzyWuzzy

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What did we learn?

Jellyfish

* levenshtein_distance
* damerau_levenshtein distance

FuzzyWuzzy

* fuzz.ratio

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What did we learn?

Jellyfish

* levenshtein_distance
* damerau_levenshtein distance

FuzzyWuzzy

* fuzz.ratio
* fuzz.token_sort_ratio

What did we learn?

Jellyfish

* levenshtein_distance
* damerau_levenshtein distance

FuzzyWuzzy

* fuzz.ratio
* fuzz.token_sort_ratio
* fuzz.token_set_ratio

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thanks!
Tombow ABT
Acid Free
N15

String Comparison In Real Life

Naomi Kriger